# Student Actions as a Window into Goals and Motives in the Secondary Mathematics Classroom

by

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## Abstract

Students come to the secondary mathematics classroom with a variety of motives. These motives shape the goals a student holds, and the actions that a student performs within the classroom. Ultimately, the approach that a student takes towards learning is a direct consequence of his or her motives. Given the significance of student motive for learning, it is important to understand better the relationship between actions, goals, and motives. The research presented in this thesis aims to do just that. More specifically, it looks closely at student actions in high school mathematics classrooms with the aim of identifying student goals and motives, and further, analysing the relationships between students' actions and their motives. Using an ethnographic perspective and methods, student actions in three different secondary mathematics classrooms were observed and in situ informal interviews were conducted. Data were first organised and analysed according to actions performed in each activity setting. Then, using classical activity theory, 10 students' actions and goals in multiple activity settings were analysed to ascertain his or her motives in mathematics class. Finally, the motives and actions of all participants were re-examined from two different perspectives: first, looking at the performed actions of all students holding a given motive in each activity setting; and second, examining the relationships between similar student actions and different motives in one activity setting. This 'crossover' approach revealed that similar student actions can be driven by different motives, and that the same motive does not always manifest in similar student action.



**Keywords**: Student behaviour; secondary mathematics; ethnographic approach; activity theory; student motives

*for my family*

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# Preface

> In many cases these behaviours are centred on proxies for learning and understanding, such as mimicking, that are not actually conducive to learning. (Liljedahl & Allan, 2013a, p. 263)

I am both a learner and a teacher of mathematics. I have been learning all of my life, and at this point I have been teaching secondary school mathematics for over thirteen years. It is my teaching experience that serves as the impetus for this research. In my career, I have taught many classes and hundreds of students who have caused me to feel amazed, impressed, overjoyed, saddened, proud, disappointed, frustrated and much more. For a long time I questioned why students acted in ways that were not in their best interest, made choices that did not make sense to me or seemed to know what they were doing but 'forgot' it all when writing an assessment. I cheered for students who achieved success, despaired for those who did not take advantage of the opportunities for help that I offered and shared the frustration of those who worked so hard, doing all that I asked of them, and more, yet never seemed really to 'get it'. To some students, it seems that trying to comprehend mathematics is a Sisyphean task – one both laborious and futile.

It is the feeling of frustration that really sticks with me, and it is for two different 'types' of students: those who could, but do not try, and those who try and try, but never really succeed. Consider a student, Jake, who does not do the assigned homework. In an effort to get Jake, and others like him, to undertake the assigned practice, I offer 'homework marks' to try make it worth the effort. This 'works' for a few students, who now submit some work, but not all, and now I have found myself in a situation where what was a 'carrot' to encourage and reward students for doing work turns into a stick to beat those who were never going to do it anyway. There are many variations on this (e.g. randomly choosing questions or pages to mark), but the outcome varies little. Now take another student, Dylan. Dylan does every assigned question and more. But it does not matter if he does every question in the book – he will only be successful on test questions that are carbon copies of those he has done before, and only then if he remembers them.

Only in the past few years have I started to come closer to understanding why this is, and how this situation comes about. Through interactions with educators, research and students, and by reflecting on my own practice, I started to change my thinking, and my perspective. I began to notice contradictions in how I and other teachers intended students to approach certain tasks and how students actually engaged with those tasks. Most teachers are aware that not all students always do what the teacher intends them to do, or are not doing it in the way that the teacher intends them to do it. However, what we do not know is *how* prevalent this behaviour is and *why* it occurs. Beyond forms of behaviour that obviously do not conform (to perceived teacher expectations) are those that appear to conform and those that actually do conform. Even behaviour that conforms to expectations is only demonstrating proxies for learning, such as completing homework or taking notes. Only a very small subset of student behaviour is actually conducive to learning. As I began to realize this, it prompted me to undertake a categorisation of the behaviour that students exhibit in the mathematics classroom and to investigate the reasons for their behaviour.

The aim of this dissertation is not to make value judgements about students or their behaviour, nor is it to classify particular behaviour as “good” or “bad”. I seek to describe and categorize student behaviour in the context of the secondary mathematics classroom first to establish what students are actually doing in particular settings. This data is then used to achieve my second, equally if not more important, goal: determining the motive(s) that drive(s) such behaviour. For, if we care at all about students’ learning of mathematics, then we need to attend more closely to what students actually do in learning situations in mathematics classrooms. It is exactly this phenomenon in which I am interested.

My investigation into student actions and motives, including my analysis and results, form the four parts of this thesis. Part I is comprised of three chapters and contains a review of the literature, discussion of theoretical perspective, and an account of methodology. The second and third parts each contain three chapters. Both of these parts concern the presentation and analysis of data, using different units of analysis. Part II looks at student actions in different activity settings, showcasing the range of student action. The first and second chapters in Part II analyse actions within activity settings, while the third looks across activity settings, identifying themes. In Part III ten individual student’s actions are examined across activity settings; these are presented as ten separate case studies, each concluding with the student's motives. The case studies are grouped by class, and thus forming the three chapters in Part III. Part IV contains two chapters; the first re-examining the analysis from Parts II and III from different perspectives (a 'crossover' approach), and the second the conclusion to the thesis.

# PART I

> The purpose of doing interpretivist research, then, is to provide information that will allow the investigator to “make sense” of the world from the perspective of participants; that is, the researcher must learn how to behave appropriately in that world *and* how to make that world understandable to others, especially in the research community. Thus the researcher must be involved in the activity as an insider and be able to reflect upon it as an outsider. (Eisenhart, 1988, p. 103)

This part of the thesis serves the purpose of narrowing and refining my phenomenon of interest, turning it from a curiousity into formally stated research questions. There are three chapters, each representing a review of the literature for a different element of my study. Together these frame, guide and permeate my investigation.

In Chapter 1, I first describe what it is that I seek to understand – student actions and motives in the secondary mathematics classroom. Following this, I elaborate on my search of the literature, providing an overview of theories and frameworks related to student behaviour in the mathematics classroom. These include: didactics, norms, practical rationality, and gaming. Upon examination, a common thread in all of these theories is motives, which led me to the topic of Chapter 2.

Activity theory is the theoretical perspective that shapes this entire work. In Chapter 2 I discuss the origins and development of activity theory, its applications in education, as well as its potential for analysing student behaviour. Both Chapter 1 and Chapter 2 contribute to the gradual shaping and defining of my research questions, which end Chapter 2.

Finally, Chapter 3 describes the methodological perspective and the methods used in data collection and analysis. The approach and methods that most closely align with my views on conducting research into student behaviour is an ethnographic one. The first half of Chapter three describes the ethnographic approach and methods, and the second half provides details about the participants, methods, and other particulars of this study.

# Chapter 1:

# Exploring Student Behaviour

> The process of schooling seems to encourage the idea that the 'game of school' is to learn symbolic rules of various kinds, that there is not much continuity between what one knows outside school and what one learns in school. […] Schooling is coming to look increasingly isolated from the rest of what we do. (Resnick, 1987, p. 15)

The practice of schooling, as a whole, is largely the same as it was when Resnick made this observation three decades ago. In fact, it has long been recognized that there exists a disconnect between what children 'learn' in school and what they encounter in the 'real world'. Analyses have shown that, "*schooling produces a variety of learning experiences and results which are unintended, if not altogether objectionable, from the viewpoint of the official curricula*[1]" (Engeström, 1991, p. 252). When this becomes apparent, it promotes the perception of school or schooling as a game. In fact, this is referred to by many as the 'hidden curriculum' (see for example, Hill, Bowman, Stalmeijer, & Hart, 2014; Martin, 2011). In this curriculum, to 'win' or succeed at the game of school is to learn the rules, play by them, and when possible use them to one's advantage to advance, assuming that to be one's goal. Continuing in this vein, it is also desirable to be efficient and economic (Hewitt, 1994) and save time, when possible.

While school may not be consciously perceived as a 'game' by most students, the manner in which they engage with it shares many undeniably similar aspects. Students negotiate the school system, balance academic and extracurricular activities, organize schedules to meet post-secondary requirements, select classes to have or avoid certain teachers, and ultimately graduate and 'finish' the game (only, for some, to go on to the next version: college or university). Calling school a game is not meant to imply that all students or any teachers *intentionally* play it as one; the problem, however, is that the activity students and teachers engage in as they fulfill perceived 'rules' or obligations often fails to realize the ideal goal of schooling: learning. For the student who recognizes the situation, it can result in a jaded view of the school system, promoting gaming and supplanting a motive of

[1] All quotations integrated into the body of the text of this dissertation are in italics. To indicate the author's emphasis within an italicized quote, I put that part in plain text.

learning with one of winning, or of beating the system. The more naïve, or less jaded, who do not see schooling in this way may end up in a continuous cycle of fulfilling meaningless tasks in an effort achieve outcomes other than learning.

If school is a game, this implies students (intentionally or not) concentrate their efforts on playing the game, rather than on taking learning seriously. Gary Fenstermacher, a researcher of teacher education, was one of the first to coin a term that concerns the student as agent, introducing the notion of ‘studenting’.

> The concept of studenting or pupiling is far and away the more parallel concept to that of teaching. Without students, we would not have the concept of teacher; without teachers, we would not have the concept of student. Here is a balanced ontologically dependent pair, coherently parallel to looking and finding, racing and winning. There are a range of activities connected with studenting that complement the activities of teaching. For example, teachers explain, describe, define, refer, correct, and encourage. Students recite, practice, seek assistance, review, check, locate sources, and access material. The teacher’s task is to support R’s desire to student and improve his capacity to do so. Whether and how much R learns from being a student is largely a function of how he students. (1986, p. 39)

Fenstermacher essentially describes studenting as *what students do*, just as teaching is what teachers do. This brief introduction describes a vast array of possible behaviour, yet appears to limit the extent of studenting to actions and activity that teachers intend for students to carry out in order to learn. A more refined definition of studenting, based on Fenstermacher’s description, might be: the actions that a student performs in order to learn. For, at first glance, it may appear that Fenstermacher does not consider student behaviour that may not contribute to the learning process, but only includes those actions that teachers would consider conducive to student learning. This interpretation, however, would be incorrect. Fenstermacher continues to explain:

> there is much more to studenting than learning how to learn. In the school setting, studenting includes getting along with one’s teachers, coping with one’s peers, dealing with one’s parents about being a student, and handling the non-academic aspects of school life. (p. 39)

Thus, ‘studenting’ involves non-academic aspects of school life as well. Following this introduction of the notion of studenting, Fenstermacher does not go into any further detail about the concept and the term does not appear again in the literature in any significant fashion for a number of years, although he himself revisits it a number of years later in a paper presented at the 1994 AERA annual meeting. In this later description, he focuses more on the non-academic aspects of studenting, with a particular bent towards what might be considered as 'negative' behaviour.

> The student becomes proficient in doing the kinds of things that students do, such as 'psyching out' teachers, figuring out how to get certain grades, 'beating the system', dealing with boredom so that it is not obvious to teachers, negotiating the best deals on reading and writing assignments, threading the right line between curricular and extra-curricular activities, and determining what is likely to be on the test and what is not. (1994, p. 1)

His focus here is emphatically different. There is no mention of learning, only of strategies students develop which, while possibly not intended to do so, subvert teachers' intentions and the goals of learning. There is a noticeable shift from the primary goal of student learning to what was, in the original definition, at best a subsidiary element. The non-academic aspects of studenting seem to have taken precedence and much of the work of studenting now apparently consists of 'beating the system'. As Fenstermacher states at the beginning of this later paper, "*To the student, school is a game constituted entirely by its rules*" (p. 1). This is not the only reference in the literature to school as a game at which students become proficient players: others will be introduced later in this chapter.

The concept of studenting allows for a broader exploration into, and discussion of, what students do in schooling situations, such as the mathematics classroom. These include those features of student behaviour that do not align with the goals of the teacher as well as those that *do* align with teacher expectations but may nonetheless not result in learning. Research exists on the topic of what students do and their role in the classroom, but the term 'studenting' has not been taken up by many. For this reason, unless it is used in the literature under discussion, I will instead use student 'behaviour', 'action', or 'conduct' to refer to what students do in the context of the mathematics classroom.

Whatever term we use to describe it, and whether or not students perceive it, the pattern of satisfying outcomes and playing by the rules results in dual casualties: motivation and learning. How is it that this situation develops? If the aforementioned pattern of behaviour exists, what *do* students actually do in the mathematics classroom? And why do they engage in such activity?

A substantial corpus of past research in the field of mathematics education has focused, among other things, on the teacher, the curriculum, appropriate task design and how students learn. Significantly fewer studies have investigated what the student does and what the student brings to the learning situation. However, several mainstream frameworks and theories have relevance for studying student behaviour. These include: didactics and the didactic contract; classroom and sociomathematical norms; practical rationality; and gaming. In the following sections, I describe these selected theories and frameworks and discuss the affordances of each for studying the phenomenon of student conduct in the mathematics classroom.

## 1.1 Didactics

One well-known theory of student behaviour uses the metaphor of a (tacit) contract to describe the relationship between the student and teacher that is enacted within the classroom. Guy Brousseau, a prominent French mathematician and mathematics educator, developed his "*Theory of Didactical Situations in Mathematics*" through extensive study of the ways in which children learn mathematics. These studies were conducted in the nineteen-fifties, -sixties, and -seventies in schools in France. Among other studies, Brousseau observed many classes at the Michelet School in Bordeaux. It was through this significant work that he developed his theory of didactical situations. The concept of *didactique* or didactics is not easily understood, and is particularly difficult for anglophones because the majority of his works were not translated until relatively recently. Only those fluent in French had access to the original works. Further, translated works can be problematic as even with the most skilled translator there is often some essence lost in the translation. For instance, Herbst and Kilpatrick (1999) note the distinction between '*connaissance*' and '*savoir*' – two French nouns that both translate to the English word '*knowledge*' (p. 6). Yet there is a subtle difference between the terms, and in Brousseau's book the former term is translated as '*knowing*.' Compounding the issue of translation is that his writings are rife with metaphor, so it is important that his terms are not used in a strictly literal sense.

Brousseau explains that the object of *didactique* is 'knowing what is being produced in a teaching situation'; "*it is not a result of observation, but one of analysis based on the* *knowledge of phenomena which define what they leave unchanged*" (1997, p. 29). As interpreted by Carolyn Kieran, "*For Brousseau, didactique is the science related to the production and communication of knowledge*" (1998, p. 596). The object of study of didactique is the "*transformations of mathematical knowledge within the conditions and constraints of the social project of education*" (Herbst & Kilpatrick, 1999, p. 6). None of these definitions seem to make the didactical terrain less muddy. It is about learning and teaching and mathematics and social conditions, yet has boundaries that include some aspects and not others. Herbst and Kilpatrick claim that the unconventional approach taken by Brousseau has value in that it uncovers and invites questions that are not even contemplated in traditional North American research. Of course, the benefit cannot be attained if one does not understand the theory. Didactics is perhaps better explained through a description of the didactical situation.

## The didactical situation

In his "*Theory of Didactical Situations in Mathematics*", Brousseau devotes an entire chapter to explaining the didactical situation. Several careful readings of Brousseau's extensive writings on the concept help to make the picture clearer. It is understandable, then, that it is even more difficult to describe this nebulous concept adequately in only few words or sentences. In his updated glossary of terms, the didactical situation is defined as one where:

> an actor, for instance a teacher, organises a plan of action which makes clear her intention of modifying or causing the creation of some knowledge in another actor, a student, for example, and which permits the student to express herself in actions. (2003, p. 2)

Several researchers have published their interpretations of Brousseau's terms, which help to provide further clarification of the concepts.

According to Kieran, the didactical situation is used to "*designate the sets of circumstances of a teaching situation*" that can be connected to the knowledge that is to be learned "*in a way that is necessary, coherent, regular, reproducible, and specific*" (1998, p. 596). Consider first the components of the situation, which Mason and Johnston-Wilder identify as:

> the learners, the teacher, the mathematical content and the classroom ethos, as well as the social and institutional forces acting upon that

> situation, including government directives such as a National Curriculum statement, inspection and testing regimes, parental and community pressures and so on. (2004, p. 79)

Brousseau describes the didactical situation as a type of game, one where the teacher assigns a problem or situation and the student interacts with it. The teacher must decide whether and what information to communicate or withhold, what teaching methods and questions to use, which heuristics to employ. The components of the didactical situation all play a role, either as an agent (the teacher and learner), an influence on one or both (the classroom ethos, social and institutional forces, and government directives), or the object (the content or mathematical knowledge to be learned).

Within the didactical situation is the particular part that the teacher delegates to the student. Brousseau defines this as the *adidactical situation*, and Kieran explains that "*[i]t is here that the student interacts with her milieu, a milieu that excludes teacher intervention and that demands productions of various types on the part of the student: actions, formulations, and validations*" (1998, p. 596). The responsibility and motivation for learning belong only to the student. The role of the teacher is to provoke through judicious choice of problems and presentation of them. *"In modern didactique, teaching is the devolution to the student of an adidactical, appropriate situation; learning is the student's adaptation to this situation*" (Brousseau, 1997, p. 31). If the teacher brings about the situation correctly, the student adapts appropriately and will learn. Of course, the presumption here is that the student has a motive for learning.

Brousseau later explains that these situations can be seen as formal games[2] and describes in detail how they could be created and enacted. Based on the definitions given, the didactical situation can be understood to include the manner in which knowledge is acquired by the student within the classroom through the complex interactions among the teacher, the student, the mathematics, and the classroom environment, which are in turn influenced by broader factors such as mandated curricula, standardized testing, pressures from parents and the community, as well as others. The adidactical situation is the part

[2] Brousseau's meaning of "game" is not synonymous with the use of game in the game of school or as it is used in game theory – the first two are metaphors, but with different connotations.

that is turned over to the student, during which the student is intended to learn, once the teacher has created the appropriate conditions[3].

## The didactical contract

A critical element of the didactical situation is the didactic contract. Yet Brousseau devotes very little space to describing this; less than two pages, a surprisingly brief explanation for such a complex and central concept. He describes it as an implicit contract between teacher and learners, together with the other components of the didactical situation, wherein the "*teacher is obliged to teach and the pupil to learn*" (Brousseau & Otte, 1991, p. 18). He later specifies the contract as "*the rule of the game and the strategy of the didactical situation*" (1994, p. 31), where one must remember that the terms 'game' and 'contract' are metaphors[4]. The *game* is played between teacher and student(s) according to a set of *rules*, which are part of the *contract* and dictate what the teacher and student can do to fulfill their *obligations* to one another (that they are to do so is also part of the contract). A glossary of terms published more recently gives a much more detailed and precise definition for the didactic contract. It is defined as:

> the set of the reciprocal obligations and sanctions that each partner in the didactic situation imposes, or believes to impose, explicitly or implicitly, on others, and those that are imposed on him or her, or he or she believes that they are imposed on him or her. (Brousseau, 2003, p. 6)

The relationship between the teacher and student is one of reciprocal obligation, the implicit or explicit delegation of responsibility for matters relating to the didactical situation[5]. This relationship evolves and changes as the didactical situation progresses. These obligations include:

- what assistance the students can reasonably expect from the teacher;
- what assistance the students can seek from each other;
- what level of explanation the teacher is obliged to provide;
- what questions the teacher can reasonably ask;
- what form of response will be considered satisfactory. (Brousseau, 1986, p. 51, D. Clarke, Trans.)

[3] This is actually quite a significant notion. For more on this, see Brousseau, 1997.

[4] See Pimm (1988) for more on mathematical metaphor.

[5] In this sense, it is related to Fenstermacher's initial (1986) definition of studenting.

Brousseau claims that this relationship and division of responsibility is negotiated and thus resembles a contract, but *"is not exactly a contract*" (1997, p. 32). Pichat (2001) explains that it is not a real contract, as "*it is not the result of a formalised agreement between students and teachers*" (p. 2), but adds that it looks as if the implicit contract structures the communication. He goes on to comment:

> During a problem-solving situation, pupils attempt to infer 'what is to be answered', what is expected, thanks to the decoding of an implicit contract they (correctly or not) infer. To that extent, the notion of 'didactic contract' (Brousseau, 1996) refers notably to the (specifically linked to definite knowledge) set of behaviours that are supposed to be expected from the students by the teacher. (p. 3)

It is the obligation of the teacher to attempt to induce the student to take on the problem, and if they will not, the teacher must provide further support. As it is an obligation of the student to endeavour to learn by taking on the problem, the refusal to do so is considered a breaking of the contract, and is of primary interest to Brousseau. In his elucidation, such a breach necessitates a renegotiation of terms, but not a voiding of the entire contract:

> at the moment of such a breakdown, everything happens as if an implicit contract were linking the teacher and the student; surprise for the student, who doesn't know how to solve the problem and who rebels against what the teacher cannot give her the ability to do – surprise for the teacher, who reasonably thought that she had performed sufficiently well – revolt, negotiation, search for a new contract which depends on the new "state" of knowledge, acquired and desired. (1997, p. 32)

He goes on to examine the consequences of the breaking of contract clauses, on the part of the teacher and of the student.

Mason discusses some difficulties that are inherent in the notion of the didactical contract. In particular, he expands on Brousseau's notion of didactic tension. Mason describes the concept of didactic tension as, "*endemic to teaching: the more clearly the teacher indicates the behaviour sought, the easier it is for students to display that behaviour without generating it from understanding,*" and the reverse (1998, p. 2). For example, when trying to help a student solve a problem, the teacher continually prompts the student, giving him more and more guidance until the student is finally able to respond to the most trivial question, 'satisfying' the teacher's latest prompt, thereby 'resolving' the difficulty. Such was the situation described by John Holt (1969) who wrote about Ruth, a student who patiently waited for the teacher to get to the 'right' question, the one she could answer. To get her to respond, the teacher's questions became progressively easier and more pointed. Mason explains that this is considered a breach of the contract, because according to Brousseau the primary obligation of the student is to learn, and the situation just described does not involve learning[6]. The inevitable tension is part of the didactical contract and Mason claims that it leads to students "*minimising their energies by making the least effort and expecting that somehow this will be sufficient for them to learn*" (p. 2). The minimisation of energy is an important aspect of student conduct and will be returned to later.

In addition to Brousseau's singular approach, his use of metaphor, and the difficulties inherent in translated works, there are other factors that contribute to difficulty understanding the concept. Brousseau is careful to note that, "*The didactical contract is not a general pedagogical contract. It depends closely on the specific knowledge in play*" (1997, p. 31). For Brousseau, this meant not just the specific subject, mathematics, but the particular content area in mathematics that was being addressed. For this reason he claimed that it was not possible to give details of the reciprocal obligations:

> We shall see that a totally explicit contract of this kind is doomed to failure. In particular, clauses concerning the breaking and the stake of the contract cannot be written in advance. Knowledge will be exactly the thing that will solve the crises caused by such breakdowns; it cannot be defined in advance. (1997, p. 32)

The nature of the contract depends not only on the knowledge, but also the actors, teacher and student, as well as the specific context or situation. The inability to provide explicit details has contributed to a limited usage and acceptance of Brousseau's ideas, at least for anglophone researchers. Together with the different possible interpretations of some of his key terms, this has resulted in a general lack of use of Brousseau's theory in recent literature, especially by anglophone authors. Warfield (2006) claims that the concepts of didactical situation and didactical contract have caused significant frustration among English-speaking mathematics educators precisely because they are difficult to understand and easy to create misunderstandings by means of a simplified description.

[6] At least not about the content. They may learn how better to subvert their teacher.

## 1.2 Social Norms

Social norms are the informal (unwritten) 'rules' that govern the behaviour of members of a group or society. Our understanding of these tells us how to behave in particular social groups or cultures, the size of which can vary from a friendship between two people to that of an entire nation. Norms can also be viewed as cultural products, including values, customs, and traditions, which represent individuals' basic knowledge of what others do and think that they should do. Behaviour fulfilling these accepted standards is called conformity, and norms are powerful tools for understanding and predicting behaviour.

The social group of interest here is the members of the school classroom, and in particular the mathematics classroom. Two types of norms are relevant and contribute to furthering the discussion of student behaviour in this context: classroom norms (non-specific to the subject); and sociomathematical norms (Cobb, Wood & Yackel, 1991). First, however, it is important to address the perspective that shapes the very foundation of these two types of norms: the view of the classroom as a 'community of inquiry'.

### The classroom as 'Community of Inquiry'

The notion of a 'community of inquiry' is grounded in Charles Sanders Peirce's and John Dewey's pragmatist perspectives on education. It draws on Dewey's ideas of communal inquiry and Peirce's idea of scientific community of inquiry. Peirce's original logic of inquiry was extended and broadened in social contexts by Dewey (1938). "*Community of inquiry may be broadly described as the collective execution of a dialogical, language-based activity whose goal is to reach communal agreement through argumentation*" (Kennedy, 2009, p. 72).

This view of the learning process is aligned with Lave and Wenger's (1991) theory of *legitimate peripheral participation*, in the sense that it is through the process of engaging in and being a participant in the community that learning about being a student occurs. Legitimate peripheral participation is described as a viewpoint on learning rather than a pedagogical strategy or teaching technique. The authors emphasise that "*this viewpoint makes a fundamental distinction between learning and intentional instruction*" (p. 40). Considering a far broader environment than the confines of the classroom, their work supports the notion that the acquisition of the associated practices of being a student occurs through a process of "*learning as participation in the social world*" (p. 43).

In the classroom context, within the community of inquiry, it is the responsibility of the students to be active participants and they are expected to become reasonable and sensible. The teacher acts as guide and partner and is recognized as fallible. The key difference between the standard model and this reflective model is that the focus is on recognizing and understanding relationships within mathematics rather than on the acquisition of information (Lipman, 1994). The goal of the community of inquiry is to enable the construction and formation of concepts through 'building on each other's ideas' rather than through traditional teacher transmission, individual reflection or debate (Kennedy, 2009). The notion of a community of inquiry underpins both classroom norms and sociomathematical norms, the nature and development of which is explored below in further detail.

## Classroom social norms

Classroom norms are the implicit or explicit expectations for behaviour in the class. Tatsis and Koleza (2008) use the term 'prescriptions' to describe "*behaviours that indicate that other behaviours should (or ought to) be engaged in*" (Biddle & Thomas, 1966, p. 103). Further, prescriptions can be one of two types: demands (rules) or norms[7]. Norms differ from rules in both construction and purpose. Rules are overtly set by the teacher in order to ensure safety and maintain efficiency. Examples of some classroom rules include 'put up your hand before speaking' and 'ask permission before leaving class to go to the washroom'. Norms, in contrast, are socially constructed by the community and concern how they will treat one another. These norms are jointly developed, explicitly and implicitly, both by the teacher and students through social interactions. Tatsis and Koleza and explain that rather than being overt, such as demands, norms are covert in nature. Norms tend to reflect pro-social values such as responsibility, respect, helpfulness, caring, and fairness.

[7] The distinction between rules and norms is often difficult to establish: there are certain prescriptions that are clearly explicit rules, and others that are clearly norms, yet there remains a lot of arguable 'middle ground'. Consequently, I will use the term 'norms' in the broadest sense.

Cobb, Wood and Yackel were among the first to use analogies from the philosophy and sociology of science in an effort to understand, describe and explain the particularities of classroom life. The authors stress that:

> a students' learning or cognitive restructuring occurs in social contexts as he or she participates in social interactions with both the teacher and his or her peers. Such communicative interactions are constituted against a background of frequently tacit, take-to-be-shared assumptions about one's own and others' obligations and expectations about the theme of the discourse, the intention or purpose of activity, and so forth. (1991, p. 24)

Though stated to be the background, it is the 'taken-to-be-shared' assumptions about obligations and expectations that were the focus of Cobb, Wood and Yackel's research. According to these authors, "*'taken-as-shared' implies that participants achieve a sense that some aspects of knowledge are shared within a collective interpretative framework that constitutes the basis for communication among the participants in the community*" (Kennedy, 2009, p. 72). Cobb and colleagues investigated the negotiation and institutionalization of these assumptions that help to shape and influence what and how students learn, beginning with the fundamental understanding of the classroom as a community of inquiry.

In acting as a guide, planner, and organizer the teacher is responsible for creating a context for mathematical inquiry intended for discussion of meaningful mathematical ideas. The teacher is the initiator of the process of negotiation of social norms, but the students are active participants in their ongoing construction and negotiation. This is in some ways analogous to Brousseau's concept of 'devolution' (Kennedy, 2009). Other similarities exist between Brousseau's work and that of Cobb, Wood and Yackel (discussed below), such as the idea of negotiation, and the emphasis on contextual and subjective factors. However, the focus on a community development of norms, uniquely understood by the individual, is a key difference from Brousseau's didactical contract, which appears to centre on the individual student's interaction with the teacher in isolation from his peers. The notion of the community of inquiry and the involvement of an experienced person also has elements in common with Lave and Wenger's work on legitimate peripheral participation. Drawing on this work, Mottier Lopez and Allal (2007) claim:

> Learning through participation in a classroom community entails two interconnected processes: the appropriation by the students of the norms,

> beliefs, practices, tools, artefacts that are elaborated collectively: the contribution of the students to the elaboration of these norms, beliefs, practices, tools, artefacts. (p. 252)

Most of Cobb, Wood and Yackel's research regarding social norms involves the development of understanding of mathematical explanations and justifications through mathematical dialogue (Cobb, Wood & Yackel, 1991; Yackel & Cobb, 1996). What they examine in their earlier work are actually social norms; Yackel and Cobb (1996) explain that in their initial studies the norms that they identified as characterizing project classrooms had nothing to do with the fact that the subject of instruction was mathematics. This led to their later analysis of normative aspects of the classroom that were specifically related to the subject of mathematics. Thus, Yackel and Cobb make a distinction between social norms (within the classroom) and what they call sociomathematical norms.

## Sociomathematical norms

Sociomathematical norms were conceived in order to analyze the mathematical aspects of students' and teachers' actions within the mathematics classroom from a social and psychological perspective (Wedege, 2010). "*For example, normative understandings of what counts as mathematically different, mathematically sophisticated, mathematically efficient, and mathematically elegant in a classroom are sociomathematical norms*" (Yackel & Cobb, 1996, p. 461). Also, "*what counts as an acceptable mathematical explanation and justification is a sociomathematical norm*" (p. 461). In contrast, social norms are defined as the "*general classroom social norms that apply to any subject matter area and are not unique to mathematics*" (p. 460). An example they offer of a social norm would be that students should justify their responses and offer different solutions from those already mentioned. So, the need for explanations or reasons is a social norm, but what determines an acceptable mathematical explanation is a sociomathematical norm. It should be noted, however, that because Cobb, Wood and Yackel were analysing norms in a mathematics classroom, many of the norms they identified would be classified as sociomathematical norms according to their later definition. This contention necessarily is supported by Mottier Lopez and Allal, who claim that, "*most of the social norms identified in the research by Cobb and co-workers are in fact closely linked to mathematical beliefs and practices*" (2007, p. 256). Like social norms, sociomathematical norms are "*not predetermined, but continually regenerated and modified by the interactions taking place* *between the teacher and the pupils*" (Kaldrimidou, Sakondis & Tzekaki, 2007, p. 90). Though Cobb and colleagues' conceptions of sociomathematical norms is significantly different in many ways from Brousseau's theory of didactical situations in mathematics, they do share the common view that the ways in which students and teacher interact within the mathematics classroom is fundamentally different from what occurs in other subject classrooms.

As stated earlier, all of these types of questions regarding sociomathematical norms are investigated in the 'context-of-discovery' of inquiry mathematics (Richards, 2002), as opposed to the more traditional context of school mathematics:

> School mathematics is a highly ritualized activity that is primarily characterized by adherence to mathematical convention whereas inquiry mathematics involves the interactive constitution of increasingly sophisticated mathematical objects that are experienced by the participants as being practically real. (Cobb, Wood & Yackel, 1991, p. 27)

It should be noted, however, that sociomathematical norms "*are established in all [mathematics] classrooms, regardless of instructional tradition*" (Yackel & Cobb, 1996, p. 462). These norms are context dependent. That is, it is the unique interaction of the particular teacher, the individual students and the specific classroom environment that determine what the negotiated sociomathematical norms will be. Thus, it is not the presence or absence of norms that differentiates classes, but the nature of the norms (Yackel, Rasmussen & King, 2000). In addition to the consideration of subject area, the norms may differ based on the particular topic being investigated. Respected mathematics educator Alan Schoenfeld supports the context dependence of research. "*Studies of teaching and learning must be grounded in analyses of what it means to understand the subject matter being taught*" (1988, p. 5).

Since norms are not explicitly taught, we can ask how they are developed. Sfard (2000) argues that:

> the unique rules of mathematical discourse can neither be learned by a simple articulation, nor can they be re-invented by students engaged into discussing mathematical problems 'in any way they regard as appropriate'. Rules of language games can only be learned by actually playing the game with more experienced players. (p. 185)

This supports the necessity of the teacher's role as facilitator, planner and organizer. The presence of a 'more experienced player', a.k.a. the teacher, "*who serves as the representative of the mathematical community, has a leading role in forming normative behaviour in the classroom*" (Levenson, Tirosh & Tsamir, 2006, p. 321) and is thus essential to the development of appropriate sociomathematical norms. These evolve not just through talking about mathematics; the negotiation process occurs as teacher and students talk about talking about mathematics. The implicit, covert nature of norms also makes identification of norms a more involved matter. Yackel and Cobb stated that norms were "*inferred by identifying regularities in patterns of social interaction*" (1996, p. 460).

Sociomathematical norms have been used extensively in the literature by a number of mathematics researchers. In addition, the original authors have continued to work to develop this concept. Common uses involve mathematical explanations, justifications and solutions, but also within these studies there are some additional relevant concepts that may serve to inform an investigation into student behaviour.

As part of a study of mathematically and practically based explanations, Levenson and colleagues (2006) investigated the place of individuals' preferences in relation to the sociomathematical norms enacted in the classroom. They distinguish between sociomathematical norms that are endorsed and those that are enacted. Endorsed norms are declared by members of the community, whereas enacted norms can be observed. The authors recount the experience of a particular student whose preferences were not in synch with the classroom norms and suggest that when a student's preferences are not aligned with the established classroom norms there may be resultant effects on the student's behaviour. For example, the particular student chose not to participate in class because his preference for mathematically-based explanations did not coincide with the classroom norm of practically-based explanations. Levensen and colleagues emphasize that, "*teachers should take into account their students' preferences when developing sociomathematical norms*" (p. 341). The establishment of sociomathematical norms in a classroom does not mean that all students are in agreement – some students' actions can be explained precisely because they do not agree with the established norms.

Yackel and colleagues (2000) emphasized the reflexive relationship between the sociomathematical norms that are constituted in the classroom and students' and teachers' mathematical beliefs and values. They contend that neither can exist in isolation and that these factors are "*mutually enabling and constraining*" (p. 277). Individuals' beliefs about mathematics and their role in mathematics, as well as their personal values, develop and evolve concurrently with the classroom sociomathematical norms: each supports and shapes the other as they grow. In this conception, "*mathematical learning [is] both a process of active individual construction and a process of enculturation*" (Cobb, Grevemeijer, Yackel, McClain & Whitenack, 1997, p. 152). The role of sociomathematical norms in the interactive regulation of learning is the subject of a study by Mottier Lopez and Allal (2007), whose results support the conclusion that, "*the regulation of teaching and learning is embedded in the functioning of the classroom microculture (its norms, practices, discourse, modes of participation) and is reflected in the activity of the individuals*" (p. 264).

Although norms certainly influence student behaviour, they are not in themselves sufficient to explain the motivation behind all student behaviour. The following section looks at explanations of student behaviour involving breaches of norms and contracts, and the concept of practical rationality.

## 1.3 Rationality

It was Aristotle who contended that humans are rational beings, supposedly meaning that humans are capable of rational thought. Whether that ability is exercised, and to what extent, is another matter entirely. The rationality (or lack thereof) of humans has been the stimulus for research in many domains, such as: economics, education, sociology, philosophy, psychology, political science and evolutionary biology. Each area has its own definition and interpretation of rationality, which, generally speaking, fall into two categories: theoretical rationality or practical rationality[8]. Theoretical rationality takes a logical approach wherein the individual makes choices to optimize the benefit. Logic, reasoning and modelling are significant aspects, whereas social action need not be associated. Practical rationality, on the other hand, involves the individual's determination

[8] Considered one of the founders of sociology, Max Weber actually identified four types of rationality: practical, theoretical, substantive and formal. For more, see Kalberg (1980).

of the best course of action to take to achieve a particular end or goal. It is therefore considered pragmatic. For example, political science and traditional economics use a mathematical modelling approach, wherein rationality is seen as the selection of the optimal solution given the information available (theoretical rationality). In contrast, behavioural economics uses a different approach, called bounded rationality (a type of practical rationality).

### Bounded rationality

Bounded rationality, a concept credited to Herbert Simon, asserts that, "*decision makers are intendedly rational; that is, they are goal-oriented and adaptive, but because of human cognitive and emotional architecture, they sometimes fail, occasionally in important decisions*" (Jones, 1999, p. 297). Instead of seeking *optimal* solutions, as theoretical rationality dictates, according to bounded rationality, decision makers seek *satisfactory* solutions. Another significant difference from theoretical rationality is that bounded rationality recognizes the limitations of the individual making the decision. According to Simon (1957), there are three reasons why human rationality is bounded: (1) humans have incomplete information about available alternatives; (2) the consequences of any given alternative are uncertain; (3) there is complexity in the environment. Key to understanding the distinction between viewing humans as rational (in the theoretical sense) and boundedly rational is first recognizing that humans are not capable of considering all possible alternatives in a decision-making situation. Instead, an individual considers a small number of alternatives and chooses the first one that satisfies the criterion the individual has set (based on his or her goals). The decision maker is also influenced by the conditions and constraints of the environment.

Byron Jones (1999), a distinguished professor of political science, gives more detail about individual limitations. He claims that humans have both procedural limits and substantive limits. Of these, procedural limits are of relevance to student classroom behaviour. A procedural limit is understandably a limit in processing capacity. This affects how we go about making decisions and refers to our internal make-up. Two particularly important procedural limits in structured, institutional settings have to do with emotion and attention. Humans have a limited cognitive capacity and a limited attention span. In addition, emotions "*play a central role in guiding and regulating choice behaviour by virtue of their* *capacity to modulate numerous cognitive and physiological activities*" (Muramatsu & Hanoch, 2005, p. 202).

The notion of bounded rationality has been used in classroom situations, specifically to understand how teachers deal with complexity (Lee & Porter, 1990). One of the ways in which teachers contend with the vast number of alternatives in any given situation is to develop and use expectations (about student behaviour). The authors found that while the framework of bounded rationality suggests many implications for research, in itself the framework has several limitations with respect to guiding empirical research. Bounded rationality furthers the understanding we can arrive at with respect to rationales underpinning student action, providing an "*explanation for why human behaviour that appears irrational might, in fact, be rational within the limitations of cognitive capacities*" (1990, p. 169). However, "*the concept of bounded rationality does not specify how human cognition translates to actual behaviour in complex real-world situations*" (p. 167). While bounded rationality explains why humans do not behave 'rationally' in the traditional sense, it does not provide a mechanism for examining how that rationality links to actual behaviour.

## Breaches and practical rationality

One of the ways in which to understand better the linkage between rationale and action is to reconsider norms (in the sense of Cobb and Yackel) and contracts (in the sense of Brousseau). In particular, the breaking, or breaching of contracts and norms can provide insight into the rationale behind student behaviour. With respect to the didactical contract, Brousseau stated, "*it is in fact the breaking of the contract that is important*" (1997, p. 32). If one takes the didactical perspective, the breakdown and process of renegotiation of the contract can explain some student behaviour. 'Breach' is a term used to signify a failure to observe an agreement or code of conduct.

The use of the 'breaching experiment' was pioneered by ethnomethodologist Harold Garfinkel (1964) in an effort to study unstated social rules. Analyzing individuals' reactions to the purposeful breaching of social norms allows for the identification of the norms and a better understanding of how people understand reality and why they perceive it in a particular way. Herbst and Chazan (2003) applied this approach in a singular manner.

They created animations[9] modelling the responsibilities of teachers and students as they carried out work within the mathematics classroom. These animations were then shown to teachers to gauge their reactions and draw out their beliefs about how the pedagogic interactions in the animations 'should' play out, in a desire to understand better the rationality of teaching. The results of their analysis were called the *practical rationality* of teaching.

Practical rationality[10] is a composition of factors that influence teacher decision making. Wendy Aaron (2011), one of Herbst's doctoral students, then applied the concept to students for her thesis, building on and extending Herbst and Chazan's work with teachers. She investigated the practical rationality of studenting[11] by analyzing breaches of classroom norms, looking at the actions students perform in the context of high school geometry instruction. She looked at studenting from the perspective of the student and was concerned with expectations[12] of how students *should* act, in relation to the teacher, the mathematical content and their peers, and in the context of geometry instruction. For Aaron, studenting included academic learning, but she also considered the balancing of obligations and goals that students must do as they go about their 'work'.

In an effort to understand better students' perceptions of the work of studenting, she studied the actions that students perform during geometry instruction. In particular, she used the contexts of making conjectures and doing proofs in geometry, using animations of breaching experiments to provoke student discussion and elicit the expected actions as well as reasons for their breaches. Breaches were classified as appropriate or inappropriate based on students' justifications for them. Aaron claims, "*there are some student actions that are not explained by the existence of instructional norms,*" (p. 258)[13] and used this as a basis for exploring student actions that depart from these norms:

9 For more on animations see ThEMaT (Thought Experiments in Mathematics Teaching) and LessonSketch at: http://www.education.umd.edu/MathEd/research/ThEMat.html.

10 For more on practical rationality of teaching, see Herbst and Chazan (2003, 2011) and of studenting, see Aaron (2011).

11 Aaron used the term 'studenting' explicitly in her research.

12 For Aaron, these expectations come from students' participation in the process of schooling and the understanding of the tacit rules that organize the social interaction of the classroom (Mehan, 1979).

13 Aaron sees these actions as breaches of existing norms (as opposed to behaviour not covered by norms).

> while it may not be rational in the sense of correct, [student behaviour] does reflect a rationality of sorts that comes from enacting the position of student. […] I mean that individual adolescents come into high schools and automatically are subject to expectations about how they should act in relation to the teacher, their peers, and the mathematical content that they are expected to learn. Even students who do not act according to these expectations are still exposed to them and are aware of them. (p. 258)

In 2012, Aaron and Herbst published their work on geometry students' instructional identities. Drawing on and extending the work on "*doing school*" (e.g., Chazan, 2000; Eckert, 1989; Fried, 2005; Herbst & Brach, 2006; Lave, 1997, 2001), they investigated how students approach proof tasks in geometry. Aaron and Herbst proposed a model for explaining a particular student's actions in response to geometry proof tasks, based on the student's disposition and the classroom environment, which includes the student's interpretation of the task at hand. They formulated three profiles based on interpretations of students' reported reasons for and ways of engaging with the given tasks. Their research concerns the instructional situations wherein students engage with specific geometry proof tasks in the geometry classroom.

The results of Aaron's doctoral work and her subsequent published work with Herbst indicated that there are multiple components for the justifications of student behaviour. These include instructional norms, professional obligations[14] and personal resources. "*The instructional norms and obligations combine to form the rationality of studenting, and individual student's personal resources mediate this rationality*" (Aaron, 2011, p. 334). See Figure 1.1, below, for an illustration of how these components work to form the rationality of studenting.

[14] Aaron uses 'professional obligations' to refer to students' commitment to the position of student or what they feel obliged to do in their role of student.

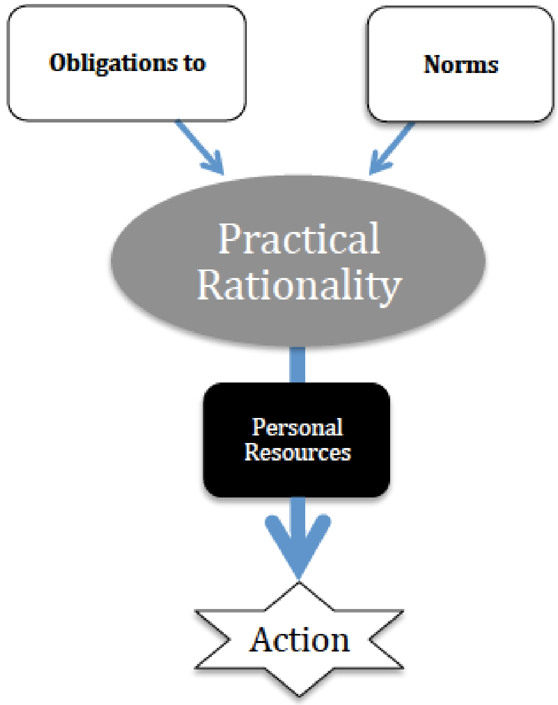


**Figure 1.1 Adaptation of Aaron's (2011) framework of the practical rationality of studenting (adapted from Webel, 2013, p. 28).**

However, in comparison with Herbst and Aaron's earlier work, in this conceptualization the norms of instruction are to be viewed from the perspective of the student. These norms constitute the tacit knowledge (Polanyi, 1966) that students have for how to act during instruction. Some of these norms are contractual, based on Brousseau's didactical contract. Others are situational and these may be interpreted as analogous to the social norms of Cobb, Wood and Yackel (1991), although it is noteworthy that Aaron makes no mention of their research. Students' professional obligations include individual, interpersonal (the class as a whole), institutional (the school as an institution) and truth components. The truth aspect refers to Aaron's claim that, "*students do have the tools to measure true and false and they support the endorsement of true ideas and reject the endorsement of false ideas*" (2011, p. 336). Students' personal resources affect students' actions on an individual level and stem from factors including students' individual cognitive abilities, emotional dispositions and life experiences.

On the heels of this work, Webel (2013) studied the student perspective in mathematical[15] group-work situations. He discusses different goals students have for working in collaborative groups: mathematical versus nonmathematical goals; individual versus group goals; personal versus normative goals. Sharing Aaron's view of studenting and building on her framework, Webel posited that students' practical rationality is mediated by their goals for working together. He videotaped students working in groups, showed the students clips of their participation, and then asked them to interpret or explain their actions.

He showed that there was substantial variety in students' goals and provided a finer distinction with respect to type of goal - in comparison to bi- or tri-dimensional goal-orientations such as mastery, performance-approach and performance-avoidance (Dweck, 1986; van de Walle, 1997). Webel introduced non-mathematical goals (p. 16), classifying students' goals first as either mathematical or non-mathematical, and then differentiated among each collective, teasing out the role of students' goals. In the end, he categorized goals on three different dimensions: mathematical/non-mathematical; individual/group; normative/personal (see Figure 1.2, below).

[15] The specifics of the mathematical topic are not provided.

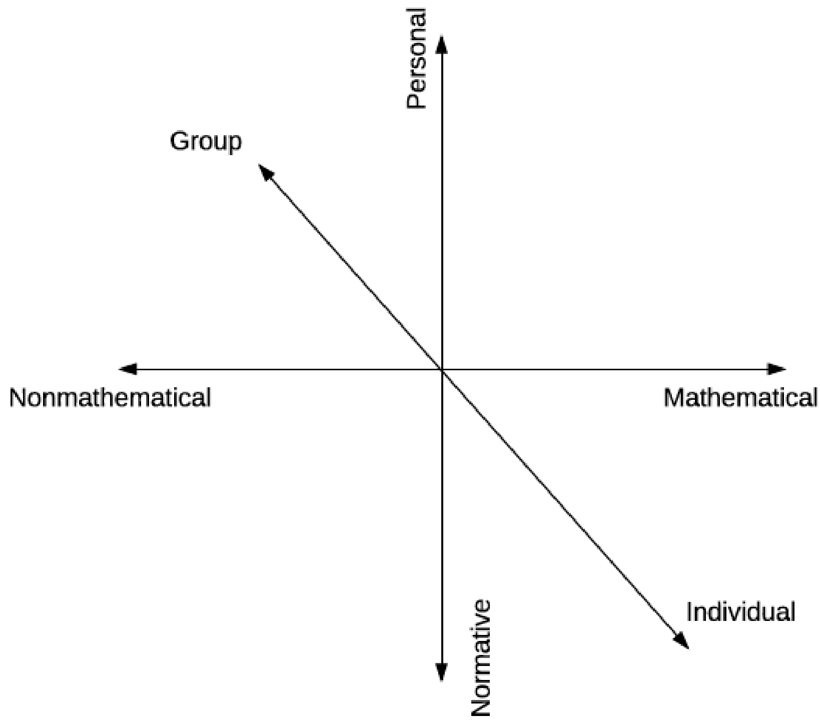


**Figure 1.2 Webel's three dimensional goal analysis (adapted from Webel, 2013, p. 48).**

One significant result of his work was that it "*reveals a tremendous amount of variation along these dimensions among the students in a single class, which emphasizes the need for research which acknowledges the diverse goals that students bring to the classroom*" (p. 52). In considering students' goals, Webel's work extends the work done with the practical rationality of studenting. And my dissertation attempts to understand this need he identifies.

Practical rationality, as used by Webel, acknowledges that students' may hold non-mathematical goals (in group-work situations). However, other types of non-mathematical goals have not yet been addressed. There are student actions that are pervasive and well-known to classroom teachers, yet are not addressed in the aforementioned literature. What about students who hold non-mathematical goals in other situations? The following section addresses student conduct that cannot be fully understood using norms, contracts or practical rationality - students who 'game' the classroom.

## 1.4 Gaming

*"A game is being played whenever human beings interact*" (Binmore, 2007, p. 1). The idea that people 'game', or strategize, to achieve desired outcomes is not new, nor unfamiliar. Nor is it new within the realm of education. It appears in the shifted definition of studenting, of which Fenstermacher spoke in 1994. It is an indisputable fact that many students actively engage in gaming; if not consciously then on a non-conscious level. Baker, Roll, Corbett & Koedinger (2005) define gaming the system as "*behaviour aimed at completing problems and advancing through an educational task by systematically taking advantage of properties and regularities in the system used to complete that task, rather than by thinking through the material*" (p. 58). Robert Fried (2005), author of "*The Game of School*", explains that students are playing the game of school when they figure out what teachers want and treat school as a trick rather than as a true opportunity to learn. The notion of students 'gaming the system' can be examined through literature in other disciplines, such as economics and psychology, and has also appeared in mathematics education literature. First, however, I will elaborate on the types of student action that fall under the umbrella of gaming, and discuss the goals that serve to direct it.

### Actions

As used here, gaming encompasses a wide range of student behaviour including, but not limited to: taking advantage of (lack of) teacher attention; manipulating the teacher's rules to suit ones own goals; figuring out shortcuts to improve efficiency and reduce effort; cheating; delaying; faking. These actions align with Fenstermacher's 1994 definition of studenting, which highlighted these types of behaviour. These can manifest in several ways. During group work, some students may sit back and wait for others to do the majority of the work. In a lesson, a number of students sit back and wait for the 'keeners' to answer the teacher's questions or wait for the teacher to answer them. More generally, students figure out how to get around policies and rules regarding homework, attendance and tests, to name just a few, in order to minimize their efforts and either maximize achievement (reward) or minimize censure or discipline. Students learn very quickly how to 'get away' with doing less work and how the teacher's rules can be manipulated.

For example, Mehan (1980) relates an example of a student using the teacher's assigned task in order to fulfill her own goals. The student, Carolyn, volunteered for a particular task (check the cupboard for recess balls) in order to accomplish her personal goal (hang up her sweater in the closet next to the ball cupboard). It would have been against the rules to leave the rug without permission from the teacher, so Carolyn used her understanding of the rules in order to select an activity that best met her needs. Aaron explains that, "*although this is not an academic task, it highlights the ways that expert students can navigate the complex terrain of classroom tasks and use them to meet their own goals*" (2011, p. 276). Examples at more senior levels include students asking for permission to leave class to go to the washroom, whereupon exiting the class they check their phones or get food.

The theme of 'playing' (a game, by the rules, and the system) can be found in several places in Kenneth Dryden's[16] (1995) popular book, "*In School*". The book is based on Dryden's experiences and conclusions about the state of education after spending a year in the classrooms of a public high school in Ontario. In his book, he describes the students who are chronic skippers as "*kids who have learned how to play the system and are winning*" (p. 103). They know that teachers and the administration have only so much time and will eventually give up pursuing them: "*They don't play by the rules*" (p. 104).

Dryden replays a conversation between two teachers who are discussing the differences between kids 'today' and in the past. "*And it's not just the 'in-your-face' stuff* […] *that's just a game, and everyone knows it"* (p. 206). Dryden contends that students are adept at calling bluffs – they know the rules and how to bend them without breaking them. They know that teachers (and parents) have only so much time and patience, and that eventually it is a good bet that they will break down and give in. It is not worth the effort.

Classroom experience tells me that students are well aware that teachers often do not have the time to do all that is asked and expected of them. For example, students seem to know that if they do not want the teacher to 'see' them or if they want to fly under the

[16] Kenneth Dryden is a former Liberal Member of Parliament and earned a spot in the NHL Hockey Hall of Fame as a goalie for the Montreal Canadiens. He is also a lawyer, and currently teaches a Canadian Studies course at McGill University, as a 'Special Visitor".

radar, they just need to be quiet, avoid breaking any discipline rules, and do not raise any flags by being absent too often or by being tardy. These students certainly hold some non-mathematical goals, but the exact nature of these goals is not known[17].

Although there are similarities, 'gaming the system' is not synonymous with cheating. "*Gaming the system generally involves taking advantage of loopholes in a system, whereas cheating involves direct violation of that system's rules*" (Baker, Corbett, Koedinger & Wagner, 2004b, p. 384). Cheating is a practice that is more prevalent in classrooms than teachers know or would like to admit. The short-term benefit to the cheater is obvious. "*Students who successfully cheat can enjoy the benefits of high grades without actually studying and learning the material*" (Bunn, Caudill & Gropper, 1992, p. 199). From a conventional economics point of view, cheating is an efficient strategy. Additionally, the probability of getting caught, thus the risk to the student, is quite low. Both students and teachers are well aware of this, and even if a teacher suspects a student is cheating, it can be quite difficult to prove. The amount of effort required on the part of the teacher, and the fact that students often do not see cheating as a 'serious' offense, can result in a high incidence of habitual cheating (Mixon & Mixon, 1996).

Finally, there are two more subversive types of gaming: faking and delaying. Faking refers to student behaviour that is purposely designed to convey to the teacher that he or she is complying with the teacher's expectations[18], when really he or she is doing something else (Liljedahl, 2006). This sort of behaviour can also be described as gaming, in the sense that the students are manipulating the teacher's perceptions and taking advantage of the situation, or the physical position of the teacher in the room, in order to satisfy their own goals over those of the teacher. Delaying fulfills a similar purpose, although the level and type of strategy employed by the student varies. Students who engage in these actions have particular goals, which promote the behaviour. I now discuss these goals in the context of the literature.

[17] It is possible that a student holds a goal of minimizing effort, avoiding attention or avoiding something else.

[18] This refers to the student's perceived teacher expectations.

## Goals

The goals a student holds are a significant determinant of their actions. When a student's conduct falls under the aegis of 'gaming', the goal appears to be to minimize effort or to maximize efficiency or some combination of these. And although at times the pursuit of one of these goals can satisfy both, efficiency and economy of effort are not equivalent. It is, however, difficult to differentiate them in the literature and thus they will not be separated here. Like the notion of gaming, the idea that students' actions have an economical basis is not new. It is present in an informal sense in some areas of mathematics education literature, as well as within the domains of traditional and behavioural economics.

For example, in his article exploring students' mathematical beliefs and behaviour, Schoenfeld (1989) discusses the relationship between prior experience and the amount of effort a student expends in solving a particular problem:

> The student comes to the problem having solved a huge number (in the tens of thousands) of mathematics problems. Whether or not the student is conscious of it this prior experience shapes the amount of time and effort that will be invested in this problem. (p. 341)

The student has developed an economical attitude towards problem solving. His or her prior experience dictates how much effort and time he or she will expend in attempting to solve a problem. For example, if the student has typically been unsuccessful with solving problems in the past, he is unlikely to invest much effort or time into trying a new one. Or, if the student knows that the teacher typically presents the solution before she can finish the task, the student may invest little effort in trying it herself. This prior experience can be seen as a facet of the students' personal resources, as described by practical rationality. Daniel Kahnemann (2011), a prominent psychologist and researcher in behavioural economics, calls this the 'law of least effort' and explains that this law is responsible for the people's tendency to take the easier route, whether in physical or cognitive activity. Taking the 'easier' route does not have to have a negative connotation – sometimes the easier route is the best way. The 'principle of economy' in learning and teaching mathematics is the central theme of Dave Hewitt's (1994) dissertation. He describes this principle as being "*concerned with the management of the human resources of time and effort, in relation to the quality and quantity of learning achieved*" (p. 2). Hewitt approaches from the teacher's perspective, establishing multiple principles for teachers to use to minimise the "*amount of time and personal effort given by a student […] to maximise the amount of their learning*" (p. 206). The critical point Hewitt makes in his definition is that the minimisation of student (and teacher) effort goes hand in hand with the goal of maximising learning.

The minimisation of effort is a concern highlighted by Mason (1998). In his description of the notion of didactic tension, mentioned earlier, he laments the mutation of the optimal relationship between the student and teacher roles. He explains the didactical contract as an understanding:

> between teacher and students, in which students agree to do (some of) what the teacher asks in expectation that they will then learn. In a culture of box-ticking accountability this naturally leads to students minimising their energies by making the least effort, and expecting that somehow this will be sufficient for them to learn. (p. 2)

This bent towards economy is not unique to the students. Mason continues:

> The same minimisation of energy even leads some teachers to treat the textbook as the teaching, seeing their task as making the work as pleasant as possible […] Student and teacher collude in expecting learning to happen almost independently or automatically, without the specific attention and engagement of the students. (p. 2)

As described here, the desire for efficiency and/or for economy of effort has resulted in a classroom contract in which the student and teacher[19] may do as little as possible to fulfill their perceived obligations.

Even those who 'know better' employ gaming strategies when time and circumstance deem it 'necessary'. For example, Dryden (1995) describes in his book a scenario in which he was responsible for preparing answers to homework questions in order to play a game the following class. Having forgotten to do his homework the night before, he recounted:

> I searched for a quiet place, quickly scanned the 120 questions, divided 120 by the number of students in the class (and the number who would likely be there), looked for the easiest ten questions, and prepared them, figuring I could always work ahead on others during the game if I had to. Some instincts never die. (p. 8)

[19] A critical difference to note here is the teacher of whom Mason speaks is minimizing effort, but he is not working towards maximizing student learning, as he is in Hewitt's work.

Echoing Mason's thoughts on the minimisation of effort, French psychologist Michael Pichat (2001) explains that students' cognitive activity is influenced by their inferred understanding of the didactical contract:

> Students do not indeed, a priori, only try to perform mathematical tasks per se: they attempt to efficiently face implicit contractual injunctions that concern mathematics. Therefore, students' activity is not similar, even in a very simplified way, to the activity of the professional mathematician. This is all the more true since, usually, *students try to maximise performance despite a minimisation of the conceptual cost that is necessary for this*. (p. 4; emphasis added)

Students are unlike professional mathematicians, not least because they have different goals. The students are fulfilling the contract, but their interpretation of the contract does not involve learning for understanding; for the students, it is enough to be able to perform on tests or comply with other inferred elements of the contract (such as completing homework or behaving appropriately). As a result, the students are primarily concerned with managing tasks efficiently and thus minimising their effort. The paradox here is that they strive for efficiency, yet they have inefficient learning strategies. Minimization of effort must be balanced with a goal of maximizing learning (Hewitt, 1994).

Even the way the school system is structured is based on efficiency and/or economy. In his book, "*Horace's compromise: The dilemma of the American high school,*" Theodore Sizer wrote: "*If students are interested and orderly* […] *many can be taught at once, in lecture theaters. Telling is cost effective, far more so than coaching. That is why it is so popular in schools*" (p. 109). Dryden's work supports this view. He refers to education as a mass system and claims that it will not improve anytime soon because the changes required to improve it are complicated and costly, not to mention the fact that people are resistant to change.

Given that is common for students (and even teachers) to hold these goals, it is relevant to discuss the outcomes of the actions they promote. Specifically, what is the result of gaming behaviour? What consequences does it have for learning?

## Gaming, game theory and learning

The nature of the classroom seems to promote gaming in many situations. Recognition of this has attracted researchers to applying a game-theory perspective to studying classroom interactions.

Senior researcher and adjunct professor in computer science at the University of Helsinki, Petteri Nurmi (2005) wrote that the uncertainty of outcomes with respect to interactions within the classroom results in "*a tendency to conform to acceptable performance levels, conserve energy expenditures, and avoid risk*" (p. 35), rather than put the maximum effort into learning. Tim Newfields (2007), a professor of economics, claimed that, "*[f]rom a game theory perspective, school classes can be seen as interactional matrices in which teachers and students try to adopt optimal behaviour in order to minimize losses and maximize returns*"  (p. 33).

Newfields studied students' actions in response to a 'points-system' he implemented to encourage student actions that promote learning. He found that "*the constant process of awarding points for interactions has a tendency to trivialize the interactions*" (p. 39). He concluded by positing: "*until students actually see the reason for the target behaviour and internalize the need for activities such as speaking up, attending regularly, or doing homework perhaps any amount of 'system engineering' will likely have limited long-term effects*" (p. 41).

The common theme in all of the literature discussed above is that students are not focused on learning, but on playing whatever version of the game they encounter. For some students this results in a focus on not making mistakes. Fried emphasized that we train students to be like this; that in fact, they think their school experience is normal. Dryden (1995) quoted Northrop Frye: "*the purpose of school is to instil a love of learning*" (p. 75), but to this day, results tell us that this is not what is happening.

However, gaming does not have to have negative consequences for learning. Baker (2007) gives an example of gaming behaviour intended to increase efficiency and decrease effort, but that does not inhibit learning. If a student engages in gaming in order to skip "*time-consuming but easy steps, in order to focus more time on more challenging material*" (p. 1064), then that is a positive instance of gaming. Context also plays a factor:

"*While gaming the system is an inappropriate use of a learning opportunity, such behaviour is generally considered acceptable (if not desirable) within the context of a high stakes examination*" (Baker et al., 2004b, p. 384).

Sometimes gaming can have positive outcomes, but overall the inconsistency in approval of gaming can certainly lead to confusion for students, particularly when teachers promote strategies such as guess-and-check for multiple-choice questions or teach 'short-cuts' that are not really mathematically correct. When such gaming tactics are used or promoted by the teacher, it is only natural to assume that students adopt them and start to view gaming as an accepted, even desired, practice.

## 1.5 Summary

The notions of contracts, norms and rationality all add valuable insight to the problem of understanding student actions within the mathematics classroom. The didactical situation and didactic contract illuminate student teacher interactions, wherein the relationship is one of (assumed) reciprocal obligation. The relationship evolves and shifts as student and teacher both negotiate the 'terms' of the contract through their actions. Although Brousseau considers the role of context in the negotiation of the contract, the role of the social environment is given much more importance when considering student behaviour from the perspective of social and sociomathematical norms.

Social norms document that students often act in certain ways to comply with tacit assumptions about how they should behave. Sociomathematical norms provide more detail about how students conduct themselves in situations that are specific or unique to mathematics (such what qualifies as an acceptable mathematical justification or explanation) and how mathematical beliefs and practices influence student behaviour. To the puzzle of interpreting student behaviour, norms add consideration of students' beliefs and values, developed over time and through experience within the social environment of the classroom.

Breaches of these norms can also be explained, from the vantage point of practical rationality. This theory brings together and extends the aforementioned contract (part of obligations) and norms, which together comprise students' practical rationality. Students' personal resources (goals, beliefs and knowledge) mediate their practical rationality, and ultimately result in student action. While contracts and norms have an underlying presumption that the student motive is to learn, practical rationality (as used by Webel) acknowledges and explores possible student non-mathematical goals in instructional situations. Finally, gaming addresses those student actions that are not oriented towards mathematics, instead being performed to achieve a goal of maximizing efficiency, minimizing effort, and/or some other end.

Fundamentally, all of these concern student actions or student motives, and when it comes to understanding better the relationship between student action and student motives, activity theory is a natural place to look – first, because its fundamental premise is that all human activity is driven by motive, and second because it is possible to determine this motive. In the next chapter, I explore the historical development of activity theory from its roots in the Soviet Union through to some present-day Western derivations.

# Chapter 2:

# Activity Theory

> [U]sing Activity Theory allows us to expose key underlying interactions and especially contradictions [and] fosters a more complex and comprehensive understanding of the features which impact on the effectiveness of a learning situation […]. (Issroff & Scanlon, 2005, p. 438)

The dynamic nature of the classroom, and of student behaviour in particular, involves constant flux, making analysis of behaviour difficult at best. Students are inconsistent in their actions across different settings, and sometimes even in the same situation at different times. There are complex dynamics at play, characteristic to the student experience, which cannot be adequately described with a reductionist view. While the theories and approaches discussed in the previous chapter work very well in isolated cases, in specific conditions or under particular assumptions, activity theory serves as an overarching paradigm for researching, and ultimately understanding, student behaviour in the mathematics classroom.

In my hunt for a theoretical framework to guide my research, I considered several options, but when I became aware of activity theory[20], it appeared ideally suited to my purposes. I chose it *because* it is overarching and allows freedom in determining motive, as opposed to being built on prior assumptions about motives and behaviour, or inviting a formulaic approach to analyzing student behaviour. As I progressed with my research, my hopes for activity theory were borne out and my selection justified, the details of which will be provided in the concluding chapter of this dissertation.

Five sections comprise this chapter: 1) the origins of activity theory; 2) developments in activity theory; 3) its applications in various domains of research, particularly education; 4) its affordances to investigating student behaviour; 5) the refined research questions.

[20] Activity theory appears in many forms, and thus I do not use the capitalized version of the term as it is not clear to which version it refers. It is also not actually a theory, but more of a theoretically-based conceptual framework. I use 'activity theory' as a broad categorization and will elaborate on the specific version I refer to when it arises.

Activity theory was developed to describe and explain human behaviour, and has been applied in many domains, one of which is education. Although activity theory was virtually unknown in the western hemisphere for almost half a century after its initial development, in the past few decades it has been increasingly used in research "*to develop an understanding of complex roles and relationships in education*" (Beauchamp, Martek & McAlphine, 2009, p. 267). The credit for this upsurge belongs to Finnish researcher Yrjö Engeström, who brought activity theory into greater use and familiarity in the West. His work, and particularly his development of the activity system, has had tremendous impact on the application of activity theory in contemporary research. But, to really understand action and motive in the individual, we have to return to the roots of Engeström's model, that is, to Alexei Leontiev and the genesis of activity theory itself.

## 2.1 Marxist and Vygotskian Origins

The origins of activity theory lie in the former Soviet Union. It was first developed by Lev Vygotsky, the founder of cultural-historical psychology, with contemporaries Luria and Leontiev, and influenced by Rubinshtein's psychology. The bulk of Vygotsky's contributions took place in Moscow from 1924-1934. His particular interest lay in the social and cognitive aspects of learning and supporting learning. The development of the theory occurred within a particular set of environmental conditions and, partially, in response to the stimulus-response model promoted by Pavlov, a contemporary of Vygotsky. Vygotsky's theory was a departure both from reflexology (stimulus-response, which later evolved in the United States into behaviourism) and psychoanalysis, the bases for the prevailing psychological theories in the Soviet Union at the time. Although it does not sit in direct opposition to behaviourism, activity theory differs in its fundamental tenets. The particular objection that Vygotsky had was with respect to the role of consciousness. He felt that humans were unlike other animals in that human activity is purposeful, and humans are capable of critical reflection upon their own activity, whereas other animals are not.

In reflexology, the role of consciousness was essentially banned, reducing all psychological phenomena to stimulus-response chains, while in psychoanalysis the concept of consciousness itself was used to explain states of consciousness, creating a circular argument. Given these theoretical limitations, Vygotsky felt there should be another explanation. He was strongly influenced by Sergey Rubinshtein, a major figure in Russian psychology, who articulated the idea of considering human action as a unit of psychological analysis. Rubinshtein's (1946) proposed "*principle of unity and inseparability of consciousness and activity"* is the basis of one of the primary principles of activity theory. Vygotsky extended and developed the scope of this principle, embarking upon a mission to create a Marxist psychology, which could be used to explain how mind and world interacted and were mutually transformed through interaction. His essential belief was that an understanding of the mental functioning of the individual is only possible with analysis of the social and cultural processes from which it is derived. Vygotsky's approach differs significantly from many Western approaches, which assumed a singularly individualistic perspective, including, subsequently, constructivism.

Vygotsky drew many of his ideas from Marx and Engels, reshaping them for the purposes of activity theory. Take, for example, the role of tools. For Marx and Engels, labour was the basic form of human activity. In carrying out labour activity, humans transform nature and in the process are themselves transformed: this activity is carried out by actions through the use of tools. The tools available at a particular stage of history reflect the level of the labour activity, and new instruments are required to carry out new forms of labour activity as it evolves. These new tools also give rise to new ideas about the world and how to act on it. Thus, there is a dialectical relationship between the tools or instruments that mediate labour and the labour activity itself. Vygotsky borrowed these ideas about how tools mediate labour activity and used them in his formulation of ideas about the mediation of consciousness, also broadening the definition of the tool to include psychological tools:

> The most essential feature distinguishing the psychological tool from the technical tool is that it directs the mind and behaviour whereas the technical tool, which is also inserted as an intermediate link between human activity and the external object, is directed toward producing one or other set of changes in the object itself. (Vygotsky, 1930/1981, p. 140)

The choice of tool and how it is used can reveal how someone is thinking. We not only use tools that shape our thinking, but we also create and transform tools through our use of them and thinking with them. For Vygotsky, language was the most important tool for collaborative human activity, because it "*carries the meanings that matter in the societies* *in which we live and so offers a window into our minds and into those societies*" (quoted in Edwards, 2011, para. 9).

> Vygotsky's new method of thinking about consciousness, as mediated by psychological tools, came to be known as the 'instrumental method' in psychology. Thus, in the instrumental act, a new intermediate link – the psychological tool, which becomes the structural center (i.e., the feature that functionally determines all the processes that form the instrumental act) – is inserted between the object and the psychological operation toward which it is directed. Any behavioural act then becomes an intellectual operation. (Vygotsky, 1930/1981, p. 139)

His initial formulation can be depicted by a triangle with stimulus A and response B at the top vertices and the psychological tool (X) at the bottom vertex (see Figure 2.1).

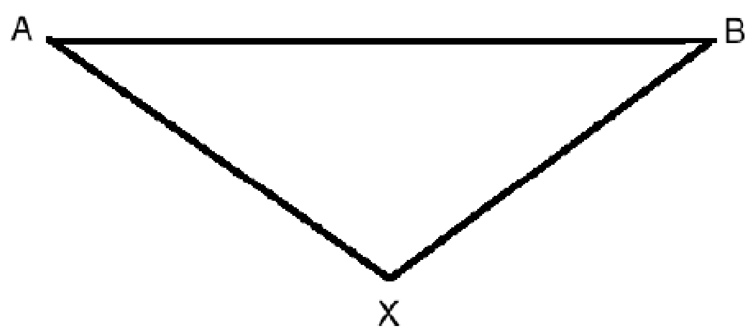


**Figure 2.1 Diagram of the 'Instrumental Method' of thinking about consciousness (adapted from Vygotsky, 1997, p. 86).**

This initial formulation was considered to be too close to behaviourism for many psychologists working in the realm of activity theory, as it is still essentially a stimulus-response model (human action is actually passive). Consequently, the initial model was reformulated to represent activity comprising a subject and an object, mediated by a tool or artefact (see Figure 2.2). The unit of analysis is now activity, defined by the 'dialectic relationship between subject and object' or 'who is doing what for what purpose' (Vygotsky, 1978). This differs from Vygotsky's initial representation in which the unit of analysis was object-oriented action, mediated by cultural tools and signs. In the evolved model (first generation, Figure 2.2) the object is what motivates and gives direction to activity undertaken by the subject. The mediating artefact could be a physical or mental (psychological) tool, including cultural tools and signs, such as language.

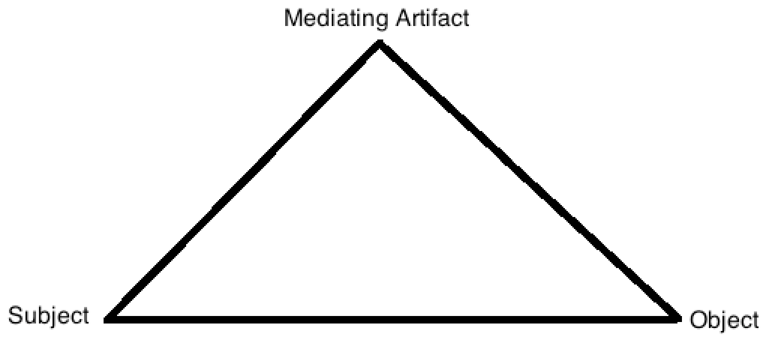


**Figure 2.2 First Generation Activity Theory (adapted from Cole & Engeström, 1993, p. 5)**

The relationship between the subject and object is referred to as dialectic, meaning that the object of an activity is both objective and subjective. Hasan and Kazlauskas (2014) offer the example of the construction of a new house. The object of activity for the client may be "*the potential of a new family home or investment property*" whereas "*for the builder it may be the physical construction of a new house*" (p. 10). The authors contend that both objects must be taken into account and that they may be at odds: "*The philosophical notion of a dialectic relationship comes from the argument that any meaningful thesis (an idea or concept) can have a valid antithesis (or opposite) and that a synthesis of the thesis and its antithesis gives a richer understanding of reality*" (p. 10).

Hasan and Kazlauskas provide a categorization of different types of tools. *Primary* tools are physical, whereas *secondary* tools include concepts, language, ideas and models. Communities, context or environment are *tertiary* tools. In Engeström's activity system[21], the tertiary tool is sectioned off and included as a distinct element in the triangle, called community.

Though this model is considered an improvement on the initial formulation, it is still a few evolutionary steps short of what activity theory is today. Critics point out that this model still failed to allow for the role of other human beings and social relations. Sadly, Vygotsky died young and was unable to expand on and provide clarification for many of his ideas. Though much of his work is 'unfinished,' it is undeniable that one of his great contributions

[21] An activity system is "*a group of people who share a common object and motive over time, as well as the wide range of tools they use to together to act on that object and realize that motive*" (Kain & Wardle, 2010, p. 1). Engeström uses the activity system as his basic unit of analysis.

was that he recognised that all human action is shaped by what we know. Vygotsky's work was carried on by many and today there exist several different interpretations of activity theory. One of the reasons for this is that the concept of activity itself was seen as problematic and open to multiple interpretations within Russian philosophy and psychology (Bakhurst, 2009).

In Russia, Vygotsky's work was furthered by Luria and Leontiev; in North America, it developed into sociocultural or cultural-historic activity theory through the work of (in no particular order) Jerome Bruner, Michael Cole, James Wertsch, as well as the more recent work of Wolff-Michael Roth, Luis Radford, and many others. In Finland, a widely recognized and popular branch of activity theory was developed by Yrjö Engeström, as mentioned above. In fact, there are a variety of approaches in the activity-theoretical tradition that share the basic principles of activity theory, but differ in how these principles are implemented.

Bakhurst explains that these can be divided into two main strands: Leontiev's classical version and its derivations, which share the same approach to activity and are built on the same philosophical and psychological foundations; and Engeström's activity system approach (2009). Though they share a common genesis, these two strands offer varying perspectives, and Bakhurst asserts that there is tension between the two traditions. While the Russian founders "*saw the concept of activity as a fundamental category to address profound philosophical questions about the philosophy of mind,*" in the West "*activity theory … has principally become an empirical method for modelling activity systems*" (2009, p. 197).

Though it has its theoretical basis in Leontiev's work, Engeström's activity system approach is commonly used for modelling organizational change, and presupposes that common activity is driven by a common group goal. Given that the goal is to investigate individual student behaviour, not to model a system, Leontiev's approach seems more suitable. The following section describes Leontiev's activity theory in detail, along with some later additions and elaborations, with the aim of determining the most appropriate approach to studying student behaviour in the secondary mathematics classroom.

## 2.2 Evolution and Development: Vygotsky and Leontiev

Together with Luria, Leontiev continued and expanded on Vygotsky's work. The unit of analysis in Vygotsky's early work was object-oriented action, but this model lacked recognition of the part played by other human beings and social relations. It was Leontiev who actually developed the conceptual framework we know as activity theory, in part by adding features devised to separate individual *action* from collective *activity*. The distinct categories of *activity*, *action* and *operation* were added as a means to differentiate an individual's behaviour from the collective activity system. Although it is called as such, it should be noted that as conceptualized by Leontiev, activity theory is not actually a theory, but more a set of basic principles and an overall conceptual framework that can be used as a foundation for theories.

### Principles of activity theory

As mentioned earlier, the premise upon which all of activity theory rests is that activity mediates interaction between subjects and objects. From that founding notion, Leontiev's activity theory has four main principles: 1) object-orientedness; 2) the inseparability of internalization/externalization of mental processes; 3) continuous development; 4) hierarchical structure. I will briefly describe the first three, and then discuss the hierarchical structure of activity theory in more detail. Both Vygotsky's and Leontiev's work, in addition to requiring translation from the original Russian, also require substantial interpretation. As a result, I have relied heavily on others' translations and interpretations.

1) One of the key principles in activity theory is "object-orientedness". The object of activity is the 'ultimate reason' behind behaviour. Victor Kaptelinin, a professor at the University of Bergen, Norway, has done substantial work in the fields of activity theory and informatics, and is well versed in the history of Russian psychologists. In his 2005 article, he refers to the object of activity as 'the sense-maker', that which gives meaning to various entities. The object of activity has import for subjects of activities and for researchers. Kaptelinin explains:

> On one hand, creating a concrete representation of the object of activity provides a basis for both rational and emotional dimensions of setting priorities and goals, commitments, planning, and coordination. On another hand, the concept of the "object of activity" is employed as a useful

> conceptual tool helping to structure and interpret otherwise fragmented and confusing empirical data. (p. 5)

For the researcher, identifying the object of activity has significant explanatory power and, according to Leontiev (1978), it is the ‘object motive’ that is the most important factor in the identification process. However, identification of the object motive is not an easy task.

2) Activity theory differs from traditional approaches with regard to its view of mental processes. In activity theory, these cannot be considered only as internal, to be analyzed in isolation from external activity. A key principle of activity theory is that there are interactions and mutual transformations between internal and external activity that cannot be understood if considered separately. Recognizing the importance of the inseparability of internal and external processes was a significant advance in the evolution of activity theory. One of most significant considerations when studying activity is it is essential that it is understood in the context of the cultural and historical environment (Kaptelinin, 1996).

Bonnie Nardi is an ethnographer and a professor and leading researcher in the area of Human-Computer Interaction at the University of California, Irvine. Well known for her work on activity theory, she explains that context is not entirely external nor internal to people:

> Context is not an outer container or shell inside of which people behave in certain ways. People consciously and deliberately generate context (activities) in part through their own objects [objectives]; hence context is not just “out there.” Context is both internal to people – involving specific objects and goals – and, at the same time, external to people, involving artifacts, other people, specific settings. The crucial point is that in activity theory, external and internal are fused, unified. (1996, p. 38)

In its current form, activity theory views context as both external and internal to individuals, and is thus both experienced and generated by individuals.

3) Although activity theory may appear complex and cumbersome, this level of complexity is exactly what is necessary in order to achieve a non-trivial analysis. Activity must be analyzed in the context of development. In activity theory development is both a research strategy and an object of study (Kaptelinin & Nardi, 2012).

4) The fourth principle of activity theory is its hierarchical structure. Leontiev described three hierarchical levels in his scheme, depicted here as a pyramid (Figure 2.3).

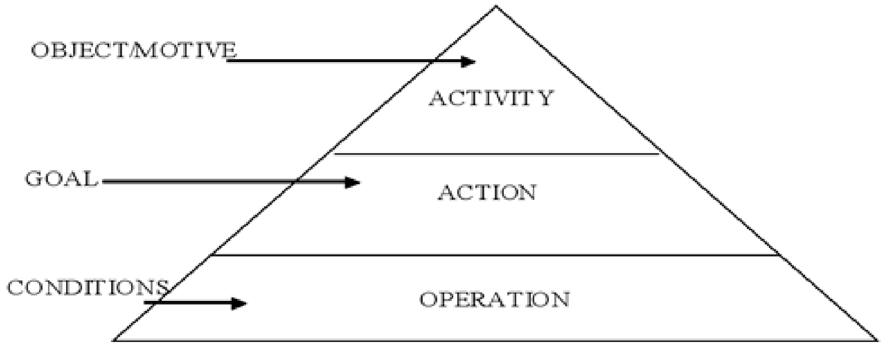


**Figure 2.3 Leontiev's Activity Theory: Second Generation Activity Theory (adapted from Hardman, 2007).**

At the apex of the pyramid is activity, which is driven by an object or motive. At the second level are actions, which are determined by goals. Finally, operations sit at the base of the pyramid; these are responsive to conditions. There are strong interrelations between these levels and there is also movement between them. Therefore, after describing the three levels in more detail I will elaborate on how transitions between the elements can occur.

**Activity, motives, and needs.** Needs, motives, and activity are interrelated and intertwined in activity theory. For Leontiev, *"[a]ctivity does not exist without a motive; 'non-motivated' activity is not activity without a motive but activity with a subjectively and objectively hidden motive*" (1978, p. 99). Activity, as Leontiev uses it, refers to a "*specific level of subject-object interaction, the level at which the object has the status of a motive*" (Kaptelinin & Nardi, 2012, pp. 24-25). The object of an activity is its 'true motive', and the "*object is perceived as something that can meet a need of the subject*" (p. 25). All observable human activity (and that which cannot be observed) therefore must have at its source some object, some motive, which drives it. All of these motives arise from needs, which are viewed as the ultimate cause of human activity. And, it is only through activity that a need can be realized.

There are two available perspectives from which to approach needs: biological and psychological. From the biological perspective, a need is an objective requirement of an organism. These types of needs include food, water, appropriate temperature, and having this type of need means that there should be something in the environment to satisfy it. From the psychological perspective "*a need is a directedness of activities towards the world, towards bringing about desirable changes in the environment*" (p. 25). Two types of needs are associated with this view; Leontiev referred to these as *need as an inner* *condition*, and *need as a precondition for activity*. The former is not 'objectified', that is, it is not associated with an object that will satisfy it. Examples of these 'inner conditions' include hunger, fatigue, and other states that may provoke discomfort, but this feeling "*cannot direct the subject and help satisfy the need, except in stimulating an exploratory behaviour that is not directed at anything in particular"* (p. 25). It is only a state of depravation for the organism and it is only when the need meets the corresponding object that it becomes capable of directing and regulating activity (Leontiev, 1974, p. 50).

> Up to the time of its first satisfaction the need "does not know" its object; it must still be disclosed. Only as a result of such disclosure does need acquire its objectivity and the perceived (represented, imagined) object, its arousing and directing activity of function; that is, it becomes a motive. (Leontiev, 1978, p. 161)

Therefore, to be a motive, a need must be actively connected with the object that will satisfy it. A need cannot be called a motive until the subject is capable of identifying the object that will satisfy that need. For example, we cannot call hunger a motive until we know that food will satisfy it. Further,

> subjective experiences, wishes, desires, etc., do not constitute motives because in themselves they are not capable of generating directed activity and, consequently, the principal psychological problem is to understand what the object of the given desire, wish, or passion is. (Leontiev, 1978, p. 165)

When the need meets its object, the need is 'objectified'; it is now seen as a *need as a precondition of activity* that guides and regulates the agent's concrete activity. "*When a need becomes coupled with an object, an activity emerges. From that moment on, the object becomes a motive and the need not only stimulates but also directs the subject*" (Kaptelinin & Nardi, 2012, p. 25). When a need is objectified, the subject knows what it is looking for. Thus, once we are aware that food will satisfy the hunger need, ingesting food becomes a motive, and directs our activity (find food to eat).

Motives drive activity, and activities are directed at goals. The top-level goal is not subordinated to any other goal and is called the motive, or object of a whole activity. At any time an individual has a hierarchy of these motives, the order of which is determined through and as a result of one's activity:

> The fact is that neither the degree of proximity to biological needs nor the degree of capacity to stimulate nor the affectiveness of one motive or another determines the hierarchical relationship between them. These

> relationships are determined by the connections that the activity of the subject brings about, by their mediations, and for this reason, they are relative. (Leontiev, 1978, p. 170)

Even top-level goals can change, although this occurs less frequently than shifts in other goals further down the hierarchy.

Motives can be material or ideal; one may be driven to acquire a concrete object, such as money, or to achieve something more cerebral, such as learning to speak another language. It is motives that motivate activity, whereas goals direct it. As well, motives are distinct from goals in that, for Leontiev, motives are not actually recognized by the subject. When an action is undertaken the individual is likely able to identify the goal that accounts for the action, but the motive is not usually accounted for. For example, an individual may mow his lawn because he has a goal of his property looking neat. He is aware of this goal, but may be unaware that the motive that drives his activity is a need for acceptance from his neighbours. Leontiev notes: "*[i]t is true that it is not difficult for us to ascribe motivation to them, but motivation does not always contain in itself an indication of their actual motive*" (1978, p. 168).

For an observer it is also difficult to determine motive, because of the complex relationship humans have between motives and goals. Unlike other animals, for humans there is a often a dissociation between motives and goals; humans often direct their efforts towards other things rather than directly toward the object (Kaptelinin, 2013). Although motives may not be explicitly conscious, that does not mean that they are separated from it. "*[M]otives are revealed to consciousness only objectively by means of analysis of activity and its dynamics … they appear only in their oblique expression, in the form of experiencing wishes, desires, or striving toward a goal*" (Leontiev, 1978, p. 171). For example, for small children the motive behind the desire to go to school is hidden, it can only be explained by observed through studying children's behaviour, such as when they play the game of "*going to school"* (p. 171).

**Actions and goals.** "*An activity is composed of a sequence of steps, each of which may not be immediately related to the motive…these steps are actions*" (Kaptelinin & Nardi, 2012, p. 26). Actions occupy the central level in the pyramid and are directed towards specific objects, called goals or purposes. Goals are conscious; the subject is aware of what she is trying to attain. This is not always the case with motives, as discussed above.

Like motives, goals are hierarchical and may often be subordinated to other goals. For example, the goal of graduating high school may have many associated sub-goals, such as passing English and Socials, which in turn have further subsidiary goals such as finishing an essay or passing the final exam, and so on. There are frequent shifts in the hierarchy of goals; a higher level goal may be surpassed by another due to prevailing conditions, such as the need for sleep being more important than completing homework when one is very tired. At the very top of this hierarchy of goals is the top-level goal, or motive, which for Leontiev is synonymous with object.

All actions fall under the umbrella of activity. "*We call a process an action if it is subordinated to the representation of the result that must be attained, that is, if it is subordinated to a conscious purpose*" (Leontiev, 1978, p. 99). A specific action may accomplish various activities and may transfer from one activity to another. Activity is also multi-motivational; it may respond to two or more motives. Both socializing and obtaining food are achieved by making a trip to the grocery store. Further, the same activity could be undertaken by two people, or even the same person at different times, driven by distinct motives. In the classroom context, one child may do assigned work because he wants to get the marks for it, while another may do the work to avoid getting in trouble with the teacher or his parents. As well, two identical motives may produce various actions, depending on the intended goals or purposes. An example of this is when two equally capable individuals each have a need for praise; one may avoid certain tasks or situations for fear of failure, whereas another may seek challenges, even though there is no guarantee of success.

**Operations and conditions.** At the base of the pyramid are operations. These are the automatic processes that are responsive to actual conditions. These conditions could be external, such as social or environmental, or internal, such as the psychological or physical condition of the subject. Operations are not associated with specific goals; rather they provide adjustments to actions in response to the current situation, and generally operate at a subconscious level. For example, when navigating a crowded school hallway between classes a student makes many adjustments to their path to avoid running into other students without being aware of it.

New operations can also arise from actions which were previously conscious. With sufficient practice and familiarity, an action that once demanded conscious attention can become automatic. A child who is just learning to multiply two-digit integers will likely work through the procedure consciously, whereas the same process would likely be performed automatically by a student in high school. When a person first learns to drive a vehicle with a manual transmission shifting gears is a conscious process. After some time and practice the process becomes automatic and no longer requires conscious thought to perform. Conversely, processes that are automatic can be made conscious again if attention is directed toward it. If the aforementioned high school student is trying to teach a younger student how to multiply two-digit numbers, they will need to be conscious of the process in order to relay the information to another.

In the interest of clarity, it is important to highlight the difference between action and operation, beyond the role of consciousness. Actions are oriented towards goals whereas operations are oriented towards the conditions in which the ‘goal’ is given to the subject. An action, directed at achieving a particular goal, does not change in response to conditions, whereas the operations that are performed will adapt. Consider driving a car on a multi-lane highway; the action of changing lanes remains the same, but the operation changes depending on several conditions such as whether there is a car in the lane next to you, which lane you are changing to and from, and the speed at which you are travelling, among others.

To offer an example from mathematics, if the goal is to graph a complex number, the action is graphing, but the realized operations change depending on conditions; for example if it is to be graphed in polar or rectangular form or whether a graph and scaled axes are provided. Differentiating these elements by orientation is relative rather than absolute as some actions are more loosely connected to the object of activity than others. In accomplishing a goal many auxiliary actions may be required and these may not be directly oriented towards the primary goal. In preparing a lesson one may need to find extra supplies, drop off originals for photocopying, move furniture, or look up a definition in the textbook. For this reason Kaptelinin and Nardi (2012) conclude that it is best to differentiate on the basis of consciousness.

**Transitions.** The transformation of a conscious action to an automatic process has been discussed above. Other shifts in the elements are also possible; for example, actions can be elevated to activity as needs shift.

Further, activity can become action if the motive driving it is lost or changed; that action may now realize a different activity. "*Goal-directed actions are much more temporary in nature and may be a step that subjects take in the process of participating in an object-oriented activity. Goal-directed actions often are individually focused and have less of a collective consequence to the community-based object-oriented activity (Leontiev, 1974*)" (Yamagata-Lynch, 2010, p. 21).

To give a complete picture of the scheme for one particular activity, we can reuse the examples of going to the store and the driving metaphor. If the motive is to go to the market to get groceries, then there are several intermediate goals with associated actions that must be performed. First, one on level, to get to the car, start the car, drive the car, park the car, lock the car and walk into the store. Taking any one of these we can derive several associated sub-goals. To drive the car one is engaged in shifting gears, changing lanes, stopping at lights, and making turns, any and all of which may be conscious processes or automatic operations depending on the experience of the driver, as well as other conditions.

In summary, in activity theory, activities are driven by motives, are performed through actions, which are directed at goals, which in turn are implemented through operations.

### Expansions, clarifications, and improvement

Many have found great value in the contributions of Vygotsky and Leontiev. There is also much room for expansion and improvement, opportunities for which arise from recognizing inconsistencies or gaps in the theory. Kaptelinin (2005) addresses some of these inconsistencies; in particular, he offers some clarity regarding Leontiev's inclusion of 'multimotivational' activities. The concept of an *activity setting* also adds an essential perspective to analysis.

The notion that activity can respond simultaneously to two or more motives has been discussed earlier, and while this appears to make sense to the reader, Kaptelinin points out that this idea has "*practically no impact on the fundamental analysis of needs, motives, and the object of activity carried out by Leontiev (1975/1978)".* Despite recognizing the poly-motivational aspects of activity, *"[Leontiev's] analysis appears to be based on an implicit assumption that there is a 1:1:1:1 correspondence between activities, needs, motives, and objects*" (2005, pp. 13-14). These concepts are not easily applied to the ideas of poly-motivational activity, Kaptelinin claims.

Thankfully, beyond merely pointing out inconsistencies and other difficulties with Leontiev's system, Kaptelinin provides a reinterpretation that resolves this issue. He suggests that the object of activity be separated from the idea of the motive. The solution exists within the situation of conflicting needs, which Leontiev deals with using his hierarchy of motives. Finding this method insufficient, Kaptelinin suggests a model that separates motive from the object of activity. If there are conflicting needs, there are two possibilities. Either those needs correspond to two different activities, or the needs correspond to different aspects of the same activity. In the former case, each motive has its own object and its own activity. There is a 1:1:1 correspondence and Leontiev's hierarchy of motives is applied. In the latter case:

> one or more of the motives corresponding to the needs affect the activity. However, even if these motives are very powerful, the activity does not have a direction and does not really start until the object of activity is defined. The object of activity is different from any of the effective motives and is cooperatively defined by the whole set of motives that the subject strives to attain in their activity. (Kaptelinin, 2005, p. 16)

This is illustrated in Figure 2.4 below.

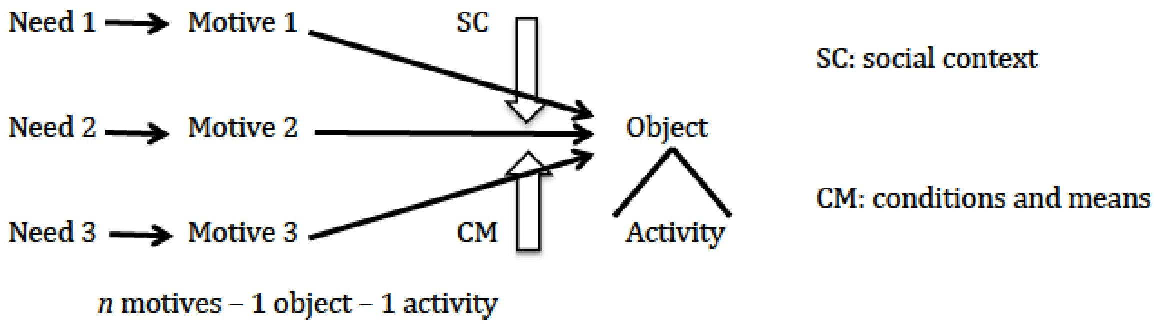


**Figure 2.4 Conflicting needs corresponding to different aspects of the same activity (adapted from Kaptelinin, 2005, p. 16)**

Two (or more) needs exist, each with its own motive. Which motive(s) affects the activity is influenced by the social context and the conditions and means affecting and available to the subject. The key difference between Kaptelinin's reinterpretation and Leontiev's model of activity is that motive is distinct from the object of activity. It is no longer a one-to-one correspondence. Multiple motives may exist at the same time, and it is not one motive that corresponds to the object of activity but a synthesis of motives that in cooperation define the object of activity. Activity only has direction and only occurs after the object of activity is determined.

An example may help to provide clarity. Kaptelinin asks us to consider a hunter whose activity is shaped by two motives: food and self-preservation:

> If both motives are strong enough – for instance, getting food is a matter of life and death but the prey is dangerous – a hunter can be in a state of confusion and hesitation. One of these motives can take over and the hunter would either flee with the risk of starving to death, or recklessly assault the animal with the risk of being killed. It is more likely, however, that [the] hunter's activity is going to be directed towards a desired outcome, which will make it possible to attain both motives. For instance, the hunter can decide to chase the animal until it gets tired and no longer presents a danger. In that case, both food and self-preservation are influencing the hunger. The object of the hunting activity, however – safely obtaining food by chasing the animal and making it tired – is what gives the activity structure and direction. (2005, pp. 16-17).

A similar situation in the mathematics classroom might be a student who desires a good mark on today's probability test, and also wants to abide by the rules. If he does not currently have a good understanding of the material, he may decide to cheat on the test in order to obtain a good mark, and risk being caught misbehaving. Alternatively, he could take the test, not cheat, but potentially do poorly. A third option is to get an ‘excused’ absence – and claim he is home sick. However, if it is possible to do so, he may go to the teacher and admit that he is not prepared for the test and ask for help and to write the test at a later date. In this case, both the desire for a good mark and to wanting to obey the rules influence the student’s activity. The object of the activity of the student is thus to get a good mark on the test by learning the material with the help of the teacher.

The model provided by Kaptelinin successfully fills the gap about poly-motivated activities in Leontiev’s model and provides a helpful distinction between the object of activity and the motive of activity. This distinction implies that “*objects of activities are dynamically constructed on the basis of various types of constraints …* [including] *the needs that the activity is trying to satisfy, available means, other potentially related activities, and other actors involved, each with their own motives and objects*” (Kaptelinin, 2005, p. 17).

There is one final component to consider with respect to activity theory, and that is the *activity setting* in which activity takes place. Activity settings allow for discussion of the role of social context or community in influencing the activity of an individual. From a sociocultural perspective, this consideration is critical and thus activity settings play a central role as a unit of analysis in analyzing activity. They are discussed in greater detail in my methodology (Chapter 3).

Kaptelinin is only one among many theorists who have taken activity theory and expanded or adapted it for a variety of reasons and purposes. The work of Vygotsky and of Leontiev continues to spawn new branches of activity theory and to build on existing ones, as well as expand its uses in a variety of domains. In the following section I explore different ways in which activity theory has been used in educational research, concluding with directives about when and how activity theory ‘should’ be utilized.

## 2.3 Activity Theory in Educational Research

Although activity theory was first conceived in the early twentieth century, it was not used significantly in Western research until much later. Its introduction to the field in the late 1980s was largely restricted to the field of human-computer interaction, but activity theory now frames work in a wide range of disciplines. A significant increase in the use of activity theory appeared in the late 1990s and early 2000s, and has since continued to spread.

In 2004, a special issue of the journal *Mind, Culture, and Activity* devoted to Activity Theory and education featured an introduction by Wolff-Michael Roth. He wrote that, less than a decade before, “*activity theory was virtually unknown*” (p. 1). Roth credits what he describes as the “dramatic increase” to the work of Yrjö Engeström. In that same year a special issue of *Educational Review* focused on the role of sociocultural and activity theory in educational research, supporting the claim that activity theory was on the rise. The eight articles in the special issue of *Mind, Culture, and Activity* originate from the Centre for Sociocultural and Activity Theory Research (now called the Oxford Centre for Sociocultural and Activity Theory Research (OSAT)), the creation of which provides further support for the expanding role of activity theory in educational research. In the decade following, the use of activity theory has continued to grow by leaps and bounds. Now it exists as a theoretical perspective in many different instantiations, all with roots in Vygotsky’s theories of activity, though some are more favoured than others.

One of the most popular constructs to employ when someone tries to understand the classroom has been Engeström’s (1987) aforementioned extended activity system. McNicholl and Blake (2013) share Engeström’s views, stating that “*activity system analysis affords an understanding of human activity that is situated in a collective context, where each activity system reveals the social and material resources that are in play in the activity system*” (p. 285). In essence, it is an orienting framework for researchers and practitioners. Bonnie Nardi’s seminal 1996 work contrasted the benefits of activity theory with traditional research methods, particularly with respect to the consideration of coping with context and situation, mentioned above. She espoused activity theory as “*a powerful and clarifying descriptive tool rather than a strongly predictive theory*” (p. 7). The predictive limitations of activity theory are a common critique among researchers, however this is largely irrelevant as most studies use activity theory as a descriptive tool. The remainder of this section looks at research using activity theory in two areas; first more broadly in general education, and then research that has specifically targeted the mathematics classroom.

## General education

Early on in its rise, the use of activity theory was largely constrained to the field of human computer interaction, though not necessarily in education. As it gained acceptance and popularity, work using activity theory in human-computer interaction in education was conducted by many, including Issroff and Scanlon (2002, 2005). In 2002, Issroff and Scanlon used activity theory in two case studies to inform understanding of the learning experiences of undergraduate, graduate, and post-graduate students interacting with technology. The later study examines how activity theory can be used to investigate issues in and improve on evaluation practices for learning technologies in higher education. Fitzsimons (2005) looks at technology-mediated mathematics for learners taking post-compulsory mathematics. She draws on sociocultural activity theory to study the considerations that must be taken into account with regard to development of these technologies. Many more studies of this nature exist (eg., Barab, Pettyjohn, Gresalfi, Volk & Solomou, 2012; Ball Anthony, 2012; Rybacki, 2009)

In recent years, the activity system framework has been applied to aspects of research in education other than HCI. Several studies exploit activity systems in various levels of education, for a variety of topics. These studies look at students, teachers, and/or administrators at the elementary, secondary, and tertiary level. For example, Katerina Plakitski (2013), a professor and researcher in Early Childhood Education at the University Ioannina in Greece, focuses on the use of activity theory in science education (the ATFISE project). Her book is a contribution to the growing presence of cultural historical activity theory (CHAT[22]) in Europe. Russell and Schneiderheinze (2005) studied how teachers implemented and reacted to a constructivist-based learning environment. Using Engeström's activity system the researchers identified the effectiveness of the implementation, teachers' goals for adopting the innovation, and analyzed cross-case issues that arose as the teachers implemented the unit. The role of contradictions[23] within

[22] The core ideas upon which CHAT rests have origins in Vygotsky and Leontiev's work, but the term itself was coined by Michael Cole and popularized by Engeström. Developed from and utilizing Engeström's activity system approach, it has been used significantly in the analysis of workplace practice, as both a research object and a guide for practice. For more on CHAT, see Cole and Engestrom (1993).

[23] Contradictions and breaches (of norms) have similarities. Breaches could be considered contradictions between what action the subject actually does, as well as what action the norm dictates the subject should perform.

and between activity systems is a significant factor in their study. Barrowy and Jouper (2004) use a CHAT perspective and activity systems to explain personal and systemic developments within a school system with regard to the creation of a proposal for funds to obtain improved computer technology and pedagogical resources. An activity theory lens is applied by Barab, Scheckler and Schatz (2004) to the study of the design and implementation of an online community. Beauchamp, Martek and McAlpine (2009) used activity theory to develop a methodological tool for studying the tensions doctoral students experience.

Fewer studies exist using activity theory in the realm of mathematics education, but it is growing with the increasing use of activity theory in many other educational domains.

### Mathematics education

In the field of mathematics education, Williams, Wake and Boreham (2001) report on a case study looking at how a college student adapts to a workplace environment, specifically with respect to the gaps between mathematical knowledge gained from coursework and the knowledge required to understand workplace practice. They conduct their analysis from an activity theory perspective, using an activity system approach. Pather (2012) used an activity theory lens to examine pre-service teachers perceptions of learning and teaching mathematics. She focused on at-risk students entering a teacher education programme and used an activity system approach to examine how a mathematics intervention programme influenced the students' perceptions.

McNicholl and Blake (2013) reported on a study concerning transforming teacher education. Using Engeström's activity system, they explored the social organisation of teacher education in England and Scotland. The professed goal was to "*reveal the extent to which teacher educators' work involves cultural and historical processes that underpin both their practical activities as individuals* […] *and their professional representations as members of an academic organisation*" (p. 286). Their activity system analysis focuses on tool use and how that reveals something about the thinking of the user and the culture in which the tool was developed (Ibid.).

Esmonde, Takeuchi and Radovic (2011) build on Worthen's (2008) study of the workplace, defining two distinct activity systems specified by different motives. These two motives are associated with the often-conflicting concerns of productivity and negotiating labour conditions; Esmonde and her colleagues identified the activity systems in the classroom as learning mathematics and doing school. Where Esmonde and her colleagues diverge from Worthen's work is that their dual motives do not have to conflict: they coexist and while they can and do occur in isolation, such as mindlessly copying notes from the board (doing school), or going beyond the scope of the classroom curriculum to discuss some other aspect of mathematics (learning mathematics), often one action satisfies both motives. "*Within the complex interlocking activity systems that make up classroom life, a variety of motives interact, prompting a variety of participation structures, interactional styles, and even mathematical forms*" (p. 240). The difficulty therein lies in that actions intended to satisfy teacher's implied or explicit expectations can look the same as actions performed in the process of learning mathematics. Esmonde and her colleagues use observed student actions and communications to interpret motives. This coincides with Kaptelinin and Nardi's (2012) "*actions first*" strategy, discussed in Chapter 3.

The common thread in all of this research is that activity theory has been used to study complex systems that are constantly changing according to forces from within and without. It allows for a holistic investigation.

## 2.4 Investigating Student Behaviour using Activity Theory: Research Questions

The popularity of the activity theory approach lies in what it offers in explanatory power. Edwards and Daniels (2008) suggest that "*sociocultural and activity theory offers a conceptual tool box to education*" (p. 108). It allows for "*representing a dynamic and evolving system in a way that preserves these dynamics without minimizing the complexity of the system"* (Barab, Schatz, & Scheckler, 2004, p. 26).

> In research that studies the complexities of real world situations, such as modern workplaces, communities groups or places of learning, Activity Theory provides language and a set of frameworks for making sense of what is discovered about the situation through observation, interviews, and other methods. (Hasan & Kazluaskas, 2014, p. 11)

Like those discussed above, and many others, I find the features of activity theory attractive, and particularly suited to the purposes of this study. The holistic approach, emphasis on the reciprocal nature of learning and doing, in addition to the other aforementioned affordances, makes activity theory a natural choice for studying the intricacies of student behaviour in a classroom context. *"The main advantage that Activity Theory offers practitioners and researchers is a holistic lens in understanding the patterns of activities in situations and problems"* (2014, p. 12). Researchers agree that activity theory provides a language for understanding and describing the changes and difficulties of students, teachers, and of the surrounding practices.

I contend that the specific phenomenon of interest in this study demands a particular perspective and approach. In what follows, I will briefly explain the approach and the version of activity theory that I will use as a lens to interpret student behaviour. The most appropriate one emerges through an examination of the goal of the research: to analyze student behaviour in high school mathematics classrooms and link it to motivation in an attempt to understand the reasons for the behaviour.

I am influenced by and sensitive to the contextual factors, terminology, and general ideas offered by many of the aforementioned approaches. However, the most appropriate version for this study is Leontiev's classical activity theory and his definition of the object of activity. Leontiev's approach is more focused on the individual than other approaches; his framework was developed for individual activities. As was mentioned earlier, this does not mean that Leontiev ignored the collective, merely that is analysis was predominantly focussed on the activity of individuals. Participation in other institutions, such as the home, and the broader influence of traditions and culture of the community are significant factors influencing student behaviour but a study of that magnitude and scope is infeasible. Thus, while I acknowledge students' values and motivations being influenced by these factors, I am analyzing student behaviour solely at the level of the classroom. My focus remains within the bounds of the classroom, though I maintain a sensitivity to the influences of factors external to the classroom. In order to subdivide the plurality of activity that occurs within the span of one-class period, I employ the concept of the activity setting[24] (Garrison, 2001). The concept of the activity setting offers a way to describe the particular context

[24] Activity settings are described at length in my methodology (Chapter 3).

within which an individual is situated. Within the classroom there are many different activity settings; identifying the particular activity setting in which a student participates provides a way to discuss the characteristic elements of the setting that influence the student's behaviour.

Activity theory is used here as both a theoretical lens and an analytical tool. My goal is to find the object/motive for students' behaviour (what is the behaviour pointing at – a need needs an object/motive). It may be difficult to differentiate between a goal and a motive and this will be a constant consideration in my analysis. Fundamentally, I agree with Pintrich's assessment that "*students are not just 'motivated' or 'unmotivated' in terms of some general quantity … there are important qualitative differences in how students are motivated and these different qualities have a dramatic influence on learning and achievement*" (Pintrich, 2000, p. 101). It is this belief that impels me to investigate these motivations.

One goal of my research is to make teachers more aware of the influences of their practices and policies on student behaviour and the effectiveness of these policies and practices with respect to student learning. I want to emphasize that conformity or apparent conformity to teachers' expectations or intentions does not mean that students are learning – if the student motive is not learning, learning may not occur. With this in mind it becomes useful to look at the phenomena of student behaviour the through the theoretical frame of activity theory. Using the framework of activity theory I can now refine and state more clearly the research questions I undertake in this study. Elaborating on my earlier stated intent to investigate more systematically students' actions within the mathematics classroom, and their reasons for them, I ask:

> *1) Using activity theory as a lens, how can I better understand the motivations that drive student actions in the mathematics classroom?;*

but, in order to answer this question, I first need to answer a second question,

> *2) Which forms of behaviour do students exhibit within and across activity settings in the mathematics classroom?*

# Chapter 3:

# Methods

> Ethnography names an epistemology – a way of knowing and a kind of knowledge that results – rather than a recipe or particular focus. (Agar, 2006, para. 57)

Given that there are certain actions (operations) that students are not consciously aware of performing, even upon reflection (Leontiev, 1978), investigations into student behaviour cannot reliably be conducted using surveys, self-reports or even interviews, alone or in any combination. To obtain authentic results it is necessary to examine students actions 'in the moment', in the setting in which they occur. For this reason, I elected to take the role of observer in three different mathematics classrooms to gather data on student behaviour.

'Behaviour' is heavily loaded term. It has many connotations, and using it often invites evaluation of the behaviour either as 'good' or 'bad'. In no way is that dichotomy present in any of my research or analysis. Behaviour is just that. Behaviour. I use the term to refer to what students *do*, whether a physical action or a mental one. Thus, for me, behaviour is more than just observable actions. What I can *observe*, of course, is only a fraction of what students actually do, so there is also a second component to my research – goals – which I accessed via *interviews*. These are discussed later in this chapter.

The purpose of this chapter is to identify and explain the methods I used to gather my research data and the views that shaped these methods. It would be impossible for me, or for anyone, to notice everything, and by my nature I am attuned to notice certain actions or inactions above others, particularly within the classroom. The methodology that most aligns with my perspective is ethnography. I am not "doing an ethnography", but I am employing an ethnographic approach and drawing on ethnographic techniques. For this reason, I will describe what ethnography (as epistemology) is, followed by an explanation of the particular approach taken in this study. One of the reasons an ethnographic approach is selected is because of its 'openness'. By this I mean ethnographers are interested in thinking about what the important questions are, rather than concerning themselves with identifying a well-defined, manageable and possibly inconsequential topic (Wolcott, 1990).

There are five sections to this chapter: first, I discuss the interrelations of ethnography and mathematics education; next, I offer a general description of ethnography; then I narrow the focus to classroom ethnography; in the fourth section, I introduce and provide detail about the data collection process for this study; the final section summarizes Chapter 3 and additionally closes off Part I.

## 3.1 Mathematics Education and Ethnography

In 1988, Margaret Eisenhart elaborated on the differences between mathematics education research and ethnographic research. At that time, uses of ethnography by educational researchers was rare, a fact Eisenhart attributed to fundamental "*differences in assumptions, goals, and primary research questions*" (p. 99). She describes research questions in mathematics education as being aimed at improving mathematics teaching and learning; the goals being to "*identify psychological, psychosocial, or instructional factors and processes that affect mathematics education and then to design and implement treatments to achieve better results*" (p. 100).

In contrast, an ethnographic approach inquires into the reasons why mathematics teaching and learning occur in a particular way in a given setting. The goal is to describe and make sense of the findings by developing, modifying or adopting cultural and social theories. The difference in approaches, Eisenhart suggests, lies in inherent underlying assumptions about schools and learning, arising from two fundamentally different ontological and epistemological perspectives. Whereas educational anthropologists come from an interpretivist stance, mathematics education researchers (historically) took a positivist approach. Generally speaking, an interpretivist seeks to understand and interpret, whereas a positivist aims to describe and explain[25]. Over the past three decades since Eisenhart's article, mathematics education research has seen a significant shift towards qualitative methods, reflecting a much more interpretivist viewpoint.

A particularly well-crafted explanation of the infusion of an ethnographic perspective within mathematics education can be found in the first chapter of Tim Rowland's 1999 book, *The Pragmatics of Mathematics Education*. The goal of his research was to explore how students use language in their mathematical talk, among other similar themes. What is of significance here is that Rowland devotes a good portion of the first chapter to explaining not only his methods, but also his methodological commitment and the interpretivist stance that underpins it. He describes mathematics education as, "*necessarily and beneficially an eclectic discipline*" (p. 5). From this perspective, the use of multiple, and different, methods in research only serves to strengthen the field of mathematics education. Ethnography shapes his view, and this is clearly expressed in his writings: "*Research into education, and mathematics education in particular, is necessarily an anthropological endeavour*" (p. 14). Further, he explains that while 'scientific' methods may give the researcher more objectivity, they may not allow for the desired insight into the phenomenon under study. What Rowland achieves is an eloquent expression of the interpretivist stance that began to get a foothold in mathematics education in the mid-to-late-eighties.

Early forays into combining mathematics education and ethnography explored and prescribed the uses of ethnographic methods in mathematics education research, such as fieldnotes (e.g Howard, 1995), and videotapes (e.g. Mousley, 1988). As acceptance grew in simultaneously influencing and being influenced by shifting views, the number of studies borrowing techniques, methods and perspectives from ethnography blossomed. The great variety in type of study and use of methods is a direct result of the openness of ethnography (see the following section). One consistent feature is that it requires a considerable amount of time in the field. Many studies that have used ethnographic

[25] Interpretivist approaches aim for complex, multiple understandings, using humanistic qualitative approaches. Understandings are expected to vary between individuals as people are expected to experience the world in different ways and have different reasons for acting as they do. Positivists seek to reduce explanations to a limited number of causes, generalizable across time and context. They favour objective scientific quantitative methods and see society as shaping the individual (as opposed to a mutual shaping).

approaches within mathematics education are doctoral dissertations, likely because of this significant time commitment and great amount and variety of data that must be collected and analyzed. Three such dissertations include Wendy Millroy's 1992 study of the mathematical ideas of carpenters, Bodil Kleve's (2007) investigation of teachers' interpretation of curriculum reform and Martin Carlsen's 2008 investigation into how tools are appropriated through problem solving in small groups. There are many other books and articles reporting on studies using ethnographic methods in mathematics education. Jo Boaler's (1997/2002) three-year case study comparing the mathematics teaching and learning of students in traditional and reform schools is a well-known example of the use of ethnographic methods in mathematics education. Other types of studies involve using critical ethnography[26] to explore social, cultural and political issues within the mathematics classroom (see for example: Edwards & Jones, 1999; Andersson, 2010; Skog, 2014).

The third factor that Eisenhart mentions is the difference in the research questions posed by ethnographers and by mathematics education researchers. She states that traditional research in mathematics education has focused on "*refining constructs of cognitive development, improving measurement devices, and modifying instructional treatments*" (p. 101). The shift to a more interpretivist stance, thus one more supportive of ethnographic methods, is correlated with a more contemporary approach[27]. Current research in mathematics education seeks to make sense of what is going on in the classroom and takes the view that learning is expected to vary by group and by individual - often theoretically based in the work of Vygotsky or Piaget (e.g. Hedegaard, 2009). However, in their 1999 book "*The Teaching Gap*", Stigler and Hiebert contend that what is found in research does not always make its way into practice. Ten years later, they argued that the same issue exists, despite initiatives to attract better teachers and have stricter qualifications. The problem, the authors point out, is that what teachers do in the classroom is determined more by the culture in which they teach than by their qualifications. To make changes that have effect, we must first learn about the culture of classrooms: "*[i]f we wish to make wise decisions, we need to know what is going on in*

[26] Critical ethnography is different from traditional ethnography in that it focuses on power relationships and assumes a critical perspective – it is does not strive to take an objective stance. Like conventional ethnography, it seeks to describe, but it also seeks to change the inequities it uncovers.

[27] See Schoenfeld (2008) for a historical account of research trends in mathematics education.

*typical classrooms*" (2009, p. 8). The best way to develop an understanding of what is going on in the classroom is to use an ethnographic approach, which I will discuss in the following section.

## 3.2 Undertaking An Ethnographic Study

My beliefs about student behaviour and how research into student behaviour should be conducted are strongly aligned with the ethnographic perspective, leading me to adopt an *ethnographic approach* for this study. I refer to my study as an 'ethnographic approach' because, as I stated above, it is not an ethnography. Harry Wolcott (1990), a well-known ethnographer, explains that the term 'ethnography' "*refers to both the* processes *for accomplishing it – ordinarily involving fieldwork and always requiring the reorganization and editing of material for presentation – and to the presentation itself, the* product *of that research, which ordinarily takes its form in prose*" (p. 47). While my study satisfies the first requirement, the *process*, it is not my intention that the *product* be an ethnography. But although my research product is not labelled an ethnography, I do nonetheless employ ethnographic methods and an ethnographic perspective and therefore feel there is value in describing the ethnographic approach. The next subsections are intended to define and clarify what ethnography is, and what an ethnographic approach to studying student behaviour entails.

### Defining ethnography: Coming to understand

Many definitions of 'ethnography' exist, and most share the same form as Wolcott's, defining ethnography by its methods, features and fundamental views. I offer some of them here, beginning with Atkinson and Hammersley's (1995) collection of certain features of ethnography:

- a strong emphasis on exploring the nature of particular social phenomena, rather than setting out to test hypotheses about them;
- a tendency to work primarily with 'unstructured' data, that is, data that have not been coded at the point of data collection in terms of a closed set of analytic categories;
- investigation of a small number of cases, perhaps just one case, in detail;

- analysis of data that involves explicit interpretation of the meanings and functions of human actions, the product of which mainly takes the form of verbal descriptions and explanations, with quantification and statistical analysis playing a subordinate role at most. (p. 248)

A general description of ethnography is that it concerns the long-term, holistic and intensive study of people's behaviour in on-going settings (i.e. communities), where the principal aim is to understand the (socially and culturally derived) organization, perspectives and interpretations that guide knowledge and underlie behaviour (Watson-Gegeo, 1997). Fetterman (1998) describes ethnography as, "*the art and science of describing a group or culture. The description may be of a small tribal community in an exotic land or a classroom in middle-class suburbia*" (p. 1). Whatever the nature of the group, the goal of the researcher is cultural interpretation. As such, the primary method used in an ethnographic study is *participant observation* (Patton, 2002), a traditional anthropological approach. The researcher is thus immersed in the culture[28] under study and conducts extensive fieldwork, a fundamental element in ethnography. Noted anthropologist and ethnographer Michael Agar (1996), like Wolcott, describes ethnography as both a product and a process. The ethnography is the product, and the process "*involves prolonged observation of a group*" (p. 53).

In the past, or in classical ethnography, this could involve weeks, months or even years of involvement with the participants, but with the introduction of the internet and other changes, the nature of the ethnography has evolved. Today, a number of approaches exist, varying with respect to methods and meanings of key elements (e.g. what it means to be a 'group', what it means to be in the 'field') (Patton, 2002). Still, ethnography is "*invariably inefficient and time-consuming*" (Wolcott, 1990, p. 65). Though time-consuming, the benefit to the openness of ethnography is that it allows for exploration of a range and variation of social behaviour in a particular setting.

Regardless of the context and the timeline, the distinctness of the ethnographic approach lies in "*interpreting and applying the findings from a cultural perspective*" (Wolcott, 1980, p. 59). Such a consideration has at the root the belief that individuals' understandings, beliefs and actions cannot be separated from their context. This fundamental underpinning

[28] See Appendix A for an expanded discussion on what culture is taken to be in this dissertation.

is shared with activity theory, a critical element when aligning a theoretical frame with a methodology.

### Narrowing the features: What is ethnography? What is not?

"*A good ethnography puts the reader in the setting, surrounded by its language, its smells, its sights, and its people, complete with their viewpoints and understandings*" (Reimer, 2009, p. 217). Thus, it is more than just a well-written narrative; it not only accurately describes real people, but also analyses patterns of their behaviour and underlying meanings. Although this description gives the reader some vague indication of what ethnography is, or should be, it does not even begin to define what constitutes ethnography – a more challenging endeavour than one might imagine. There are many similarities among journalistic inquiry, case study, oral history and ethnography, so one might be forgiven for some confusion over exactly what has been conducted. In fact, the differences are often only in the intent of the researcher and the aspects of the deeds and accounts most carefully attended to of the group under study (Wolcott, 1990).

Ethnographers themselves find it difficult to explain exactly what it is that they do when they are doing research. Wolcott states "*You have to get a look around to get a 'feel' for the setting and the people in it*" (1978, p. 45), while Fetterman describes ethnography as "*what ethnographers actually do in the field*" (1989, p. 26). What they can agree on is that ethnography is not reducible to its features[29] (i.e. a field technique, duration of time in the field, rapport with subjects, good description – Wolcott, 1987), and that the deep focus of ethnography results in what Geertz (1973) calls "*thick description*" – description that includes many possible meanings of an event. In addition to describing, ethnography also situates beliefs and practices within a larger theoretical context (Reimer, 2009). Beyond being selective about details and cognizant of presentation, there is a necessity to analyze and an element of creativity required in ethnography.

Ontologically, ethnographers see what they study as varying according to environment factors, such as social, economic, political, situational or personal. From an epistemological perspective, research findings are "*an intersubjective product of the*

[29] See Appendix A for an elaborated discussion of what ethnography is and is not.

*researcher and the research*" (p. 4). In addition to these foundational orientations, Whitehead (2005) identifies other attributes associated with ethnography, with the caveat that it is not an exhaustive list:

- ethnography is a *holistic* approach to the study of *cultural systems;*
- ethnography is the study of the *socio-cultural contexts*, *processes*, and *meanings* within cultural systems;
- ethnography is the study of cultural systems from both *emic* and *etic* perspectives;
- ethnography is a process of *discovery*, making *inferences*, and *continuing inquiries* in an attempt to achieve *emic validity*[30]*;*
- ethnography is an *iterative* process of *learning episodes*;
- ethnography is an *open-ended emergent learning process*, and not a *rigid investigator controlled experiment*;
- ethnography is a *highly flexible* and *creative* process;
- ethnography is an *interpretive*, *reflexive*, and *constructivist* process;
- ethnography requires the daily and continuous recording of *fieldnotes*;
- ethnography presents the world of its *host population* in human contexts of *thickly described case studies.* (pp. 4-5)

A description of some general methods employed in ethnographic research can be found in Appendix A, but as Wolcott asserts, "*Ethnography is only a broad prescription for research*" (1990, p. 63). As my research takes place in the classroom, in the following section I elaborate on the particular methods used in ethnographic research in classroom situations.

## 3.3 Classroom Ethnography

Here, I introduce classroom ethnography, together with the methods used for collecting and analysing data, make comments about the scope and limitations of classroom ethnography and introduce the notion of activity settings (a construct which complements the ethnographic approach, and helps to structure the collection and analysis of data).

[30] Understanding the study host(s) from their own system of meanings (p. 5). The only way this can be achieved is by spending considerable time in the hosts' world.

Finally, I offer a summary in an effort to bridge the divide between theory and its application in this study.

‘Classroom ethnography’ involves the application of ethnographic research methods to the study of interaction, action, behaviour and discourse in educational settings. These settings may be more formal, such as the typical school classroom or adult education program, or less formal such as day-care or pre-school (Watson-Gegeo, 1997). Classroom ethnography is classed as ‘microethnography’, because it “*zeroes in on particular settings*” and gives “*emphasis to particular behaviors in particular settings rather than attempting to portray a whole cultural system*” (Wolcott, 1990, p. 64), allowing for exploration of the range and variation of these behaviour. The focus, as with ethnography in general, is on holistic analysis and the perspective of the members of the group situated in the local context:

> In contrast to quantitative approaches to classroom research, classroom ethnography emphasizes the sociocultural nature of teaching and learning processes, incorporates participants’ perspectives on their own behavior, and offers a holistic analysis sensitive to levels of context in which interactions and classrooms are situated. (Watson-Gegeo, 1997, p. 135)

As ethnographers of education, Spindler and Spindler (1987) explain that schooling is a *calculated intervention* in the learning process, as differentiated from learning that occurs naturally over one’s lifetime. As such, behaviour that occurs within the classroom setting is often uniquely different from that in other contexts.

Erickson describes a school as, “*a partial community whose members (ideally) hold achieved statuses, in which rights and obligations are not reciprocal, in which the goods and services exchanged differ markedly in kind, and in which knowledge is non-traditional and rapidly changing*” (1973/1984, p. 54). Within a school community, he describes the classroom as a political economy in which, “*students offer deference to the teacher in exchange for kind treatment and the purveying of knowledge*” (p. 54). The view of the classroom as an economy – one in which there is an exchange of sorts between the teacher and students of grades or marks for demonstration of learning, or being left alone for compliance – is not new and is in fact quite common. Students’ different perceptions of this economy may partially account for their rationales for and responses to social interaction in the school. For example, students’ perceptions of how the system works and what qualifies for exchange influences their responses and behaviour in the classroom. I am interested particularly in what Spradley (1980) calls the *acts*, *activities* and *events* that are carried out by students, as well as the motives that drive them. An *act* refers to the smallest unit of behaviour, *activities* are sets of related acts, while sets of related activities comprise *events*.

### Methods for classroom ethnography

The specific methods used in gathering and analysing data about student behaviour in the classroom setting for this specific study will be discussed later in this chapter. What follows is a description of the general methods used.

**Collecting.** The methods for data collection fall into Whitehead's core ethnographic methods[31], including secondary data analysis, fieldwork, observation, fieldnotes, participant observation and semi-structured interviewing, with the addition of non-classical focus group interviews.

Secondary data analysis is a member of the core class of ethnographic methods, referring to analysis of data that already exists. In this particular study, an analysis of secondary data constitutes a careful and detailed review of the literature on student classroom behaviour (see Chapter 1). The purpose of this analysis is to explore research assumptions, determine gaps in the research on a particular topic, and suggest appropriate methods for data collection and analysis.

Primary data collection involves fieldwork. A fundamental belief inherent in the fieldwork approach is that individuals' beliefs, understandings, and actions cannot be considered in separation from context. In keeping with this principle, classroom ethnography concerns students' and teachers' activities and beliefs as they take place in the classroom. It involves the "*intensive, detailed observation of a classroom over the period of its duration (e.g., semester or year), recording a large sample of classroom activities on audio- or video-tape. Observations are supplemented by interviews with teacher and students*" (Watson-Gegeo, 1997, p. 136). As discussed in the preceding section, the duration of the study is one cycle, or one semester or year depending on the course and school. "*[B]eing there – to observe, to ask seemingly stupid yet insightful questions, and to write down*

[31] See Appendix A for an elaboration on ethnographic methods.

*what is seen and heard*" is "*the most important element of fieldwork*" according to David Fetterman (1989, p. 19), an expert in ethnography research. The interviews are typically less formal and less structured than traditional interviews, and in fact are often more akin to a conversation.

Ethnographers study the "*dialogue of action and interaction*" (Spindler & Spindler, 1987, p. 3). This involves interviewing anyone within the group (e.g., student, teacher, principal, janitor, parents) as well as observing all action in the classroom. This is necessarily a recursive process:

> We observe, formulate questions, ask them, observe some more, and so on until the patterns of behaviour and the native explanations for them coalesce into repetitive sequences and configurations. We try to interpret how teaching and learning are supported and constrained by understandings, many of them implicit, that govern the actions of teachers and students. (p. 3)

Interviews, observations, collection of site documents such as photographs, videos, films, surveys, bulletins, and other texts are all part of the information gathering process. In fact, multiple techniques and methods characterize ethnography – Reimer (2009) explains that "*data collection is tailored to meet the information needs of each study; the ethnographer determines the information required to address the study's research questions, and designs a mix of techniques to elicit that information*" (p. 209).

When there is an issue that requires distinction one can use *contrast interview questions* and *select observations*. Select observations might be used to try to find the difference between behaviour under particular circumstances; for example, does a student only try an example during class when he is not sitting next to a friend? In other cases, observation will not elicit the differences and contrast interview questions must be used. For example, if the ethnographer is interested clarifying the difference between rationales for seemingly identical behaviour (i.e., two students not taking notes), then the researcher must ask the students a question to confirm the hypothesis.

Observation and interview should never be in balance however, states Wolcott, as "*one or the other should be the preferred mode for any specific research project as meanings or actions compete for the ethnographer's closest attention*" (p. 49). The diversity of methods allows for triangulation and verification of the accuracy of the data, and analysis thereof. Fetterman's 'law of diminishing returns' determines when the ethnographer ceases collecting data. “*When the same specific pattern of behaviour emerges over and over again, the fieldworker should move on*” (1998, p. 20). This is the point of saturation.

**Analysing.** Analysis of data begins during collection, and continues for some time after the fieldwork is completed. The ethnographer tries to identify patterns in the observed behaviour and come up with themes. These tentative themes frame the subsequent data collection and ultimately the eventual analysis (Wolcott, 1987). Fetterman describes the initial phase of analysis wherein “*[t]he ethnographer begins with a mass of undifferentiated ideas and behaviour, and then collects pieces of information, comparing, contrasting, and sorting gross categories and minutiae until a discernable thought or behaviour becomes identifiable*” (1998, p. 92). This ‘poorly defined model’ is then compared and contrasted to the original observations, revised, more observations are made, data is added, and the revised model is compared. Agar (2006) calls this “*iterative abduction*”. It is necessarily abductive because both inductive and deductive logic rely on old concepts; ethnographers produce new concepts. “*They can’t deduce or induce because old knowledge … doesn’t work*” (para. 62), and therefore ethnographers must use abductive logic. This iterative process continues until the researcher is satisfied with the result, the accuracy of which may be verified by an individual in the group or by a co-researcher. “*You are done when abductive work leads to no more abduction*” (Agar, 2006, para. 81).

Although ethnography is primarily descriptive and does not make value judgements, results are not necessarily restricted to the single particular group studied in the field. Generalizations are made; what Wolcott calls “*cultural stereotyping*” (1987). This stereotyping can only occur when the skilled ethnographer knows the particular cases “*exceeding well*” and recognizes “*a critical distinction between generalizing and overgeneralizing*” [The researcher must stay close to what he or she has observed and speculate] “*how culture may be reflected in that behaviour rather than to equate that behaviour as* ‘*culture in action*’ [It is also important to recognize that] “*ethnography never can be more than partial and incomplete*” (p. 50). Ultimately ethnographers aim to link the local to the theoretical, and hence to generate theory. Theories often begin to emerge from the collected data during the fieldwork process:

> [T]he ethnographer begins with data, looks for patterns and regularities, formulates tentative hypotheses for further investigation, and finally develops some general conclusions or theories. The analytic process

> moves from the bottom up, from specific observations to broader generalizations and theories. (Reimer, 2009, pp. 212–213)

The process is open-ended and exploratory – the ethnographer begins without preconceived ideas or hypotheses and lets the theory emerge from the data.

## Concerns, limitations, and scope

Ethnography is not a precise science – in fact, it is not a science at all. It is inherently subjective and is thus open to interpretation. Data and analysis are checked and rechecked for consistency and veracity, but there are other concerns regarding classroom ethnographies. Watson-Gegeo (1997) describes three such issues common to these types of ethnographies: superficiality, within data sampling, and reductionist tendencies. Additionally there are concerns about perspective and analysis. For the sake of brevity I will address only the larger concerns of superficiality and perspective here. A more thorough discussion can be found in Appendix A.

The danger of creating a superficial caricature of the classroom, or 'blitzkrieg ethnography' (Rist, 1980), is real, but can be avoided if the researcher spends enough time in the setting, and avoids adoption of the first plausible explanation that arises. Details about decisions made regarding analysis, inclusion and omission of data, and the rationales for those decisions, should be made explicit. Evidence supporting the results should be provided for the purposes of independent analysis.

Regarding perspective, although the goal is to take the view of the student (the insider), the researcher is an outsider and it is impossible to completely dismiss that perspective. A further issue with perspective is that a researcher who is familiar with the classroom (thus an insider in some respects) is less likely to question what is second nature to her. Both of the concerns regarding perspective can be mitigated by awareness, careful reflection and attempting to 'see' the setting from the perspective of an outsider.

If one is aware of these potential pitfalls and is careful with both data collection and analysis (i.e., sufficient good quality data is collected and the data analysis is 'deep' enough), then classroom ethnography is a viable and useful approach to studying student behaviour. Issues of perspective must be addressed openly and honestly.

## Activity settings

The notion of an activity setting is a useful construct for interpreting how participant activities are influencing and being influenced by the social context. Sociocultural theorists suggest that researchers should study the shifts in participation that occur as the individual participates in a particular activity (Rogoff, Baker-Sennett, Lacasa & Goldsmith, 1995). The focus is not on the individual acting alone, but on the interaction of the individual with others in the community. Incorporating these two important elements, namely the activity (*cognitive and motoric action*) and the setting (*external, environmental, and objective features*), is what makes activity setting a particularly attractive concept (Rivera & Tharp, 2004, p. 207). According to Tharp and Gallimore (1988), activity settings are the who, what, when, where and why of everyday events that take place in what Hedegaard[32] (2012) calls institutions. They are *bounded* systems related to the social environment in which activities and actions are tied to related activities with similar objects (Gallimore & Tharp, 1990).

It is the specific setting that provides that context in which activities take place and influences the types of activities subjects are likely to encounter. The activity setting is the "*unit by which community and culture are propagated*" (O'Donnell, Tharp & Wilson, 1993, p. 504). Within a given activity setting a child encounters the cultural values and traditions of the particular community and its practices. The duration and nature of the activity depends on the context of the activity and it is the context that provides the purpose, resources, and constraints of the activity. People, positions, the physical environment, time, funds, and symbols are all important characteristics of the activity setting. These elements are interdependent within the activity setting and must be assessed in relation to one another.

Some examples of activity settings offered by Hedegaard (2012) include: participating in lessons, having recess and lunch, doing homework, having play time, preparing for bed. As with all contexts, two people in the same activity setting may experience different social situations. For example, the activity setting of preparing for bed is likely experienced very

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differently for the parent putting the child to bed than for the child herself. Activity settings are also dynamic: as the child and parent grow and change with time the characteristics of ‘preparing for bed’ will change, as will the individuals’ experience of it.

Rivera and Tharp (2004) state that, “*[o]bservation of activity lays the foundation for the formation of principles for culturally compatible pedagogy, which may serve to assess and assist the teacher in delivering effective pedagogy*” (p. 208). They contend that the first step is to identify and find the bounds of the activity setting itself; following that the components of the activity setting can be described.

In the particular case of this study, the institution of concern is the classroom. School can be analyzed with respect to activity setting units, such as learning centers and independent self-study groups (Tharp & Gallimore, 1988). Identifying activity settings and determining their bounds is of value to understanding the behaviour that is enacted within them. It serves the purpose of subdividing the entirety of classroom activity into manageable chunks, within which particular patterns and expectations of behaviour can be anticipated. Though some activity settings are predetermined, others emerge in the process of research and analysis.

## A final word

Ethnography is not a particular method, technique, or duration of study. “*What ethnographers strive for is to ‘get it right’*” (Wolcott, 1987, p. 54) and achieving this aim is not tied to a particular method. The nature of ethnography is inherently subjective and requires constant vigilance on the part of the ethnographer with respect to perspective. In my endeavour to ‘get it right’, I must acknowledge and be cognizant of the fact that I am in one sense an insider – familiar with the customs and practices of the classroom – and yet I am an outsider as I am not a student and can never really become ‘a native’.

With these considerations in mind, I would like to reiterate that I am not “doing an ethnography” – I employ an ethnographic approach and ethnographic methods and techniques in order to investigate student behaviour. Additionally, the unit of analysis for ethnography is typically the group – my unit of analysis is finer. I focus more on the individual.

From both an ethnographic and an activity theory perspective (discussed in the previous chapter), the impossibility of detaching individuals' behaviour from context demands that students' actions and comments be studied from within the classroom. In this research I undertake a 'bottom-up' approach – attempting to collect and analyze data without preconceived ideas – yet recognizing that inevitably there will be an 'etic' slant to my account. Also, acknowledging these preconceived ideas is why I use analytic induction rather than grounded theory in my analysis (discussed below). Although primarily descriptive, as discussed earlier there are links between ethnography and theory. Every situation is unique, "*yet not so unique that we cannot learn from it and apply its lessons more generally*" (Wolcott, 2001, p. 175). Such is the case with my research. I hope that what I learn can be applied to the understanding of student behaviour.

## 3.4 Data Collection, Analysis, Setting

Data for this study was collected during the 2013-2014 school year. Three groups of students participated, from three schools, taking three different high school mathematics courses. All schools were located in British Columbia; two in the Greater Vancouver area and one in a more rural setting, outside of the lower mainland. This section has three subsections, each of which provides detail on at least one aspect of the study. The first discusses the types of data collected and the specific methods used, while the second elaborates on two methods of analysis (one ongoing, one post-data collection), and the final, longer, subsection aims to paint a rich picture of the participants and settings.

**Collection and techniques used.** The three secondary mathematics classes I observed were: Foundations of Mathematics 11, PreCalculus Mathematics 11, and Foundations and PreCalculus Mathematics 10. Throughout the semester in which the course took place each of the three classes was observed for ten to twelve periods, each ranging from 60 to 75 minutes. An interpretivist approach and qualitative data collection techniques were deployed, specifically taking fieldnotes and carrying out interviews inside (informal, semi-structured individual) and outside the class (informal, semi-structured focus-group). In addition, there were two questionnaires given to one class and two initial surveys given out to the other two classes[33].

Within the classroom I undertook a role of *moderate participation* (Spradley, 1980), meaning I was present in the setting but only participated minimally in a conscious attempt to balance emic and etic perspectives[34]. Further, I took on the dual roles of semi-participant and observer, first because it allowed me to observe and make notes regarding the details of student behaviour and my immediate thoughts about them. Then, as a semi-participant, I was able to interact with the students and get a better understanding of their goals and ultimately their motives.

I took copious fieldnotes, recording much of what the teacher and students said, and most of what I observed, and found relevant, or thought might be relevant to the study. I also audio-recorded some lessons and the majority of post-lesson work time and other activity settings where I would have an opportunity to move about and talk with students. I hand-wrote notes during class, feeling that a computer might be distracting, then typed my notes into a word document on an on-going basis, so that what was said and done in a previous class was fresh in my mind when I next returned. The audio recordings were also transcribed into a word document on an on-going basis, but not as frequently as the field notes due to the time required to process them.

The interviews I conducted took place within the physical and temporal bounds of the classroom, for reasons revealed earlier and discussed in greater detail below. I conducted informal, unstructured and semi-structured interviews – informal because they occurred within the classroom setting and were not pre-planned; unstructured because there was an open-ended approach and the questions were not necessarily pre-formed nor asked in any predetermined order. However, occasionally there was a pre-constructed list of questions I wanted to ask particular students. In these instances the questioning took more of the form of a semi-structured interview. These informal interviews were conducted in real time whenever my desire to know more about a particular student's behaviour coincided with an opportunity to ask about it. Of necessity, then, these brief sessions often

[33] The questionnaires and surveys can be found in Appendix B.

[34] 'Emic' refers to the insider's view of reality whereas 'etic' represents the outsider's perspective.

took place during transitions between activity settings or while students were doing individual or group work and I decided that the interruption would not be too intrusive to the students' classroom activities. All were audio-recorded and fieldnotes were taken as well. All study participants took part in the informal interviews, although some students were asked a greater number of questions, more often. The reason for this was two-fold: some students displayed more 'interesting' behaviour than others, and some students were more willing to talk about their behaviour than some of their peers. Additionally, some students were more frequently absent from class and consequently were able to be interviewed on fewer occasions.

In addition to the in-class informal interviews, three focus group interviews were conducted; two sessions with students from the PC 11 class, and one session with five students from the FMP 10 class. These three interviews were each held after the regular class had finished for the day. The students who participated volunteered to stay to be part of the discussion. For the two sessions conducted with the PC 11 students, five students attended the first session, and four attended the second, with two students attending both. Five students from the FMP 10 class volunteered to participate in the interview. The goal of the focus group interviews was to explore students' thoughts about a setting that had not been observed during class (such as a teacher on call (TOC) for FMP 10), and to question students about particular practices, such as homework, or problem-solving tasks. An additional purpose was to probe students' feelings about particular conduct (such as cheating) in a setting wherein students might feel they could hypothesize about others' reasons, rather than divulging (potentially 'incriminating') details about themselves.

### Analysis: Analytic induction and activity theory

The analysis of the observed behaviour and interview data was conducted using a process of analytic induction. First, I describe analytic induction and its methods, and then discuss the details of how I went about coding my collected observations. Only after this process had concluded did I set about determining student motives using activity theory and an "*actions first*" strategy (Kaptelinin & Nardi, 2012).

**Analytic induction.** Given that people develop "*multiple realities*" that they assume in different contexts, and that these roles are complex and undergoing continuous development, Whitehead contends that rather than start with "*predetermined hypotheses to be proved or disproved as objective social fact*", one must begin with "*open-ended exploratory attempts to learn as much as possible about those realities*" (2005, p. 6). Complementing Whitehead's assertion, Michael Patton holds the view that positivist, realist, and analytic induction approaches share "*the presumption that there is a real world with verifiable patterns that can be observed and predicted – that reality exists and truth is worth striving for*" (2002, p. 91). Aligning myself with these views, rather than try to impose a framework on students' behaviour, I seek an understanding that yields correspondence with the real world, what Patton calls a "*correspondence perspective*".

Patton describes analytic induction as "*a strategy for engaging in qualitative inquiry and comparative case analysis that includes examining preconceived hypotheses*" (2002, p. 493, my emphasis). Researchers enter the field having already developed rough hypotheses, based on hunches, assumptions, or prior analysis of research and theory, which he calls sensitizing concepts. Sensitizing concepts refer to categories that the analyst brings to the data. The origins of these concepts lie in the research literature and give the analyst "*a general sense of reference*" and provide "*direction along which to look*" (Blumer, 1969, p. 148). These theories are then "*revised to fit emerging interpretations of the data over the course of data collection and analysis*" (Gilgun, 1995, p. 268).

Analytic induction involves both the development and the testing of theories. "*Analytic induction […] begins with an analyst's deduced propositions or theory-driven hypotheses*" (Patton, 2002, p. 454). When a 'deviant' case (an exception) is detected the process of analytic induction requires revision of the theory. Thus, it "*is a procedure for verifying theories and propositions based on qualitative data*" (Taylor & Bogdan, 1984, p. 127, cited in Patton, 2002, p. 454). In analytic induction, these theorizations and concepts are used in a descriptive way as a "*valid conceptualization of reality*" and it is necessary to that we consider them as "*tentative and provisional all the way*" (Tacq, 2007, pp. 192, 193).

A defining principle of analytic induction, described by Glaser and Strauss (1967), is the continual refining of the hypotheses by actively searching for negative cases, which contributes to the authenticity of the results. One of the benefits of this continuous searching for new (and deviant) cases is that it forces on the researcher a state of permanent reflection (Tacq, 2007). "*We learn more from counter-examples than from examples*" (p. 203) because exceptions stimulate reflection. When we consider the cases that do not fit the identified pattern we improve our understanding of the pattern as a whole, and may find alternate explanations. Tacq cites Peter Manning's (1982) work on analytic induction in which Manning claims that analytic induction is "*almost imperative in the study of deviant behaviour*" (2007, p. 206). Analytic induction has great capacity to generate theory, and to revise theory through careful analysis of 'deviant' cases. Within the classroom, I see a case of behaviour as 'deviant' when it differs from behaviour that might be expected or deemed to comply with (teacher) expectations. I do not interpret 'deviant' behaviour as 'bad' behaviour.

There is debate with respect to interpretation of the methods of analytic induction as described versus as practiced. Most concerns involve the use of analytic induction as causal analysis, and making universal propositions. Current research is more supportive of analytic induction as a research methodology. Gilgun (1995) explains that "*contemporary researchers have de-emphasized universality and causality and have emphasized instead the development of descriptive hypotheses that identify patterns of behaviour, interactions and perceptions*" (p. 269). Other disadvantages put forth by Tacq (2007) are: a failure to predict, inability to deal with matters of degree of variation when searching for universal statements, inefficiency because of procedural variations, and failure to produce true causal analysis. None of these disadvantages is a concern in this study as I am not using analytic induction for the explicit purpose of generating theory about student behaviour – I am using it to identify patterns and to test those patterns. My purpose is not to determine the cause of phenomena, at least not via analytic induction.

One of the critiques of using an ethnographic method as an insider is that it can limit the questions one asks. However, awareness and reflection can mitigate that problem. One advantage of the analytic induction approach is that it shares the belief that we must constantly examine and re-examine "*the propositions that have become the dominant belief or explanatory paradigm within a discipline or group of practicioners*" (Patton, 2002, p. 494). As an insider, but one who is aware of the need to think beyond my preconceived ideas about student behaviour, I try to keep this belief at the forefront of my thoughts, looking beyond expectations and beliefs to uncover unanticipated rationales for student behaviour.

**Seeing the codes, coding the data.** After transcribing the fieldnotes and audio-recordings I began the formal coding process. Computer qualitative research software, nVivo10 for Mac and nVivo11 for Mac, was used to assist in the coding and further analysis of the data.

My initial experience in the classrooms, followed by typing up my fieldnotes and audio recordings, had already given me some insight into and sensitivity toward what some of my codes might be. Two previous studies (Liljedahl & Allan, 2013a; Liljedahl & Allan, 2013b) also provided a basis for predetermined hypotheses and sensitizing concepts in the initial inductive coding scheme. My personal experiences as a secondary mathematics teacher also shape my analysis of the data. I began with some codes for different activity settings – lesson, problem solving, work time, talking about homework. Some other early codes were: paying attention, taking notes, asking a question, cellphone use, chatting, gaming and trying an example (or not).

In creating my codes[35], I tried to keep my judgement at bay and refrain from using only codes that signified compliance or non-compliance with classroom rules. I began by coding the fieldnotes from one school, and coding for many things, some not relevant to the current study, but possibly of interest at some later date. It was a laborious process, proceeding line by line in a conscious decision to code for anything I thought might be interesting. One utterance or observation might have multiple codes, or not be coded at all (though this was rare). For example, a fieldnote stating "*Tiffany using cellphone*" during a lesson would be coded as: *teacher giving a lesson*, *not paying attention*, *cellphone*, *not taking notes*, and *distracted or focus*. I wanted to be as thorough as possible since I wanted to avoid having to return to a piece of transcript or note that had not been coded. Of course, I returned to the data multiple times to recode because as I progressed new codes emerged and I would have to go back to find instances in the previously coded material. It was a comprehensive and exhaustive process, which was repeated when I started the coding the transcribed audio recordings from the same school. This process

[35] A full list of the final codes can be found in Appendix C. nVivo uses the term 'node' to define what I would call a 'code'.

was repeated with each of the other two schools. As I progressed, I needed to return to the ‘old’ data less and less frequently and I eventually reached a point of saturation where no significant new codes emerged.

The interviews were transcribed and then coded using the same process of analytic induction as that used for the observations. Whenever possible the students’ words were transcribed verbatim, however, sometimes this was not possible due to one student talking over another, a student speaking too softly or not clearly, or other background noise such as PA announcements. In these cases the meaning of the student’s utterances was written, if it could be deduced using the student’s previous words, or constructed using the researcher’s field notes. As above, it was an iterative process of coding and recoding until a point of saturation was reached. I also employed a holistic approach, looking at patterns of behaviour with a broader lens, rather than the more restrictive coding by phrases or sentences.

Later, I was able to use my codes to conduct searches and queries to compile all phrases or sections for a particular code (node) and also to search the text for particular words or phrases when I needed to find something. However, sometimes it made more sense to search the original word document in order to get more of the context. For example, when I wanted to find all instances when a particular student was mentioned or interviewed I could search the word document for his or her name. I also used nVivo to do a matrix comparison of multiple codes, such as *taking notes* and *using notes* or *trying an example* and *getting stuck*, though I did not do much of this. In the end, I had 212 codes, some related and overlapping, though only a fraction of them were relevant to the study. Some of the codes were used less than a handful of times, such as *teacher leaving the room* and *getting help from a family member*, while others link to over one hundred different utterances or instances, such as *doing work during class*, and *chatting*. One thing I chose not to do was go back and combine similar codes within nVivo, and if I found a code was not useful or relevant I did not delete it, but also did not use it in coding further data. For example, I used the codes *extra practice* and *giving a similar example* a few times each, but stopped using them when I realized that those types of codes would not assist me in answering my research questions. So the very small number of references to these particular codes does not imply that some mention of extra practice occurred only three times in all classes for the duration of the study. I did not, and did not intend to, come up with a comprehensive yet condensed list of codes for others to use in future research. The purpose of the codes was to help me to identify types of behaviour and to keep track of what I had ‘seen’ in the data, so that I could become aware once a saturation point had been reached.

**Determining motive – actions first.** After collecting, transcribing, coding and compiling the behaviour that occurred in different activity settings, I could then shift the unit of analysis to that of student. Making a particular student the ‘unit’, I used Leontiev’s model of activity theory to arrive at a hypothesis for the motive underlying student behaviour. To accomplish this I used Kaptelinin and Nardi’s (2012) “*actions first*” strategy, wherein an individual’s observable actions and expressed goals are used to determine the lower layer (operations) and upper level (motive) of Leontiev’s three-layer model. Once actions and goals are revealed:

> the analysis can be expanded both “up,” to progressively higher level goals and, ultimately, motives, and “down,” to sub-goals and operations. The expanding scope of analysis may not cover the entire structure of the activity in question but be sufficient for the purposes of the task at hand. (Kaptelinin & Nardi, 2012, pp. 30–31; see also Kaptelinin et al., 1999)

I looked at a student’s actions within and across activity settings, and considered their goals (revealed through their actions and the interviews). Together, these allowed a determination of the individual’s global motive(s) in mathematics class.

## Participants and setting

As stated previously, I conducted my observations and explorations in three different secondary mathematics classes, with the permission of three very welcoming and helpful teachers. Two of these classes were located in metropolitan Vancouver, and the third was in a more rural city outside the lower mainland. The courses for the two urban classes were PreCalculus of Mathematics 11 (PC 11; 28 students) and Foundations and PreCalculus Mathematics 10 (FMP 10; 27 students, 1 excluded[36]). The Foundations of Mathematics 11 (FoM 11; 15 students) class took place outside of the lower mainland. All three mathematics courses are on the university stream, although taking FoM 11 limits entrance to certain university programs.

[36] One student chose not to be part of the study.

Each classroom had a different teacher, physical environment (classroom set-up), and other distinguishing features, however, there were many similarities in how they functioned, what students were asked and expected to do, and how the teacher structured the class. These similarities are also partially attributable to external constraints set by the school or the Ministry of Education such as curriculum, duration and time of day for the class, the size and location of the classroom within the school, the students enrolled in the class, and some of the resources provided (desks, tables, chairs, boards, etc.). For the most part, these are things that are beyond the teacher's, and the students', control and thus are beyond the scope of this paper. This paper is bounded by the things that *are* (potentially) within the students' and teacher's realm of influence.

Other similarities in classroom form, function and structure can be explained by expectations. Through their own experiences as students and through teaching, teachers develop expectations about what a mathematics classroom should look like and how it should function, including what gets assessed, how it is assessed, and what methods one uses to teach. These expectations are also a factor influencing the classroom environment and community, such as the tasks and activities that students can or should be asked to do and how these are structured. One could describe these 'identities' as analogous to the "instructional identities" of Aaron and Herbst (2012), discussed earlier in Chapter 1. They use this term to describe that students come to mathematics class with expectations based on their prior experience, and these experiences form and influence their attitudes towards mathematics and actions within the mathematics classroom. However, as discussed earlier, the expectations I refer to within this paper are broader in scope. Likewise, the differences are partially a consequence of what resources can be afforded and how they are allocated, but are also a result of teacher preferences and values.

The purpose of the remainder of this section is to provide a vivid description of each class in an effort to situate the reader. My aim is to offer a window onto my impressions in my role as an accepted semi-participant/observer, but not a full-fledged member of the group (neither teacher or student). For each of the three classes I describe the school, the teacher, the course, and then provide an exemplar of a typical class period. This description is offered not as a means to judge any of the teachers, but rather to provide some background and context for the classroom in which student behaviour was enacted. As much as possible in this chapter, I have attempted to provide an "*account of*" rather than an “*account for*” (Mason, 2002) both the teachers’ actions and the setting in which the students participate. There is no significance to the order in which I present the classes; first is FoM 11, then PC 11, and finally FMP 10.

**School 1.** Grant Matthews teaches in a beautiful new high school in a small city in South Western British Columbia. There is a large rural area surrounding the city. It has a fairly small range of significant cultural backgrounds with the population being largely Caucasian with a large proportion of First Nations in the city and surrounding area. While it does have many socioeconomic layers, there are a large number of residents whose income level falls below the poverty line. As it is the only high school in the city and surrounding area it hosts the full range of student abilities. The majority of students walk, take the school or city bus, or are driven to school. A small proportion of the older students drive. The school is one block off a fairly busy street and there are some small convenience stores and fast-food restaurants within walking distance. The regional library, community pool, ice arena, skate-park, and many multi-purpose recreational fields and a lawn bowling club are within a five minute walk.

Grant was friendly and engaging, and his teaching style is best described as traditional. He wanted his students to understand math, and tried to get students excited about math and make connections to the real world. For example, he spent some time in the summer before the school year (2013–2014) crafting a really good lesson to introduce quadratic equations. For Grant, this meant putting incorporating technology (videos), really working on the problems (exercises) he chose for students and demonstrating a high level of energy and enthusiasm during the lesson. He incorporated interesting videos of kids doing bike jumps and bouncing off a trampoline into a lake – he described these actions as “parabolating” and really tried to get students interested in the lesson. At one point during the video he exclaimed, “*Wow, that guy just did a really awesome parabola*!”

The course, Foundations of Mathematics 11 (FoM 11), is one of three possible courses students can take to get the Ministry required grade 11 Mathematics credit for graduation. Of the three possible courses, FoM 11 is designed and largely perceived to be in the middle in terms of difficulty, but limits students in their post-secondary choices. For this reason, many students opt to take PC 11 even though it may not be the most appropriate course for them. The content and nature of FoM 11 often allows for a more relaxed atmosphere and there is often more opportunity for interesting divergences. For this reason it is sometimes considered preferable to teach and more interesting than the more rigorous PC 11, which must prepare students for PC 12. FoM 11 has a required project component, which also differentiates it from PC 11. Most students in the particular class observed and described in this study will likely go on to some sort of post-secondary schooling, predominantly in some sort of trade, an arts-based program, or a field such as nursing. The two students in this class who may continue their studies in a science-based program at university are taking PC Math 11 in addition to this course (one concurrently, one subsequently). Mr. Matthews shared some thoughts about struggles with FoM 11:

> [It's] kind of weird because you get weak students that struggle and you get good students that don't do anything. The first few times we [the school] ran this course they just loaded it up with kids that should be in A and W[37]. The first time I taught it they all cruised at a 50 [percent]. I had that type of a crowd – a 50 is all I want. They cruised at a 50 and then we hit Chapter 7 [quadratic functions and equations] and I lost them. Ended up with mass failure. But this is the probably the best group I've had just as far as energy for working and stuff.

At the time, the school was two years old and the classroom was brightly lit. It was situated on the ground floor, second room from the end of the building, keeping the hallway immediately outside the room relatively quiet during class. A wall of north-facing windows looks out to the street at the front of the school. Other than during the immediate period before and after school and during lunch break the street is relatively quiet. The daily block schedule alternated but this class always took place either first block in the morning or second block, immediately before lunch.

Desks were arranged in six columns of either five or six, all facing the two whiteboards and a Smartboard at the front of the class, with the windows on their left. Colourful posters and flags decorated the other walls; on the back wall there was also a grouping of well-known inspirational quotes that had been reproduced by past students. One reads: "*It's not that I'm so smart, it's just that I stay with problems longer*" (Albert Einstein). When students entered the room there was an agenda on the Smartboard or the whiteboard at

[37] Applications and Workplace Mathematics 11 is the 'lowest' of the three possible grade 11 math course to get credit for graduation. It severely restricts post-secondary options and is often perceived as a course for 'dummies' and kids with behaviour problems. This results in many students and parents avoiding the course, even if it is the most appropriate with respect to content.

the front of the room. Homework was listed on a board at the back of the room. There were 18 students in the class at the beginning of the year. After the first couple of weeks that number was reduced to 15 due to timetable changes and other factors that will be discussed later. There was no assigned seat plan, so throughout the semester students sat where and with whomever they pleased.

On day one of the class Mr. Matthews described FoM 11 to students as a course that is less demanding than PC 11 and is designed for students who want to go into nursing, for example. He described the topics as ‘not so heavy’ (as PC 11) and gave his rationale for the order that the topics will be addressed. Also, on this first day Mr. Matthews explained his policy on cell phones and headphones to students: he advised they stay away from them, but would allow them to listen to music while they were working so long as they were not ‘taking advantage’ of the privilege. If students could not avoid using these devices or abused the privilege Mr. Matthews warned them that he would hold onto their ‘stuff’ until the end of the day if he needed to. He told them they would be assigned homework every day (and they were). He explained that he expected them to show all their working and their assignments for a particular unit would be due by the day of the chapter test. They could be submitted any time throughout the unit and were graded and returned promptly, within one or two classes. Tutorials were offered most mornings and lunches, during which students could get help, do corrections on quizzes to improve their mark, or get extra help in preparation for a retest (they were allowed one rewrite per test, provided that they legitimately tried in their first attempt). There were no rewrites for midterms or final exams. Students were not required to take notes, although this was never explicitly stated.

On a typical day, when students entered the classroom they found their seats and put down their bags. Often they chatted with friends or went to ask Mr. Matthews a homework question or hand in an assignment or set up a time for a re-quiz. At times Mr. Matthews initiated conversations with students, asking how the soccer team was doing, or about some other topic. The sound of the bell usually prompted students to quiet down and look to Mr. Matthews to begin the class.

On a rare occasion, a puzzle would be put on the board to interest students; many tried it and once a solution was offered the class moved on. However, a typical class began with Mr. Matthews asking if there were any questions from the homework, and if so, he solved them, sometimes with student assistance. If there were no questions he sometimes raised a particular homework question that he thought[38] the students should have found problematic and then went over it.

Once any questions have been reviewed Mr. Matthews moved on to new content. The format of the lesson usually consisted of Mr. Matthews introducing the topic and then providing a number of examples of different types of questions. Mr. Matthews put effort into making his lessons, trying to make sure he showed an example of each type of question and provided a clear worked example and notes for students to follow. In a typical lesson, for example on graphing quadratic equations, he went over how to solve different examples of problems, usually progressing from basic single-step questions to more difficult and more involved ones. He invited student questions and asked for student help to solve them, prompting: "*how do I start?"* or "*What do I get if I plug in x equals 3?*" Occasionally he called on students, but usually one or two volunteered and if they provided a correct answer he briefly explained it to the rest of the class and then moved on. He checked in with the rest of the students, asking, "*does that make sense?"* or "*do you know how I got that?"* Sometimes students asked for further explanation, but more typically they nodded or did not respond at all. When this occurred Mr. Matthews occasionally choose specific students and said something like, "*Chelsea, is that okay*?".

Following the lesson homework was assigned and students were expected to work on it, if there was time. On day one he informed students, "*you are expected to work to the end of class*". While they were working Mr. Matthews circulated or did other tasks such as follow up with students who needed to submit an assignment, or he handed back assignments.

**School 2.** Janet Hill teaches in a school that has been rebuilt within the past decade. The building sits on the edge of a ravine within a well-established residential area and close to a major highway in the Lower Mainland. The student population is primarily Caucasian with a significant number of smaller groups representing other ethnicities. For roughly two-thirds of students English is the language spoken at home. The school draws from a catchment of mostly middle class families but there is also a significant proportion residing

[38] He stated a few times that students "*should have found this one difficult*."

on or below the poverty line. Many students work after school and on weekends; a small but significant number have to work to help support their family. Most students walk, take the city bus, or are driven to school. A small number of students drive. It is a ten to fifteen minute walk to two different shopping areas.

Mrs. Hill is personable, loves teaching and genuinely cares for her students. The intricacies and wonder of mathematics inspire her and she exhibited a great deal of her enthusiasm to her class about mathematics, particularly problem solving. Mrs. Hill had high expectations, but was also realistic about students' abilities and limitations, as well as being aware of the other demands on student time. The students found her friendly and approachable and they showed respect for her. Her teaching of this class can best be described as mostly traditional; she wanted to help her students develop an appreciation for mathematics, but also took seriously her duty to prepare students for the next mathematics course (PC 12) and for future university mathematics courses. She encouraged her students to be self-reliant and to check answers with the calculator rather than with her and also expected them to take responsibility for their learning: "*If you forget this then you should be taking a look at your notes from yesterday.*" Mrs. Hill provided many opportunities for students to get extra help, holding tutorials several days a week in the mornings for students to come and work through problems, do corrections, and ask for assistance. The nature of the course, the composition of the class with respect to student abilities, and Janet's desire to incorporate meaningful activities and engaging problems for students all contrived to make time a constant pressure, within each period and over the course as a whole.

PC 11 is one of three ministry approved courses satisfying the graduation requirements for British Columbian high school students. Of the three courses, it is considered the most difficult, largely because it is the most algebraic and abstract of the three. For students who want or need to take Calculus or Sciences at university, it is a prerequisite. It is also a prerequisite for many Arts programs, although students can also take two other mathematics courses (FoM 11 and FoM 12) as an alternate route. Because many students do not want to take two courses when they could get away with one, and because they do not want to prematurely limit their post-secondary options, many students opt to take PC 11, even though they lack the requisite mathematical foundation to be successful in the course. This often leads to a diverse classroom composition: very strong and competent students, paired with students with a very weak mathematical understanding who may not be successful in the course. This creates a need for a very skilled teacher, one who can challenge the very strong and help to raise the very weak students for the duration of the year. Janet Hill is one of those very capable and caring teachers who is adept and finding and maintaining the delicate balance of the needs of her students.

The size of the classroom was more than adequate and allowed some room for student movement. Positioned on the corner of the building on the second floor, ample light was provided by the windows on the back (south) wall and on one third of the of the west side of the room. The windows overlooked the parking area at the front of the school; one street away from a busy boulevard. A bookcase and cabinets for storage occupied the remaining length of this west wall. Low shelves inhabited the space under the windows at the back of the room. The front wall of the classroom held a large whiteboard and pinboard with posters and informational bulletins. A rolling projector table sat in front of a pull-down projector screen at the head of the room and Mrs. Hill's desk sat at the front of the room adjacent to the single entrance to the room. Posters adorned the front and west wall, the overriding theme being mathematics and the role of mathematics in the world. The final side of the room was a sliding whiteboard wall separating this classroom from that of the adjoining class. Desks were arranged in four rows of double desks, three with four pairs, and the fourth row having three pairs of desks. Students sat in designated spots, the assignment of which changed at least twice throughout the semester based on Mrs. Hill's assessment of students' progress in the course and how well an individual was working with his or her seatmate and nearby classmates.

At the start of class[39] students trickled into the room and set up at their desks. The class typically began with a review problem from the previous class or a problem-solving task, which usually occupied 10 to 15 minutes of class time. Students remained in their seats for the majority of these problems, although some cross-pollination occurred. One example of a problem-solving task given is the problem with twenty counters, similar to the game "Nim[40]". Another period began with Mrs. Hill projecting the following onto the whiteboard:

[39] The class took place after lunch.

[40] See Appendix D.

> Two mathematicians are each assigned a positive integer. They are told that the product of the two numbers is either 8 or 16. Neither knows the other's number. This is their conversation:
>
> First mathematician: "I don't know your number."
>
> Second mathematician: "I don't know your number."
>
> First mathematician: "Give me a hint."
>
> Second mathematician: "No, you give me a hint."
>
> At this point, one of the mathematicians knows the other's number. Assuming that they always tell the truth and do not guess, what is the number and who has it?

It was rare for Mrs. Hill to provide the solution to these problems: instead, she 'worked' the room, providing hints and provoking questions. However, for the above logician problem, she went through the solution step by step, using a process of elimination. Sometimes students solved the problems and Mrs. Hill asked them to explain their solutions to the class. She repeated, clarified, and extended their explanations for the rest of the class, depending on the thoroughness of the explanation and the difficulty of the task.

At the start of each new unit, Mrs. Hill distributed to students a photocopied package of '*skeleton notes'*; these bare bones of notes include definitions of key terms, explanations of content and the examples that Mrs. Hill later demonstrated for students, as well as those she asked students to try on their own during the lesson. There was an expectation that students bring these notes to class and follow them during the lesson, although Mrs. Hill did not make a habit of checking that students were taking notes. However, a student observed to not have notes or paper out during the lesson usually provoked a comment or question from Mrs. Hill as to the whereabouts of the package. Her rationale[41] was that having the package reduced the amount students had to write, and the time it would take to copy the notes. Also, if a student missed a class he or she would have some idea of what they missed and might be able to complete the lesson on his or her own.

Following the initial class problem, Mrs. Hill began the lesson. She intended students to have the package in front of them as she used her tablet to teach the lesson, projecting on the whiteboard or overhead screen. The lesson took anywhere from thirty to sixty minutes, depending on the topic and the number of questions to be worked through.

[41] I had an informal conversation with Janet about the purpose of the skeleton notes.

Occasionally Mrs. Hill diverted from the lesson to explore in more depth an interesting student question or comment. During the lesson, when students responded to questions or provided answers, Mrs. Hill did not always address an incorrect answer but did sometimes take the time to investigate how the student came to that result, especially if it was a common student error.

Following the lesson, Mrs. Hill assigned homework and students were expected to begin working on it if there was time remaining in class. Every three or four classes there was a quiz on previous content (usually from one or two prior lessons). When there was a quiz it took place after the lesson. If students finished the quiz with time remaining in class Mrs. Hill expected they would begin their homework, however, she was not particularly strict with this and often students were allowed to relax.

**School 3.** This school is an older building in a well-established residential neighbourhood located in the Lower Mainland. It has a strong academic history, a good reputation, and is a French Immersion school which gives it a certain status and draws a particular clientele. Students come largely from upper middle class and middle class families; few, if any, are at or below the poverty line. Many students had jobs after school or on weekends; mostly to provide extra income for themselves, not for contributing to the household. There is a broad range of ethnic diversities represented in the school with no group standing out as a significant majority. The school sits on a relatively quiet residential street with light traffic throughout the school day. There is a shopping area with fast-food restaurants and grocery stores within a ten-minute walk from the school.

Michael Johannson is a caring and experienced teacher. He is enthusiastic about teaching mathematics and demonstrated this to his students every class. Once a self-described "traditional teacher", utilizing the latest technology and resources to present material to his students, now he embraces the technology of the whiteboard marker believing that students are more engaged and learn more when they are active, working on vertical surfaces and in visibly random groups. These, and other aspects of the ideology of "*building thinking classrooms"* (Liljedahl, 2016a) are fundamental in his present teaching. Mr. Johannson is concerned with student understanding, and feels that this understanding is often best achieved as a community of learners. His philosophy was present in the problems and tasks he chose for students, in the questions he posed and the way he framed them, and in the way he structured his teaching. Students demonstrated a high level of respect for Mr. Johannson, and most although not all, professed to favour his teaching methods. He has high (but realistic) expectations for his students with respect to taking responsibility for their own learning and being proactive about getting help and writing makeup tests if they were unsuccessful the first time.

FMP 10 is one of two provincially developed grade 10 Mathematics courses. The other, Apprenticeship and Workplace Mathematics 10, limits student choice of future mathematics courses and post-secondary options to mostly trades programs. After successfully completing FMP 10 students can take either FoM 11 or PC 11, or both. As it is the only Mathematics 10 course for the large majority of students, the composition of this type of class tends to be quite diverse; there is a vast continuum of ability and competency levels, ranging from students who will struggle and may not pass, to students who have little to no difficulty maintaining an average in the high nineties. The curriculum involves significant algebra, including expanding and factoring polynomials, linear functions and equations, and systems of linear equations, and also right triangle trigonometry, measurement, and radical numbers. Several of these are new topics for students and many find them difficult. Mr. Johannson allowed his students to write retests, with a maximum retest mark of 75%, because an “A” student needs to achieve an “A” on the first test. He explained that he was testing for learning, and a student had to complete all corrections on the original test before being permitted to write a different version of the test.

Mr. Johannson’s classroom was a lively and crowded space. Situated on the third floor, the classroom had one half wall of windows overlooking an inner courtyard. The painted brick walls were decorated with ‘math’ posters as well as some other inspirational and sports posters. A projector screen hung on the front wall above whiteboards, which were installed on three of the four walls. Twenty-eight desks sat in quartets, either two by two or a row of four, so that students could work together. Each desk had a letter or number on it; corresponding letters denoted different sections of the whiteboards around the room so that when students were asked to get up to try questions on the board (which occured multiple times throughout each lesson) they had a designated space to work at. Mr. Johannson’s desk sat at the rear of the class near the windows, and facing the single entrance door on the opposite wall of the room.

Students walked in and immediately looked to find that particular day's seating arrangement, which was projected onto the screen from Mr. Johannson's tablet. A photo of each of the twenty-eight students is overlaid on a particular seat, randomly selected each day by Mr. Johannson.

Mr. Johannson used a tablet, an IPad, and another laptop frequently within the class. For his students, however, the most important technology was the whiteboard marker. Students were encouraged (and expected) to work out questions cooperatively on vertical surfaces around the room, or on smaller writing surfaces that could be taken to their desks. Throughout a lesson students had to get up and move around to use different whiteboards around the classroom or to grab the smaller board to bring to their desks.  The atmosphere was often one of organized chaos. Discussion was encouraged and students were expected to explain their reasoning; answers alone were not accepted. Incorrect answers or rationales were often explored for their potential to illuminate common errors and student (mis)understandings.

Each class period typically began with a problem-solving task. One day it was the "frogs jumping" problem, another the "five interlocked rings", and another day it was a checkers problem. While students worked on the problem Mr. Johannson encouraged them to think and to persist by asking provocative questions and providing extensions (*What if there were eight frogs*?) or strategies for simplifying a problem (*What if there were only four frogs*?). He tailored his responses and prompts to the individual needs of the groups. Generally enough time was allowed for a few groups to 'solve' these tasks – sometimes all, and sometimes none. The solutions were rarely addressed as a group. They were intentionally left to encourage students to puzzle them out for themselves.

Following the initial problem-solving task, Mr. Johannson projected or wrote a starter question or task on the whiteboard to get students thinking about the topic at hand, usually by asking a question related to the content addressed in the previous lesson. Sometimes students were prompted to recall and share the important concepts from the previous lesson. The onus was always placed on the students to remember; Mr. Johannson never 'told' them what they had done. After students had recounted as much as they could, occasionally summarized and possibly extended the explanation, if a student had raised an interesting comment or question. A task related to the previous topic was assigned, and pairs of students got up and either got a board to bring to their desk, or moved to the wall mounted whiteboards to work on the task. During this process Mr. Johannson circulated, looking at student work and asking questions, making suggestions, and noting what issues students ran into. If a student asked Mr. Johannson for help, a typical response was: *“Don’t worry, keep trying, it’ll come.”* Or, if they needed a nudge or had noticed something interesting he asked a question or made a comment.

After students had finished the problem, or had reached an impasse, they moved back to their desks. Often students looked at what other students were doing to try and get an idea for where to start, or how to continue when they got stuck. This practice was encouraged. When Mr. Johannson felt it was time, he called the rest back to their seats. Most classes he took a photo of one group’s work (not always the most correct work) to use for discussion once all students were seated. Students were encouraged to ask questions as they looked at their peers’ work, and the creators were invited to explain what they had done, and why. Errors and reasoning were discussed, and, if as a whole the class was not able to resolve the problem, Mr. Johannson made a suggestion or demonstrated how to proceed. The process of assigning a task, getting up and working on it, and coming back as a group to discuss it occurred three or four times throughout the “lesson”. When it was necessary, Mr. Johannson introduced new strategies and terminology. Following this, if there was time, the homework was assigned and students were asked to work on it.

## 3.5 Summary

Having established ethnography as an approach well suited to answering my research questions, I then considered methods of analysis. Given my ethnographic approach, however, I first needed to take my own experience into account. I am a practitioner of the craft of teaching secondary mathematics, and thus I was an insider in regard to the collection and analysis of my data. To both collection and analysis I brought preconceived ideas stemming from my experiences as a teacher, and ‘sensitization to theory’ as a researcher. This meant that I needed to be aware of alternate explanations for student behaviour, and to ask questions about *why* things are done in specific ways, rather than taking it for granted because “*that is just the way it is done*” (such as expecting that homework would be assigned because that is what always happens). I needed to question constantly rather than assume I knew the answer, and remind myself to try to ask the questions an outsider might ask – things that an insider would not think of asking. In contrast, during the process of collection, I was also largely an outsider in my role of researcher. I was not the classroom teacher, nor a student in the class. Yet I was also a pseudo-insider in each classroom because I *am* a teacher, and I have taught the particular courses the students were taking. This particular position meant that it would be impossible for me to approach the data as a 'blank slate'; consequently analytic induction was a more natural fit than grounded theory. I chose analytic induction as a method through which to identify patterns and categories of student behaviour.

Having identified the 'big' ideas (the larger structure), I then had to think about more of the details – what exactly would I do with analytic induction? How would I structure my analysis and by what means would I conduct it? "*What counts as a unit of analysis is the critical question in qualitative research*" (Wolcott, 1990, p. 63). I selected activity setting as one of the units of analysis for student behaviour. It seemed a very good fit as I felt it would provide natural divisions within the class period, and allow me to work with manageable chunks of 'recognizable common activity[42]'. I could then identify and classify student behaviour that occurs in particular classroom situations, a stated goal of this study. I also look at students' behaviour across these domains. Some activity settings were identified prior to the study, based on my prior experience, and others emerged as I observed the functioning of each classroom. These settings, and others, will be discussed in more detail in Part II. After this, Leontiev's model of activity theory provides a framework for theorizing the motive underlying student behaviour, The means by which this is accomplished are provided by Kaptelinin and Nardi's (2012) "*actions first*" strategy.

[42] I use 'recognizable common activity', not because all students have the same activity, but because all those in the classroom (the students, teacher, and I) could recognize the setting and typical activity within in (and the setting would be 'common' to all).

# Summary of Part I

The three chapters that form Part I describe in detail my phenomenon of interest, examine previous approaches and potential frames, and discuss the specific methods and perspectives I used to gather and analyze my data. Chapter 1 elaborated on different theories and approaches to understanding student behaviour. In Chapter 2 I first reviewed the origins of activity theory and its evolution, then focused on its usage and applications in education, and culminated with my research questions. A description of ethnography, its methods and its use in education formed the first half of Chapter 3; in the second half, I gave details regarding the participants and specific methods employed in this study, including analytic induction.

Activity theory, ethnography, and analytic induction are highly compatible and well suited to exploring and responding to my research questions. They allow me to investigate student behaviour while acknowledging and resisting preconceived ideas, avoiding judgements, and I greatly value the flexibility and openness that they permit.

As mentioned in the introduction, there are four parts to this dissertation. The following diagram is intended to provide a road map or overview for the reader.

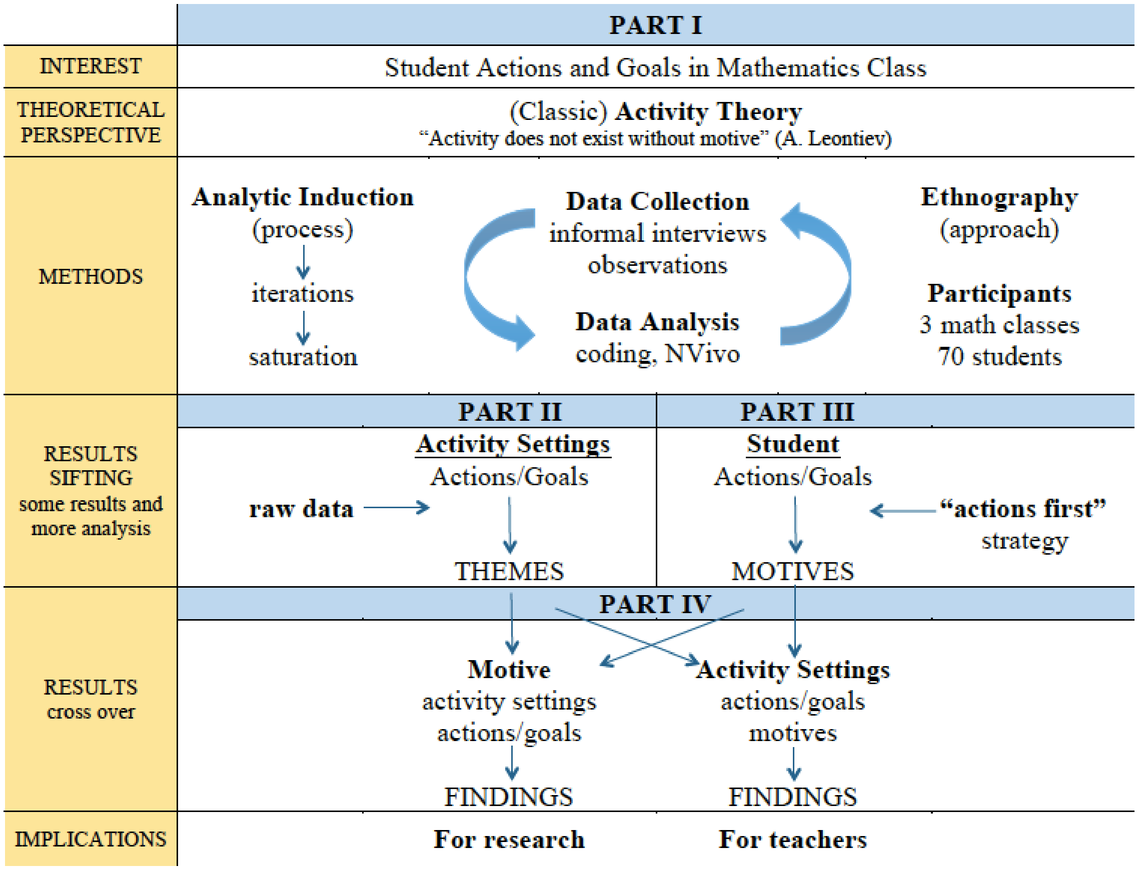


**Figure 3.1 Map of my dissertation**

Parts II and III both involve initial analysis of data, but using different approaches. In Part II, I look at students' actions and goals within and across particular activity settings. For each activity setting I report on the types of behaviour from the entire group of participants. In Part III, I again look at student actions and goals in different activity settings, but this time I consider each student separately. Therefore, in Part III, I present case studies for each of ten chosen students. Part IV contains two chapters. The first of these is a secondary analysis of the data, wherein I use a "crossover" approach and re-examine the findings of Parts II and III from two different perspectives: actions of students with the same motive; motives of students performing the same actions. The second and final chapter of Part IV summarizes and concludes the dissertation, discussing implications, avenues for future research, and limitations of the research herein.

# PART II

> No description is entirely dispassionate and objective, precisely because it is made by a person who necessarily has personal propensities, sensitivities and concerns […] To *account-for* something is to offer interpretation, explanation, value-judgement, justification, or criticism. To give an *account-of* is to describe or define something in terms that others who were present (or who might have been present) can recognize. (Mason, 2002, pp. 40-41)

Student actions provide some insight into student goals and motive, however, it is far from the full story. If we liken student activity and motive to a movie, from the teacher's perspective you see each scene from only one perspective. Taking only one scene from the movie (one activity setting) limits the view even further. Continuing this analogy, looking at student actions in a particular activity setting, but from the researcher's perspective in the room, offers a wider lens and thus a bigger section of the movie screen. Students' actions provide information about a specific instance in time, but only small fragments of a big picture, that is constantly changing (like watching a movie on a big screen, but you can only see one small section of the picture and there is no sound). Taking it a step further and adding in the student's goals, revealed both in their speech and actions, provides an even wider lens and turns on the sound, for at least one character in the movie. So while all aspects of the movie are still unknown, there is at least a hope of discerning a little more about what is going on.

I struggled with how to present my results, first intending to remain true to a traditional presentation of data, then analysis and discussion, but it soon became apparent that it would be impossible to write a comprehensible results section with such a structure. Returning to the movie analogy, discussing actions and goals separately would be like trying to understand what is happening in a five-minute segment of a movie by listening to the audio and then watching the picture, without sound. It makes much more sense to experience the audio and visual together. Therefore, I present actions and goals (observations and interviews) as closely as possible.

The aim of the three chapters that comprise Part II is to look at student actions and goals both within and across activity settings. Taking the 'raw' data, in Chapters 4 and 5 I provide a “with the grain[43]” account of student behaviours observed over the course of the study, the result of which aims to be a comprehensive typology of student behaviour within the mathematics classrooms observed. Interwoven with student goals exposed in speech and action this allows for a discussion of possible student motives. Beginning with similar or identical student behaviours in particular activity settings, such as “taking notes”, I then consider the different goals arising from discussions with students with respect to these particular behaviours. Both Chapters 4 and 5 consider student actions in particular activity settings; Chapter 4, however, considers typical elements of a mathematics classroom, such as notes and homework, whereas Chapter 5 describes student conduct in less typical, and/or less frequent features of the mathematics classroom, such as assessments and student presentations.

In Chapter 6, I examine common student conduct observed in multiple activity settings, adding validity to the hypothesized goals from Chapters 4 and 5. Thus, the analysis is still ‘with the grain’, but reaches across activity settings. In these three chapters I generally will not mention what classroom the student belongs to, except in instances where it does matter (e.g., vertical surfaces classroom), and in those cases I will identify the classroom.

Analysis is an ongoing process and it is difficult and confusing to try to comprehensibly discuss student behaviour in isolation from what students revealed in conversation; what I have attempted to accomplish in this chapter is a marriage of student narratives with my observations of their actions intertwined with my interpretations of their rationales. Where it is relevant, I have identified the particular classroom and teacher; when not mentioned it the particular teacher or classroom is not a significant factor in the observed conduct.

[43] Watson (2000) used the metaphors of working with and across the grain to talk about patterns in mathematical generalizations. I appropriate this terminology to structure both my analysis and discussion of results.

# Chapter 4:

# Within Activity Settings – Typical Lesson Elements

In this chapter I share descriptions of the behaviours I observed in 'typical' activity settings within the mathematics classroom[44]. And, since student actions cannot be adequately explained without some context, I have chosen to include selected excerpts from the informal student interviews to support and enrich the analysis. As previously mentioned, some of the activity settings were predetermined, whereas others emerged throughout the observation process.

Four typical elements of classroom life are presented here: direct instruction; notes; now you try one; homework. A brief summary of these elements will be provided at the conclusion of this chapter; a more thorough summary of all activity settings is at the end of Part II (after Chapter 6). First, however, are some comments on transitions between activity settings.

## 4.1 Transitions between activity settings

Transitions between activity settings (Gallimore & Tharp, 1990) usually occur multiple times within a one-class period. There is always some span of time between the end of one activity setting and the beginning of another. During this time students may be moving, chatting, taking out or putting away materials, or dawdling. Student action during this time depends on many factors, some of which are: the nature of the preceding activity setting; the nature of the subsequent activity setting; when the transition takes place (i.e., near the beginning or the end of the class period); the perceived expectations of the teacher for the subsequent activity setting. And, of course, there are innumerable factors internal to the individual student. I offer here descriptions of two typical one-class periods to illustrate

[44] In this chapter and the remainder of this dissertation I use present tense when making general comments about student behaviour, based on prior experience or general knowledge. I use past tense when speaking about data collected during the course of this research.

both the occurrence of transitions and the nature of student action during different transitions.

### Lesson 1

The bell rang to begin class. Mr. Matthews began class promptly and introduced the new chapter students were starting that day. Shortly after he announced this, he began handing out review material for the previous unit, as the test had not yet been written. He spoke a little about the format of the test. During this time one student still had headphones on and another was using her phone. Others were paying attention. Mr. Matthews then moved to the SMARTboard© and tried to find his notes and the video he wanted to use to start the new unit. This can be seen as a transition from his general introduction to the more direct instruction part of the lesson. As he worked with the technology students started to get organized and a few chatted quietly. Mr. Matthews was having difficulty finding the video and as time passed, the noise level in the class increased. Eventually he found one and the lesson began. There were small breaks during the lesson when students were asked to “try one”. These were not transitions as the direct instruction continued and students continued to work at their desks. At the conclusion of his lesson, Mr. Matthews assigned homework. In the transition between lesson and when students were supposed to work on the assignment there was a lot of chatter. The noise level in the class increased significantly, students got up to move around, and when Mr. Matthews gave additional information about the assignment some students were not attending. Some students began to try questions but a few never actually moved on to starting the assignment. There was not a lot of time left in class, and many students packed up early.

### Lesson 2

Students walked in and found their seat assignment for the day projected on the screen. Shortly after the bell Mr. Johannson asked a student to hand back quizzes from a previous day. He then started the instructional portion of class by asking students to recall what they did last class. He used the ensuing discussion to segue into the new topic and posted a graph. Students were asked to make up a story to go with the graph. Most students quickly transitioned from the seated discussion to working on the vertical surfaces (or horizontal whiteboards at their desks) in groups. There was some chatter, most of it regarding the task they had been asked to complete. When Mr. Johannson recalled them to their desks there was little dawdling. Students transitioned from group work to class discussion with minimal delay. Another problem was posed and students again got up to work on it. This transition from instruction to task took a little longer for some students. When he eventually called them back to their desks, Mr. Johannson had to convince one group to come and sit down (not because they were delaying but because they were still discussing the task and had not begun to transition). A longer discussion and some instruction ensued, followed by another transition to a group task. In general, transitions further into the class period seem to lengthen; students tended to take longer to move from one activity setting to another. After the final class discussion homework was assigned. The transition from instruction to homework was significantly longer. Many students were slow to take out books, return markers and whiteboards, and get started on the assignment. Some chatted, delaying starting, while others worked on the homework. A few never began to work on it and chose to socialize or sit quietly until the end of the period.

There were many more transitions in Mr. Johannson's class as compared to the other two classrooms I observed.

## 4.2 Direct Instruction

During a formal or informal 'lesson' students have the opportunity to exhibit a multitude of different behaviours. For the edification of the reader, direct instruction is taking place when the teacher is introducing new content and is directing student attention. As described in the previous chapter, the activities students had occasion to perform and the tasks they were asked or expected (explicitly or implicitly) to do during direct instruction differed in accordance with the teacher and the nature of the material.

Activities like 'taking notes', and 'trying examples' are discussed in subsequent sections. What can be found here is a discussion of other behaviours such as student reactions and responses to being 'called on' and general activities observed during the lesson, such as paying attention, doodling, etc. The particular topics featured here are: student involvement (in the lesson); and, paying attention (to the lesson). This description is offered to provide a richer picture of the classrooms and to place the other activity settings in context.

### Student involvement

When 'giving' a lesson, it is common for the teacher to ask for student participation either by requesting they volunteer answers or by calling on students by name. The purpose of this may be to gauge student understanding, maintain student attention, or both. The questions asked[45] may be mathematical in nature, but do not have to be. A non-mathematical question may be asked of a weaker student to involve them, but not put them at risk. First we will look at examples of students who volunteered, then focus on students who were called on, and finally a particular subset, who responded that they did not know, or avoided answering.

**Volunteering answers.** There are many factors that influence whether or a not a student will volunteer during a lesson; the classroom culture, relative risk the student feels, and topic are only three such factors, and are interdependent. However, I cannot begin by first determining the conditions and predict student behaviour – I begin with the actions. Some students voluntarily participated in class lessons. I can suggest three possible reasons for students volunteering answers, supported by the data.

First, it may have been a strategic move on the student's part if he or she knew there was an expectation that all students take part. If they did not volunteer the teacher may have called on them, and asked them a question they could not answer. To avoid this, a student may have chosen to respond to a non-mathematical question, such as when Emily volunteered to read out a question. Or, they chose an 'easy' question to answer, such as "*What is a good number to choose for x?"* [to plug in to a table of values].

Second, students may have volunteered if there was an expectation that students participate and if the classroom had been demonstrated as a safe place to take risks, and

[45] The nature of the questions asked by the teacher or by students is only discussed here through the lens of their purpose in involving students.

one that often rewarded risk-taking. Thinking out loud is valued and often recognized (by students) as leading to greater understanding for the majority. The following exchange is a bit long, but illustrates this situation.

There was a particular question one day in Mr. Johannson's class that everyone was struggling with[46], to some extent. Many students were able to find the slope and the y-intercept, but they were having difficulty interpreting what these values represented in the context of the problem. Some students also had the slope inverted. Tyla began by saying, "*The slope is the cost of the ball…which is one-fifty*." Asked to explain for everyone else, Tyla continued: "*Well, three over two is one point five so…"* Mr. Johannson confirmed that this was the cost of the ball, but then Tyla said, "*Oh!*" Prompted to try again, she began, "*Cause it says the balls thrown is x, and then that one, x, I don't know…"* The question gave the information that the variable *x* represented the number of balls thrown, but Tyla had not quite solidified her understanding. A boy volunteered, "*Because it's a three to two and if you scale it down it becomes a one to one point five*." Mr. Johannson asked, "*But how come it's not three balls costs me two dollars?"* Sol ventured, "*Um, cause it's divided, um, oh wait, never mind I don't actually have it*." Then Cara raised her hand: "*Because the y is…the…ball? Never mind. Ignore me*." But she continued, "*Because the number of balls is …."* After a few second Doug raised his hand. "*It's backwards. It should be balls on top and the dollars on the bottom*." Asked to explain why, Doug said, "*Because x is the balls which, in the equation the x is the three, and then the dollars is the two for the y. So it's upside down*." There was silence in the room for about ten seconds. Then there was some more discussion about the slope before they came to an agreement and then talked about what the y-intercept represented. Doug tried again: "*Um, it's the cost of renting the dunk tank. Because you start with negative profit."* Mr. Johannson pressed for a deeper explanation of what this meant, in connection with the graph and what the x- and y-values represented at the intercept. Xander spoke up, then Donnie, and they finally ended the discussion.

The majority of the students in the class ventured a guess or volunteered an answer at some point for the above example. It is clear from both Sol and Cara's attempts that they

[46] Students were given information about the profit from running a dunk tank with a certain number of balls, and a second profit with a different number of balls.

felt no risk in saying what they were thinking, even though it was not yet clear to them. Doug even spoke up to contradict something that Mr. Johannson had said was correct, because it did not agree with what he was thinking at that point. Silence followed his speech, not because students were waiting for Mr. Johannson to tell him he was wrong, but because they were thinking through what Doug had said and were trying to make sense of it with their own thinking.

And finally, in any class there is usually a handful of students who just like to answer questions – possibly because they know the answer, or they like to take part, or they see answering a question (even if they are wrong or just guessing) as indicating to the teacher that they are trying to learn. When a teacher on call (TOC) asked, "*Do you remember how the slope is calculated?",* Meghan spoke up: "*Rise over run*." Maria suggested: "*I would expand the right side*," in response to Mr. Matthews' request for help with an example. It is not possible to determine, from only these isolated incidents, exactly why these students volunteered. However, over time and over an assortment of activity settings, the reasons become clearer. For now, the plausible rationales for these behaviours are enough.

**Calling on students.** During one of the first classes of the year Mr. Matthews was reviewing some basic algebra with his students. The following exchange transpired:

Mr. Matthews: Scott, what would you do with this one?
Scott: Uhhh…. [shrugs]
Mr. Matthews: Bryce?
Bryce: Uh, no.
Mr. Matthews: Maddy?
Maddy: What?
Mr. Matthews: Can you help us?
Maddy: Isn't it like….like terms? Two 'x'?

There are a number of plausible reasons for the student responses. Scott may not have remembered, or been unwilling to put himself forth as one who knew the right answers so early in the course. Bryce may have just copied Scott seeing as not knowing was 'accepted'. Maddy clearly wasn't paying attention initially, but did provide the correct answer. In another class, Mrs. Hill asked, "*Instead of (2,4) what's it going to be? Richard?"* Richard had been chatting and was not paying attention to the lesson, likely provoking

Mrs. Hill to 'put him on the spot'. Richard answered incorrectly, but rather than let him off the hook Mrs. Hill led him through the solution, getting him to participate along the way.

A little later, Mr. Matthews called on Tiffany. She replied, "*One sec…doing number three.*" At this point, it was still too early to determine the reason for this particular response, but given her behaviour over the next few weeks, it is more than likely that she was avoiding responding. Later that block Mr. Matthews asked Tiffany another question, one to which she could respond correctly, but also one that was not mathematical in nature. In another class, a TOC asked Maya to read out a question, another no-risk way of involving students.

When the teacher has posed a question to a number of students or to the class and the correct answer has not been provided the teacher has a couple of options. He or she can provide some additional guidance, or can call on a student whom they are relatively certain can answer correctly (either because they have seen them solve it, or they have some confidence in the student's capabilities). Having seen his work on the vertical board, during the subsequent class discussion Mr. Johannson asked: "*So, Doug, what's the slope?"* Once a student had provided the correct answer, and the teacher had given some indication that this is correct, the teacher may have assumed that all students are on board and subsequently moved on with the lesson. More commonly, teachers 'checked in' with students by asking some variation of: "*Does that make sense?*", "*Did you understand?",* "*Are you guys okay?",* or "*Are you with us, Chelsea?"* Invariably the response was, "*Yes*," for somewhat obvious reasons.

Finally, students who responded "*I don't know*" when called on could have been: trying to avoid answering; covering that they were not paying attention; or, possibly they genuinely did not know. It was rare for a teacher to call on a student who was not likely to know the answer, unless the teacher was trying to get them to pay attention.

## Paying attention

Often a defining feature of direct instruction is that the teacher is standing at the front of the room (or stationed at some other point) and is generally observant of what the students are doing (or appear to be doing) while he or she is teaching. There is also an expectation that students are to pay attention while the teacher is talking and writing.

Given this expectation and the fact that the teacher is more likely to notice non-conforming behaviour, some students will pretend to pay attention. For example, what the teacher saw could be: a student glancing up occasionally and writing in a notebook, when in fact I could see the student was doodling; a student facing the board appearing to attend to the explanation, while really I believe the student was daydreaming; a student writing in a tilted notebook, when actually I observed the student is surreptitiously using a cellphone. These types of behaviour align with what Liljedahl (2016b) calls 'faking'.

Students who were doodling or using a cellphone may have been able to fool the teacher, or may have gone unnoticed by the teacher, but their inattention was noticeable from another vantage point, or by someone who was not thinking about teaching a lesson. Some students, such as Tasha and Max, occasionally worked on assignments (for math or other classes) while the lesson was being taught. Neil appeared to be watching, but still had his headphones in his ears. It was less apparent that a student was not paying attention if they were just staring at the front - they could have been daydreaming, or they could have been thinking and following the lesson. Tasha was using her cellphone during class, occasionally looking up to make sure she had not been caught and was in the same spot on the notes as Mrs. Hill. Being caught did not deter her – shortly after being told to put the phone away she took it out again. Use of a cellphone is not always an indicator of inattention, however. After observing Melissa using a cellphone during class I assumed she had been texting. But when Mr. Matthews called on her she was able to answer his question. When I asked her about it she explained that she was using her phone as a calculator to try the example that the teacher was doing, a possibility, but difficult to verify.

Some students made no attempt to fake paying attention. Trevor and Todd were not paying attention to what the teacher was saying one day, despite the fact that I was sitting with them. They may have not drawn the teacher's notice, but they knew they were not fooling me. From the teacher's perspective, the most obvious indicators that a student is not attending to the teacher or the lesson is that they are not looking at the teacher, they are trying too hard to be surreptitious about multi-tasking, or are chatting with another student. These types of actions indicate that the student is not trying to fake it. Candace and Emily were noisily chatting one day and consequently were scolded by Mr. Matthews, not only for their inattention, but also for being disruptive (and disrespectful). Another day, immediately after the class has been advised to pay attention and "*get this down*," Tyrone and Morgan began talking and ignored the explanation. A little later, Mr. Matthews said, "*Tyrone, maybe it would work if you turned this way*." Of course, some students expose their own inattention: Candace piped up one day, "*Wait, hang on, what question are you doing?*" She and Emily had been chatting again. Slav was not chatting, but was cutting the label off of a bottle instead of paying attention to the problem they were working on. However, it is not necessarily the case that a student who obviously is not paying attention is not interested in learning. Some possible reasons for not paying attention (and not faking it) were: the material has already been mastered; the student preferred working one on one with a tutor; or the student was trying to figure out an earlier concept or problem. Alternatively, the student may not care about faking it if: she was too focussed on something going on with a friend or in her own life; he was already failing and had given up; or, she was bored and was not concerned with conforming to expectations. These, and other possible rationales are depicted in the following diagram (Figure 4.1).

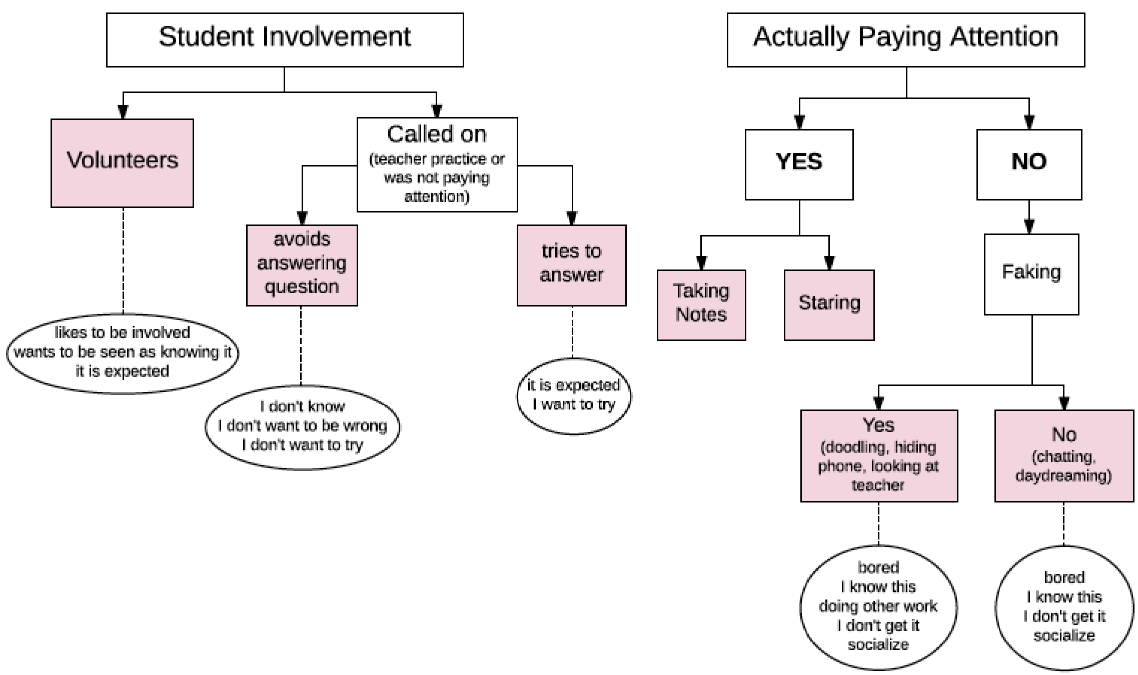


**Figure 4.1 Student reasons for actions during direct instruction**

Finally, a few students mentioned that they took notes during a lesson in order to help them pay attention and remain focused. On the other hand, sometimes writing notes meant that students were unable to follow the explanation – they were not able to attend to both aspects. This is discussed in the following subsection.

## 4.3 Notes

Even though few teachers require that students take notes, many students (correctly) perceive that most teachers see note-taking as an indicator that the student is paying attention and is learning, or at least trying to learn. It is a common, and commonly misunderstood or misrepresented, practice in the majority of secondary school mathematics classrooms. Taking notes is often seen as a "*proxy for learning"*. Liljedahl (2016b) uses the term 'proxy for learning' to refer to some sort of measure (concrete or observable) that is employed as a substitute for learning. Some other proxies for learning include: students are quiet and appear busy, students are apparently engaged, the class is ordered and calm, at least one student has answered a teacher question correctly.

Like most secondary mathematics teachers, it was rare for any of the teachers participating in this study to explicitly tell students to take notes. However, it was often implied, as with Mrs. Hill. Her skeleton notes, distributed to students at the start of each new chapter, demanded of students to fill the blank spaces by trying the examples and writing down other salient information. She stated that she did not require it of students, but on more than one occasion she questioned students about the location of these notes when the package was not visible during a lesson.

Mr. Matthews stated that he did not require it of students "*at this age*[47]" but on some review days he told students "*this is important…write this down*", or "*this is probably going to be on the test, make sure you get it all down*". In fact, eleven out of fourteen students surveyed in Mr. Matthews class stated *"yes"* when asked if they thought Mr. Matthews expected them to take notes. The remaining four responses were: "*I don't know. I don't recall him asking us to*"; "*I think he'd like us to but he won't make us. It's our choice to learn*"; "*No. Not very often, but I do for my benefit";* and the final student qualified, "*When they are written on the board, yes*."

It appears that for the majority of Mr. Matthews' students, it is expected that they write down notes that are written on the board. When he explicitly asked them to copy something down, they all appeared to be writing.

[47] He mentioned that he would require it of grade 8s and 9s, and sometimes grade 10s.

Taking notes was a rarer practice for students in Mr. Johannson's class than those in Mrs. Hill's or Mr. Matthews, but they were available online for students to use. A few students chose to take their own notes. Student conduct with respect to note-taking is subdivided into two categories: actions; and reasons. Following this is a brief summary of why (the reason or rationale) students took, or did not take, notes.

### Actions

I have chosen to subdivide this section according to the frequency and quantity of notes taken by students during a lesson. One could argue that this is a subjective measurement as I did not actually record the quantity of notes taken by any particular student, nor count the number of times I observed a student taking notes down. However, field notes and audio recordings provide a reliable record from which to abstract these distinctions. There are three subsections: never or rarely taking notes; taking some notes, most of the time; always taking notes.

**Never or rarely taking notes.** From the very first day Tiffany did not bother to write notes at all. The only thing I ever observed her writing (other than doodling) was the assigned homework questions. When I asked her why she never took notes, she replied: " She didn't appear to pay attention to any of the examples, notes, or discussions during class. However, when Mr. Matthews explicitly asked students to "copy this down" she appeared to be writing, and once asked him: "*Do we copy this down?*", to which he did not respond. On the rare occasion I was able to 'sneak a peek' at her notebook it was mostly doodles and homework questions.

I noticed Tyrone was selective in his note-taking and shared my observation with him. He concurred and explained: "*I only write down the examples with formulas that I need. I know how to do it once I get the formulas down to look at so I can know how to do it for the booklet*." When I asked how he knew which formula to use for which question he explained that it depended on how the question was formed: "*So if it's like the quadratic, or it's the vertex form, you know.*" Tyrone did not appear to ever write down anything other than these formulas and possibly information pertinent to them. I never noticed him write down any definitions, and he said that he would write down things he did not understand and ask about them later, but did not write down anything he felt he understood. Unlike Tiffany, Tyrone did not 'fake' writing notes. When he appeared to be taking notes, he was.

Most students were happy that they did not have to take notes in Mr. Johannson's class. Jineane was one who expressed this, and Todd was especially vocal: "*That's awesome. Notes suck*." Although the notes were provided online, neither Todd nor Jineane accessed them often, and stated that they 'should' do it more. Todd admitted that he *"should use them all the time"* when he is confused but he also said he did not do it *"enough"*. Jineane agreed: *"if we have a test and I'm confused then you go dig it up",* however, in practice she never actually did this: *"Come on, let's be honest here. I never look at them*". Todd preferred 'fill in the blanks' because he felt he was appropriately engaged and learned more. When there were too few notes he felt *"my mind isn't even engaged enough,*" and too many notes meant, "*I'm just not going to do this because this is just way too much work*."

Despite their preference for not having to take notes, it appeared that both Jineane and Todd felt that taking and having some sort of notes was beneficial for them. Referring to her science class in which they did some notes and lots of projects, Jineane explained that she felt it: "*helps more because it lets you keep your homework and she [her science teacher] marks it for you.*"

**<u>Taking some notes, some of the time.</u>** If a student took notes, they some wrote them verbatim and others chose to write them in their own words. He or she may have written down everything or been more selective.

Candace and Emily justified their choice not to take notes during a review class: "*we were just watching*" (Candace) and "*we weren't writing it down … we were paying attention*" (Emily). In another conversation Candace's statements contradicted her actions: "*I write everything down* [on the board], *but I don't always use it*[48]." I followed this statement by asking her reason for taking notes: "*Just in case I need it*,*"* and, "*it keeps me happy*". Candace found her notes useful: "*if we're doing a worksheet or something I forget, I just*

[48] Based on my observations, this may suggest that Candace is not a strong enough mathematics student to discern what is important and what is not. Or, it is possible she only writes down examples that she thinks will help her to complete her homework.

*look at my notes*." However, I observed Candace not taking notes on several occasions. Her seatmate, Emily, also indicated that she usually took notes but I recorded several times that she did not have any notes written, when most others did.

Morgan declared he took notes, mostly in his own words, when the material was difficult, but not when it was easy and not when there were a lot of notes. In that situation he would listen and then try to write the notes down later. If he took notes, the purpose was for later use, either for homework or review before a test: "*I take notes because I forget a lot of the time so I just refer back to them*."

Tasha took notes, but intermittently. She often used her cellphone to text in between copying down what Mrs. Hill wrote on the board. She shared that she did not take notes in some of her other classes, not because it is too easy and she did not need to, but because: "*I just get bored. Or I'm too sleepy. Or I'm studying for a quiz in the next class*." Toby, also in Mrs. Hill's class, took some notes, but could not make sense of what he had written. "*I have to go find my friends and ask to see their notes.* […] *They actually write down the steps whereas I think I'll remember the steps and then it turns out I don't*." He also added that he did not take notes if it is too easy.

In Mr. Johannson's class, Sol said she used the online notes *"just for studying.*" Her classmate, Xander, thought it was worthwhile taking notes, and occasionally took some. His rationale concerned the value of notes for completing assignments: "*I think that notes help with math because if you forget how to do a problem you can refer to it over and over until you get it*."

Interestingly, Xander also commented: "*We don't take notes in this class 'cause I did that last year and I understood it more.*" He preferred having some notes because he liked to have something to refer to if he had difficulty with his homework. This is interesting because it speaks to the utility of notes, but also because Xander had access to the online notes but didn't use them[49].

[49] Xander had the option of taking notes, but did not, even though he prefers having them. This suggests he was not willing to put in the necessary effort.

**Writing down everything.** The term ‘everything’ used in this section refers to everything that is written on the board. Very few students actually wrote down verbal explanations offered by the teacher that were not written on the board. In Mr. Matthews’ class only Maria and Stephen made notes beyond what was written down on the board.

Both Maria and Stephen took comprehensive notes during class, whether verbatim or in their own words, but the way they used them differed significantly. Maria wrote down everything written on the board and also made notes about what Mr. Matthews said. She explained: “*I won’t remember anything later if I don’t write it down*.” Stephen also wrote down what was on the board and what was said, but in contrast to Maria, he did not try to memorize them and refer to them to complete assignments, but used them as a platform to “*comprehend the stuff*.” To accomplish this he took his notes from class and entered them into a computer program, adding any thoughts and related information from his experience, or easier ways to think about the concepts. Refreshing his memory by reading and writing his notes for a second time helped him to understand “*stuff I didn’t catch the first time around*.”

The following section explores in more detail the reasons students gave for their respective note-taking practices.

## Reasons

If taken, notes were used for various purposes such as: to prepare for assessments; to complete homework assignments; to help one focus on the lesson; to comply with teacher expectations. For others they languished in a notebook, to be discarded at some later date when a bag or locker was emptied. In this section I discuss individual students’ purposes and rationales for their note-taking practices, organized by the four purposes listed above. At the end I will make some summary comments regarding tensions students felt regarding note-taking.

**Prepare for tests or other future reference.** The primary purpose that students took and used notes was to prepare for tests. Maria stated “*I have to write it down and look at it before the test and then I’ll remember.*” Meghan said: “*I find them useful because they kinda like refresh your brain… they remind you about what you were thinking about it.*”

Marcus found his notes useful to "*refer to*" when "*do[ing] homework*" and occasionally for reviewing for a test.

Melissa used discretion in her note-taking. She wrote down verbatim everything that she considered important (explanations of procedures, formulas, definitions of terms) so that she could look back at them later, but for examples her practice was to write down: "*enough to keep track of what I'm doing*…*so I don't get lost in the equation.*" Her stated purpose was to have the definitions to review before the test, and I conjecture that because she did not write down full examples she was not using them to complete her homework assignments, or at least not for mimicking[50].

Chelsea tried to take down everything Mr. Matthews put on the board. She explained, *"it is useful to go back* [and look at these notes] *before the exams to try and remember all the formulas.*" Meghan chose to write her notes verbatim. "*I find it easier to start in certain words. So you know how to do it, so it's already study worthy."* Meghan made substantial use of her notes to study for tests and especially the final exam. This is discussed in more detail later in this chapter in the section titled "Preparing for Assessments". Two students said that they would keep their notes and use them in the following year[51] if they "*forgot how to do something*."

**<u>Complete homework assignments.</u>** Many students used notes to help them complete homework assignments. Judy and Kristi claimed that the notes were a *"good reference"* and Kristi added that she used hers for *"every question".* Then, *"by the time I get to the test I know what I'm doing. Most of the time."* Shanna looked at her notes "*all the time*". She stated that she had her notes with her when she did her homework. Then, "*just before the test I find I have to stop because I find that I get really reliant on the notes, depending on them, so I find I have to memorize*[52] *more, but with homework I'm always looking back*

[50] Mimicking (Liljedahl & Allan, 2013a) refers to the student practice of completing a mathematics question by referring to a similar question and working through line by line (horizontally), changing the numbers and repeated the steps in the worked example. (As opposed to starting with the question and working vertically through it, carrying through reasoning from the previous step.)

[51] Unfortunately whether the students used the notes in the future cannot be verified. However, on a personal note, I know well one student who took copious notes and saved them for years, never once referring to them.

[52] The emphasis on memorizing suggests that Shanna did not really understand the concepts.

*at them.*" As mentioned above, Marcus too found his notes helpful when he was doing his assignments. Most of the comments made by students who used their notes for the purpose of completing homework assignments signal in some way that they were mimicking.

**Focus on the lesson and/or physical link to material.** Another function of taking notes cited by students was to help focus on the lesson and to create a physical memory. Richard explained: *"for the first little bit I kind of do* [use my notes]*, and then afterwards not really, unless I'll do a quick review before a test."* If he used them for review, the purpose was chiefly to look up terms and definitions. He liked having notes to look over again but felt primarily that, *"it's the initial process of getting it engrained in your head of writing it all down."* Miranda said she would zone out if she was not writing down the notes, and liked having them because she got confused. Similarly, Rory admitted he would doze off if he didn't take notes: "*I mostly just take them so that I don't lose focus in class.*" Beth wrote exactly what her teacher projected on the overhead. She liked having notes in case she forgot something and to have to refer to when she was doing her homework. She added: "*I also find that physically writing something helps me remember it more than just looking at it. So I like getting printed notes but … the more you write the more you remember because you've physically actually written the words*."

Although Scott confessed to losing one of his math notebooks before the end of the semester, he was not concerned because for Scott, the value was in the writing of the note, not the use. Taking notes helped him to focus in class and to remember the material. "*It helps me just remember them better. Like if I'm just looking at them [the examples on the board], I don't really remember them as good*." The taking of notes was useful to Scott, but he did not actually use the notes for studying or anything beyond the current homework assignment, if that.

**Compliance with (perceived) teacher expectations.** As stated earlier, no teacher had an explicitly stated rule about taking notes, though in Mrs. Hill's class and Mr. Matthews' class, it was often implied and sometimes suggested. For their students, then, taking notes was possibly construed as an action in compliance with teacher expectations. Taking notes was never required in Mr. Johannson's class, and most did not. Notes were available online for students to use as they wished, but few took advantage of this.

Taking notes was rare in Mr. Johannson's class; students who wrote notes did so for one or more of the reasons mentioned elsewhere in this section. In the other two classes, where taking notes could be perceived as expected, the rate of note-taking was much higher. Students who took notes for no other reason than because they thought they "*should*" fall into the category of compliance with teacher expectations. These students are identifiable through their statements about their note-taking purposes.

For example, on his note-taking survey Morgan wrote that he thought the teacher wanted them to take notes because they will help them [the students] but when asked why he took notes (when he did), Morgan seemed unsure: *"uh, probably because they're useful to me.*" Slav and Mathias wrote notes, but not because it was useful. Slav admitted he took notes only because: "*I'm not allowed to use my electronic devices. So what else could I do?"* and Mathias stated that he would not be doing anything else if he was not taking notes, "*so you might as well just write down the notes and make sure you actually do understand it*." It is interesting that Mathias correlated writing down the notes with understanding the material, especially when one contrasts his statement with that of Chelsea in the following subsection.

**Tensions.** "*I'm not really thinking about what I'm writing, I'm just thinking about getting it all down…so it's like you're not taking in the information of what you're supposed to do. I don't really understand how to get the answers*" (Chelsea). One of the issues some students voiced with respect to note-taking was that they spent so much time trying to copy down everything that was written on the board that they missed things the teacher said. Like Chelsea, Jake shared that he feels like when he's writing down notes he is "*not actually learning it* … *'cause I missed the explanation*."

Beth found the writing of notes beneficial, but admitted that if there were too many notes she had difficulty following and her writing got really messy: "*Sometimes everything I write just starts to look like gibberish to me … like, 'what do these numbers mean, why are they here?'*" Finally, writing something down did not mean that it could be found again. Candace wrote down an example during a review class and somehow could not find it less than fifteen minutes later.

### Note-taking: Actions and reasons

Many of the students who took notes used them or intended to use them for a specific purpose or purposes. In contrast, a great number of students who wrote notes, sometimes very substantial quantities of notes, confessed that they made little use of them. The following diagram (Table 4.1) summarizes the actions and rationales for taking notes that students voiced (or implied, through their actions and comments).

**Table 4.1. Summary of goals for note-taking and note-using actions**[53]

| Action | Reason/Rationale[54] |
|---|---|
| Never or rarely taking notes (perhaps appearing to take notes, or only writing them when directed to) | Comply with (perceived) teacher expectations (if rarely or if faking it) |
| | Minimize effort |
| | Can get them online |
| Sometimes or always taking notes | Comply with (perceived) teacher expectations (if rarely or if faking it) |
| | Have worked examples to refer to for homework (mimic or not) |
| | Have a resource to study from |
| | Focus on the lesson |
| | Learn by writing |

Figure 4.2 (below) depicts the same data, but in a different format. The flow-chart diagram shows students' reasons for their actions during the activity setting of taking notes.

[53] This table, and table 4.2 are unique to these two sections (note-taking and now you try one). I use them here and not for other sections (such as direct instruction and homework) because it was possible to present the data in this format (and in a figure such as figure 4.2). This adds another perspective, but when I attempted to do this for activity settings such as homework and direct instruction it did not add anything of value.

[54] These rationales, and those in similar subsequent tables, were gleaned both from observations and interview data.

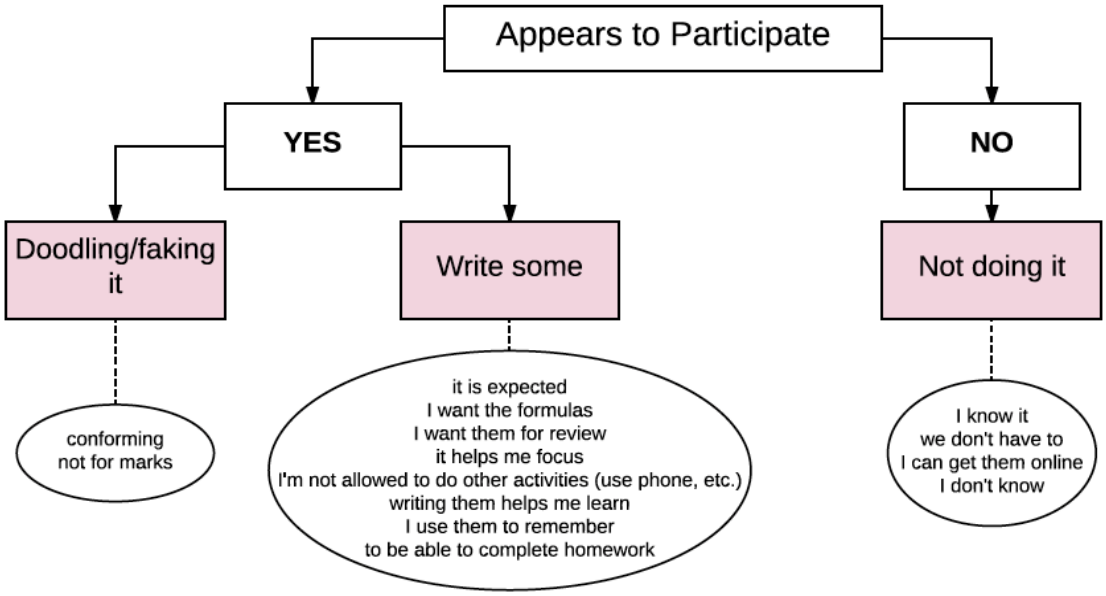


**Figure 4.2 Student reasons for actions during note-taking**

## 4.4 “Now you try one” – doing mathematical tasks

Within the context of the classroom, mathematical tasks are of at least two types: topic-relevant questions and “real” problem solving (explored in the next chapter). The first type of task often occurs frequently in the context of direct instruction, wherein the teacher provides an example, then directs the students to try a similar question. The assigned task usually is only a minor adaptation of that which was demonstrated. In my study, the length of time given for students to try it varied with the teacher, type of question, speed at which most students completed the task, and many other factors. Student participation in these tasks varied, for many reasons that will be elaborated on below. This third type of activity setting is referred to as “now you try one”. Below, I offer an introduction and a transcript to orient the reader as to the nature of these tasks.

It is common practice for a teacher to demonstrate and write down the full solution for an example (an exemplar), and promptly thereafter give students a similar question for individual or partner practice. While students try the example the teacher might circulate to check on student progress, other times he or she might write up the solution while students worked, or else attend to some other issue such as speaking to another teacher who had come to the door for some reason. I witnessed such actions in the activity setting "now you try one" countless times in two of the three classes I observed. The exception was Mr. Johannson's class as he rarely demonstrated for them, instead preferring to let them try each problem together. He provided hints and suggestions where needed, and summarized with a class discussion. That said, even though the conditions were different from the other two classes, Mr. Johannson's students *were* asked to try mathematical tasks, pertaining to the topics they were learning at the time, and thus observations from those settings are discussed here.

The following selection of student responses[55] is offered as brief introduction to the variety of possible actions students undertake when in the activity setting of "now you try one."

| | |
|---|---|
| Researcher: | So when you're asked to try an example, do you usually do that? |
| Richard: | I usually try it, but if I can't solve it quickly I usually just wait for her [the teacher]. |
| Rory: | If it's so easy I don't even need to bother with it, like two plus two, yes, I know it equals to four, but if it's one that's like, oh, I'll try it, I get this, I'll do it really quickly kind of deal, and then I have time to just look around and see what they're doing [Mrs. Hill], or if I don't understand what's going on I'll stop, I'll wait until they [the teacher] do the example. |
| Tasha: | Never. Well, math sometimes now, but before it was never. Like in physics he gives us examples and I'm just the second he says example I just drop it. |
| Toby: | I just do it in my head and wait for the teacher to go over it and that's when I write stuff down. |

As can be seen, not only is there difference among the behaviours of individual students, there is also variance within the behaviour of an individual (Tasha). Such data serve to highlight the importance of role of context influencing student action.

The following analysis is categorized by the grouping of student behaviours arising from analysis of the data in the "now you try one" setting. One notable difference between this section and the previous, note-taking, is with respect to appearances. If a student did not

[55] This conversation is taken from one of three focus group sessions that were held outside of class time. The students volunteered to stay after class and share their thoughts.

appear to be taking notes, then he or she was not taking notes. However, it IS possible for a student to appear to not be trying examples when he is actually doing it (in his head)[56]. For this reason, I have approached this subsection with respect to what students ACTUALLY did. First, student actions are grouped by two broader headings: those who actually attempted the task, and those who did not try. Within these larger cohorts of data can be found distinctions between the reasons for particular actions, and some similarities between behaviours with respect to trying and not trying. These arise and are discussed in more detail below. Following the presentation and discussion of the two mutually exclusive sets of actions is a summary section providing general comments about student behaviour with respect to these tasks, as well as an analysis of the goals prompting the different actions observed.

### Trying

If a student tried an assigned task, there were a number of possible action states. I discuss these states here to provide some structure for the ensuing discussion about reasons for trying a task, which point to student goals. Figure 4.3 (below) illustrates the action states and possible student moves between them. I constructed the diagram based on my analysis of observed student actions in all three classes in the study. Unlike the other diagrams in this chapter, which represent states, this diagram is dynamic.

[56] The same cannot be said for *appearing to* do something like take notes or a try an example – in both cases a student could be faking it. To clarify, a student who appears to take notes could be actually taking notes, or faking it. If a student appears to not take notes, she is **not** taking notes. If a student appears to try an example, she could be trying, or faking. If a student appears to not try, he could be trying in his head, or faking.

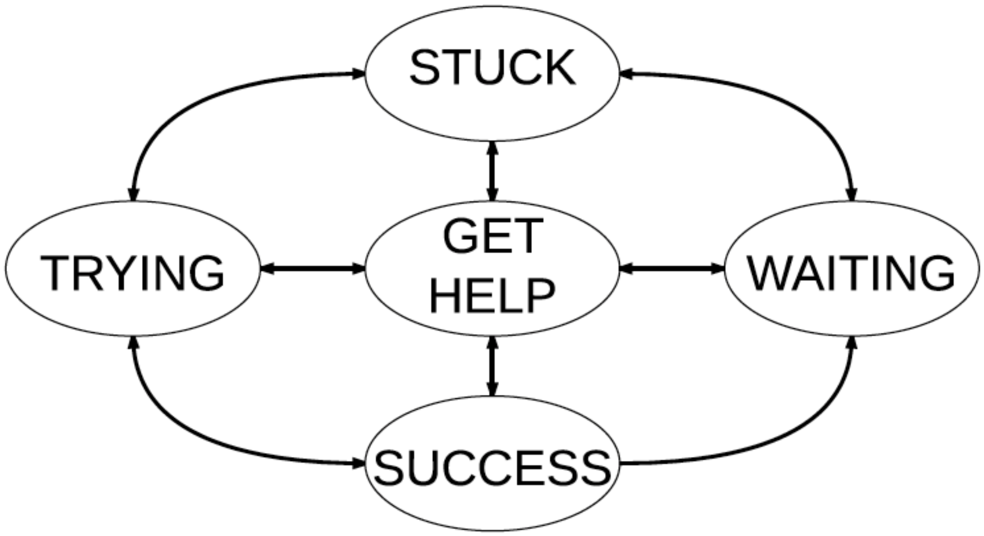


**Figure 4.3 Dynamic diagram of the shifts in action during "now you try one"**

There is no official starting place for students: a student may begin and immediately be stuck. Or, a student may never begin and remain waiting. It is a flow chart of processes. Some of these processes can be seen, such as getting help. Others are visible at times, but not at others. For example, a student who appeared to be waiting may have actually been trying the task in his head, or vice versa.

Some student outcomes when a student tried a task included: being successful with the task[57] and waiting patiently or helping a peer; or getting stuck, at which point the options included giving up, actively seeking help from a peer or the teacher, or waiting passively for someone to help them (shifting the student from trying the task, to waiting for the teacher). If the student sought help, in some cases it led to immediate success with the task, in others the student continued to work on the question and got stuck, others were successful, and I saw may students who at some point during the task decided to stop and wait.

Some are possible end states, such as success or waiting, and others are more transient. Even success and waiting can be transient as a student has the possibility of leaving these states and re-entering another state – for example, if a student thought he was successful

[57] "Successful" with the task here indicates that the student has completed the question to he best of his or her ability and has reached a final solution – that may or may not be correct. It does not indicate that the student understands or as learned anything.

with the task and then realized he had made an error he could return to trying the task, or shift to waiting for the teacher to provide the correct answer.

The following four subsections describe the actions of students who tried tasks, at least initially, and include a discussion of contextual factors influencing those actions. The discussions are grouped under the following headings: visibly trying the task; doing it in my head or doing it on the calculator; getting stuck; being interrupted.

**Visibly trying the task.** Many students tried the tasks that were given during class time. The multitude of contextual factors that influence student behaviour in this activity setting makes it difficult to definitively identify the one, or combination thereof, that tipped the scales for any particular example or on any one day. What can be said is that very few students tried every example, every time, and those who did had varied success.

What was most commonly observed was inconsistency. Usually Keiran got stuck and/or waited for the teacher when tasked with a question to try. However, once when asked if he had tried some of the questions, Keiran said, "*I wrote them all down. I tried them all.*" While 'writing them down', and 'trying' are not indicators that a student comprehends and can correctly solve the task, in this case Keiran was successful, saying, "*he understood*." A common response received from a student when asked if she tried a question successfully was, "*I got it*," and often when asked why, replied, "*it was easy*." Actions of students who did not try, or tried and got stuck, are discussed in a following section.

One interesting, and not altogether unanticipated finding was that requiring students to work in pairs, and on a vertical or horizontal whiteboard, produced significantly different student data than the other two classes observed. Almost all of Mr. Johannson's students tried the examples, at least initially, as compared with classes where students were expected to try problems while remaining at their desks. Clearly there are other factors influencing student response to "now you try one," but working on a non-permanent vertical or horizontal surface seemed to be a differentiating factor. However, it should be noted that 'trying' and 'succeeding' do not necessarily go hand in hand.

As mentioned above, very few students tried every example, or even the majority of "now you try one" tasks. Maria was one exception to the norm. She tried every example, though she was not successful with every problem she tried. Sometimes she got stuck and asked for help, or ran into other obstacles, such as inadequate time; these difficulties are described in the following sections.

**Doing it in my head or doing it on my calculator.** Some students, such as Toby in the transcript provided at the beginning of this section, appeared as if he was not trying a task but he was actually doing it in his head. I include these actions here as trying, but it is of significant importance to note that through mere observation, it would appear that Toby is NOT trying. Other students, such as Melissa and Mika, among others, also stated that they were doing the problem "*in my head*." The issue here is transparency – are they actually doing the problem? Or are they just following along the teacher's explanation and seeing that it 'makes sense'?

Another possible way to try a problem, without writing, was to use a calculator. I often saw students plugging away on their calculators when asked to try an example. Asked about his use of his calculator, Jake explained, "*I was doing the calculations ahead of time.*" This happened frequently with questions requiring conversions – students did not write anything down, instead proceeding to plug away at their calculator. The issue here is that students often did not know what they had done incorrectly if their result did not match the solution (was it a 'typo' or did they multiply instead of divide)? Plugging away at the calculator is also a potential incidence of faking – a student could claim she was trying the question when instead she was mitigating boredom or feigning compliance by hitting buttons.

**Getting stuck.** A third possibility when trying a task is to get stuck; students who attempted a "now you try one task" often ran into difficulty. When a student got stuck, there were several different reactions I observed: seek help from a peer; ask the teacher for help or wait for the teacher to be nearby, then ask for help (proximity question); or just give up. In what follows I discuss in more detail different student actions and reactions to the state of getting stuck. I have also included some student comments about working with and getting help from a peer, as this helps to explain their reasons for seeking help, or not. In this subsection I differentiate the analysis into three categories: asking a peer; asking the teacher; giving up.

*<u>Ask a peer.</u>* Having a partner to work with, or being able to ask a peer for help often helps students to get further with a task. There was a lot of collaboration in all the classes I observed. Students asked peers questions about: checking answers; confirming or determining the appropriate procedure to use next; and others understanding of a concept (both seeking help and for affective reasons).

Some students actively sought help and were open to receiving help from peers. For example, when Doug and Xander were stuck on a problem, Mika actually took the initiative to come over and help them get started on it. But not all students were willing to make the effort or were not comfortable asking a seatmate or another peer for help. Toby stated, "*I never ask my partner for help. Unless it's my friend. I don't ask Eva for help – ever."* Although Toby was a very strong student, Eva was close to top in the class, and asking her made him "*feel really stupid*[58]." Even if a student was willing to ask, there was no guarantee that additional progress on the task could or would be made. Marcus said, "*I can sometimes turn around and ask Richard, just his explanations don't always quite work for me*." In Kyle's class, they were asked to pair up and try the tasks on a vertical or horizontal whiteboard. Kyle explained the difficulties he found with trying problems with a partner and getting stuck.

> It's difficult to get involved too because someone decides to do something and you stop, like Jineane said, you can take over if you know what you're doing but if you don't know what you're doing, but if both of you don't know what you're doing you got, well, you're stopped.

However, at other times Kyle was observed borrowing[59] ideas from other groups as a way of getting 'unstuck'. Magda's comment about partner work raises another problem, regarding the issue of becoming dependent on the person next to you. "*For example, for help you always ask them but then when you do it on the test you obviously don't have that person to help you out so you struggle with it*." Finally, Sol explained that when she was stuck, she would go to her partner first, but if her partner was having difficulty as well, then they would ask the teacher.

[58] This is discussed in more detail in Chapter 7.

[59] "Borrowing" is a term used by Liljedahl (2015) to refer to the practice of students going to seek ideas or information from their peers to help them progress with the task at hand.

*Ask the teacher.* Asking the teacher for help invites possible consequences and can have a purpose beyond or separate from improved student success with the task at hand. For example, some students do not want to let on to the teacher that they have difficulty understanding the material and/or they want to stay 'under the radar.' For others, asking the teacher for help is an indication to the teacher that they are trying to comply or meet expectations. This indication may be false, if the student signals for help as a delay tactic[60]. There is only one teacher in the room, and often a significant number of pupils needing assistance. Getting to each student takes time. As Tasha said,

> It takes FOREVER [for the teacher to get to me]. I sit beside someone who doesn't necessarily understand it either, so I want to ask Shanna for help, but every single time I turn around the teacher is like, "turn back to your desk and ask your partner." But I can't. That's the thing. So what am I supposed to do now?

Marcus was concerned about appearing to not be doing his work while waiting for the teacher to come and provide help. Both Marcus and Tasha authentically wanted the teacher's assistance but experienced frustration with the time it took for the teacher to make her way to them. In their efforts to seek assistance elsewhere, they often chose to get up and ask a friend, an action for which they were sometimes reprimanded, as the teacher expected them to ask a seatmate.

*Give up.* Of course, many students who tried a task were unable to complete it successfully. Keiran, sitting quietly, caught my attention and I asked about his progress with the questions the class had been asked to try. "*I wrote them all down and did it but…,"* he trailed off. He did not ask the teacher or a peer for help. It is not clear whether Keiran felt that he had satisfied the teacher's expectations by writing the questions down and making an attempt to try them, and it is also not clear what he meant by saying he "*did it*". Perhaps he got a solution but found out it was not correct, or perhaps he was indicating that he followed a procedure correctly but did not understand why. When a student was stuck and did not want, or have the opportunity, to ask for help, the default action was to wait for the teacher to solve it.

**Being interrupted.** Finally, sometimes when the students were asked to try a question they were not actually allowed sufficient time to try it prior to the teacher interrupting to

[60] Delaying is discussed in more detail in Chapter 6, as a general theme across activity settings.

present the solution. If the teacher started working on problem, or began setting it up before students had adequate time to process it and start it, then students were often distracted and curtailed their progress to check the teacher's work – and subsequently waited for the teacher to complete the solution. In this situation students were forced to make the choice of trying it on their own or listening to the teacher explanation and copying down the correct solution – there was not time for both.

When I asked Scott and Maria if they had tried an assigned question, Maria explained that she had been trying to figure it out, but then the teacher had said the answer. Only once did I overhear a student asking the teacher to wait so she could finish a question on her own. When her teacher started to announce the final answer to one task Beth shouted, "*Wait! I'm so close….*" I also observed the interruption coming from a stronger or faster student who finished before the rest and called out or gave the teacher the answer. Once this had occurred, often the teacher would acknowledge the solution and either request the student explain or the teacher himself would provide the solution.

This type of interruption, though common, did not always occur. However, when it does, one possible consequence, supported by my observations of student behaviour, is that if it happened multiple times some students gave up on trying an example at all and just waited for the teacher to do it. In fact, it appears some students appeared to come in on day one of a new class 'pre-conditioned' to wait for the teacher to solve it (see "waiting for the teacher", below).

### Not trying

Factors influencing whether or not students at least started to try the tasks include: level of conditioning[61] and/or minimizing cognitive effort, duration of time given for the task, level of difficulty of the problem (if too easy and they "knew" the answer they did not do it, or if too difficult they might wait for the teacher).

[61] Some students are so used to the teacher providing the solution that it is a conditioned habit for them to just wait for the teacher to solve the task when they are given a question to try in this context. Minimizing effort goes hand in hand with this type of conditioning.

A particular behaviour many students exhibited was that when they were assigned a task they would copy down the problem from the board and then wait for the teacher to do it. Or, if they tried it initially, they gave up when they ran into difficulty. As it is used here, the term ‘initially’ is meant to indicate: that students were more likely to attempt these types of questions in the early stages of the course; and, that throughout the course students might make an initial attempt at a question and then give up and wait for the teacher.

Although upon initial observation these actions (or inactions) appear homogenous, a prolonged observation period and deeper analysis reveal distinctions in the reasons, or goals, that prompted students’ behaviours. Six categories emerged from the data, differentiated by students’ rationales for not trying an assigned example. There is significant blurring between some categories, and certainly some overlap – one student may have multiple reasons for not trying a task, or giving up, based on his or her goal. The four categories of reasons are presented in the following order: conditioning and reducing cognitive effort; wanting perfect notes; insufficient understanding or tools; already knowing how to do it.

**Conditioning and reducing cognitive effort.** Waiting for a teacher appears to be a learned habit, as I noticed this occurred even on the first day of new class. For example, in one class, at least five of the seventeen students waited until the teacher wrote the question on the board, proceeded to copy the question down into their notebooks, and then waited until the teacher wrote the answer up. These students were not all lazy, nor were they incapable of attempting the question; they had developed a habit of waiting for the teacher to solve a problem. In short, they had learned that if the teacher gave a problem to try, it could be expected that the solution would be given.

In contrast, some students deliberately choose to wait for the teacher as a way of reducing their own effort. One day, about halfway through the semester, Candace waited until Mr. Matthews had completely filled in a table of values and plotted the points before she began to fill it in and plot the values. This occurred despite the teachers’ statement to the class: “[this] *is probably the most important question to look at* […] *so really try it.*” Candace had previously had no difficulty with this type of task, so it is reasonable to assume she was capable of completing it successfully.

Xander waited as well, although Mika started to try to explain it to him. When asked if he was relying on the teacher to review the problem, Xander responded in the affirmative. During one lesson, Maya was observed sitting patiently when given a task to try. When asked if she was waiting for the teacher to do it, Maya replied in the affirmative, adding, "*I just wait for her to do it*." Maya's reason for waiting was not made clear at the time, but in a later conversation she explained that she likes to have neat notes.

When given a problem to try, Beth was observed to only write down what the teacher had written on the board, then sat and appeared to stare into space without writing anything else or picking up her pen or calculator. Once the teacher began explaining how to do the exercise, Beth wrote it down and picked up her calculator to replicate the calculator steps. In the same class, however, Shanna thought it was only "*maybe later*" that the teacher might go over the answer. It was not a guarantee that this particular teacher would provide the full solution to an exercise; it was dependent on the success of other students in the class. On another task, Beth asked, "*What are we trying to find?"* When the teacher replied, Beth tried to draw more information from her about exactly what to do with the problem. It was not so much that she was waiting for the teacher to do it (with the class) but more that Beth wanted the teacher to tell her how to do it right then. Beth had not taken the time to try and think about the problem, she was asking for specific direction for what to do, so that she could carry out a procedure.

**Perfect notes.** Several students, when queried about their delay in attempting an assigned task, explained that they wanted to wait for the teacher to do it so that they did not mess up their notes. Mathias, for example, explained that he waited for the teacher because he did all of his work in pen and did not want to "*screw it up.*"

Alternatively, students tried a question but erased it, such as the case with Todd and Paul. They drew a graph, and then erased it, stating that, "*it didn't look good*," even though it was on a whiteboard and would not have future use. I observed Maya using a mini-whiteboard in class to try the tasks, and asked her why she preferred that to trying a problem in her notebook. "*I don't know, I just kind of…for my notes I like to have it look all nice. I don't want to do it wrong, and then erase it. My homework's for when I can do it*."

**Insufficient understanding or tools.** Keiran stated that if he ran into difficulty with a task he would wait for the teacher to solve it: "*if I don't really get it I'm just going to see how he writes it, like better.*" Tyrone, seated near Keiran, was another who did not write anything down or draw the graph until after the teacher had completed the problem. He often tried things in his head, and based on his actions across all activity settings, I can conclude he also waited for the teacher in order to reduce his cognitive effort. However, when asked about his actions in this type of situation he stated that he would wait for the teacher, "*if you don't understand it,*" and, "*if you're not being so sure, so you can look*". Tyrone stated that he would wait for the teacher if he did not understand it, but his actions suggested that there were other reasons he would wait.

During a review for the final exam I asked Scott why he had not tried to do the question about rates and conversions. He explained that he did not remember "*doing that stuff*" so he waited for his teacher to do it and then "*wrote it all down*". Trevor and Kyle in Mr. Johannson's class were asked what they were doing while others were working on a practice problem; both students replied that they were "*waiting for the explanation*" and "*waiting to see how we do it.*" They had asked a peer for help, but remained stuck, and subsequently waited for the teacher to go over the question. When I asked them directly what they do when they get stuck Trevor replied, "*we usually ask him or wait until he goes over it after.*" He followed this by stating, "*I don't really know what we're doing right now.*" Although Trevor said that he would ask Mr. Johannson if he was stuck, what he actually did was sit down and wait for Mr. Johannson to go over the problem after most of the students had finished.

Chelsea explained that she was not able to do the given question because "*we've never been given a conversion chart. So, it was just kind of, we didn't really know what to do*." But she also admitted that she did not really remember how to do the problem.

Another possible reason a student would wait for the teacher is because they did not come to class with the appropriate tools – any of the following: a calculator, pencil, or paper.

**I know how.** Finally, some students did not try the examples because they knew how to do it (or thought they did). After observing Tyrone from across the classroom, I asked him if he had tried one of the conversion questions. He replied, "*No, I remembered how to do* *it. Completely*." When pressed he added, "*well, you just multiply it by the ratio kinda thing and it's really easy. I remember how to do it*." Referring to the same problem, when I asked Melissa why she had not tried it she replied, "*oh, I know how to do it, I just didn't remember the conversion from pounds to kilos*." Stephen explained: "*I looked at it and it seemed like pretty simple stuff, so I just did it over in my head.*"

### Summary of actions and reasons for "now you try one"

The following table is organized by *observed* actions (appearing to try and not appearing to try), and the possible goals associated with the two actions. I chose to organize the results in this manner because this is what the teacher sees.

**Table 4.2. Summary of goals for "now you try one"**

| Observed Action | Reason/Rationale |
|---|---|
| Appearing to Try (successful, asking for help, or interrupted) | Comply with (perceived) teacher expectations - tried it, or sought help |
| | Know how to do the task – tried it, successful, or sought help |
| | Perfect notes – try it and erase it, write it when teacher does it |
| | Reduce writing – I did it on my calculator |
| | Comply with teacher expectations – fake it (use calculator, doodle) |
| Not appearing to try, or stopping (trying and then stopping, not trying) | Reduce writing – I did it in my head |
| | Reduce writing (physical effort) – wait for the teacher to do it |
| | Reduce cognitive effort – wait for teacher to do it |
| | Not understanding – wait for teacher |
| | I know how – don't do it |
| | Conditioning – wait for the teacher to do it (also associated with reducing cognitive effort) |
| | Conditioning – won't have time to finish before the teacher interrupts, so |
| | Perfect notes – wait for the teacher |

Each goal has a note describing the observed action in more detail. For example, under the action "appearing to try," one potential goal is to "reduce writing." The action associated with this goal is "I did it on my calculator." In contrast, there are two categories for "reduce writing" under the action "not appearing to try, or stopping." One is linked to the action, "I did it in my head," which is significantly different from the other other, "wait for the teacher." Waiting for the teacher, in this situation, is more in line with the goal of "reducing cognitive effort." There is a lot of blurriness and overlap in the distinctions between the goals presented above.

Figure 4.4, below, represents the same data in a flow-chart format.

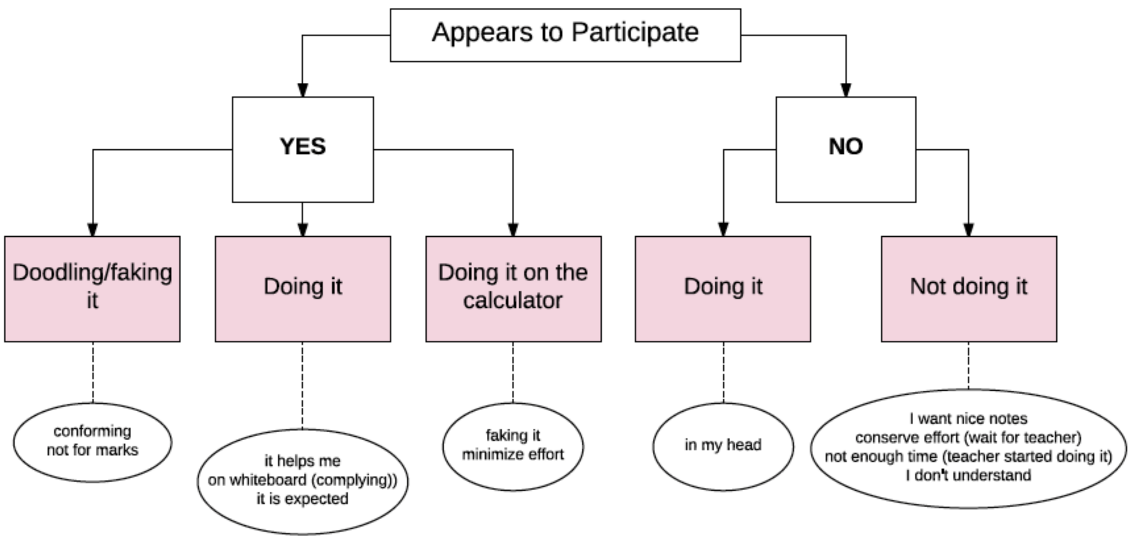


**Figure 4.4 Student reasons for action in for "now you try one"**

These goals may not be a students' primary goal, but they are possible goals. Each goal is associated with a host of others, some dominant in certain settings, others taking precedence at different times. With multiple observations of a particular activity setting, over time, it is possible to identify some likely candidates, but not with certainty. If a student actually does not try it at all the reason could be one or a combination of: he wants perfect notes; he is reducing his effort[62] (cognitive, physical, or both); he does not understand the task and/or how to complete it; or, some other reason.

[62] Rather than intentional, this could be a learned habit because he knows the teacher will not give him enough time to complete the task before presenting the answer.

## 4.5 Homework

The term 'homework', as it is used here, refers not only to those tasks assigned for students to complete outside of class time, but also to assignments given to students to begin or complete within class time, but are distinct from the period of direct instruction[63]. This differentiates 'homework' from tasks like 'now you try one' discussed in an earlier section, and projects and problem solving, which will be discussed in Chapter 5. Practices for collecting homework differed with respect to the teacher: Mr. Matthews collected every assignment for homework marks; Mrs. Hill rolled a die to select one assignment per chapter; and Mr. Johannson randomly selected one homework assignment for each of the four units in the year. Mrs. Hill also had a policy that if a student achieved an 'A' on a test they automatically got 10/10 for homework. I note these conditions because they are significant influences on student practices regarding assignments in these classes.

Within the setting of homework, I have organized the following analysis into three categories: first, talking about homework (that which was teacher directed - going over the homework questions at the start of the following class); second, the student action of actually doing the assigned homework (or not) together with student rationales for their actions (including delaying starting); and finally, student methods for completing (i.e., getting help, copying). I then provide some summary comments and discuss individuals' reasons for doing or not doing homework.

### Teacher directed talk about homework questions

In two of the three classes, there was often opportunity for student inquiries about specific homework questions, usually at the start of the proceeding class. When this occurred, it was sometimes student directed, "*How do we do number thirteen?",* and other times teacher initiated, *"Does anyone have any questions about the homework?"* or, more specifically, *"Does anyone want to go over number eleven?"* Responses to teacher requests for questions varied – sometimes students asked for help with particular

[63] This differentiates homework from the 'now you try one' examples that students are asked to do during direct instruction.

questions, sometimes there was no response[64]. When students did ask for help, most often the teacher would first ask all students to review the question, and then the teacher went through the solution, usually soliciting student help throughout the process of solving. If specific questions[65] were raised, the teacher either moved on to the new material, or sometimes chose a question to review with the class.

Because Mr. Matthews collected every assignment, there appeared to be more frequent student questions about particular homework problems than there would have been if it was not collected. Students would often take time at the beginning of class, or after a lesson to ask each other about solutions to problems. Sometimes this involved copying, but often explanations were offered or requested. Mr. Matthews' students also asked questions of him, usually of the nature "*can you do number twelve?"* or "*how do you do number ten?*" For example, after returning and reviewing a quiz, Mr. Matthews asked the class if there were any questions from the previous day's homework. Tiffany asked for number fourteen, at which point the bulk of the students began to take out their homework to either check the answer or copy down the solution given by Mr. Matthews. Although the majority of students appeared to be paying attention, during his presentation of the solution Mr. Matthews had to rebuke both Candace and Emily for continuing to chat, despite an earlier warning. Meghan then asked for number sixteen, after which someone else asked for number fifteen, to which Mr. Matthews exclaimed, "*I was hoping someone would ask!"*

Compared with Mr. Matthews, it was a rare for Mrs. Hill to take class time to go over homework questions (students had ample opportunity and encouragement to attend her tutorials to get help). Instead, she often started the class with short questions similar to those on the previous day's homework (these are considered 'now you try one's). However, on one occasion after having left a worksheet for a TOC to assign, Mrs. Hill

[64] It was not clear whether this was due to students having no questions, having questions but not wanting to ask in front of their peers, or not having questions because they had not tried the questions.

[65] When students hadn't completed certain questions, but didn't ask, it may be because they thought they should have known how to do it and didn't want point out their lack of understanding, or they may have not wanted to put in the effort to actually do the question and write it down.

found that the students had not completed the task[66]. She took the time to go over some of the question on the sheet, and gave students time more time to work on the other questions. Another day, students had previously been given a review worksheet for an upcoming test. After overhearing some student comments Mrs. Hill asked if the class wanted her to "*go over the last two questions*" on the sheet. A resounding "*yes*" from the class convinced her to provide a full solution, also emphasizing that one was a "*classic*" word problem, and implying that both types of problems would likely be represented on the test. With the exception of one or two individuals, student attention was undivided and the majority copied down the solution or reconciled it with what they had already completed. In addition to these few instances, Mrs. Hill did answer individual questions if they were asked during class time (this is discussed below in the section on methods of completing homework).

Students in Mrs. Hill's class on the whole appeared to be more concerned with *knowing how* to do problems, and with getting correct answers, in comparison with the other two classes. This may be due to the nature of the course (PC 11) and thus the composition of the class, as well as the age of the students.

When the teacher chose a particular homework question to review (after students had not taken up the opportunity to ask questions), it is likely that the teacher felt the concept was important, and quite possible that the lack of student response was perceived as evidence that the students did not try the question. Though teachers were not interviewed for their thoughts on this issue, their actions suggest that teachers felt that certain homework questions were significant for student learning (as evidenced by Mr. Matthews' excited response and Mrs. Hill's actions regarding the two worksheets, both described above).

### Student actions regarding homework (in class)

The specific behaviours with respect to homework, and students' rationale for their actions or inactions is discussed in this section. Students' level of completion of homework varied between classes, between students, and even between days for certain individuals. There was a lot of space between the extreme ends of the homework completion continuum:

[66] See more on this in Chapter 6 in the section on TOCs.

doing no homework, ever; and completing every single question of every assignment. Where a particular student fell on this continuum depended on internal and external factors.

Many reasons were provided for not doing homework – other academic assignments, extracurricular commitments such as sports or clubs, work, or physiological reasons, to name a few. For example, when Keiran was sick he explained, "*yesterday my head was throbbing … I wanted to do homework yesterday but I just couldn't focus on anything."* Chelsea said that she had started a review package[67] in class but "*I didn't really work on it any more because I had other exams to study for too.*" When I commented that no one had asked questions from the review package assigned the previous day, Chelsea voiced her opinion that no one had done it. When Tasha had difficulty with one particular topic on a quiz, she revealed that she could not do any of the recommended homework questions of that particular type. Thinking she had given up, I responded, "*ah, so you got stalled on one and didn't …"*, but she interrupted, correcting me. *"No, I did try working on others but …",* she trailed off. Though she had reportedly made more than a passing attempt at the assignment, the end result was still that it was not completed.

The variety of actions and differences in rationales for any given action regarding homework made it very difficult to pigeonhole students, or student behaviours, into categories. There were students who just did not do homework during class (or did it only rarely), those who delayed starting and might get some questions done, and those who more often than not worked on their homework during the class time provided. What follows is very loosely divided into instances of students observed either doing the current homework assignment, or not. I emphasize that the grouping refers only to whether or not students did the work during class; many students choose to do their work at home. As I chose to record only what I observed students doing (and saying) in class, the collected data concerns only student actions and what students said *about* doing or not doing homework. Samples of observed student behaviours, and student comments, are provided below within each of the two subsections: not doing homework, and doing homework.

[67] It was an assignment to be worked on during class and thus is qualified here as homework.

**Not doing homework**. By the time in the class period the activity setting of ‘homework’ was reached, many students were mentally and physically spent. They were simply too tired to attempt the homework during class, if at all. Others preferred to use the class time to be social, or just did not want to do the homework. The following accounts depict situations in which students were not doing the homework they were assigned that day.

One day, after the class had been assigned problems for homework, I noticed that Michelle was not doing anything. When I asked her why she was not doing the work during class she replied that she usually goes to a friend’s house after school: “*It’s better if someone else is doing it too. I help her.”*[68] Another day, Candace was working on a previous day’s homework (but not the current assignment) because it had to be handed in before the test. She was, *“just getting it done.”* Meghan was using her book to hide her use of her cellphone instead of doing work (faking it). When asked, she explained that she would do her homework after school or in her other classes. Tiffany had missed the previous day’s class and told me she would catch up by looking at the homework written on the board and doing the questions. However, she did not appear to do anything of the sort, or really anything at all, other than socializing.

Kyle rarely did homework during class. After seeing this over a number of classes I asked him about it. He professed to do his homework at home, with a tutor using Skype. He explained that he had a tutor primarily for organizational purposes: his tutor helped him schedule and prioritize his assignments and then he worked on his assignments on his own. I noticed that Mika did not appear to be writing anything down during the time given to students to work on their homework. He informed me that he was, “*doing it in his head because* [he was] *too lazy to write it down*”. Laziness was a reason offered by several other students when queried about doing homework in class. Being tired was also a complaint. On a day when the room happened to be fairly warm, Max sighed, “*I just want to take a nap*.” Kristi, too, was not getting much accomplished on her homework one day. She felt it was going okay (in terms of her ability to complete the questions), but added,

[68] Interestingly, after I moved away, Michelle went up to the teacher and explained why she wasn’t doing the work and asked if her plan for completing the assignment after school was okay. This is discussed in further detail in a case study in Chapter 8.

"*I'm really tired though so I can't focus very well. I didn't get much sleep. I was awake for a tournament this weekend*."

Xander typically delayed starting homework assignments, perhaps doing one or two questions, and chatting intermittently for the remainder of the time. He said that he worked on them at home. In one conversation he admitted he did not complete the previous days' homework assignment and expressed his frustration. "*I couldn't do it even though I followed the steps in the textbook. I got the wrong answer for 'x' and no answer for 'y'.*" This was one of the only occasions when a student mentioned actually using the textbook for anything other than the assigned questions and checking answers.

Jineane, Jackson, and Gary were not doing any work one day because they said they did not know how to do it. When asked what they do when they get stuck, Gary offered, "*Ask for help*." I pushed, "*Okay, that's probably what you should do, but what do you actually do?*" Jackson replied, "*Sit here and do nothing.*" Like Jackson, Todd[69] rarely did homework during class – he delayed, went to the washroom, socialized, but managed to avoid putting pen to paper. He did say he did some work at home, particularly after he had struggled with a concept in a previous class. He appeared to be easily distracted in class and made little effort to attempt to focus on a given task. One day, however, instead of socializing Todd was completely focussed on a graphing assignment using Desmos©. He was so absorbed with his project that he even stayed after class to continue to work on it.

One class, Hannah, Miranda, and Maya had chosen to work on the problem set (an assignment) as opposed to the homework on the most recent lesson. Miranda had already finished the set but was helping the other two. Hannah explained that she chose to do the problem set because, "*I really don't understand it. I understand what we're doing* [in class], *like I know I can do it by myself."* Maya, however, said that she was just tired of doing the homework[70] and was thus working on the problem set by default.

[69] A deeper and broader analysis of Todd's actions is provided in a case study in Chapter 9.

[70] Kyra may have been tired/bored of doing the homework, or tired of the effort and hoping for success on another task.

I asked Travis why he wasn't doing the assigned work one class and he replied: *"I got a six out of six on my quiz."*[71] Mathias stated that he usually wouldn't do homework: "*If I need practice then I'll actually do it. If I don't need practice for it then I won't.*" For Toby, homework was something that he might do depending on how much of his time it would occupy and what time he had available. For example, after finding that his homework assignment was much more than just four questions, he laughed: "*Okay, maybe I won't do it during focus* [the 20 minute silent reading period]*"*. Like Mathias, he rarely did homework: "*If I'm understanding the unit I do no homework, ever. That's why I usually don't do homework in most of my classes, because I usually understand it*".

Sometimes students just chose not to try certain questions. Scott remarked to Maria, "*I've never been able to finish a Sudoku in my life,*" so although he tried most of the others he skipped those problems in his homework.

**<u>Doing homework.</u>** Reasons for doing homework were less varied than rationales for not doing it. Commonly offered (and implied) reasons for doing homework included: it's worth marks; I need to know it for the test; I need to learn it; it's expected.

One reason offered by students when I questioned them about why they were doing homework during class (as opposed to doing it at home) was that they just wanted to finish it. Such was the case with Siobhan and Sabine. They said that they just wanted to get it done so they did not have to take it home. Sabine professed to do all of her homework, all of the time because, *"you learn it, so then it's easier on the tests and the quizzes."* Usually her assignments were started at school, but completed at home. If she had difficulty with a problem she looked at the textbook or looked at Mr. Johannson's notes online. During class one day, I remarked to Sol that she appeared to always start her homework as soon as it was assigned. She agreed that she did her work in class because she thought it helped her learn, adding however, "*I generally don't do it if I actually know it*."

[71] As the quiz had been on prior material, it is possible that Sean felt he would be successful with the current material (and did not need practice), or, he may have thought he could 'coast' for a bit.

Thomas completed every homework assignment and did extra (more difficult) practice prior to the test. When I asked him, *“Do you have to do it?”,* he seemed unsure of how to respond, so I rephrased the question, *“Do you have to hand it in?”,* to which he replied in the negative. He had finished everything else and confirmed that he was doing it for extra practice because he wanted to do well on the test.

Some students, such as Jineane, so rarely did homework that I was curious when I observed that she was doing some work. When I asked her why she was doing that particular assignment she replied, “*it’s easy*.”[72] Similarly, Max frequently delayed starting, but on one occasion I noticed him working. He explained: “*I have a lot to do so I need to catch up on it to prepare for the test next week.*” Cara divulged that she did not usually do her homework, so when I observed her working on an assignment in class I asked her what prompted her to do it. She responded: *“I’m just tired and I should probably do my work and I have missed an entire week of school.”*

### Methods of completing homework

There are many actions that students can undertake when attempting to complete a homework assignment, some of which were touched on above (such as looking to the textbook or class notes). Two notable actions, not yet discussed, are presented briefly here: getting help, and copying.

**Getting help.** Teachers encourage students to get help with homework they are struggling with. Some students took advantage of this opportunity while others did not, and some actually exhibited more initiative to look for assistance elsewhere, for example, on YouTube.

Many students asked the teacher for help, often when he or she was nearby. This occurred frequently, in all of the three classrooms. Students were observed to ask questions when the teacher was in close proximity – sometimes it appeared that the student wanted to show the teacher that they were working (sometimes faking it) and for other students it was a legitimate question but perhaps the student just waited rather than making the effort to get up. All teachers were willing to give assistance, though they resisted giving answers

[72] This begs the question, “If it’s easy, why do it?”

and encouraged students to think about the problem before giving up. Toby, for example, explained that his teacher had said that students could ask how to do a question "*if we really don't get it,*" adding that the teacher would tell them if their answer was right or wrong.

It was common for students to ask a peer for help, and most often they only asked one nearby. When seat choice was up to the student, they sat by their friends so their lack of movement to ask others for help is likely due to the fact that they were already next to the people they were comfortable asking. In classes where seating was assigned, it was more common for students to get up to move and ask a friend, or someone they thought was 'smart' and would be willing to help them (although teachers in these classes encouraged students to first work with their assigned seatmate).

Using an online resource is a potential avenue for students to follow when they need help, and it is a suggestion that many teachers make, but it requires that students have take the time, make the effort, and have the ability to filter through an often overwhelming number of options, as well as the capability to process and understand the information in the format it is presented. Only a few students mentioned using the internet as a source of help. For example, although Max was inconsistent in completing homework, he demonstrated some initiative when he found completing the square difficult. He volunteered, "*I watched some videos online [YouTube] yesterday and I understand most of it.*" Sol, mentioned earlier, had stated that if the homework was easy she would not do it. She added, "*If it's hard I'll take it home and find some sources to learn it. I've found a few YouTube channels actually that teaches stuff*."

**Copying.** Copying is a relatively quick and easy way of completing a homework assignment. There is little positive benefit for students in the way of understanding, yet students still do it, primarily because the homework is worth marks.

When I asked a group of students about whether they had to do the problem set[73] assignment, Toby replied "*Well, technically no, but you don't really want to get zero out of six*." When asked, he freely acknowledged that there was a LOT of copying on these. In

[73] Their teacher assigned one problem set per chapter, due one or two classes following the chapter test.

fact, Toby claimed that the teacher said copying was fine, as long as each student had the answer in his or her own words. Marcus added that they had to understand it, but contradicted that statement by admitting he did not understand a third of the current problem set and he "*completely copied the answer off the guy behind me. I didn't ask him how he got the answer, I tried to do my best to work through it a little bit and write down words, but* …". Both Toby and Marcus admitted that they copied the assignment because they wanted the marks.

### Homework summary: Actions and reasons

An assortment of reasons exists for why students appear to do, or not do homework in class. The weather, level of fatigue and other physiological factors, degree of understanding of the content, degree of difficulty of the material, behaviour of one's seatmate, number of assignments for other classes (and due dates), demands of other activities (athletics, hobbies, work, service), all influenced student behaviour with respect to homework. The following diagram (Figure 4.5) depicts the actions of students and reasons provided for these actions, as provided by students, during the activity setting of homework in class.

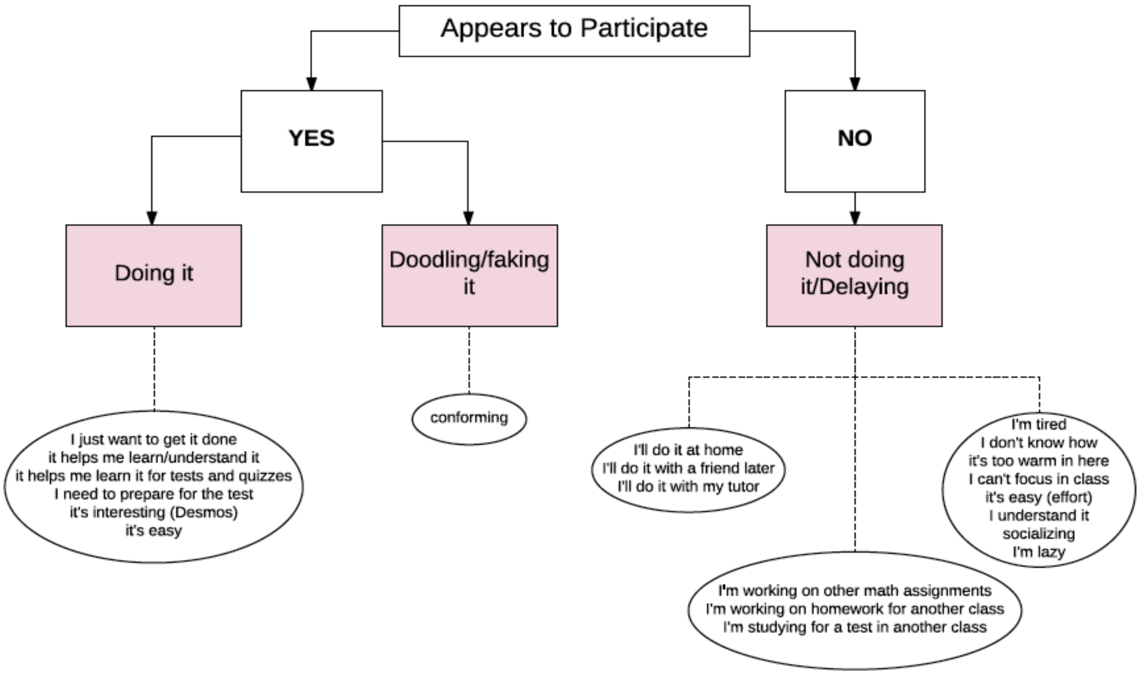


**Figure 4.5 Student reasons for doing or not doing homework in class**

## 4.6 Summary

The four activity settings discussed here were typical elements of classroom life, commonly part of each class period. In each of these activity settings (direct instruction, now you try one, note-taking, and homework) there were multiple students who occupied varying positions on a continuum from not participating at all, to fully participating. The reasons for a given action were sometimes similar, and sometimes different, such as those given for not doing homework (e.g., too tired, other work, doing it with a tutor later), or reasons for writing notes (e.g., it is expected, I need them to memorize, I would be bored otherwise). The intent of gathering and analysing this data is to contribute to a typology of student behaviour in the mathematics classroom, and for later use in determining student motives. At this point not much can be said, as this is only the first chapter of results and only a part of a larger puzzle; or a few short scenes, to return to the movie metaphor.

However, what this first chapter of data and analysis unarguably demonstrates is that there is great variation in student action within classrooms, within a given class period, and within activity settings. In the next chapter I continue to explore student action in activity settings, but in ones that are not typical or occur less frequently in the classroom.

# Chapter 5:

# Less Typical/Less Frequent Elements of the Classroom

> From the actions of the participants, it was clear to me that other intentions often eclipsed their desire to learn the required mathematics. […] Even when students want to learn mathematics, they may intend different things: to be able to perform an algorithm, to understand, or to be able to communicate. (Wagner, 2008, p. 41)

As in Chapter 4, in Chapter 5 I describe and analyse the student conduct within particular activity settings. The activity settings discussed in Chapter 4 typically form the backbone of daily classroom experience, but there are other settings that are considered to occur less frequently in classroom life (e.g., quizzes and tests), or to be less typical aspects of the mathematics classroom (e.g., “real” problem solving). Four of these such activity settings comprise this chapter: “real” problem solving; presentations; review day; and, quizzes and tests. Student actions and comments are provided as evidence; as much as possible I have attempted to provide an *account-of*, and indicate when I am *accounting-for*.

## 5.1 “Real” problem solving

In Chapter 4 I looked at the activity setting “*now you try one*”, which takes place within a lesson. The second type of problem solving, described here, occurred in isolation from the lesson and usually took place at the beginning of class, and is different both in nature and in purpose from the “now you try one” tasks. First, problems of this type tend not to be assessed, at least not using standardized assessments. Second, though they may be associated with the topic of the lesson, more often the tasks have no connection to the curriculum to be presented that day, or even that year. Thus, students are not ‘primed[74]’ for these tasks. Finally, teachers do not usually provide any direct guidance for how to

[74] A student who has been ‘primed,’ in the sense that the term is used here, would have been given recent experience with the particular technique, method, or concept that is relevant to resolving the given task.

solve them. Some generic problem solving strategies may be suggested, such as, "*try a simpler example,*" or "*go look at what another group is doing and see if you get an idea*," but nothing so prescriptive as "*what do they all add to?*", or, "*try making a linear equation*." While the problem itself may not be one a student would encounter in the 'real' world, the intent is that the process and strategies the student draws on to resolve the problem are akin to those they would use to solve a problem they would encounter outside of the classroom. For this reason, I refer to these types of tasks as "*real problem solving*."

It was a common occurrence in two of the three classrooms[75] for the teacher to begin the class with a problem, to be attempted by the students in pairs or small groups. This task was not linked to the topic of the day, but instead was intended to get students thinking, playing, and engaged with mathematics. As one student said, "*They kind of wake your brain up*." These activities were never assessed, in any of the three classes. Two examples of these problems[76] are: "Frogs," and "Seven Rings." Student reactions and involvement with these tasks varied in accordance with intrapersonal and contextual factors. I divide the following into two subsections: student actions, and student affect.

### Student actions

Many students found these problems intriguing, some were frustrated, and others did not value them because they were not for marks. Thus, while some students engaged with the problems wholeheartedly others made little to no effort. There was often great conversation about the problems, whereas for other problems, or for other students, the task was ignored completely. Finally, although some tried and persevered, other students got stuck and waited for their peers to solve them.

In this subsection I have chosen to group student activities by some themes that emerged, rather than solely by exclusive categories of participation. The four themes arising from student actions in "real" problem solving settings are: resisting; talking about problems; persistence; giving up.

[75] These problems were only introduced in the third classroom in the context of the logic and problem solving chapter, making them part of the curriculum and not "real" problem-solving tasks.

[76] Examples of these tasks can be found in Appendix D.

**Resisting or not doing it.** Some students showed little or no interest in problem-solving tasks. Of these, some mustered the effort to participate at a minimum level, going through the motions and providing some support to their partner. Others exhibited their disinterest through obvious disengagement: doodling on the board; working on other tasks like homework or corrections; or, just staring off into space.

One day when I noticed Xander[77] appearing to not do anything, I asked him about what his progress with respect to the problem. He replied, "*I don't even know what the problem is*." I suggested "*the rings?*", to which he responded, "*I don't get it. Like they're interconnected, you're trying to pay the person,*" and trailed off. At this point his partner, Paul, interceded to try to explain the problem, but Xander did not seem to make any effort to make sense of it. Paul, with Xander watching, continued to work on the problem for a short while. Xander then asserted, "*You can't cut gold like that*," precipitating a brief discussion about the softness of gold. Paul tried to get back to the problem, "*Yeah, anyways, forget about that,"* but Xander interrupted, "*Is there any style [of ring] that's made from a meteorite? Maybe a meteorite would be more expensive than gold.*" When asked later during class about why he had not started the problem earlier, Xander said that he "*didn't fully understand the question*" and "*didn't hear all of it.*" He added that he had been "*wishing*" that the teacher would repeat the explanation of the problem because he was distracted. "*I was throwing the marker out and I didn't really catch it* […] *and it's not really an easy question, you know?*"

On another occasion when he was partnered with Sabine on the "Frogs" problem, Xander was observed to be doodling on his desk. When I approached they were engaged in an argument about what Xander's doodle looked like. Listening for a minute, I suggested to Xander that he had let Sabine start trying the problem without him, which he denied. "*No, we were both working on it a minute ago. I was drawing a frog to open up my mind*." He explained that doodling helped him because it "*passes time*" for him, adding, "*I can still pay attention while I'm doing it*."

In the two excerpts, above, Xander's comments could be taken at face value, however, when considered with other comments and compared to his actions in many other "real"

[77] Xander's behaviour is discussed in greater detail in Chapter 9.

problem solving settings, it appears that Xander did not take the problems seriously, tended to delay starting them, and was easily distracted, often trying to distract his partner from the task at hand.

Mika, also, appeared to resist starting the problems. On more than one occasion Mika only began to work on a problem when the teacher or I was in proximity. During the "Frogs" problem I noticed that Mika seemed to not be paying any attention to what his group was doing. I went over to sit next to them, as Mika announced, "*I just killed that frog and jumped over him."* As I sat there, Walter and Mika worked on the problem for a few minutes. I asked Mika why he started to work when I came and sat down. "*I think I was, I was thinking of an idea and realized that six frogs is too hard and we decided to move on to three… and…well…let's move on to one and go back to three later*." In my interpretation, Mika was not being serious about thinking of an idea – it was clear to me at the time that he was just making an excuse for not starting. His comment about moving on to one frog[78] suggests that he was not taking the problem seriously.

Among other topics, I asked one focus group about student behaviour in the "real" problem solving settings. One question I posed concerned why some students would not engage with the tasks. A student in the focus group offered that it depended on how one felt that day. "*Sometimes I just don't want to do anything. So if you don't have to do this, it's not for marks, then you just don't do it*."

**Talking about the problem.** Some problems provoked a lot of student discussion. Students talked about strategy and about particular methods or techniques for solving the problems. Below, I offer excerpts from some of the transcripts to illustrate.

Doug and Ryan were working on the "Frogs" problem and offered to demonstrate a pattern they found for solving it.

| | |
|---|---|
| Doug: | Okay, let's just start with two. |
| Ryan: | You don't want to shift everything to one side until you can't do anything. |
| Doug: | Wait. I just got this mixed up. |

[78] The teacher had suggested to the class that they could simplify the task by reducing it to three frogs on each side instead of six, but Mika's suggestion of trying only one frog makes no sense.

Ryan: I think it was like, move this one, move this one…

Doug: And that works for everything [for any number of frogs]. Just upscale it.

This problem got a lot of students talking. It is also of consequence to note that Doug and Ryan not only solved the problem; they OFFERED to demonstrate their solution, and to explain HOW they solved it.

In another class, Toby explained his strategy for winning a game similar to "Nim[79]".

> See, I think I always win. Because you put down two, if you put down two, I put down one, you have to put one down. You put down one, I put two, you have to put down one. So no matter what I win in this situation.

Toby and his partner appeared deeply engaged with the problem and were explaining their reasoning to one another.

In comparison with other classroom activity settings, "real" problem solving was unique in that it was the only time that students seemed to *volunteer* to explain to others – as opposed to being *asked* by the teacher, or a peer, to justify their reasoning or explain their method. The students that did it seemed to take pleasure not only in figuring out a solution, but also in being able (and having the opportunity) to explain it to others. As one further example, Mika and Jineane were working on the "checker problem" at the beginning of class one day. After a period of sustained effort, they solved it, drawing the teacher's attention with their resulting excitement. The teacher asked Mika and Jineane if they were interested in explaining it to the class, and they were eager to do so.

The final two themes concern student responses to being stuck – they either persisted, or ultimately gave up.

**Persistence and engagement.** For some, the problem-solving tasks were a real challenge and a welcome change from the more "formal" mathematics done in class. Many students would persist with these tasks whereas they would not for a more traditional task that linked to the lesson topic. For example, Rory, when asked about the problem-solving

[79] "Nim" is a game of mathematical strategy. Its origins (and its variants) are said to reside in China. For a detailed explanation of the game, see Appendix D.

tasks shared, “*Sometimes I don’t get them of course but I’ll keep trying*.” In fact, some students actually improved their persistence over the semester.

A few months into the course, having started every class with a problem-solving tasks, the teacher spontaneously complimented the students. “*I have to say I’m impressed with your persistence. I don’t think a couple of months ago you would have stuck at it for so long*.”

Noticing Mika and Jineane were not immediately successful with the “checker problem” (mentioned above), I asked Mika how they were doing.

| | |
|---|---|
| Mika: | Oh, it’s going good. We are trying to find a pattern. Cause like, with puzzles there is always one so we’re focusing on that. |
| Jineane: | Maybe if we try that…. |
| Mika: | We tried the middle, the corners |

As they tried different approaches they said “*no, that doesn’t work, that doesn’t work, it doesn’t work, it doesn’t work, no you can’t do that…”.* They were engaged with trying many different things (not just repeating the same failed approach). They used and spoke of at least one strategy; looking for patterns. As mentioned above, their persistence paid off. Perseverance did not guarantee success, however, as Todd experienced with the “Frogs” problem. Despite repeated unsuccessful attempts he was not dissuaded him or less interested; though signalled his frustration when others were able to solve it and he had not[80].

This type of engagement can be referred to as a state of ‘flow[81]’ (Czikszentmihalyi, 1990). In the observed classes, students in this state demonstrated excitement and ownership of a problem. They did not want to put a problem away – not because they wanted to delay a lesson, but because they were so engaged with the task. The teacher often had to come around and collect the manipulatives, forcing students to ‘shelve’ the problem.

80 Todd’s experience is discussed in detail in the later subsection on student affect in problem solving.

81 ‘Flow’ is the mental state of being fully immersed in an activity, accompanied by feelings of energized focus, full involvement, and enjoyment. One is completely absorbed in what one is doing. Flow has been correlated with positive affect, increased persistence, and some studies suggest better performance although the findings here are mixed (Landhäußer & Keller, 2012).

However, an individual might deeply engage in one problem, but not the next, and not all students persisted in any given task. When asked to play (in pairs) a strategy game with 20 counters, students engaged in playing the game, but got bored after a few rounds. None of the students really seemed invested in wanting to win the game or in trying to find a strategy to help them win. Michelle asked, "*I won twice, do I have to play again?*" When asked how she won, she explained, "*You just wait until three, no four, then take one".* Her teacher plunked the collection of twenty counters in the middle of the table and challenged, "*Win*". Michelle still was not interested in trying to find a long-term strategy. She exhibited this behaviour more than once; for another task she stopped after she found a few counterexamples, telling the teacher when he came by that they were "*done*" and had "*found one*." Responding, "*There are a lot. I need you to find a pattern*," he moved off, after which Michelle returned to the task for a short time, but was unable to find the pattern.

**Giving up.** The final theme explored in this subsection on student actions in "real" problem-solving tasks concerns students who genuinely attempted tasks, but got stuck. When this happened they either: persisted (see above), got help and then gave up, or just gave up as soon as they encountered difficulty. Students' reasons for giving up on a task are loosely organized below by: time factors and other priorities; discouragement after repeated unsuccessful attempts; and, confusion.

When asked about his attempts to solve these types of tasks, Richard shared, "*I try them, then if I don't get them in like the first five minutes I stop*." Tasha also gave a five-minute time limit for the duration she would try a task before giving up. She explained: "*The thing is, they're fun to do and once you start it you kind of want to go at it but when you realize you have a lot more work to do, you put the other priorities first*." For Tasha, these priorities were doing homework or studying for a quiz or test – she prioritized work that was for marks, or was more related to learning the curriculum to be tested. Marcus agreed with Tasha about having other priorities. When these students hit a roadblock, they chose to abandon the task in favour of continuing with other assignments, rather than persisting with the task or getting help.

Mika and Zack, too, chose not to persist with these tasks. Over the semester they did not seem interested in trying to seek help to solve any of the problem-solving tasks[82], nor were they particularly receptive to help being offered. However, unlike the aforementioned students, they did not cite other priorities as a reason for disengaging. There were several instances when Mika seemed disinterested in the task, but rather than working on other assignments he prioritized socializing with other classmates.

Limited time and prioritizing other activities was not the only reason students did not persist when they got stuck. When I noticed Kyle sitting while others were working on a problem I asked him if he typically tried the "starter" problems. He replied: "*Yeah, I tried it once but couldn't…a few times actually but I didn't get it".* In this instance, Kyle had tried the problem and after a few failed attempts with little to no progress and no assistance he gave up. During a focus group session, I observed to the interviewees that a few of their classmates seemed disinterested in the problem-solving tasks. With this prompt, a few participants shared other reasons they, or their peers, might give up. Sol thought people would give up, "*if it gets too hard*," and Jineane added, "*Or if it gets too frustrating*." Although he did not feel this way, Todd shared his thoughts on how others might view the problems: "*Some people think 'oh, it's extra credit,' it doesn't really matter at all, plus this is like, frustrating me, so why should I do something that really frustrates me?"*

Another example of giving up due difficulty encountered when trying the problem occurred when a teacher demonstrated the 'proof' that 1 = 2 and challenged students: "*if you don't believe it, find out where the error is.*" The majority of the students seemed intrigued with the task, knowing that there had to be a mistake somewhere, but they appeared confused and frustrated by their inability to find the error. They seemed to think the teacher was tricking them, and some students gave up and started chatting.

Finally, some students gave up or completely disregarded a task because they did not understand the problem. The initial struggle to even grasp the details of the problem seemed to turn some students off. One example of this type of problem is the "Die Hard[83]"

[82] Except the checkers problem, when Mika worked with Jineane.

[83] This was the name the teacher gave to the task. The full problem is in Appendix D. The abbreviated version is, "Given a 3 cup, a 5 cup, and an 8 cup container, how can you precisely measure out 4 cups of water?"

problem. For this problem students were given small connecting blocks and paper to model the task. One group of three did not really understand the details of the given task, even after receiving additional explanation. After some help they were able to understand what the question was asking, but ended up shifting blocks around in the same way, getting the same result again and again[84]. I tried to prompt them by providing some suggestions, but either these were not helpful, or possibly their confusion with the task had coloured their engagement with it and they were no longer interested.

### Student affect

Student affect with respect to the problem-solving tasks ranged from ambivalence to strong feelings of excitement or intense frustration.

There was a lot of evidence that many students felt ambivalent about the problems. Xander is one such example. He explained how he viewed the tasks: "*Some people would rather prefer to have more time on the lesson and not to do stuff like that.*" However, he did acknowledge that not everyone shared his feelings, adding that, "*other people would like to have their brain kind of put into action*."

Though Xander was far from alone, there were also many who seemed to have strong, and often mixed, emotional reactions to the problems. These students found the tasks intriguing and enjoyed doing something different, but experienced strong negative feelings if they were unable to solve them. To illustrate students' feelings about them, I offer some comments students shared during a focus group interview.

Toby generally liked the problems and found them fun: "*Cause like wow, I'm good at this, I got the answer, that wasn't even that hard*." In the same session, Tasha described the problems as "*the fun stuff*," that "*doesn't have anything to do with the rest of the lesson*." She found that these types of tasks were "*de-stressing*", unless she couldn't solve them. When they did "*get them right*" they experienced strong positive emotions: "*You're like, yes*!", exclaimed both Toby and Tasha.

[84] They exhibited functional fixedness – for more on this see Ashcraft (1989).

As mentioned by Tasha, another attraction of the problem-solving tasks was that it was something different (from the typical classroom experience). Todd[85], who was generally distracted during class, really got involved in the problem-solving tasks. He saw typical classroom mathematics as "*just a bunch of numbers written on a board*," but problems were different. "*With problems it's actually like, theoretically and you're doing stuff – with the skyscraper thing, that was awesome because we actually got to see, like physically see what was going on*."

Another reason students shared for liking the tasks was that if the problem was interesting time passed quickly. Toby explained, "*because you look and half the class is gone and that's pretty good*."

But when they did not get the answer or get stuck on the problem, they experienced negative feelings. After stating he liked them when he solved them, Toby added, "*but then when you don't get the answer that's just, that's no fun*." Tasha agreed, and Marcus did not seem like the problems. He found them deceptive because at first glance "*they seem rather simple*" but then "[when] *you start looking into it* […] *it can be a bit of a nightmare*." He acknowledged that difficulty was okay, because "*you're supposed to be thinking more critically*," but felt he was not "*mathematically inclined,*" and this explained his difficulty with the tasks.

None of these, however, can compare to how Todd felt when he had an unsuccessful problem solving experience. As he and Jineane were working on the "Frogs" problem, I joined them and asked how it was going. Todd announced, "*I'm going to have a heart attack*." Both he and Jineane expressed that the situtation was "*stressful*" because they had not yet solved the problem. When asked why he felt stressed, Todd answered, "*Cause I need to figure it out. I've never not finished one*." His "*perfect record*" was in jeopardy and at this point the teacher interrupted to tell the students to finish up. Todd kept trying but had little hope: "*Now we're just 'hail-marying' it. We're not going to figure it out*." When another group announced that they had solved it Todd exclaimed, "*Oh I hate you! I hate you. I've finished more equations than all you guys put together*." In another conversation

[85] Todd's engagement with the problem-solving tasks is particularly interesting because he was usually distracted in class and didn't do much work. His actions are discussed in greater detail in a case study in Chapter 10.

at a later date, in talking with Todd about puzzles and problems he blurted: "*Puzzles! I figured out like every puzzle, except that stupid pen cap one* [Frogs]". His unsuccessful experience with the task had clearly left an impact.

## Summary

"Real" problem solving is an activity setting in which a student's true colours were brought to light. When the material is not to be tested and the tasks are 'real' problems that often require perseverance, ingenuity, and effort, some students' goals become easier to identify. For example, a student who values marks above all else is more likely to refrain from participating in this activity if they have more 'important' things to do, as compared to a student for whom marks are lower on the goal hierarchy.

In this section I discussed some broad themes for student behaviour in the context of "real" problem solving. The diagram below (Figure 5.1) depicts the actions and possible reasons for these behaviours, and an explanation follows.

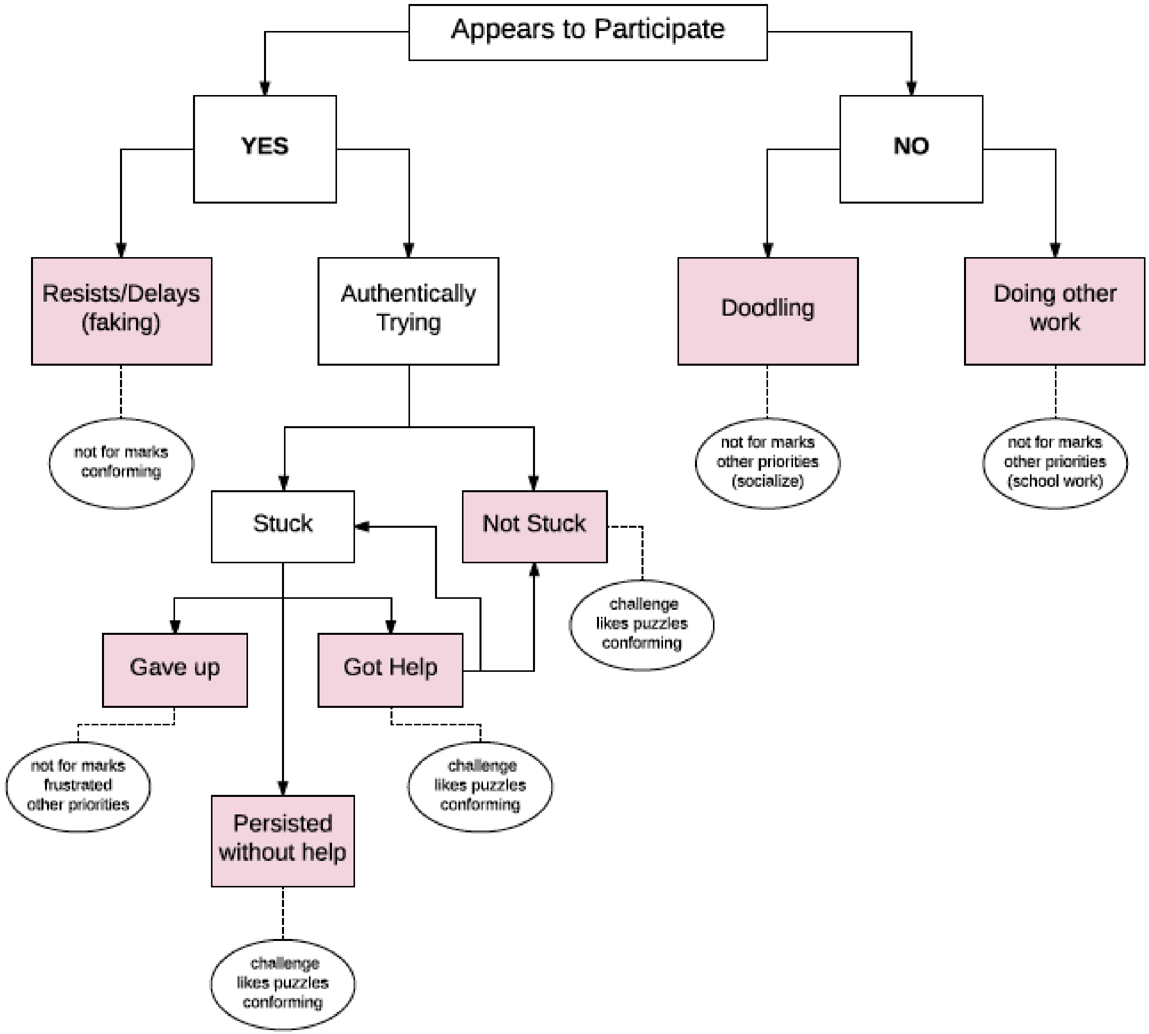


**Figure 5.1 Student reasons for actions during problem solving**

Considering all observed student actions during these settings, students exhibited one or more of the above behaviours, classed first by whether students appeared to try, or did not appear to try. If students did not try at all, they were either doing other work (a semi-legitimate[86] activity), or occupied with some other non-legitimate activity such as: doodling, using a phone, or chatting. Students who appeared to try were either faking participation by resisting or delaying, or were authentically trying. Those who tried were either got stuck or did not. If they got stuck, some persisted (possibly seeking help), and others gave up. The reasons are suggestive of student goals. Students' affective experiences with these tasks also provided insight into their goals.

86 For more on semi-legitimate and non-legitimate activities, see Shannon (2009).

If we consider the possible reasons underlying student conduct during these tasks, there are several potential explanations for participating, or not participating.

For example, the goal of students who authentically tried to solve the problems could have been to conform to teacher expectations (to please the teacher or avoid negative attention), or to solve the problem because they enjoyed the challenge (some students liked a challenge and/or liked puzzles). Those students who did engage deeply with the tasks often experienced strong emotional responses. Whether they loved them or experienced significant frustration, they displayed significant interest in solving them – at very least indicating that their primary goal, at that time, was not marks. They truly wanted to solve the task. Students who were less emotive or who for whatever reason disengaged early held a variety of other goals.

Problem solving was one of the settings in which students made less of an effort to fake engagement (although some did delay). If a student delayed at the start or during the task, he or she was likely uninterested and only faked trying it to conform. Possible reasons for not trying appeared to be because it was not worth marks, not relevant to the topic (and thus not likely to be on the test, and thus indirectly worth marks), and other reasons similar to those for not participating in other activity settings.

## 5.2 Student presentations

Student presentations[87] in most high school subjects tend to have some common features. Students work in pairs or groups (assigned or by choice); topics are decided (assigned or chosen); there is a period of work time (in and/or out of class time); students present their topic to an audience consisting of the teacher and other classmates; and there is usually some form of assessment (by the teacher and/or peers).

While student presentations in a mathematics class can share many or all of these characteristics, they may differ from other those in other subject areas with respect to the topics being presented. For example, in a Socials class, students usually present on

[87] The type of 'formal' presentation, discussed in this section, differs from the type when students are asked (or volunteer) to explain (with little or no preparation) how they solved a problem that was assigned to the whole class.

different topics, whereas in Mathematics class it is most likely that all groups are presenting on the same topic, or even the same type of question (such as different versions of problems utilizing the same or similar solution methods). Further, in a Socials class the content presented by students may not have been covered during class time. It is common for students to be assigned (or choose) and research a topic that their peers have not encountered. This makes the presenters the authority on the topic in the classroom. In Mathematics, by contrast, the topics students present on are likely to have been already introduced by the teacher, or will be taught in class at a later date. Their presentations are intended to introduce, review, or reinforce a concept that is part of the curriculum. It would be very rare for a group to present on a topic with which the majority of the class has no experience.

When students present to their peers they are forced to "*raise the register*[88]" (P.Liljedahl, personal communication, October 10, 2013). At the level of collaboration, students use a much lower register than they do when they are presenting to their peers, but they present at a lower register than when they are writing mathematics.

I offer the general comments about presentations to provide some context what follows. Now I will describe the format of and process by which the observed presentations were conducted, then discuss the presentations with respect to the audience and the presenters, and summarize with some comments about the benefits of presentations in mathematics class.

## Overview of format

Students in one class were assigned word problems in groups of three and given class time to work on them. Though each problem pertained to the same topic (logic and reasoning problems in one case and quadratic equations in the second) the actual problems were unique to each group. At the start of the following class, the teacher gave them some more time to prepare and some direction, telling students that their role was that of the teacher. "*You're explaining how this happens and you need to make it as clear*

[88] The term 'register' refers to the level of formality of the language used.

*as you can."* He then gave them five minutes to plan how they were going to present to the class.

One group volunteered to go first. Each presentation began with a group member reading the question for the audience. Then, a second group member explained the procedure, while the first or third member showed the group's work using the document camera. The teacher interrupted frequently to ask questions, and provide guidance to the group presenting, for example, asking them to slow down and give more detail and explanation as to why they had proceeded in a particular way. He restated explanations for the class, often in clearer terms. Occasionally he also had to point out errors in the students' solutions. Periodically he checked in with students: "*Is that making sense, Tiffany?".* Students usually replied in the affirmative, though their blank looks made it appear some or most of them did not really understand.

It was rare for students to ask questions during these presentations. One exception to this was Meghan, who asked a question about the location of the vertex when Stephen was presenting. This indicated that she was following along and attending to the explanation.

### Comments on the audience and on presenters

While their peers presented, the audience appeared to be paying attention and following along, yet from my perspective it seemed doubtful that the students could follow the explanation, or even if they could follow it they would likely be unable to do a similar or identical question without help. For example, the solution presented by Stephen's group particularly hard to follow. The work presented using the document camera was written in all different directions, all over the paper, so that the sheet had to be turned multiple times throughout the process. One student's reaction was: "*Wow*", and "*Oh my God*", as they tried to comprehend the scrawled notes going every which way on the paper. At one point, the teacher said: "*Wow, this is tricky. Where are we? What are we doing here?"* Since Keiran was presenting Stephen's work[89], he was unable to point to the location of the part of the solution under discussion. The audience, and the group, even had difficulty identifying which form of the quadratic function they were using. This could point to their

[89] Stephen was the only member of the group who actually did the problem, and he used a method from physics rather than the process or concept they had learned in this class.

general lack of understanding, but it is more likely indicative of their inability to follow the explanation. After the teacher had repeated the question at least twice, and reminded students that they had learned the particular form two days ago, somewhat hesitantly someone volunteered: "*vertex?*" After ten minutes of presenting and re-explaining, the final group was asked to present. The teacher suggested that this group's question would be "*less intense*" than Stephen's.

One unfortunate aspect of these particular group presentations was lack of accountability. Tyrone and Morgan allowed Melissa to solve their assigned problem after they had struggled with it on the day it was initially assigned (Melissa was absent). Melissa ended up explaining the solution during the presentation while Morgan and Tyrone wrote it out and asked if anyone in the class had any questions. In another group, Stephen certainly understood what he had done to solve the problem, but Keiran and Tiffany just as clearly had as much or more difficulty following his explanation as the rest of the audience. Scott and Maria shared an understanding of how to solve their assigned question, but the third member, Emily, was only tasked with asking the audience if they were keeping up "*alright*". The teacher had to remind her to do this multiple times.

### Summary

On the two occasions I witnessed student presentations in the class, both times it appeared that students gained little to no mathematical benefit from the exercise. Doing the problem itself may have been of benefit however, some group members were unable to solve the prescribed task using the procedures introduced in class, or even at all. Stephen solved his groups' question by using his graphing calculator and methods he borrowed from physics, but his solution was inaccurate. Morgan and Tyrone were not able to solve their question or follow Melissa's solution to it. The audience gained even less as they were tasked with trying to follow a solution that even several of the presenters didn't really understand.

All of this is not to say that presentations in mathematics class have no benefit to students; but as this was the only class that used them, I have to base my analysis on these observations.

## 5.3 Review day

It was common for the three teachers to schedule a 'review day' for the class period preceding a chapter or unit test. An individual student's actions on these days often differed from his or her typical behaviour during a regular class period. This was potentially due to the reduced structure on these days, with the exception of the games and teacher-led review, described below. The format of a review day had slight variations, but overall there were general similarities across all three classes. It often began with a fifteen to twenty minute teacher-led review of the chapter, usually with a sample problem from each section of the unit. Following this the remainder of the class would be given to students to work on assigned questions from the textbook for practice, or to work on old assignments.

This section is split into three activity settings: the teacher-led (lesson style) part of the review; games (game-show style and group activities); and, the independent seatwork portion. In each section I have included observations from one or two classrooms, but not all three, as each type of review was not observed in each classroom[90].

### Teacher-led review

A common practice for teachers on a review day is to try to guide students to organize and structure their studying for the test. Often this involves reviewing examples of problems from each section of the unit, particularly those that 'might' appear on the test. Two teachers used this type of review at least once, but it was not observed in the third class.

One teacher usually[91] spent a review class working through problems with students. He wrote questions on the whiteboard one at a time and solicited student help to work through them. These questions were representative of the key concepts to be assessed on the test, and usually were of a similar format to the actual test questions. Student participation

[90] Review days occur more rarely than typical activity settings (such as 'notes' or 'homework). As a result I was unable to arrange to observe every classroom on a review day. One teacher had only four unit tests over the entire year, so review days were rare.

[91] Once, he had students do review questions in groups and present the solutions on the following day (the day before the test). The audience was expected to follow along and take notes. This was discussed in the preceding section on student presentations.

in these reviews varied and their actions during a review sometimes differed from their behaviour during a regular lesson. For example, three students who normally took notes during lessons opted to not write anything while the teacher reviewed what to expect on the test and went through examples. Tiffany provides another instance of a minor departure from typical conduct during a lesson; usually she hid the fact that she was texting during class, but during this review her cellphone use was not concealed as carefully. The majority of students, however, appeared to pay attention, although not all volunteered answers or tried the problems on their own. A few students volunteered answers several times, whereas others appeared to try every question but chose not to share their thinking or results unless they were called on. Typically the volunteer provided a short response to the teacher's question, or gave step-by-step directions for the teacher to follow to solve the problem. In the process of solving the teacher asked procedural questions or definition type questions, e.g., "*What do we do next?",* "*What is the axis of symmetry*?", and, "*What form is this?*" More rare, open-ended questions included ones such as, "*What can you tell me about the graph?"*

Sometimes students asked questions, usually regarding whether a particular concept would be tested or if a formula would be given. Meghan's question is typical: "*Is standard form on the test?".* Other queries can be classified as clarification questions: "*How do I do that?*", or, "*Which form is that?*" Scott, however, once asked an extension question: "*If you gave us those two roots, how would you graph it?"* Sometimes students were so busy writing that it appeared they had no time to try the problems on their own[92].

## Games

Games can follow a teacher-led review, or be used as an alternative. Two types of review games were observed in the course of this research: first, game show style, which is led by the teacher and involves teams of students competing to answer a series of questions under some sort of time constraint; and second, group or partner activities, which are not generally subject to time constraints and require students to solve a puzzle or task using

[92] See the section on "taking notes" in Chapter 4 for more about this tension.

the concepts and procedures covered in the current unit. One of each type is presented below[93].

**<u>Game show style.</u>** A few months into the semester the teacher introduced a game he called "Questions for Candy". This was played at least twice during the semester; the first time taking place as review for the unit on geometric reasoning and proof. Students grouped themselves in twos or threes and came up with a name for their team. Teams earned points for answering questions correctly, and once a certain number of points were accumulated, the team got candy and their points total was reset to zero. Rather than taking the first responders, the teacher waited until three or four groups had raised hands and then selected a team to answer. Students were permitted to use their notes, textbooks, or any other resources they had at hand. Interestingly, most students supplied reasons for their answers though the teacher did not explicitly require this. Many students used their calculators to guess and test. This was not an entirely successful strategy as it frequently took more time than it would have if they had worked through the problem (assuming they knew how to do it).

Most appeared engaged with the game, although several students were not able to answer many, or any, of the questions. The game was a novelty for them and they enjoyed it, sharing that they felt they paid more attention then they usually did on a review day. Scott liked the game because he, "*get[s] bored just doing it,*" on his own. Morgan commented that he, "*like[s] those team things,*" to which Keiran gibed: "*that's the only way you can get him to work.*" However, it appeared that they did not all feel it was a helpful review for preparing them for the test. Chelsea appeared unsure: "*I think it helps,*" and Jake paused before he added, "*Yeah. Sort of*." Maria liked the game but felt, "*it would be better if we had stuff that we didn't already know how to do so we'd know how to do it.*" She also conceded that she had difficulty following the questions because the game moved too fast and she would have preferred to have a sheet with the questions in front of her. Usually quiet and keeping to himself, Turk stated that he enjoyed the game and said he learned, "*a bit*." He laughed when pressed to explain what he had learned and supposed he might have learned a bit on the last question. Stephen's judgement was that

[93] A third type, similar to the group task style of review, is a group presentation. Students are asked to solve a more difficult question from the unit and then to present the solution to the class. A section on student presentations can be found earlier in this chapter.

the review was "*alright*": the candy was a good incentive, but the review "*didn't cover the basics.*" The material was, "*pretty fresh in [his] head,*" so he did not feel that he learned anything. The competitive aspect appealed to the majority of the students, as did the candy prize, with Melissa being a notable exception. Her comment, when asked about her experience, seems derisive: "*It's ridiculous, you know, people get worked up over such a silly little game. I can understand how* some *kids like it.*" She would have preferred to do the review on her own. Meghan felt that she too would have preferred to review on her own, because she would have accomplished more.

Although much of the above concerns more what students *said about* the game rather than what they *did* during it, there is merit in considering their comments as it points to their goals and reasons for participating. There was widespread engagement with the Questions for Candy game, but the students' comments imply that they were hesitant to say that it had helped them learn or prepare for the test. So while the game had a positive affective component for most of the students, from the students' perspective, and my own, it seemed to be less successful as a learning activity.

**Group puzzle or task.** Another teacher also introduced a game or activity for review. She handed out photocopies, scissors, and tape for pairs of students to work with on the day prior to the sequences and series unit test. Students were tasked with cutting out triangles and trying to make a hexagon with them, with some conditions. Each edge of each triangle had a term, a sum, or an expression for an arithmetic or geometric series or sequence. The goal was to match the edge of one triangle with the edge of another with the same value. For example, if one edge had $1 + \frac{1}{2} + \frac{1}{4} + \cdots$, that would align with the edge showing $S_\infty = 2$. However, instead of a sum, the corresponding edge might show $t_6 = \frac{1}{32}$. Unfortunately, there were errors on the handout, which the teacher found and pointed out to students, but this added an element of confusion to the task. Many students, such as Beth and Chloe, appeared overwhelmed and unsure of where to begin. The teacher suggested students begin by organizing the pieces, and then provided further assistance by identifying the triangular pieces that formed the outside perimeter of the hexagon. She shared with me that she was worried that the task was too difficult and too long, but had only realized this after she had given it to students.

Although initially students appeared engaged, few groups made any progress, and it was not long before many began to do other things such as play with the scissors and stare off into space. Many expressed confusion; Beth, in particular, shared that she had difficulty with the task: "*It would be frustrating if it was for marks*. *It's just a long tedious process of flipping, flipping, flipping.*" Beth's statement contradicts her actions, however, as she was just sitting, not 'flipping' or otherwise moving, which was the reason I approached to talk to her. Noticing that Slav and his partner, Marcus, had stopped working I asked them if they had given up. Slav replied, "*No, we have it all right here*." He showed me his hexagon, but they had made the shape without attending to whether or not the sides of the triangles matched up. I commented on this and Slav admitted, "*Yeah, we got the shape, but* [the expressions on the edges] *don't match.*" When I asked if they were going to continue, Marcus conceded: "*Probably still should try. Should we?",* he asked Slav. They began to try to pair edges again, but seemed to be going about it without any enthusiasm.

This game activity differed from Questions for Candy in design and in how the students participated. Students worked in partners instead of groups of three or four and there was much less of a competitive aspect. There was initial engagement with the review activity but many students got frustrated with the amount of work that needed to be done to find even one pair of matching edges. This led them to give up working on the task, or, in the case of Slav and Marcus, to faking progress.

### Self-directed or peer-directed review work

Although the intention is still that the material is reviewed, and students can work together, this type of review differs from a game style partner task. Self-directed and peer-directed review includes situations in which students are given a review assignment (textbook questions or a worksheet), and/or students can choose to work on reviewing the unit material in whatever way works best for them (reading notes, practicing example from the lessons, looking over old homework, etc.). The time given for this type of review can extend to a full class period, or be only five or ten minutes depending on what the teacher chooses to do and how the class period unfolds. Here I have included a selection of data from a review day in one teacher's class. Following these observations is a short section with students' thoughts about review day. On this particular review day, the teacher began the class by leading students through what the teacher indicated were carefully chosen questions.

Following the direct review, the teacher assigned textbook problems for students to practice individually, or in small groups (depending on individual preference). He advised students to: "*Focus on questions you need to, pick and choose, do the ones you struggle with,*" and, "*make sure you can do the quiz questions well*.*"* He encouraged helping each other: "*That's why I gave you the question as a group. I want you to struggle through those things together rather than me telling you what to do."* He also indicated that he wanted them to do what works for them. "*I want you to take responsibility for what works best for you. I don't want you to - bust your butt to try to finish all the questions here and you're not understanding [the questions you're doing]."* Although each homework assignment was collected and marked, the teacher announced that the review he had assigned could be used to replace an older homework assignment, because he wanted them to use their time well.

In this setting students had a greater range of acceptable tasks: reading notes, completing past assignments, doing assigned review problems from a booklet or the textbook, and even sometimes working on assignments or studying for other subjects. Candace chose to use the review time to rewrite a quiz. This was common in this class; students often used review days to rewrite tests and quizzes that they needed to make up, or needed to improve. It was a bit like a 'catch-up' day. Tyrone, for example, asked, "*What do I need to do to make up the Chapter 4 test?"*

After 'releasing' the class to work on review, the teacher typically circulated, responding to student questions about missing assignments, what might be on the test, or about how to do specific questions. He also checked in with students, asking: "*Do you need help? You're doing okay?"* Sometimes this was a method of trying to get students to focus on their work. It was not always successful. Candace replied in the negative, and then she went back to chatting. Melissa managed to tune everyone out and focus on her work by putting on headphones. Meghan was packed up and playing a game on her cellphone, but stopped when the teacher started writing important terms to know for the test on the board. Some students did not even come to class on review day, perhaps because they thought they would not miss anything (no new content) and would not have to catch up;

some students implied that it was more efficient for them to review on their own. Neil, on one review, did not show up to class until there were only twenty minutes left[94].

I asked students to complete a survey[95] on their review practices in and outside of class; their answers for the most part coincided with my observations during class. Jake, Chelsea, Turk, Stephen, Neil, Melissa, and Maria wrote that they would do the assigned review questions. Although Candace, Emily, and Tyrone also wrote that they would do work and get help, I frequently noticed them chatting instead of doing work. Their actions contradicted what they wrote on the survey. Others chatted, but those students divulged that fact in their survey response. For example, Scott, Morgan, Meghan, and Keiran indicated that they would do some work, but were also likely to chat. Keiran, in particular, noted that he would: "*try to do my assignment usually but sometimes I just get destracted* [sic]." One student, Tiffany, did not complete the survey despite my numerous requests and reminders, and her assurances that she would[96].

**Student comments on review day.** The purpose of this section is to shed some light on the reasons underlying student behaviour on review day. There tended to be a lot more chatter on these days and significantly more 'goofing off'. I asked students about this phenomenon and they provided honest, and sometimes illuminating responses.

Chelsea described review days as: "*less strict than a 'normal' day.*" Tyrone shared that on a review day: "*If we already understand it we usually just end up sitting here and talking*." Tyrone was referring to Morgan and Keiran as well, who generally had a weaker grasp of concepts and would be drawn into conversation even if they did not understand the material. This concurs with Keiran's earlier comment Morgan not working except in the 'Questions for Candy' game. When asked about his conduct (not working) Keiran suggested he would, "*get it done before next day*" if he was going to do it. He added, "*Well, I'm probably going to come in too before the exam next week*" to ask about *"whatever I*

[94] It is possible that Neil came only to get the important information about what would be on the test and any other last minute details.

[95] See Appendix B.

[96] In my opinion, Tiffany would have written what she thought she 'should' have (that she would do work, and get help if she needed it), but if she had written this, her actions were contradictory.

*didn't understand*." Tyrone, also not working, commented: "*Today's the last day of school too*."

I continued to press, trying to get at how review day was different from the time provided for individual work at the end of a regular lesson. Were they allowed to work together more than on other days? Morgan said he did not know. I also suggested that perhaps the reduced productivity on review day was because students thought they already knew the material and had not been given anything 'new' that day. Neither Keiran nor Tyrone was able to provide a reason. "*Sometimes you do [work] and sometimes you don't. I don't know."* Tyrone agreed, "*Yeah, I don't know."* Keiran volunteered a bit more: "*Well, I know how to do some stuff like this. Sometimes if you have a hard one* […] *you actually do it, but if you have one that's not as difficult you might* [not]."

To the same question, Candace thought it was because there was "*not as much direction on study days. 'Cause when you have things that you have to get done boom boom the next day, so you have to do them, so we actually have something we have to hand in*." The fact that the review booklet was "*not for marks*" influenced her efforts on these days.

Neil explained: "*It's just … you don't really have your brain going at this time. You're not really worrying about later on*." He thought it might be the amount of time given as well: "*We have so much time it's like* 'I'll get it done the last day' *and won't worry about it until then."* Melissa, too, commented on the lack of urgency felt on a review day in comparison to a regular class, resulting in lack of productivity.

However, unlike Candace, Melissa did not see any difference between a review day and a normal class with respect to student socializing. Her rationale for this is insightful: "*Social status is more important than education*." She continued, sharing that the chatter and lack of productivity I was referring to happened a lot in her other math class (she was taking PC 11 concurrently). In contrast to her conduct in FoM 11 (head down and working on her assignment), in PC 11 she stated that she was in the half of the class that "*never does anything*." She said she tries (to work), "*but … friends get distracting*." So, while in one mathematics class Melissa was able to focus, the presence of her friends in her other class significantly affected her productivity.

The students who were productive and found the review day useful were in the minority. Meghan found review classes useful because: "*I figure out what I struggle with*." Stephen, Melissa, Maria, and Meghan were the only students out of a class of fifteen who consistently appeared to accomplish anything substantial on a review day.

## Summary

Review days come in several forms. Three of these were discussed in this section: teacher-directed review; group activity (game show and single task); and self-directed or peer-directed review. Student behaviours vary according to the type of review, and under the influence of many other factors.

The three diagrams below (Figure 5.2) depict student behaviours in each of the three types of settings: teacher-led review, game-show style, and individual/partner work (single-task game style and student-directed review are paired here).

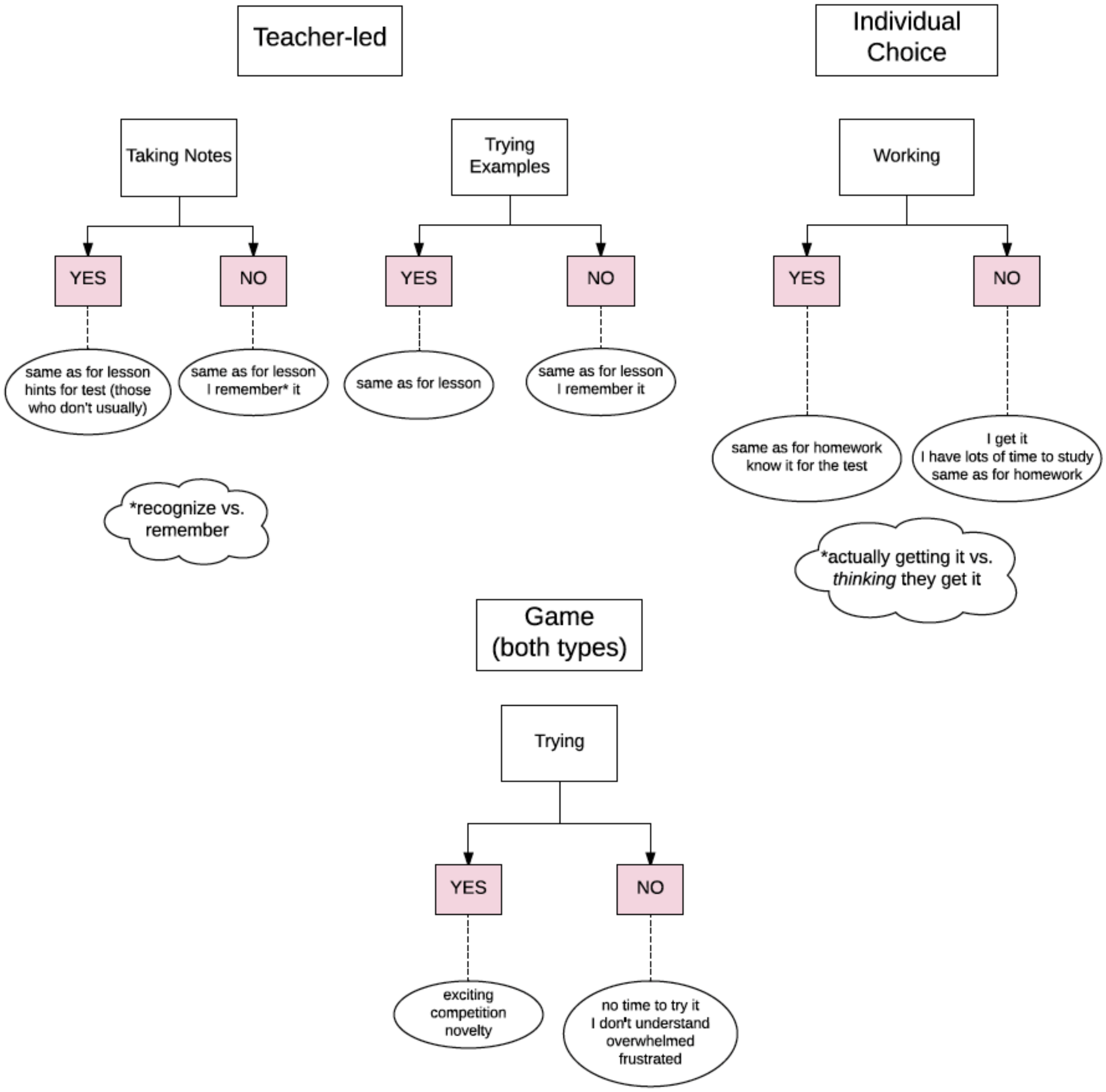


**Figure 5.2 Student reasons for action during review day**

There are a few comments that can be made about student action on review day. The teacher-led review and examples are similar to the results for direct instruction and do not need repeating here. Likewise, the individual choice review is much like homework time, though it is usually a longer period of time. What can be added are the two comments are made in the diagram with respect to these two types of review: recognizing versus remembering; and, actually getting versus thinking they get it. It is common for students to conflate *recognizing* a concept or procedure with *remembering* it (not to mention understanding it). This appeared in the data as well, usually through students expressing that they “*know*” the material, but “*blank*” on the test or they do not “*do well*” on tests. This is a similar issue to that of ‘getting it’ as compared to ‘thinking they get it’.

My observation of the game style of review invites some comments. From the teacher’s perspective it appears that the majority of students are engaged and excited about the game – and many are, possibly because it is a novelty. However, this situation is not really conducive to learning the concepts, or even getting much practice with procedures. The students who answer the questions knew the material already, and those who did not know do not really have an opportunity to learn it. In terms of benefit to the students, this is a similar scenario to student presentations.

## 5.4 Quizzes and Tests

The methods students use to prepare for assessments and the manner in which they were administered differed among the three classes, as did the frequency and weighting of the assessments. With minor deviations, approximately 70-80% of each class mark was based on chapter tests, with the remaining 20-30% being made up in the form of quizzes, assignments, and projects. In this section I focus on three aspects: how students prepared for assessments; the approaches students took to writing assessments, and their actions during the assessment; and finally I discuss the form and manner by which feedback was provided to students, and their responses to it.

### Preparing for assessments

Most students prepared for assessments in some way, whether it was reading over notes, trying examples from the textbook, looking over previously completed homework, revisiting previous quizzes or assignments, or working on a review package. Sometimes the teacher suggested strategies for studying, or selected specific problems for students to review because it ‘might’ be on the test. The first part of this section discusses what teachers did and said to help students; the second relates what the students did and said. Preparations that occurred on a review day were discussed in the previous section; additional methods that occurred outside of that time will be provided here, although there is some overlap.

**<u>What teachers did and said.</u>** Teachers often provide guidance for students to help them prepare for the upcoming test, and to develop good study skills in general.

When one teacher assigned review for the test he told students: *"Think like a teacher. Why might this one be here? There might be one similar to it on the test."* The day before a different test he referred to a recent quiz, stating: *"That first question on the quiz? There will be one like that tomorrow. Easy marks."* He advised them, *"Make sure you can do the quiz questions well,"* and in selecting from the assigned review problems, *"Pick and choose, do the ones you struggle with…these are VERY specific to the test."* Unlike the other homework assignments, the assigned review questions were not collected for marks. Students were told to only do as much as they needed to be ready for the test. He told them he wanted them to take responsibility for what worked best for them and master what they were able to rather than spend their time trying to understand the more difficult problems. His suggestions for problems and concepts for students to review were quite overt and prescriptive, sometimes telling students, *"There's two questions on the this test like that. Make sure you can do them."* This occurred more for types of questions he indicated many students would find difficult.

The teacher emphasized that students should understand not just how to get the correct answer but WHY the answer was correct. Students were advised to scan the assigned review problems to see if they found any confusing or troublesome; then they could ask him for assistance before they left class. One suggestion he offered to students was, *"When I was studying, [I] would look at my notes, cover, and test myself."* He also cautioned students about distractors in multiple-choice options: "*The wrong answer will be there to trick you.*" In addition to the general comments about what to review, on at least one occasion he gave individual students advice about what specific topics they should review based on his assessment of that student's understanding.

Though he was clear in his expectations, this teacher was realistic. After postponing a test to after the weekend, he agreed with my comment that students would find the extra time helpful, and added "*if they studied*." But having adequate time to prepare was not an indicator that students would do well. After the first test he expressed his confusion with the results: "*I don't know what went wrong. It really seemed like they had all the concepts* *and there was a lot of time for review.*" Upon reflection he recalled that students had the most difficulty with questions requiring explanations of reasoning.

Neither of the other two teachers was quite as prescriptive about which particular review questions might be on the test. For example, when one teacher was going over a revenue problem in the quadratics unit, she referred to it as a 'classic' problem. A student quietly said: "*So is this on the test?*". His friend, sitting nearby, laughed and said: "*Of course*". Although the teacher did not explicitly state that there would be a question like it on the test, most students understood the implications of her statement. She did tell them that the hardest part of the test would likely be the word problems. Review questions were assigned, but not collected.

The third teacher also did not collect the assigned review questions. For various reasons[97] he did not provide students with a lot of direction regarding what would be on the test, or what questions to practice. Referring to the review questions and a recently returned quiz, he told students: "*Let this be an indication to you for how ready you are for the test on Monday*."

The differences in how much direction and information was provided regarding exactly what would be on the test are due to many factors, one of which is likely the nature of the course (FoM 11 vs. PC 11), another the personal beliefs of the teacher, and a third being the experience and maturity of the students.

**What students did and said.** There were a few ways students prepared for assessments, particularly tests. Some students made use of their notes, either rewriting or synthesizing them, or just reading them. Another method was to do old homework questions and/or the assigned review questions. Some students were strategic about the practice questions they did, others less so. Many used a combination of reviewing notes and reading or doing practice questions. Finally, some students did nothing to prepare. Whether it was trying problems or reading over notes, students indicated that the majority of their review was done at home. Consequently, this section contains mostly what students *said* they did as opposed to what they *did* that was observed.

[97] See the earlier description of each teacher in Chapter 3.

*Notes.* Many students read over their notes to prepare for a test. Reasons given for this included: *"So I can see what we need to know"*; *"Only certain notes…most of my notes are reminders and shortcuts to different things"*; and, "*It helps me remember the steps for equations.*" Meghan read through her notes for the final exam and did examples, and said she would use her notes to help her with her final review booklet. Although Scott took notes in class he said he did not usually use them for review. When asked how he used them, Morgan said that on a review day, "*I just sit there and read over the notes*." He added that he wanted to be able to take the formula sheet into the test.

Far beyond merely reading over his notes, one of the activities Stephen performed to prepare for tests was to retype all of his notes into OneNote[98]. In doing this, he would add in any additional related information he could think of, often drawing from his experiences in other classes, such as physics or another mathematics class, or real life. Stephen sometimes did this on an ongoing basis throughout a unit, but often he did the majority of it towards the end and thus this became a significant review for him. I had no evidence of any other student going to this extent. Some prepared a study sheet with important concepts, but even this type of preparation was often limited to making note of all the important formulas. When the teacher provided a summary of the important concepts and types of problems for students, some students used this as their study sheet.

*Practice questions*. The most common type of review students did was to do a set of review questions assigned by the teacher (either a booklet or textbook questions). Like many students, Richard preferred doing examples to reviewing notes: *"That's how I learn; by doing questions and figuring out the answers."*

Some students were strategic and took the teacher's advice, only doing problems that they knew they had not mastered and might have difficulty with if they appeared on the test. Maria was one such student: *"I like doing the ones with the variables, 'cause I have a hard time with those ones. Number one I wouldn't do, I should know how to do that."* When reviewing for the final, Scott chose what he had determined was the *"hardest"* unit (quadratics) to work on first, as opposed to the trigonometry unit, which he thought was, *"not that hard."* Yet, on another occasion Scott admitted that when he was doing review

[98] This was discussed in more detail earlier in this chapter in the section on "Notes" and can be found in Stephen's case study in Chapter 8.

questions he was usually doing the ones he already knew how to do. Stephen contributed: *"I don't go through all the questions, I go through just the units that I thought might be a bit difficult for me. But I'll do one or two of each of* them [the other questions] *though."* Others, such as Meghan and Jake, saved what they thought was the most difficult unit (quadratics) for closer to the final exam. Melissa, however, just went through the problems in the order they were given, despite the fact that she could likely do the easier ones with no difficulty and did not need to do them. Her rationale was: *"[I] thought I might as well go in numerical order."* Many students did the same; just worked through the review booklets in order.

Chloe, Shanna, and Jelena did the review assignment for a dual purpose: to prepare for the test and to get the marks for submitting it. Erica commented that she had done the ones on the assignment that she already knew how to do, but needed to review a couple of the word problems. Sometimes, like for Erica, the practice of collecting assignments led to students reviewing material they had already mastered in a desire to get the marks for completing the work. Thomas, however, had completed all of his assigned work so he chose to work on an optional extra practice worksheet to ensure he did well on the test.

Certain students procrastinated until just before a test to do all of their homework. This became a type of review for them. For example, Beatrice would wait until later to do her homework, unless there was an upcoming quiz. Max was another such student. On one occasion he explained to me that he was doing his homework because he wanted to get it done before the test, so that he was ready for it. Kyle only did 'homework' as review before a test. *"The only time I really do homework is for a test. I do the back of the book. For final exams I'll do like, half the questions in the entire book."* But Kyle was strategic too: *"If there's stuff I don't understand…I'll do all of those*[99]*. All of the questions in those chapters."*

_Nothing._ Some individuals did not review for all assessments. Kyle, for example, admitted after one quiz: *"[I] did better than I thought I would. Cause I didn't study. At all."* He explained that he did not study for his math quiz because he was studying for a socials test. It was not uncommon for some students to use quizzes as study tools: rather than

[99] It is not clear how Kyle would do them if he did not understand them. It is possible he meant he would try them.

study *for* them (since quizzes did not significantly affect their grade), they used quizzes to gauge their understanding, and to use to study *from* after the fact.

**Preparing for assessments - a summary.** Students' actions regarding preparing for assessments can first be differentiated by whether they did something, or nothing. If they did some sort of preparation, they either: used their notes; did practice questions (review assignment or past homework); or did some combination of notes and practice. Actions and reasons are summarized in Figure 5.3, below.

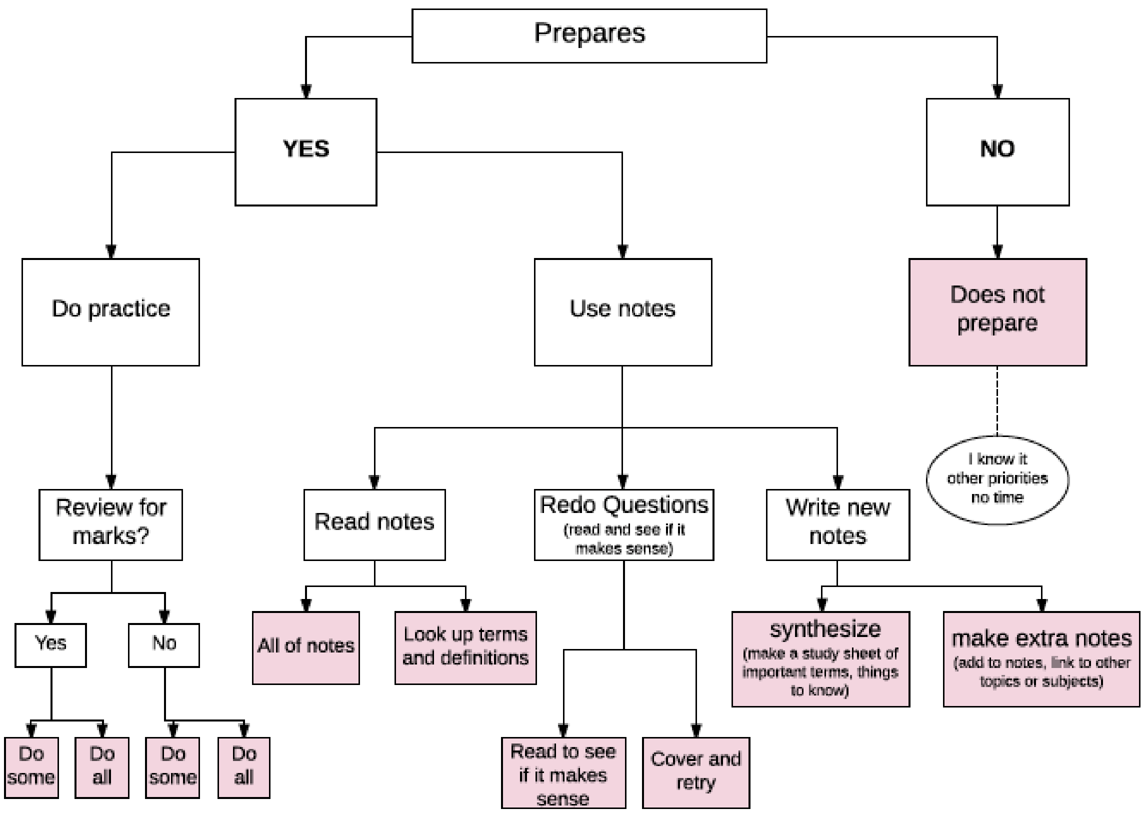


**Figure 5.3 Student actions to prepare for assessments**

In viewing the diagram it is important to note that a single student may have studied using both notes and practice (thus the 'pathways' are not mutually exclusive); further, that same student may not have prepared at all for a different assessment.

This diagram differs from others in this chapter in that I have not attached student reasons, as there was too much overlap between the possible reasons for different actions. For example, a student who wanted to be able to answer all the test questions could have:

read all of the notes or just terms and definitions, redone the questions, written new notes or summarized, and done all or part of the review. The difficulty here lies within the student. Students have different ways of studying, and different conceptions of what it means to understand, and what they need to do as an individual to be able to understand. What I have done instead is only put in reasons for those actions that linked to only one or two goals. For example, if a student took his or her notes and rewrote them, adding material and making links within mathematics and with other subjects, then I was reasonably certain that he or she had a goal[100] to understand the material.

### Writing assessments

Assessments in all three classes took the form of quizzes or tests, with the exception of one or more projects in one of the classes. Quizzes were usually written individually, although two teachers used partner quizzes on occasion. All tests were written individually. Student actions and comments about writing assessments are the two areas that comprise this section. Each is then further subdivided by emergent themes. Finally, a synthesis of what students did and said is presented in diagram form, allowing for an analysis of possible goals.

**What students did.** Five aspects of student behaviour while writing assessments comprise this subsection: a) strategy; b) focus; c) finishing; d) asking questions; e) cheating.

*Strategy.* Students approached tests in different ways. At the outset, some flipped through the test, possibly to get an overview of the difficulty of the test, or to identify potentially problematic questions. Others began with the first question and worked through questions in order. Some students employed a strategy of starting with the long answer questions and working on the multiple choice[101] questions later.

A strategist, Meghan often began with the questions worth the most marks. Stephen also flipped, but did not appear to use mark values to choose his order. Most students,

[100] The student likely has multiple goals – understand, do well on the test, etc.,

[101] Multiple choice questions constituted a portion of tests in all classes, and represented anywhere from one-third to one-half the total marks for the test.

however, attempted questions in the order they appeared and occasionally skipped some questions. These questions may or may not have been returned to later. In the FMP 10 and FoM 11 class time was never a constraint. Most students seemed to finish within the class period. In the case of FoM 11 class, if they did not finish in the allotted time, they were permitted to return at lunch to complete their test. In contrast, time was a significant factor in the PC 11 class and many students were unable to finish some tests during class time. If this happened, the teacher often let them stay after class to finish.

*Focus.* In each class there were students who remained focussed on the test or quiz for the entire time it took them to finish it. More commonly, once students had been writing for a while some began to look up and stare at different places in the room, shifting their focus from the task at hand. Usually students returned to writing the assessment shortly, but as time progressed the 'pause' intervals lengthened and the 'writing' intervals shortened.

In one class, the teacher did not allow students to submit tests until the end of the block, explaining: *"We only have four tests*[102] *in the whole year. So they're a big deal. I'm trying to teach them the idea of not handing them in early and going over them."* Being forced to retain the test for the entire period, I observed many students flip their test over multiple times, as if they were done but then decided to try something again, either because something came to them or they were just so bored they needed to do something and the test was the only thing they had to look at. Some students doodled on the test when they had completed all they could do, whereas others stared into space. This "blank stare" was observed frequently in each of the three classes during assessments. Because no student was asked exactly what he or she was thinking at the moment, I can only guess that they were either 'zoning out' or trying to puzzle out the problem.

*Finishing.* In my teaching experience I have noticed that my students often feel the need to "get rid" of a test once they have done what they can, or once they are tired of trying. There was often a rush of students to hand in a test once the first had been turned in, as others felt that it was now 'acceptable' to be done. I observed this in two of the three

[102] In the FMP 10 class there were only four tests in the year, plus an exam, compared to approximately eight chapter tests and a final exam in both the FoM 11 and PC 11 classes.

classes, but not the third due to the teacher's rule about not handing it in until the end of the period.

Not every student rushed to submit a test or quiz. Some used every available second. Beth, for example, held on to her quiz until the last possible minute, even though she did not appear to be writing or checking her answers (though she told me after that she was checking her work).

Stress is a common reaction to a test environment, and when time is a factor the anxiety is heightened. The tension was palpable during one PC 11 quiz as the end of the period neared. Only one student had finished the quiz by the final bell. At that point, the teacher counselled them, *"don't feel rushed,"* and she stayed as long as the students needed. Although time was occasionally a factor in this class and the others, this was never the teacher's intention, and a solution to the problem was always found either by allowing students extended time after the regular class time, or allowing them to return to complete the test at a later time.

*Asking questions.* Some students asked a lot of questions during tests. Sometimes the individual wanted to make sure they had understood a question correctly, or wanted to confirm a piece of text that might not be legible. On other occasions students were trying to get more information from the teacher; either about the accuracy of their answer, or about how to do the question itself. After observing Michelle[103] calling her teacher over several times during the first test of the semester, I asked the teacher about the nature of her enquiries. He replied: "*she was really trying to get me to give her the answers,*" and said that he had told her, "*you just have to do your best*". In total Michelle asked more than seven questions during that test. When another student was stuck and hoping for some guidance, the teacher encouraged her to do all she could: "*You can do something with what you've got. You know lots, you just don't know it all."*

Questions were asked as the teachers circulated during the test. Sometimes these prompted general announcements if the teacher perceived that a number of students might be having the same difficulty. For example, during one quiz, Keiran asked a question

[103] Read more about Michelle in a case study in Chapter 8.

resulting in the teacher addressing the entire class to tell them they only needed to be concerned with graphing in the first quadrant[104]. Teachers provided clarification when necessary, gave encouragement and general suggestions ("*Can you think of something we did that was similar?)* but refrained from "giving" hints or specific suggestions for procedures.

*Cheating.* In this section I discuss only what I noticed with respect to students cheating. In the following section, 'what students said', I address what students said about cheating. I observed a few instances where students may have been cheating, but I can not be certain. Some students left books or papers open on the floor near their desk; this may have been intentional, or merely accidental and I was not able to determine if students were looking at it during the test or quiz.

For example, when Chloe had finished her quiz, she began to pack up but did not hand in the quiz. Instead, she nudged her quiz closer to Beth, sitting next to her. I noticed one pair cheating multiple times. One day, I saw Desirae cheat off Maya's quiz (the teacher also mentioned later that she thought this had occurred). During another quiz I caught Desirae staring at Maya's quiz multiple times. Desirae appeared perplexed by the questions on the quiz. Towards the end of the quiz time her staring became more obvious and her gaze lingered longer.

**What students said.** Students were very outspoken on issues about which they felt strongly. One such topic was handing in assessments. Another topic on which students spoke quite candidly was cheating. Students' comments on both of these issues are discussed below.

*About handing in tests.* As mentioned earlier, one teacher had a rule that students could not hand in their test until the end of the block. Students tended to dislike this rule. Jineane felt that it was too much time because, "*I finish tests really quickly, so I finish it within like, ten minutes and then I'm just sitting there for an hour*." Todd and Jineane felt that the test sitting on the desk was "*mocking*" them, with Jineane personifying the test: "*It's just sitting*

[104] Students seemed to be confused by the graph supplied which had no x-axis or y-axis given. The students 'should' have recognized that they only needed positive x- and y-values given the nature of the problem, but most did not and the teacher seemed to want to provide a little guidance so they had a better chance of completing the assessment successfully.

*there and it's like, "*ha ha, you've got something wrong, fix it*" and you're thinking 'what did I get wrong?', and it's like, "*find out." She added, "*It's like getting a weight off your chest when you hand it in you feel like, satisfied*."

These students disliked having to sit with the test because of the psychological demands it placed on them and for the anxiety they felt. For many, once they "*got rid of it*" there was a sense of relief that it was over, that there was nothing else they could do. Once submitted, regardless of whether they had answered questions correctly, the burden was removed and they could stop questioning themselves. Todd, particularly, commented that he spent too much time second-guessing and sometimes changed his answers to incorrect ones as a result of this feeling. Others did not feel this burden but just wanted to do something else because they were bored.

*About cheating.* As stated earlier, cheating was not something that was observed to occur frequently. However, during two focus group interviews (in two different classes) I raised the issue for discussion and found it was an offense that students confessed to, albeit not in the particular class they were in at the time. I began with some general questions, asked about whether they were influenced by consequences for being caught, and used the scenario of Desirae cheating off Maya to allow students to hypothesize about why a student might cheat.

For some, there was a dilemma about cheating. Todd felt confused because growing up he was told "*do whatever you can to do the best that you can do, but also stick morally, don't cheat, don't do stuff that's bad*." It was clearer for Kyle, who stated that he did not cheat for personal reasons (not consequences).

Other students were also asked if the consequences of getting caught cheating would influence their actions. This did not seem to be a factor for most of them. Despite his dilemma, Todd admitted, "*honestly, most of my tests I've cheated at least once*." His rationale was that in a test situation you need assurance: "*you always second guess yourself […] because you want to get the question right so much*." Jineane agreed, "*you ask your friend and you feel more comfortable with it*." Toby too, admitted he would look at someone else's quiz or test: "*I'll look to see if it sparks anything in my memory so I'll know how to do it."* However, if looking at it did not help him to solve it on his own, "*…then*

*I just leave it because I'm going to need to go to a tutorial anyway to figure it out*." For Toby, cheating also dependent on how badly he needed the marks; if there were a number of questions he could not solve, his thinking was: *"I should really try and figure out the answers just by looking around*." But if there was only one question he could not do, then it would not be worth it. "*[I]f you get caught and you were already going to fail the test or something, it's not going to make any difference*." Rory concurred, "*Because if you don't know the subject you're going to try and get answers any way possible*." Desperation was a reason offered by Jineane too. Kyle figured that the reason others did was due to temptation, whereas Sol put it down to curiosity, "*wonder*[ing] *what the other person has*," although she did not cheat. Xander figured everyone had the potential to cheat, depending on whether one was lazy, or whether someone could do it in his head but not be able to express it on paper. "*You can be the smartest person ever but still be pretty lazy and not want to do the question but you could have it all in here [points to head] but you can't express it on paper*."

Liking or disliking a teacher did not influence whether or not they cheated, and Toby and Rory figured it would be easy to cheat in most teachers' classes, "*Because the eye glance, you could just do a scan*," said Rory. Some teachers made it easier to cheat than others. Toby and Rory related a story of one mathematics teacher who left the room during which time a fellow classmate looked up the answer to a question using his phone. Interestingly, both Toby and Marcus, two of Desirae's classmates, felt that it would be very difficult to cheat in their class due the spacing of the desks. Marcus added, "*It would be pretty obvious*." The orientation of the desks was one method teachers used to discourage and mitigate cheating. Sol commented that the desks were *"nice and spaced apart so it would be obvious if you were to try to cheat"* and Jineane chimed in *"not even whispers happen."* In contrast, Kyle explained that he and Todd wrote tests in the learning centre, an entirely different setting: *"It's hilarious",* grinned Kyle, *"the teacher will give you answers"*. Somewhat contradictorily, though Todd stated that he had cheated on most of his tests at least once, he also claimed that he had never been told an answer while writing in the learning centre and that he had never cheated off anyone else while writing in the centre.

Intrigued by Toby's response about not cheating because he would have to go back and figure it out anyway, I asked a group of students if they would go back and learn the material if they successfully cheated on a test. They responded was that it would depend on whether the material was a significant portion of the unit, and how much other work they had to do.

**Writing assessments – a summary.** The following diagram (Figure 5.4) represents student actions when writing assessments.

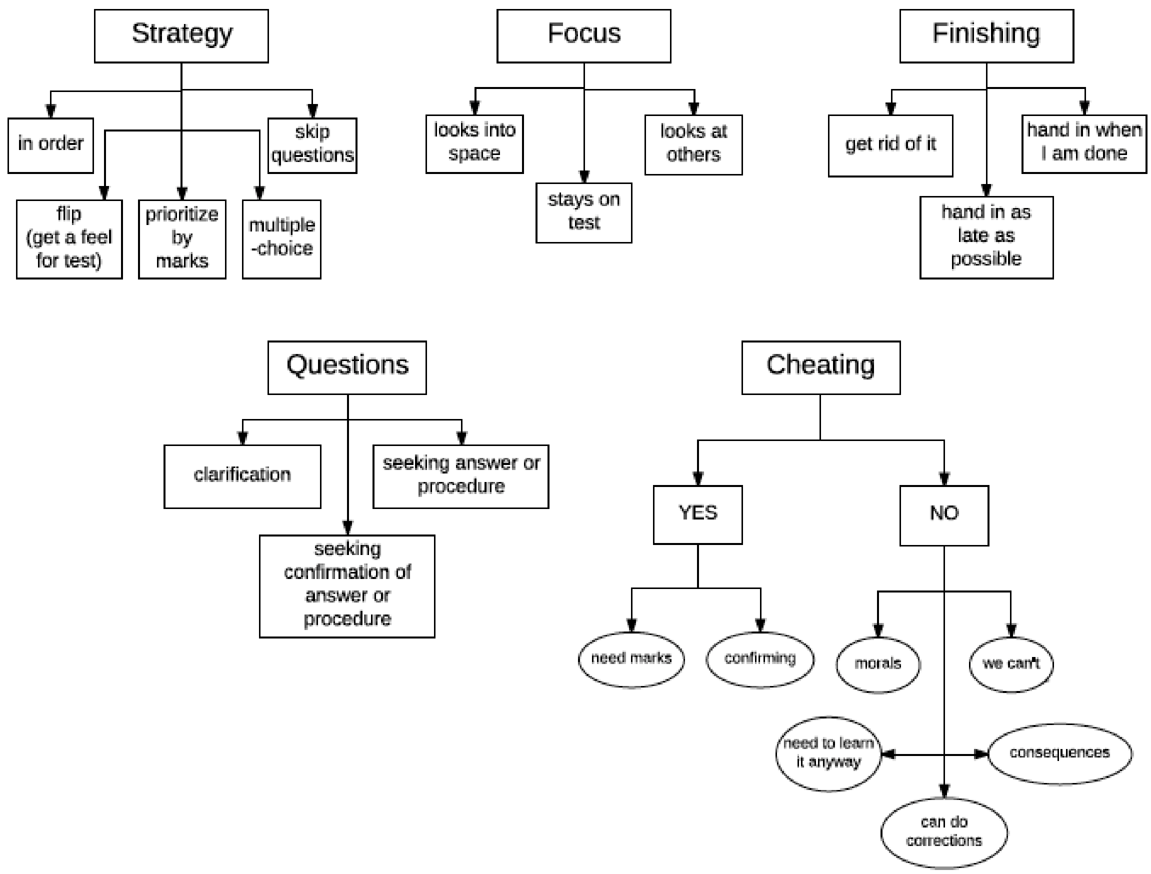


**Figure 5.4 Student actions during assessments**

The only category for which I have included reasons is cheating. For the others, student reasons are self-explanatory or a reason is not applicable.

## Feedback on assessments

After an assessment, such as a quiz or a test, teachers often 'go over' questions that were problematic for a significant number of students, or they at least provide the opportunity for students to review their result and ask questions of their peers or the teacher. Such was the case with the three teachers in this study, although there were differences in the manner in which the review was conducted. These teachers also allowed some form of rewrites or corrections for marks on quizzes or tests (or both). A synopsis of student comments and actions regarding rewrites follows the description on general feedback on assessments.

**Returning assessments.** If time permitted, one teacher discussed quiz questions immediately after they had all been submitted. He reported that on occasion the students would mark the quiz in class. The almost instant feedback seemed to harness students' interest, and the opportunity to rewrite the quiz offered incentive. Students appeared more attentive at these times, as compared to their responses when a quiz was not returned until the following class. Another teacher did not usually review the quiz questions, instead expecting that students would take it upon themselves to do corrections either to earn additional marks or because they wanted to figure out how to do the problems. Occasionally he commented on a question if it challenged many students. Unlike these two teachers, who handed all tests out to students at the same time, the third teacher did not hand tests back to students. Instead, she called them up individually to talk to them about their tests. She explained that if she gave back all the tests and went over all the questions, some students would be bored. Doing it this way allowed her to address students' questions on an individual basis. However, some students took advantage of her occupation with students at her desk and socialized instead of doing their work. She did hand back quizzes, and wrote the final answers (not solutions) on the board so students could check. After returning quizzes to students she walked around responding to any individual queries.

After one particularly difficult quiz my query, *"How did the quiz go?"* was met with general laughter. Despite their obvious struggles with the material, the students seemed unsure or undecided about what their next steps should be. Emily somewhat vaguely said she would *"get some help"* because she was *"probably going to have to figure out how to do it".* However, she did not copy down the graph the teacher drew when he reviewed how to do the question (and students would not be returned their quizzes until after the test). She seemed unconcerned about figuring out the questions, whether that was because she was too confused, it was too much effort, or she just did not care enough. When Jackson got his quiz back he just stared at it. He did not even seem to be focussing on it, but appeared to be using it to avoid doing other work. Later he shared that he had been really busy with hockey practice and games, implying that his poor result was due to a lack of time to study. Seeing her test mark, Tasha complained: *"I can't do tests. I do know what I'm doing in the homework but then when it comes to the test, I just blank[105]. Every single test just brings my mark down which makes me hate exams even more."* She shared that when she sees the questions after the test she sometimes knows what to do, but not always.

Doing well on a test was not necessarily an indicator of mastery or confidence. Scott expressed surprise after a particularly good result on a test. He was the only person in the class to correctly solve one problem and after witnessing his reaction I sat down to chat with him. He agreed with my assessment that he seemed amazed at his test mark, and particularly surprised with his success with one particular problem. "*This question, I screwed up so many times, I put the wrong numbers in so I had to redo it twice*." Yet he realized his mistakes and achieved a perfect score on the test. Scott was surprised and pleased with his result, but did not seem to have a lot of confidence in his understanding. My sense from looking at his work and from talking with him is that he plugged numbers into the formula until he got an answer that made sense to him. He expressed surprise after receiving a good result on a different test because he had not studied or handed in the homework for it. His explanation was that it just somehow sunk in and came to him during the test.

Sometimes even teachers are surprised by test results. One teacher expressed some confusion about his students' marks on the first test. "*I don't know what went wrong. It really seemed like they had all the concepts and there was a lot of time for review. [The marks were in the] 50 to 60 range. I thought they'd be more like 67*." After further discussion, he figured that students had more difficulty in the long answer part of the test: "*Where they have to explain the whole concept*." He shared his mild frustration about students not understanding the importance of providing reasoning and being able to explain why an answer is what it is.

**Assessment rewrites and corrections.** One teacher allowed rewrites for quizzes and tests, on the condition that students come to see him to go over it. Several students took

[105] Tasha did some homework, but I was unable to determine the extent to which she referenced her notes when she did homework, and whether she was using them to 'cue' her work on the assigned questions.

advantage of this opportunity over the course of the year. Another teacher endorsed corrections on tests to obtain extra marks or as a requirement for being allowed to write a retest. Students could replace their quiz mark with a better test mark if they did their quiz corrections and attended a tutorial. Answers for quizzes were written on the board but students were expected to show all their work on their corrections, and were expected (and reminded) to do them individually (as opposed to copying them off a peer). This opportunity was taken up by a majority of her students. The third teacher did not allow retests at the start of the year, but reversed his policy midyear, setting a cap of 75% on the retest mark. To be afforded the opportunity of a retest, his students had to complete all their corrections on the original test. Quiz corrections could also gain students marks. Mika explained: *"You need to prove to him that you know the stuff and if you prove it to him then you can make your mark better."* The offer of marks for demonstrating improved understanding was sometimes taken up by students, but not always.

When I noticed Kyle doodling on his quiz, I asked how he had done. He said that it was okay, and that he did better than he thought he would, adding, "*Cause I didn't study at all,"* instead choosing to study for a socials test. We continued to talk and I asked about his most recent math test, which Kyle felt "*went okay,*" adding, "*I passed so… I'm probably going to redo it and get a higher mark*." Asked if he was able to do corrections on the quiz, Kyle replied, "*[W]e can do corrections on the quiz and I think you get like, two or three bonus marks but …"* He trailed off so I suggested that it maybe it was not worth it to do the corrections. "*Well, actually it is worth it so I'll probably just correct it, like show the equation and what not, and then, do that and get* [more marks*]."* It appeared that Kyle was not strongly committed to a particular course of action.

**Feedback on assessments – a summary.** There was a noticeable difference in student attentiveness and interest in finding out the solutions to assessment items when the feedback was close to immediate. Although some individuals would do their corrections and try to understand the questions regardless of when the assessment was returned, there was a significant cohort of students for which the immediacy of the feedback significantly impacted the time and effort they were willing to devote to 'figuring it out'. Figure 5.5, below, summarizes the actions of students after an assessment was returned.

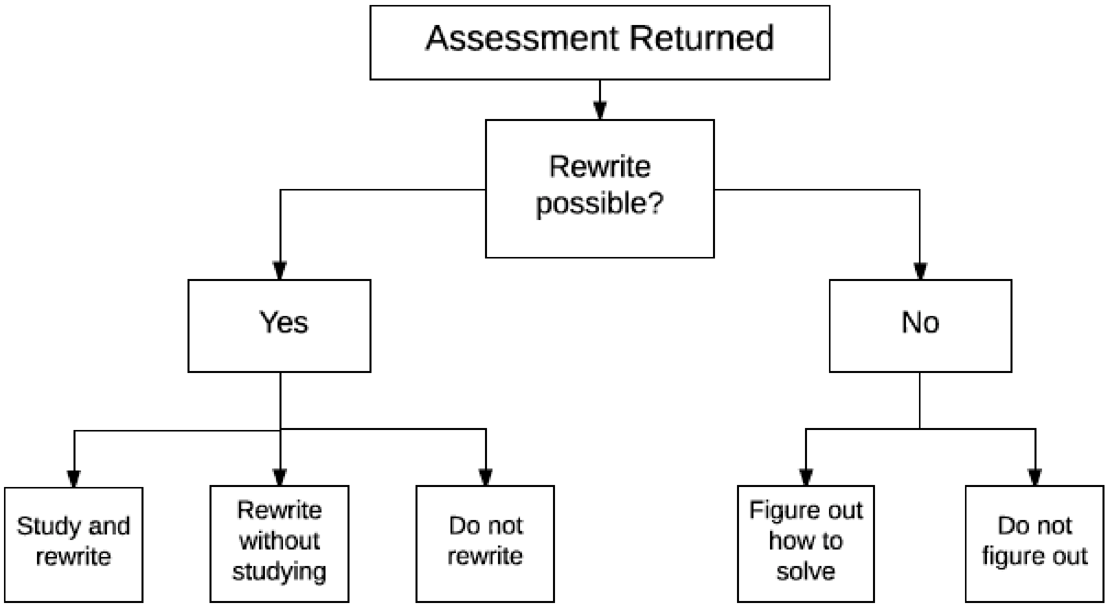


**Figure 5.5 Student actions after assessment returned**

Overall the offer of marks for corrections or the opportunity for an entire rewrite seemed to increase student interest and effort with respect to actually attempting to figure out how to do the problems students were unsuccessful with the first time around. This said, the offer of corrections for marks or rewrites was not taken up by all students, nor was it taken up by any particular student all the time, with the exception of one or two students per class. If students chose not to look over their returned test, or not to rewrite or do corrections on assessments, some reasons included: it was too late; it was too much effort; the student had moved on to new material; and, the student did not need the marks (because they were still passing, or at their desired mark).

## 5.5 Summary

Four activity settings that are less typical or less frequently occurring in the classroom were reviewed in this chapter: problem solving, presentations, review day, and assessments. For example, it is typical to have assessments, but they are less frequent (do not occur every class). The same can be said of review days. Presentations are not only less frequent but are also less typical (presenting to the class was only observed to occur in one of the three classes). Problem solving varied in frequency among the classes.

While it occurred on almost a daily basis in one class, it was very rare in another; thus it could be called less typical and less frequent, depending on the class. Student actions and comments within and about these settings were summarized and themes were identified, when possible.

There are a few interesting points to review from this chapter. One reason I group these 'atypical' activity settings is that sometimes students' actions change in novel situations, such as the game style review, and problem solving. The general theme here was that students participated more, though for the game style review they may not have gained anything in terms of learning mathematics. For review days, however, student actions seemed to go the other way. I observed that students who tended to chat a bit and delayed starting homework during a typical class often occupied a greater portion of time doing this than doing work during review day. One possible explanation is that they had greater span of unstructured time, and many voiced that they had time to study later.

As with the previous chapter, the results herein show that there is significant variance in student action within even one activity setting in a one-class period. That being said, in this chapter and the previous one can see patterns of similar behaviour. In the following chapter, I look across activity settings and discuss student behaviours that occurred in multiple activity settings.

# Chapter 6:

# Across Activity Settings

> The hardest thing to do with data is to analyse them, to draw out of them some essence, so as to abstract and generalize from them. (Mason, 2002, p. 162)

In Chapters 4 and 5, I reported, organized, and analysed the data within specific activity settings. What became apparent through the process of collecting and analyzing the data within settings was that frequently the same student behaviours occurred in several different activity settings. There were also noticeable shifts in student behaviour when there was a significant change in an environmental element, and finally, particular tensions arose in multiple activity settings.

Chapter 6, then, contains the remainder of the ‘raw’ data. As with Chapters 4 and 5, the analysis is conducted “with the grain” (Watson, 2000), but in this chapter I look for themes across activity settings. Looking across the activity settings for themes adds validity to the hypothesized goals from the first part of this chapter and provides additional information for conjecturing student motives. As before, analysis is an ongoing process and it is necessary to present the results as a melange of student behaviours and verbalizations.

Four themes comprise this chapter: avoidance behaviours, waiting for the teacher, students having other priorities, and student conduct with a TOC. There may be some overlap between these, for example, some students waited for the teacher as a delay tactic to avoid work.

## 6.1 Avoidance

Avoidance within the classroom can take many forms. Most of these fall under one of two broad categories: avoiding attention, or avoiding tasks. These two categories comprise the bulk of this chapter, and the methods described within each of these two subsections can be referred to as “*How students avoided*.” The third, and final, subsection addresses the response to “*Why students avoided*.”

## How students avoided attention

There were a few students who seemed to want to avoid attention, at least from me and from the teacher. There is a distinction to be made here between avoiding *all* attention (from the teacher and peers) and wanting to avoid *negative* attention (from the teacher and/or peers). Students whose behaviour falls under the former category are often described as withdrawn, whereas the latter category suggests students want to "fly under the radar." I provide a list of possible actions that imply each of these goals, together with student exemplars.

Many actions fall under both categories, so the primary indicator that a student was trying to avoid all attention was minimal interaction with their peers. Also included are actions such as: avoiding eye contact (with the teacher, unless being spoken to directly); not volunteering; not asking questions; and not initiating interactions (with the teacher, and possibly with peers). Neil and Jackson were two students whose conduct fit these criteria.

Neil spoke to me a few times but usually seemed to prefer to be in his own world. He was absent several times over the semester, frequently walked in late, and when he was in class he kept to himself. He wore headphones for a significant portion of class time, occasionally even during the lesson, but otherwise he appeared to be paying attention or working in his book. He rarely spoke in class, but did participate during group activities, when it was required. Jackson sometimes interacted with his peers but he was generally quiet and did not draw attention to himself. I did not ever see him ask questions of his teacher, and though he would interact with me it was clear that it was not by choice. During informal interviews he responded to my direct questions, but did not go out of his way to elaborate. He participated during group activities, to the extent that it was required.

Sometimes students tried to avoid negative attention. This type of goal can be associated with actions[106] such as: only asking questions when the teacher is in proximity so that the teacher thinks he or she is working at the given task (these questions tended to be trivial in nature, or non-mathematical); not asking content-based questions in class and not coming for help (because to do either would reveal lack of understanding); avoiding eye

[106] While there are several possible reasons for these particular actions, the reasons suggested here imply that the goal is to avoid negative attention.

contact; concealing non-compliant behaviours (from the teacher); and sometimes avoiding assessments.

Tiffany was very social with her peers. She did not interact much with her teacher, but neither did she go to great lengths to avoid it. Her desk was usually empty, unless she was concealing her cell phone use or studying from a driver's license book. The fact that she concealed her "illegitimate" activity suggests that she was trying to avoid negative attention (from the teacher). From the start of the course she struggled with the material, but she did try in the early days, and asked her peers and sometimes the teacher how to do questions. When she was called on (by the teacher) to provide an answer to a question she put off providing one, saying, "*one sec…doing number three,"* but more often would just say, "*I don't know*." If I asked a direct question her response was either, "*I don't know*," or it seemed she gave me whatever response she thought I wanted to hear. For example, when she missed a class I asked her, "*What do you do to catch up?"* She replied, "*I look at the homework on the board and I do the questions*." It is possible Tiffany copied down the question numbers, however, about two months into the course she asked the teacher where to find the homework assignment (it was on the chalkboard and had been written there every day, in the same place). When I asked if she ever took notes she answered, "*No*," and responded, "*I don't know*," when asked, "*why?*" Even if she did copy down the questions, she did not or was not able to complete many of them. She also never returned either of the surveys I asked the students to fill out. I offered to give her a new copy of one but she assured me she had it and it was done, but it was at home. I asked her at least three times but she never gave it to me. After about three months in the course her mark was around thirty percent. At that point she stopped showing up to class.

Trying to avoid all attention is inclusive of most, if not all, of the actions that are observed to occur with a goal of avoiding negative attention. However, a student wanting to avoid all attention, such as Jackson, almost never initiated an interaction with the teacher, whereas a student with a goal of avoiding negative attention (such as Tiffany) may ask a question of the teacher (attracting attention) in an attempt to prevent the teacher from thinking that he or she is lost, not paying attention, or not doing the assigned task (thus avoiding potential negative attention).

The second type of avoidance behaviour discussed in this subsection is avoiding work, a much more common categorization of student action observed during the study.

### How students avoided tasks

Avoiding or delaying starting a task was a frequently occurring student action. I was sometimes amazed at the skill demonstrated by students. This conduct was observed at the beginning of class, during problem solving, while students were asked to try examples during a lesson, during homework time, and in several other activity settings. Ways to avoid doing tasks included being absent and delaying. Also, students used common tactics to delay, and chose to engage in certain activities as an alternative to doing a given task.

**Absences.** One of the most extreme ways to avoid a task is to choose to not come to class. Some possible reasons students avoid mathematics class may include: they are not prepared for an assessment (test or quiz); they have not done the homework, or are not up to date with the current material; they have other activities they prioritize, such as hanging out with friends, sleeping, or studying for an assessment in a different subject; they dislike the teacher or certain students in the class; or, they may have a 'legitimate' reason for missing class such as an appointment or family obligation.

Three students in the study showed a pattern of absences; Neil, Tiffany, and Devyn. I did not ask any of these three students for their reasons for missing multiple classes[107]. So, while it is possible that there was a legitimate reason for every absence, the evidence suggests otherwise.

For example, Neil was absent for a test one day, but I saw him walking towards school ten minutes before class began. Considering his actions in other classroom activity settings, it is likely that Neil may have skipped that class to avoid writing the test. His other absences can also be attributed to a desire to avoid work, an assessment, or boredom.

[107] Part of the reason I did not ask was because both Neil and Tiffany seemed reluctant to talk to me. Cara was not reluctant, but she was absent several times and I missed the opportunity to ask when she was in class.

Cara was absent from the class on a few of the days I was there; she also mentioned missing classes for other subjects, but did not elaborate on her reasons. Sometime after this conversation I noted her absence during a unit test; she had emailed the teacher to ask for extra time and spent the test block studying. Having spoken with Cara and observed her behaviour on several occasions it appeared Cara missed class to avoid boredom or work, as opposed to avoiding this particular class.

Tiffany had many absences; in fact, her attendance seemed to be negatively correlated with her mark in the class. With two months left in the semester, and thirty percent in the course, she stopped coming to class at all. Her teacher said she, "*pull*[ed] *herself out,*" because she didn't officially withdraw from the course. As discussed above, Tiffany appeared to have a strong desire to avoid negative attention[108]. Thus it is most likely Tiffany missed class because she wanted to avoid mathematics and her situation, as opposed to missing class in favour of doing some other, more desirable, activity.

**Delaying: General comments and examples.** Delaying starting was one method by which students put off or avoided an unwelcome task. Commonly observed behaviours included: chatting with peers; leaving the class; getting up to sharpen pencils; looking for texts or notebooks other needed materials; or just taking a lot of time to begin the task. If students had tools such as markers or manipulatives, they often delayed by playing with these, and afterward took their time returning them. Some students were so skilful that they managed to delay starting a task until class was over. I offer some examples of student actions here, and then discuss some common tactics and contributing factors that arose from the analysis.

When one activity had finished, students took their time preparing for the next activity. After being asked to start their homework, it took Lindsay two minutes to get out paper, and then took time to find a pencil, which she then had to sharpen. Another day, Xander just took a lot of time to get his books out, then started chatting, then got up to sharpen a pencil and wandered a bit, returned to his desk, sat down and began chatting with

[108] Being absent is also a way to avoid negative attention, but it was not included above this type of absence was more rare than being absent to avoid work, or in favor of another, more desirable activity.

someone else. I asked Maya how the homework was going and she replied, "*Oh, you know. Just slowly getting out my notes*."

Of all the delayers, Todd was a master. His behaviour is discussed in depth in Chapter 9, but here I will outline some of his delay tactics. His timing was impeccable, as if he had a second sense about when he was about to attract attention. The following description is typical of Todd's behaviour in a setting in which the students had more freedom[109], such as homework time.

> Todd moved around the room and chatted with peers for a time, then returned to his desk. He started writing down the numbers for the assigned questions, waited a bit (not writing or moving from his desk), then got up to sharpen his pencil. He returned to his desk after stopping to visit with some classmates. After sitting down he slowly paged through his textbook to find the correct page, then asked the teacher if he could go to the bathroom.

Having noticed this pattern, one day I asked Todd about it: "*I noticed that it's taking you a bit of time to get started today*." He replied, "*Oh, that's normal*," and laughed. "*I hate myself – why do I get so distracted? I need to be in a vacuum*," he once stated, indicating he was quite self-aware. Yet it seemed he sought, and welcomed, distraction rather than it being something unavoidable that 'happened to him'.

Jineane also often delayed by taking her time flipping through her textbook to find the right page, or to find a blank page in her notebook. Trevor was another accomplished delayer. He chatted, was slow in finding his books and the correct page, and, having found the correct page, might restart the process and flip through the book again. Towards the end of a class he slowly packed up his materials, and if the teacher commented that he had packed up too early, Trevor restarted the whole process of taking out his books, finding his pencil, finding the page, until it was time to pack up again. When I commented that his avoidance of the class homework was "*skilful*," he said, "*I just don't like doing my homework in class*," adding that he does it at home.

[109] 'Freedom' refers to the fact that students had more choice during homework time with respect to the task they worked on: homework, quiz corrections, review for tests, working on material from another subject, etc.

In fact, having seen Trevor's notebook and been present for some classes when the teacher checked homework[110], Trevor did not appear to do his homework at home either. However, whereas Todd was very honest about his delaying, Trevor made excuses: "*I had to go tell* [the teacher] *about the test I have to redo. I had to do corrections first*." Yet Trevor somehow spent at least ten minutes accomplishing this, and had not been working on anything in the meantime. Irrespective of their honesty about their methods, Trevor and Todd were accomplished gamers[111] when it comes to delaying doing work in class.

It was not typical for Toby to engage in delaying behaviour like that described above, but on one occasion I noticed and spoke to him about his lack of productivity. He had spent a few minutes playing with the zipper on his backpack, unzipping it as if he was going to get his books out, then zipping it up, then repeating the process. In response to my comment, he said, "*There's three minutes left!"* While it is true that three minutes is not much time to get anything accomplished, there was ten minutes left in class when he began. In another class, Marcus and Mathias protested, "*It's math, right?",* when I commented on their choice to play a game of 'Connect Four' in class instead of doing the assignment.

**Avoiding and delaying: Tactics and alternate activities.** Below I discuss four common delay tactics and two activities that students engaged in, instead of doing the prescribed task. The delay tactics include: putting up a hand; needing materials; leaving class; using a calculator. The two alternate activities are: chatting; using a cell phone. For each of these I discuss at least one student example.

*Putting up a hand.* Often students raised their hand to ask a question as a way to delay starting a task. If the teacher came over to answer the question, the student either: asked a question to which they already knew the answer; asked a non-mathematical question (such as "*When is the test?"*); or, asked a question they actually needed help with. What is common to all of these is that the student did not continue working whilst he or she was waiting for the teacher to notice that they need help. Rather than moving on to another question or another task, the student raised his or her hand as an 'excuse' to not do work.

[110] The teacher checked homework very infrequently, and the selection process was randomized. See Chapter 4 for more details about teacher's practices regarding marking and collecting homework.

[111] See Chapter 1 for more on gaming.

In one class, I observed Neil raise his hand, wait, then lower his hand, then raise it again. Neil desired the teacher's help, but while he raised his hand, he made no other effort to get the teacher's attention. He sat, hand raised, waiting. He put his hand down before the teacher saw it and continued his work. This occurred three times in the same class period – raise hand, wait, lower hand – never actually obtaining the teacher's help. Neil was doing some work, and I believe he was stuck on a problem, but he also took advantage of the opportunity to delay. It was neither a proximity question, nor did he actually obtain help from the teacher.

*Need materials.* A deficiency in the necessary materials to complete a task was used as an excuse by students. Textbook, calculator, paper, pencil, eraser – a lack of any one of these was cited as a reason for delaying or avoiding work.

Chelsea could not do some of the examples during one lesson because she had not brought her calculator to class. Donnie could not graph the equations they were asked to do one day because his smart phone was dead. Emily forgot her book at home and could not do the homework so she played on her phone instead. Rory started one question, but then spent the remainder of the class delaying in various ways. Asked what he was working on, he answered that he was working on the homework, but, "*I realized that I was doing something completely wrong so I was trying to find my eraser*."

One day Trevor was sitting at his desk with the textbook open, but claimed he didn't have any paper. Next to him, Jineane had paper but no textbook. I said, "*here you are sitting with work, but no textbook and here is Trevor sitting with a textbook but no work…so (laughing), maybe you could join* [together]." Sometimes my questions provoked changes in behaviour, and others, such as this exchange, had no effect on student action. Even the teacher's suggestion that they share resources enacted no change.

Some students will do unusual things to delay doing work. One class I watched Kyle wandering around the classroom searching for paper towels to clean the marker off his desk. Cleaning one's desk is not an activity most students engage in unless they are trying to avoid a more undesirable task.

*Leaving class.* Students asked to leave class to go to the washroom, retrieve forgotten items, pick up something from the office, and many other reasons. Sometimes these were valid, and sometimes they were merely excuses because the student wanted to go chat with a friend, use their phone, or just needed a break from the classroom. Asking to go to the washroom was a common request in the classes, though it happened least often in the PC 11 class. Asking to leave the class occurred most often during a transition from lesson to homework, or during seatwork. Some students asked frequently, whereas others never left the room during class time.

Both Lindsay and Michelle requested to leave the room frequently. When they did obtain permission, they were never quick to return. On one occasion, Lindsay left class to go to the washroom (across the hall) and was gone for over ten minutes. Another day, Michelle did the same thing. Not too many days later, Michelle asked to leave to go to her locker to get something for another student, but the hallpass was gone. When the teacher asked what she needed, she said she wanted a pencil sharpener, and was told that there was one in the class. She returned to her desk, but complained to her peers about how the classroom pencil sharpener makes the pencil rough. She acted perturbed that she had not been permitted to leave.

Other items, such as textbooks, were also forgotten in lockers, but teachers often had extra copies in class to loan.

*Calculators*. A calculator was a required tool for certain units in all three mathematics courses in this study. Calculator use was prohibited on certain sections and on portions of tests; for example, the FMP 10 course has a non-calculator section on the provincial, so in preparation for this teachers often put non-calculator sections on chapter tests. In both PC 11 and FoM 11 there are non-calculator sections of tests to assess students' ability with and understanding of graphing functions. However, there are also areas where calculator use is required and students are being assessed on their facility with the calculator. One example is the statistics unit in FoM 11 and the trigonometry units in all three courses.

While calculators are a useful tool, and often necessary, they were also observed to be a distraction, and one 'valid' way to avoid actually doing work. Using a calculator for this purpose constitutes putting up a façade, or faking. For example, students appeared to be plugging numbers into their calculator at random, at times even when there was no reason to use a calculator. In these instances I assumed the student was bored and was using the calculator as a distraction. For example, after finishing a quiz one day Ravi started playing with his calculator. As there was nothing else on his desk, I concluded he was avoiding doing the assigned homework and was randomly punching in numbers and operations.

*Chatting.* Chatting was not a tactic used to delay, but it was an alternate activity, something that students did instead of doing what they had been asked to do. Chatting often occurred in the transition period between activity settings, and continued into the subsequent activity setting. It was most common for this to occur immediately following a lesson, while homework was supposed to be started.

Candace and Emily were often engaged in non-mathematical conversation instead of doing an assigned task. They wrote the question numbers down, looked at one and said, "*I don't get it*," and started talking about how to do something on their cellphones. On a number of occasions the teacher had to prompt them to start the homework. Maya and Hannah spent most of a lesson chatting instead of following what the teacher was saying and doing. Marcus and Slav actually faulted their teacher for their socializing: "*I don't know why she put us together*," said Marcus. Melissa did not chat "*in this class*," but she admitted her friends were a distraction in the other mathematics class she was taking concurrently. She said she talked a lot more in the other class.

There were several students who could not seem to help themselves, or at least did not appear to put much effort towards focusing. Max was chatting to Travis one day when his teacher asked him, "*are you doing anything useful?*", at which point he moved back to his desk. Shortly after, however, he returned to chat with Travis. Of particular note here is that Max had to get up from his desk and move to reengage in conversation, an action for which he had received censure only minutes before. Sebastian and Paul claimed they were "*having a spirited debate*" about a question on the assignment when I suggested that they were, "*doing pretty good at this whole delay thing*." The topic of their debate actually had very little to do with the question, and nothing to do with mathematics.

Xander tried to use my presence as a 'valid' activity to replace working. He liked to try to engage me in conversation. After watching him delay for ten minutes I went over to speak to him. He had the first question number (4) written down. When I asked why he had not started, he claimed that he had. I pressed, saying that all I could see on his page was the question number, and assured him that I was not challenging his assertion and he was not in trouble. Xander replied, "*I'm working on it right now. I just pulled open my books*." I agreed with him, and he explained, "*[P]ersonally I just get distracted easily sometimes*."

Sometimes when I walked by students who were chatting, one of them would shift the conversation to something mathematical – such as asking a peer what the homework questions were, or what solution they had obtained for a particular question.

*Cell phones.* Cell phones often appeared when students were 'finished' with a task or assignment, if they thought they could use without concealment, and without getting in trouble. However, they were also commonly seen during lessons, homework time, and other 'inappropriate' settings.

Melissa appeared to be scrolling through music one day but quickly put her phone away when her teacher approached. Stephen too, spent a lot of time scrolling through music during homework time. Another student was seen texting on his phone but when the teacher neared, he turned to take part in the mathematical discussion that was taking place behind him. Michelle had her phone out and was told, "*Don't 'google' the answer, put it [the phone] away*." Meghan was concealing her phone behind her binder and playing a game instead of doing homework – she had previously said that she preferred to work at home. I often saw Tiffany texting in class and it did not go unnoticed by her peers either. During one conversation in which I asked how Tiffany felt about the review game they had just played, Keiran piped up, "*Don't listen to anything she says, she was texting the whole time*." Candace, Emily, and Tasha were chronic offenders when it came to cellphone use. They often texted during the lesson, concealing phones in laps, or behind books or binders. Tasha also left class to talk on her phone (one day just disappearing from the room without pretext). More so than avoiding work, Tasha seemed to want to avoid boredom and achieved this through texting back and forth with a friend from another school. I asked if she was using her phone to look something up (for class), but she said: "*No. I'm talking to a friend."*

The majority of the examples just provided come from female students, and it is true that this population abused the use of the cellphone during class. However, it was not just girls that found cell phones irresistible. Keiran, Scott, Gary, and Travis, were observed using their cell phones multiple times, but not as frequently as many of the girls.

Most of the cellphone use I observed was likely inappropriate use, for, unlike a dedicated calculator, one would assume using a cellphone is cannot be a legitimate or ‘seems legitimate’ action during these times. And, it is true that cellphone use was usually concealed by faking taking notes or hidden behind a book. However, students sometimes claimed to not have a calculator with them and stated that they were using their cellphone as a calculator. For example, Melissa frequently used her phone as a calculator, so it was difficult to judge whether she was actually doing work, or was texting or emailing. Seeing her using her phone one day during a lesson I assumed she was not paying attention, yet when the teacher called on her she responded with the correct answer. When I questioned her about it she informed me she had been using the phone as a calculator. On another occasion, the teacher noticed Candace using her phone, and asked: “*Is that a calculator right now?*” She did not reply, and hastily put the phone away.

In addition to being a calculator, there were other legitimate instances of cellphone use during class time. Although Michelle was a frequent cellphone abuser she made very good use of her phone while she and Jake were working on a logic problem. The problem involved using a grid and a paperclip and trying to find certain ways of placing it on the grid. Rather than making a sketch of each case, she placed the paperclips on the page and then used her phone to take a picture of the layout. She referred to these pictures to ensure she was not repeating a placement she had already done. Phones were also used to graph linear equations using the online application ‘Desmos’.

### Why students avoided

Students offered many reasons for not doing what was expected of them, for example needing materials, needing help, having to do something else, but ultimately there are deeper reasons for their avoidance. I try to get at some of those in what follows. I first offer students’ rationales and then my analysis.

**Students' rationales.** When students were made aware that the teacher or I thought they were delaying, or avoiding starting a task, they often provided rationales or justifications for their conduct, or attempted to correct our assumptions. Needing materials, not understanding, or having to complete another task, were offered by students. Beyond these, students provided other reasons for their conduct.

Xander said, "*I just get distracted easily,*" when asked about his delay in starting his homework. Todd also said he got distracted easily, but unlike Xander, Todd seemed to take ownership for his own distraction. Trevor explained to me that he had not done any homework yet because he had to do test corrections.

Sometimes I gave students an 'out', not wanting them to think I was judging them or condemning their behaviour, such as that offered to Sebastian and Ryan, "*Some people I find just don't do work in class because they'd rather do it at home*." While some students jumped at the offered excuse, others did not bother. In the given example, Sebastian actually replied: "*No, that's not us*."

**My analysis.** As mentioned earlier, some students are avoiding attention, and others are avoiding tasks. For those actions for which the outcome was avoiding a task, I have identified two student goals: avoiding effort, and choosing to engage in a more desirable activity. The two are not mutually exclusive, and one is often a secondary benefit of achieving the other, but here I offer a student example for each distinction and support my claim regarding the ability to identify the higher-ranking goal.

First, there are students who choose to engage in a more desirable activity, but their primary intent is not necessarily to avoid effort. Many of the students who chatted just preferred to socialize during class time, when their friends were close by. Meghan for example, was not doing the homework in class, but was going to do it at home. Playing a game on her phone or chatting with her friends was a more desirable activity (and she did do her homework, so the effort was made).

Students who have a goal of avoiding effort may also engage in an activity that is more interesting (to them), but their choice of activity tends to point to the higher goal. Some students did not bother to do anything else or pretend to do something but just sat at their desks quietly staring off into space. Cara did not try to conceal the fact that she wasn't doing her work during homework time; she just did nothing, or on at least one occasion, did work from another class. Other students just take the opportunity to ‘zone out’. While ‘zoning out’ may be more desirable than doing a task, it is more likely here that the primary goal was to avoid effort.

**Final note**. One of the difficulties inherent in this type of research and method is the unintended consequences of my probing questions. By asking questions to try to discover the rationale behind student behaviour, I often affected their behaviour. Paul ‘zoned out’ frequently, but took his books out and started working when I asked him about what he was doing. This result was more common with some students than others. Jineane, like Paul, was often seen staring into space during homework time, but my questions did not provoke any change in her behaviour (nor were they intended to do so).

## 6.2 Waiting for the teacher

Although waiting for the teacher can be an avoidance tactic, there are other potential reasons driving the behaviour, and thus it is included here as a separate section. Some reasons students ‘wait for the teacher’ include: conserving effort and/or being efficient; not understanding; wanting perfect notes.

### Effort/efficiency

Effort and/or efficiency were rarely the only reason a student would wait for the teacher. Usually there was another goal, such as the student wanted to have the ‘right’ answer, and it was more efficient to wait for the teacher to do it than to try it and potentially get it wrong. Or, the student looked at the problem, did not immediately know how to do it and did not want to try, so he or she waited.

Gary, for example, did not know how to do a question one day but did not want to ask for help. He did not like the teacher’s method of helping because he just wanted the shortest possible path to the answer. “*Like, to get the answer it’s like really short, but [the teacher] takes the long way.”* So it was less work to stare into space and wait for the solution to be presented to the class.

Yet while effort often appeared together with another rationale, it was not necessarily always a factor influencing student behaviour. There were students who made the effort and successfully completed the example, but waited for the teacher to complete the solution before they committed to writing in their notebook. Similarly there were students who tried examples on their own, but were unsuccessful and subsequently waited for the teacher to complete the solution so they could copy it down. Specific examples of these cases can be found in the following two sections.

### I don't get it

When students are asked to try an example or are assigned a question to complete there is an expectation (implicit or otherwise) that they will at least attempt it. There is also a presumption that students have the capability and requisite understanding to at least begin a question or do some part of it; yet, it was common in all three classes for students to wait for the teacher to do the problem without making a stab at it themselves.

Seeing Kyle and Trevor sitting and waiting while most other students were up and working on a question, I asked them to tell me what they were doing. They had been asked to graph two linear equations, but the boys said they were, "*waiting for the explanation*," and "*waiting to see how we do it."* They professed that they had no idea how to begin, and I established that they did not ask anyone for help. Noticing Gary and Jackson also making no progress on the question, I ventured: "*You guys are delaying, delaying, delaying. So can you tell me what you're doing?"* Gary confessed, "*I don't know how to do it. I don't even know what they [the equations] mean*." They said that if they were stuck, they would ask for help, however I noticed they had not done that, so I countered, "*Okay, that's probably what you* should *do, but what do you* actually *do?*" Jackson replied, "*Sit here and do nothing*."

Whereas the students in the previous examples habitually waited for the teacher without attempting a problem on their own, the following students usually tried problems – thus effort was not a factor influencing their behaviour in the following instances. Rory usually tried examples, but, "*If I don't understand what's going on I'll stop, I'll wait until they [the teacher] do the example*." Asked about a particular problem on a review package, Chelsea admitted that she did not remember how to do it. She said she would wait until the teacher did it, “*Because then I can write it down and see how he got all the steps.”* Beth usually tried examples on a scrap piece of paper, so when I saw that she did not try a particular question, I assumed she was unsure of how to begin the problem. She waited until the teacher explained how to do the problem and calculated the final answer. Beth then copied down the full solution from and worked through the steps on her calculator.

### Perfect notes or I want it ‘right’

Finally, there were students who waited for the teacher to complete a solution even though they might have been able to solve the question themselves. The reason they gave me was either: they wanted their notes to be neat; and/or, they wanted to make sure the answer they wrote was correct. I asked Maya one day if she was waiting for the teacher to do it, as she was not trying the given example. She replied, “*Yeah. Pretty much. I just wait for her to do it*.” Asked why, she initially responded that she didn’t know, but then added, “*I just kind of … for my notes I like to have it look all nice. I don’t want to do it wrong, and then erase it.”*

In this situation Maya had not made any attempt to solve the question so the effort involved could have been a factor. Yet, when Maya had a whiteboard to use she tried the examples, and still did not write anything in her notes until the teacher went over the solution. She gave the same reason as she did above; she wanted her notebook to be neat. Though he rarely had difficulty with the problems, Mathias also waited for the teacher complete solutions because he did everything in pen and did not want to “*screw it up*.”

Toby waited as well, explaining that he did the problems in his head and then would, “*I wait for the teacher to go over it,*” after which he would “*write stuff down.”* Toby may have been more concerned with having the ‘right’ answer, than with producing neat notes[112]. Candace’s actions fits this profile too; she waited until the teacher had completely filled in the table of values on the board before she copied the values onto her own sheet and proceeded to plot the points on the graph. Although I saw her using her calculator to work out the values it appears that she wanted to make sure the answers were correct before she committed them to her paper and plotted them. Beth usually tried the examples during

[112] This assertion is supported by Nick’s comments on his inability to understand his own notes (see Chapter 8).

class, but did not write anything down in her notes until Mrs. Hill began to write up the solution. Beth only wrote what was written on the board.

## 6.3 Other demands, priorities, distractions

Students have many demands on their time. Often these other commitments take precedence over what needs to be done for mathematics class (both in and out of class time). Many students felt tension in trying to balance the demands on their time.

During one focus group interview, Hannah shared that she had to do homework from all her other classes, some of which was collected daily, and she also had a job, boxing, and tried to get to the gym every day. "*Like, I try to do as much as I can, but I never… everything never gets done*." Toby added that universities "*don't just look for school stuff*," but that students are told that school must come before everything else. Tasha shared that she would "*love*" to come to morning tutorials but had three other siblings, her dad works, and her mom can not drive her because she has to get everyone ready for school.

Of course, students prioritize differently. One day in class I noticed that Tiffany had not copied down the solutions to her teacher had provided for some homework questions, ones that Tiffany had told him she had had difficulty with. I thought she might attend a tutorial with him to get help, but I overheard her tell her friends that she did not want to attend a tutorial that day because it was her birthday.

The factors that students mentioned that influenced their achievement, or ability to fulfill their commitment to mathematics, are discussed in the following order: sports and work; other mathematics work and other curricular work; physiological. Although it is tempting to use the term 'excuses', the word holds connotations that are neither valid nor fair for several of the situations described below.

### Sports and work

School, club, and rep team sports factor heavily in many students' lives. A previous student (not in this study) once told me that he had to leave school three days a week, drive for an hour-and-a-half to go to a two-hour practice, and then drive home again. This scenario is not the norm, but participating in high-level competition can significantly impact students' academic achievement. Several students in the classes I observed cited sports as a reason they were not able to fulfill the expectations in mathematics.

A few days before the final exam I asked Scott about his progress on the assigned review booklets. He said that he had not been able to do "*all of it*" because he had wrestling, adding that it "*takes up a lot of my time*." Jackson played hockey for a rep team. He had difficulty with much of the material in class, and was not the most diligent student when it came to homework. "*Sometimes I try and do it at home [the homework]….it's just tough with practice. I have lots of hockey*. *Like, upper level hockey,*" he justified.

Depending on the time of year, some students have multiple sports to contend with. Kristi was one such student. She was not making much progress on the assignment in class one day and when I asked about it she described her situation. She hypothesized that she was "*sleep deprived*" as she had only got six hours of sleep the previous night. She had not been able to start her homework until ten at night because she had soccer tryouts and then track.

Only a few students mentioned a job as a draw on their time. Hannah, in first part of this section, cited her job as well as a host of other activities that demanded her time and attention. Maya revealed a similar situation. She expressed some minor concern over the fact that she knew she had to do homework, but was, "*not on top of it*." She listed her other commitments: "*Work, dance, and social studies, English, Math, and Bio, all this semester*."

### Working on a different math assignment or other curricular work

Students sometimes opted to work on a mathematics task or assignment in lieu of that which had been assigned that day. Among others, reasons for this choice included that alternate task was more interesting, or it was of more value[113] to the student.

For example, one day in class Maya was working on homework from an earlier lesson instead of doing the current task. She said it was because what she was doing was worth

[113] Value, as used here, could refer to the mark value of the assignment, or the value to the student in terms of learning and understanding.

marks, whereas the current task was not. Likewise, Trevor spent his homework time waiting to talk to the teacher about a retest. He had to do the corrections on the test to earn a rewrite.

Other than being ‘worth’ more, some students chose to do other math assignments because they were more interesting. Todd, who rarely did homework in class anyway, was so deeply engaged with working on a Desmos© assignment that he stayed past the end of class. He chose to work on it instead of his usual practice, socializing and otherwise delaying. Tyla also was ignoring the homework in favour of the project: “*I was trying to think if I wanted to use this…,”* she explained, looking at some sample work on the website.

Not all students prioritized more interesting assignments. Tasha talked about the mathematics problem sets. She found them fun, and absorbing, “*but when you realize you have a lot more work to do, you put the other priorities first*.” So even though the problem set was more engaging, the time she would devote to it was ‘worth more’ if she invested it in other math assignments.

It was not uncommon to see students working on assignments for other classes during the homework time in mathematics. Sometimes this was due to poor time management or choosing to do other things instead of doing the assignment at a more appropriate time (such as watching television instead of doing homework the night before). Others had not put off work, and were just prioritizing the tasks that needed to be done. The following are some examples of what students said about doing work for other subjects in mathematics class.

Travis shared that he had previously had difficulty completing his assignments, but he had learned to manage his time a lot better from having to balance a lot of hockey commitments with a heavy academic course load in the first semester of the current year. He had had to figure out how to budget time to ensure he completed his homework. That said, during math class one day he was reading a novel for English instead of doing the assigned homework. When I asked him about it he told me that he had to read six chapters that evening, and his that his English teacher was “*scary*” so it had to be done.

Kyle’s comments about not doing the homework in class support the notion that some students value marks. “*I’m probably just going to study it a bit at home, but I have more* *important things for other classes that actually change my mark."* Kyle's mathematics homework had only a small probability of being worth marks, so he appeared to feel that as long as he understood the material, he could prioritize other school work.

Some students made a habit of doing work for one subject in another mathematics class. Max, for example, frequently worked on physics. *"I have this huge physics test tomorrow,"* he explained when I asked him about what he was doing one day. Physics took up a significant portion of his time, he said, and they had many quizzes and tests. Kyle was pleasantly surprised by his result on one mathematics quiz because he had not studied. "*I did better than I thought I would. Cause I didn't study. I was studying for a socials test.*" Chelsea did not do some of the review packages for math and said she could not ask any questions as she had not done much of it, *"because I had other exams to study for too."*

Having these demands did not necessarily mean that a student would choose one, or any, to work on during class. When asked about his lack of progress on the current assignment, Xander complained, "*It's just, I have a lot of work for other classes."* He described some of the assignments he had to get done, yet he wasn't actually working on anything in class. His lengthy 'to-do' list was not sufficient to motivate him to do anything but take a break.

Cara rarely did mathematics work in class, but neither did she usually do other work. When I saw her working on something one day I asked about it. She covered her papers and explained, *"It's for psychology. I wasn't there for the last class so I'm just going to catch up on the assignment."* Rory shared his thoughts on prioritizing different work, explaining that it depended on what you have more difficulty understanding, and how less important or lower priority tasks get put off.

> It really depends because you might go, oh, I've had more trouble with physics, I really want to get that done and I get the math so I really want to do the physics homework so you use this time to get the physics done and if you have spare time later you might go, okay, I'll do math.

## Physiological

If a student was really sick he or she was not usually at school. More common was that students came to class while they were under the weather. Keiran had been absent from school the day before but did not want to miss another class. "*I can't really think straight* *today*," he volunteered. He said that he had wanted to do homework the day before, when he was home, but he "*just couldn't focus on anything*."

Rather than being ill, sometimes students were just tired, either physically, mentally, or both. Putting his head on his desk one day Max moaned, "*I just want to take a nap."* When asked why they had not yet started the assignment, Judy complained, "*I'm tired of school."* Kristi chimed, "*I think I have attention problems,"* adding, "*Math [in] fourth block is not ideal*." Mathias also commented on the schedule: "*I am just so tired today. School needs to start later*." Having difficulty making progress on an assignment one day, Travis claimed that he knew how to do it, but could not summon the energy or focus to actually get it done. His seatmate, Max, contributed, "*It's kinda like, what's your mood.*" He and Travis felt that it had been a really long day.

Having difficulty focussing or being distracted were not uncommon reasons for not doing what the teacher expected or had asked them to do. Amira had trouble doing homework in class. "*Sometimes it's hard for me to focus. Lots of distractions."* Todd, too, said that he was easily distracted in class. He cited a learning disability, adding that he did not like blaming his behaviour on it. But he also said, "*I'm probably just a little bit lazy. I could probably just do stuff*." Like Todd, some students just said they were lazy when asked about their work habits. "*There's also the laziness factor*," said Rory one day. Some days, he continued, you just don't feel like doing anything. *"I just don't want to do anything. So if you don't have to do this, it's not for marks, then you just don't do it*."

## 6.4 TOC

When there was a teacher on call (TOC) student behaviour was often quite different as compared to that observed with their regular teacher. Some students skipped class, whereas others took the opportunity to alter seating plans, be deceitful about regular classroom practices and due dates for assignments, and engage in activities to an extent that they would not normally do with their usual teacher, such as using cellphones, chatting, and being unproductive.

The most extreme change in behaviour is that students saw or heard that there was a TOC and they simply chose not to go to class. Tyrone, for example, was absent when there was a TOC. There may have been a legitimate reason, but when his name was called for attendance Tiffany proclaimed, "*Skipped*." Michelle, too, was absent, even though I had seen her shortly before class began. Increased truancy was not an issue in another class, and a few students told me that they didn't think it would be done in PC11 or PC 12 because, "*most people are here to learn."*

Students tried to take advantage of a TOC. Asked how things are different when there is a TOC, Tasha laughed. "*Seating changes. If the teacher doesn't leave a seating plan – we automatically grab our bags and we just switch*." Students 'mess' with the TOC in other ways too. "*If there's homework to hand in,"* Toby began, "*don't tell about it*," chimed Rory. If the TOC asked about an assignment, they said they would tell them it was not due. Toby went on, stating that if there was supposed to be a quiz they would get out of it by saying they had not known about it, or had not studied*. "You can get out of a lot of stuff,"* he finished.

Further, students often did not work to the same level or pay as much attention as they usually did. In one class the students seemed quieter and outwardly well-behaved during the lesson. Of those who appeared to be paying attention, several seemed a bit confused. However, during the lesson I also observed Tiffany studying her driver's license test guide, Candace braiding Emily's hair, Neil counting his change (with his headphones in the entire class), and Meghan and Chelsea were chatting. There was an increase in cell-phone use and other 'inappropriate' behaviour. I noticed Morgan and Jake both using a phone with the TOC, but I never saw them do it when their teacher was present. In another class when there was a TOC there was an increase in student chatter, and some did not pay attention (whereas all students appeared to pay attention with the regular teacher). The TOC seemed to be a bit confusing, but no students asked questions.

Although Todd did not accomplish much even when the teacher was present, he summed up the situation with a TOC nicely. "*When there's a TOC I know that I really don't do anything.*" He elaborated: "*I feel like there's a stigma around TOCs, that you don't really have to like, do anything, you can just kind of chill."* Asked directly if they paid attention when there was a TOC, Kyle clarified, "*We don't not listen, we just don't try as hard*." Jineane explained, "*We have them [the teacher] all year and we get used to them. I guess like, getting used to another person [the TOC], it's just like, why even bother?*"

Part of the reason that students 'slack off' is that the expectations are lowered. Students in all three classes seemed incredulous when I asked whether the teacher expected that they had learned anything with the TOC, or had completed any assignments. Jineane stated, *"We know that [the teacher is] going to go over it again when there's a TOC here."* Students don't feel responsible for any assignments: "*Teachers don't usually collect work when they had a TOC,"* explained Toby. When Toby's teacher returned she worked through some of the assignment that she had left for the TOC to give to the students, and then gave the class extra time to work on it.

Upon their teacher's return, the students claimed that the TOC did not explain the lesson (a continued review of graphing linear equations). However, I had observed that class and TOC *did* explain the lesson, even asking students, *"Have you seen this before?"* When they nodded he asked, *"You bored? You want me to just buzz through this?"* They nodded again and he quickly went through the remainder of the lesson.

## 6.5 Summary

In this chapter I looked at four patterns of student action, which I first noticed during my observations, and then saw confirmed when I did a more thorough analysis of the data. Whereas in Chapters 4 and 5 the themes took place within activity settings, those discussed in this chapter occurred across multiple activity settings. I titled these themes: avoidance; waiting for the teacher; other priorities, demands, distractions; TOC.

Many students avoided both attention and tasks throughout my observations. The reasons for avoiding tasks were varied – some wanted to do something else and/or wanted to avoid effort. Avoiding tasks and attention are not mutually exclusive, however. Some students avoided tasks because they wanted to avoid attention (potentially revealing a lack of understanding). Others chose to do tasks (or fake it) in an effort to avoid attention. A student who wanted to avoid effort and attention often had to strike a balance as the achievement of one goal necessitated leaving the other unsatisfied.

Waiting for the teacher was a common action, particularly in 'now you try one' tasks, and during homework. For some this was a way to avoid effort, or to ensure that one's notes were 'perfect'. For others, waiting for the teacher was the best way to figure out how to do something that they did not understand. Sometimes waiting was a habituated response if a student knew the teacher always went through the examples, or if sufficient time was not provided.

Other priorities, distractions, and demands on student time frequently came up as topics throughout my informal interviews with students. Extracurricular activities such as sports and work, other assignments, and physiological factors all played a role in influencing student actions and goals, in multiple activity settings. Students have many demands on their time and have to set priorities, which do not always include mathematics.

And finally, student behaviour when the class had a TOC was quite illuminating, in some cases. Beyond the fairly benign switching of seats and adjusting of classroom norms and expectations, there was a much lower level of productivity. At least one student skipped class when there was a TOC. Student action when there was a TOC was quite informative when deducing their motives, as will be seen in Part III.

# Summary of Part II

The three chapters that form Part II describe student goals and actions within and across activity settings. Chapter 4 looked at student action within the typical activity settings of direct instruction, note-taking, now you try one tasks, and homework. In Chapter 5, I added some less typical or less frequent activity settings: problem solving, student presentations, review days, and assessments. Finally, in Chapter 6 I discussed themes that emerged across activity settings. Interesting patterns of student behaviour were observed when there was a TOC, and there were persistent and common actions that arose, such as waiting for the teacher, managing other priorities, and avoiding.

The totality of these chapters provides a comprehensive (but not necessarily complete) typology of student behaviour within the mathematics classroom. Just as student action in one activity setting does not provide enough information to deduce motive, no single chapter here will suffice either. If one wishes to determine students' motives it is necessary to focus on each particular student and consider their actions and goals both across and within activity settings. This type of analysis is the aim of Part III.

# PART III

> What is important in qualitative research in general […] is not the validity or accuracy of the description, but the effect, the action that that description sets up inside others. (Mason, 2002, p. 229)

Looking at specific student actions across settings provides more insight into the reasons underlying student behaviour. In Chapters 7, 8, and 9, then, I look “across the grain” (Watson, 2000) and analyse the varied actions of particular students over multiple activity settings for the duration of the study. Thus, while in Part II the unit of analysis is the activity setting, in Part III the unit of analysis is the student.

In total, case studies for ten students comprise Part III. The students discussed in these chapters have been selected because they exhibited ‘interesting’ behaviours; sometimes contradictory to their stated goals, sometimes in opposition to the teacher’s intentions (implied or stated), and sometimes just fascinating for other reasons.

In the following chapters I take each chosen participant in turn and describe their engagement in the class through my observations of their behaviours and our conversations. Taken together with their previously determined goals in specific activity settings, using Leontiev’s Activity Theory I deduce the primary motive that drives their activity in the mathematics classroom. For each student I try to provide a narrative that gives the reader some context and perhaps a deeper connection or insight into the student of interest. The aim is twofold: first, to identify each students’ primary motive, which according to activity theory cannot be articulated by the student himself; and second, in doing so to demonstrate that to determine the primary motive of a particular individual it is necessary to have multiple observations over a period of time, across different activity settings.

The three chapters are divided by classroom teacher, and thus by course. The intent is not to differentiate students’ actions with respect to the course they are taking; however, it is acknowledged that the content and demands of each mathematics course likely has an effect on the structure of the classroom and the approach each teacher uses. To clarify, although we can differentiate Mrs. Hill’s approach to teaching PreCalculus Mathematics 11 (PC 11) from that of Mr. Johannson’s approach to teaching Foundations and PreCalculus Mathematics 10 (FMP 10), it is important to consider that if they were teaching the same course their approaches might be (more) similar.

The chapter order is not significant; they are addressed in order of course ‘difficulty’, with first PC 11, second FoM 11, and lastly, Foundations and PreCalculus Mathematics 10 (FMP 10). Thus, in Chapter 7, I analyze the actions and goals of two students from Mrs. Hill’s PC 11 class. In Chapter 8, four students from Mr. Matthews’ FoM 11 class are discussed, and finally, in Chapter 9, I discuss four students from Mr. Johannson’s FMP 10 class.

Within each chapter there is no significance to the order in which each particular student case is presented. Each case begins with a brief description of the student, based on my impressions of their personality and character; then a much longer body wherein I describe the student’s actions and comments within the classroom; and finally there is a short summary, concluding with my analysis of that individual’s motive(s) in the in that class. Within each case the second section (body) differs slightly depending on the relevant themes; for example, the body of Xander’s case (in Chapter 9) includes a general description, followed by two themes, whereas Maria’s (in Chapter 8) has only a longer general description, because it made more sense to discuss her conduct holistically. The subsection headings may differ from one student to the next as they are not intended for direct comparison here, but are used to organize which activity settings provided relevant information for a given individual student. Some students made interesting comments and/or performed actions that were noteworthy in certain activity settings, such as assessments, whereas others’ actions in these settings did not add anything significant for analysis or discussion.

It bears repeating at this juncture that a fundamental belief that underpins all of my research is that student behaviour is influenced by context. The size of the effect of a specific element of the context varies depending on the student. The subject area is one context where an individual’s behaviour can be different. Johnny might be focussed and hardworking in English class, but distracted and withdrawn in mathematics. Another contextual factor is the teacher – he or she can have tremendous impact on student behaviour. Or, the teacher may have little effect on student behaviour – some students behave in much the same way in any mathematics class.

Given the scope of this study I did not have the opportunity to observe students in other math classes, much less other subjects. However, I was offered some insights. One such came from Melissa, who was taking two math classes at the same time and discussed with me her behaviour in her other class. The difference in Melissa's behaviour in her other class, as discussed in Chapter 5[114], stemmed from the composition of the class, not the teacher. Other insights I gleaned from general conversations with students when they spoke of other math teachers or spoke in generalities about behaviour in mathematics class. From these exchanges I concluded that, speaking broadly, a student's actions were often the same in different math classes, irrespective of the teacher[115].

[114] While in Mr. Matthews' class Melissa tended to stay focused on tasks and do what she was assigned, she reported that in her other mathematics class she was more distracted and more likely to chat and socialize with her friends.

[115] Michelle, however, was a different story. In Chapter 8 I provide a summary of Michelle's actions in the context of Mr. Matthews' FoM 11 class.

# Chapter 7:

# Mrs. Hill's Students

> Okay guys, get your notes out! We don't have very much time today, okay? Alright, so today we're going to do a mixture of what we did yesterday and the day before with the special triangles – we're going to put it together. (Mrs. Hill, addressing the class)

To set the 'scene' for this chapter I offer a summary of the description of Mrs. Hill and her classroom from Chapter 3. The school is located in the Greater Vancouver area, and serves a primarily middle class student population, many of whom have after school/weekend jobs. Mrs. Hill's love for teaching was consistently exhibited in her positive demeanour and the exuberance with which she interacted with her students about mathematics and mathematical problem solving. Her approach to teaching could be described as traditional, and she endeavoured to encourage in her students an appreciation for mathematics in addition to taking seriously her obligation to prepare them for future mathematics courses.

The course observed was PC 11, a prerequisite to PreCalculus Mathematics 12 (PC 12), which serves as a gateway course to most business and science-based university programs. As such, the class draws a certain population of students. Toby and Beth were two of the students who elected to take the course, taught by Mrs. Hill in the particular semester of the research study. This particular class was observed 10 times from February to the end of April, on a weekly[116] basis. Two focus group interviews were held in May, in two consecutive weeks. Five students volunteered for the first group, and four for the second, with two students attending both.

Case studies for Toby and Beth are developed and analysed in this chapter. Their conduct and comments, collected over time and across a variety of activity settings, provide data, the analysis of which suggests each student's primary and secondary motive in mathematics class.

[116] There was a two-week hiatus for Spring Break and two other missed weeks (1 in March and 1 in April) due to scheduling conflicts.

## 7.1 Toby

*"If I'm understanding the unit I do no homework ever. That's why I usually don't do homework in most of my classes – because I usually understand it."*

Toby was a friendly and approachable young man, who gave candid responses, notably so because they were often self-deprecating. He was not entirely sure of his reasons for taking the course, but knew he that wanted to get into university, for something, possibly engineering, and thought he would need this course.

In what follows I will give a description of Toby's observed actions within the classroom as well as excerpts of conversations, organized by different activity settings or the subject of conversation (i.e., TOC, cheating). Early on the students in this class were given a Mathematics Student Survey[117] and asked to rate their responses to twenty-nine questions concerning taking notes, doing homework, group work, problem solving, beliefs and feelings about mathematics, reviewing for tests, and learning and teaching preferences for mathematics. I use Toby's survey responses to support my observations of his conduct and what he said. The analysis is divided into four sections: observable classroom behaviour; assignments; assessments; general comments. A summary and analysis of Toby's primary and secondary motive concludes the case study.

### Observable classroom behaviour

Mrs. Hill began most of her classes with starter problems, which usually had nothing to do with the topic to be covered that day. Toby shared that he enjoyed these problems, especially the feeling he got when he was able to solve one. He also liked that the problems also helped to pass the time, "*because then you look and half the class is gone and that's pretty good*."

[117] See Appendix B.

When Mrs. Hill gave her students a game-theory problem (Nim[118]), Toby seemed particularly engaged[119] with it, possibly because this problem was given at the end of the block when students were typically assigned homework and he found the problem was a more interesting (and acceptable[120]) alternative. Toby was a fairly strong mathematics student and had good problem solving skills. The following excerpt shows his ability to strategize and to communicate his thinking.

> See, I think I always win. Because you put down two, if you put down two, I put down one, you have to put one down. You put down one, I put two, you have to put down one. So no matter what I win in this situation.

Following the starter problem, for which Mrs. Hill usually did not supply an answer, there was a formal lesson, usually prefaced by Mrs. Hill asking students to take out their notes[121].

During a lesson Toby appeared to be attentive and would volunteer answers to Mrs. Hill's questions. These questions were usually short, requiring only a single step or two, and were designed to provide feedback to Mrs. Hill about how her students were doing with the material and to help ensure they stayed alert and focussed.

For example:

| | |
|---|---|
| Mrs. Hill: | So for instance, if this one's seven, what would you expect this one to be? |
| Toby: | Seven root three? |
| Mrs. Hill: | So with the information we have, we've got an angle and it's opposite and we've got a side. What could we find right now? |
| Toby: | Angle C. |

Toby's responses were almost always correct.

On the initial survey, Toby expressed a strong agreement with the statement: "*The teacher knows the right answer and will give it to us eventually*." This corresponds to his observed

[118] See Appendix D.

[119] The term 'engaged' is used in this dissertation in an everyday sense, as opposed to a theoretically defined one.

[120] Acceptable to the teacher.

[121] As described in Chapter 5, students had skeleton copies of notes to fill in terms and try examples.

conduct and comments regarding trying examples during class. Toby would do some of the examples students were asked to try during the lesson, but not all. Asked about his practice regarding this, Toby said: "*I just do it in my head and then wait for the teacher to go over it and that's when I write stuff down*." Given Toby's habit of doing them in his head, it is possible that when he did not immediately know how to do a given question, or if the question could not be worked out without writing something down, Toby might not do it because of the effort required. This hypothesis is supported by some of Toby's comments in other activity settings, found below.

Sometimes Mrs. Hill asked students to try examples on the whiteboards or the windows; this got students up and moving. When this occurred Toby would participate, and if he and his partner finished earlier than others, they doodled on the board or the window.

Toby 'strongly agreed' with the survey statement, "*mathematics is mostly memorizing,"* and indicated that he takes notes to help him learn the material. He 'somewhat agreed' with the statement, "*I take notes because the teacher tells me to*."

During class I saw that Toby wrote down some notes, usually after Mrs. Hill had written them down. I had the opportunity to ask Toby about this one day in class. Asked why he takes notes, he replied: "*I'm terrible at taking notes."* As this contradicted what I thought I had observed, I asked for clarification. Toby explained that he took notes, "*but I look over them and I have no clue what I've done*." He related a recent incidence in which he had tried to use his Physics notes to study for a quiz over a holiday weekend, but, "*I had to go find my friends and ask to see their notes because I had no clue what I did.*" Toby took notes, but did not take complete notes, thinking he would "*remember the steps*" because the material made sense at the time. Later, when he needed to review his notes because something in the homework did not make sense, he found that what he had was not sufficient to help him. "*When I look over it later when it doesn't make sense [the homework or something] and it still doesn't make sense."* He continued talking, claiming he was "*terrible at taking notes*" but he was lucky because some of "*[the material] just sort of clicks and that's what I usually get 'A's on. And then what doesn't click...I try and forget those parts."*

Toby's note-taking habits seem to be guided by efficiency and effort. He takes notes partly because he feels the teacher expects it, and because he intends to make use of them at some point (but is often unable to follow them because he has not written enough). If he does not take notes, it is "*because it's easy and [I] don't want to do it."*

Following a lesson Mrs. Hill assigned homework, usually from the textbook. Students were expected to work on this during the remaining class time.

## Assignments

Although on the survey Toby responded that he 'somewhat agreed' that he does homework because it helps him learn, he 'strongly agreed' that he did homework because it was worth marks. However, he rarely did much homework during the given class time. Toby and his seatmate were often playing games, doodling, or just chatting. He would often pack up early, once explaining that he'd done the previous day's homework and would go to a tutorial to finish the current assignment.

Toby's completion of homework seemed to be heavily influenced by the amount of effort required and the value he receives in terms of marks. When I overheard Mrs. Hill joking with Toby about something I walked over ask Toby what the conversation had been about. He responded that he had not done one of the homework questions because it had four parts and for each part it asked for the domain and range and then to draw the graph. "*[S]o I said each domain and range but I'm not going to draw each graph. That's a lot of work.*" He explained that he understood graphing and did not find it difficult, adding, "*[i]t's not hard – it's just a lot of work*." His seatmate called him lazy, and Toby agreed: "*Hell yeah*." He complained that he lost "*a lot of marks off on quizzes due to graphs because I wouldn't draw the lines long enough*" and the teacher would "*get mad at me.*" It was clear that this had happened more than once, and Toby was aware of what he needed to show, but was not willing to do it.

Given Toby's statements, it is not that he did not know what to do, rather, it is that he was often lazy and was not overly concerned with conforming to teacher expectations or mathematical 'rules'. However, on another day when Mrs. Hill was talking about simplifying $\sqrt{8}$ to $2\sqrt{2}$, Toby asked for clarity about whether "*that's how we have to do it on a test* *then?"* This suggests that he had some interest in having the answers in the format the teacher desires.

On another day, Mrs. Hill was talking to Rory and Toby about the homework. Rory was showing Mrs. Hill that he had started his homework and she suggested that Rory try to influence Toby to do his. Toby countered that he was not easily influenced and would, "*do [the homework] tomorrow during focus. It's only four questions*." When it was pointed out to him that there were actually fifteen questions he laughed and admitted he probably would not do it during 'focus.' Rory stated that Toby was never going to do it, and Toby's response seems to indicate Rory is correct. "*When she says it's even more questions that just discourages me more*."

Toby's actions regarding homework were heavily influenced by the perceived amount of work and the value he receives from actually doing the work. For Toby the primary value of doing the work seems to be in getting marks for it. When asked if he did homework, he explained that it would depend on whether or not he 'gets' the material. "*If I'm understanding the unit I do no homework ever. That's why I usually don't do homework in most of my classes – because I usually understand it*." Mrs. Hill's policy of giving full homework marks to a student who got an 'A' on the test for a given unit usually worked in Toby's favour. Even in classes where there was not a 'back door' to getting marks for homework, Toby sometimes chose not to do it, based on the effort required. When he had only completed half the assignments in one unit, therefore receiving a 5 out of 10 for homework, Mrs. Hill told him he could get full marks if he did the other five days. Toby shared his thinking: "*Do I really want to do five more days that I haven't even started? Just for 5 marks, and I decided, no*." He gave an example from another course, where the teacher gave three marks for completing a twenty-question assignment, stating, "*I won't do it, 'cause twenty questions isn't worth three marks*." He saw the bulk of his homework assignments as "*a lot of work if you're not going to copy*."

Toby frequently delayed starting homework in class, avoiding it by chatting with friends or on one occasion actually going through the motions of unzipping his backpack, looking like he was taking out books, then zipping it back up and repeating the process. When Mrs. Hill noticed, she told him to "*do something useful."* He countered, exclaiming that there were only three minutes left in class, adding that he had finished the first part and he was "*I'm getting this stuff."* He said that he was going to do the homework in a tutorial session before school the next day, which was where he said he normally did his homework. He had difficulty doing homework at home, not due to distractions but because he could not "*force*" himself to do it. I wondered how he was able to make himself come early to school to do it, and he explained: "*[I]n the morning I don't really have to do anything. I just have to leave ten minutes earlier to catch the early bus*." Often students ended up doing their homework in another class, which supports the notion that efficiency is a significant factor in their actions. Toby and his peers admitted that their drafting class was "*pretty much a spare […] so we all do work [for other classes] in drafting*."

In addition to textbook homework, Mrs. Hill also assigned problem sets at the start of each unit, to be collected two days prior to the test. Asked to describe them, Toby said: "*They're problems. And they seem like fun, because math problems can be fun, and then you have to explain how you got the answer and that's when it all goes downhill*." Although he said that they did not have to do the problem sets, he said he did not want to get zero out of six for a mark on them. Given the difficulty of some of the problems, and the fact that they were for marks I asked if there was any copying. Toby said there was "*LOTS of copying*," and that the teacher knew about it, and had said that copying was fine it each student wrote the answer in his or her own words. Regarding the problem sets, Toby said they were "*fun, if you get the answer. Cause like, wow, I'm good at this, I got the answer, that wasn't even that hard. But then when you don't get the answer that's just, that's no fun."*

Toby's actions around homework were heavily influenced by the value he receives in terms of marks balanced with the effort required to attain those marks. He indicated on the initial survey that he "strongly disagreed" with the statement, "*I do my homework so that I don't get into trouble with my parents*."

## Assessments

For each unit Mrs. Hill typically gave one to two quizzes a week and a test at the end of the unit. She allowed students to do corrections on their quizzes to gain extra marks, and they could do corrections during a morning tutorial. Toby usually did well on quizzes and tests, if he showed his work. On one particular quiz he said: "*I got perfect, except we*[122]

[122] This quiz happened to be a partner quiz.

*only got three out of six, because we showed no work*." Toby said and his partner got distracted and started drawing on the quiz and when they realized there was only ten minutes left they rushed to complete it and did not have time to show work.

Sometimes Toby used reasoning and logic rather than the methods taught in class. Toby explained to Beth how he found the equation of a given quadratic function question without showing work (he used logic and reasoning rather than rote algebraic methods). He agreed with my suggestion that he would rather use something that makes sense than follow an algebraic method. "*If it's easier […] when you understand the question you don't need all the algebra.*"

Again, Toby's actions appear to be realizations of a goal of efficiency and minimal effort. Marks are also a considerable factor in Toby's actions. He came to Mrs. Hill's morning tutorials to work on his homework and to do quiz corrections, but did not really need help; he was just fulfilling Mrs. Hill's requirements for getting the marks. He often asked Mrs. Hill for extra marks, and would carefully go through his tests looking for them.

I asked a focus group[123] about test-taking practices and whether there was an opportunity to cheat. They seemed to think that it did not happen in their class and it would be difficult to cheat because of the desk placement, but that cheating had taken place in other subject classes and in past mathematics classes. Given that admission, I asked them, *"If you, or if someone was going to cheat on a test, why would that be?*" Other students responded that they might cheat if they did not know the subject at all, or if they were stressed. Toby explained:

> For me it's more like, if you don't get a lot of it, like if you go through a test and there's only one question you didn't get, you don't really need to cheat cause you're not that stressed. But if you went through the test and there's like ten questions you didn't get you're like "I should really try and figure out the answers just by looking around" because you sorta need those ten questions…

Toby did not feel he 'needed' to cheat on a quiz or test if there was only one question he couldn't get, partially because of the consequences of getting caught, but also because they could do corrections on their quizzes to get full marks anyway. However, he did admit

[123] Two focus-group sessions were conducted with volunteer students from Mrs. Hill's class.

to glancing at someone else's quiz to see if it "*sparks anything in my memory so I'll know how to do it. But if looking and looking at the answer doesn't help then I just leave it because I'm going to need to go to a tutorial anyway to figure it out."* I followed up by asking if Toby had cheated on a test, and not been caught, would he try and learn the material after the fact? He replied, "*If it was like a really big part of a unit … and then I don't do it because that's too much work*."

Generally this group felt it would be hard to cheat in mathematics because it would be difficult to look something up on a phone and because you have to show you actually know what you're doing. Most students felt that the teacher would give them a warning first anyway, as Toby said, something like, "*keep your eyes on your own test*".

So while Toby indicated that he would not normally 'cheat', he might glance at another's quiz or test to get an idea. If he did cheat, he might review the material after, but not if it was too much work.

### General comments

This section contains some discussion of Toby's conduct on review days and when there was a TOC, as well as his comments about getting help.

Before a test Mrs. Hill usually had a review class during which she would lead a bit of review and then students could use the remainder of class to work on assignments (homework or problem set) or study. At the start of a review class Mrs. Hill provided a small number of problems for students to try to ensure they knew what they needed to know for the upcoming test. Toby usually did some review, consisting of reading the notes, trying problems he had previously had difficulty solving, but often he was just chatting with his friends.

One day when I attended the class, I found there had been a substitute teacher (TOC) for the previous lesson. I asked a focus group of students about what happens in class when there is a TOC. They indicated that they would switch seats, avoid telling the TOC if they were supposed to submit an assignment that day, and Rory said, "*try to get out of anything you can*." I asked the students whether they would skip class if they knew there was a TOC, as I had seen it in another class, but the group felt that would not happen in a

'PreCalc' class, though they could see it happening in other classes. Other than moving seats, and not being particularly concerned about completing any assignments given by the TOC, Toby's behaviour was not markedly different.

Toby was a competent mathematics student, and did not often have difficulty with the mathematical topics in the course. If he did, he rarely asked his seatmate for help, unless his seatmate was a friend. In particular, he never asked Eva for help because, "*it makes me feel really stupid*." He gave an example of a difficult quiz[124] on which he had scored 6.5 out of 12. Once he found out what most of his peers got, he thought his was not that bad, but then he found out Eva had got a perfect score. He said he would rather ask the teacher for help than ask Eva. Most of the time Toby would ask his friend Mathias for help.

### Toby's motive

Toby's conduct seems to strongly tied to a desire for efficiency and mitigation of effort, strongly counter-balanced by a desire for marks. He took some notes, because he perceived it was expected and because he occasionally looked at them later to review or help with a homework question, although he had difficulty gleaning much from them. He would not normally cheat on a test or quiz because it was not worth the consequences and because he could get the marks anyway by attending a tutorial, something that he did frequently in order to work on his homework and do quiz corrections. For Toby, this only meant catching a bus ten minutes earlier so it was 'worth it'. In the case of "now you try one," Toby might try the problem in his head but would not write anything down until Mrs. Hill had provided the answer.

Figure 7.1 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Toby's actions, his voiced and otherwise indicated goals, and, extrapolated from these, his motive.

[124] Mrs. Hill commented: "*You can do corrections. That's why it can be a difficult quiz."*

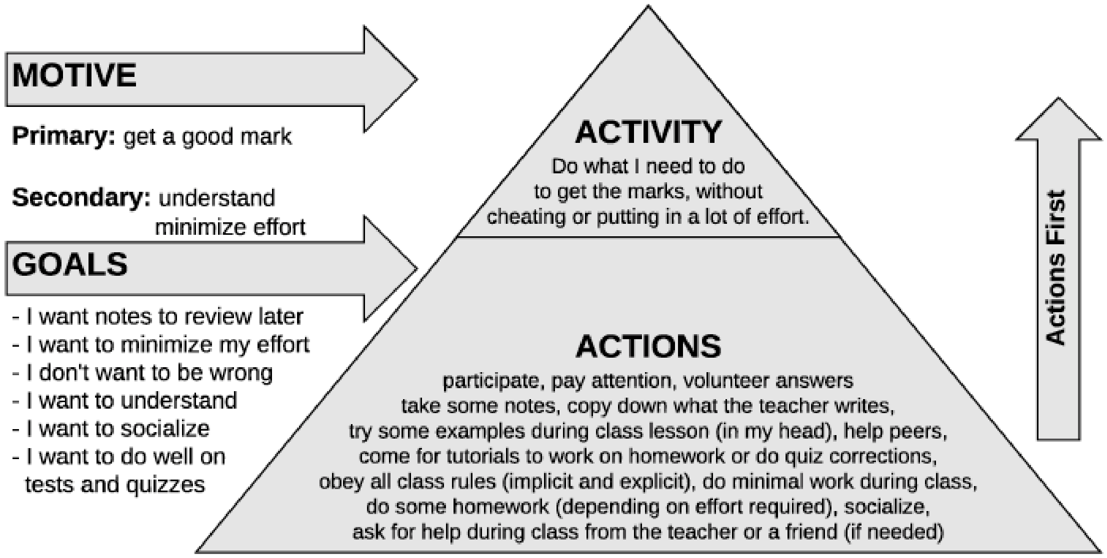


**Figure 7.1 Using an 'actions first' approach to determine Toby's motive**

Toby, through his observed conduct and comments, presented as a mostly engaged student, concerned with understanding the material and largely complying with teacher expectations, and ultimately driven by the desire to get a good mark. A strong secondary motive was to conserve effort.

## 7.2 Beth

*"I don't hate math, it can just be a little tiring at times. But it's a bit hard. It's something I have to work harder for. I find myself putting more effort into my math."*

Beth, like Toby, was a student in Mrs. Hill's PC 11 class. She was amiable and talkative, but not overly chatty. From day one she struck me as hard working and attentive; with further observation she also appeared competent but unsure, requiring frequent confirmation of her solutions. Though she had the option of taking either PC 11 or FoM 11 to satisfy the mathematics prerequisite for her desired area of study, Biology, she explained that she chose PC 11 because it opened more doors. Beth also mentioned that she if she took the course now (in high school), she would not have to pay to take it later if she ended up needing it.

In what follows I describe my observations and provide some excerpts of conversations with Beth that took place during different activity settings over the duration of the study. These are organized into three broader categories: direct instruction and taking notes; reviewing; assignments and assessments. A summary and analysis of Beth's motives concludes the case study.

### Direct instruction and note-taking

Beth was very attentive during a lesson. She took detailed notes and would occasionally volunteer answers to Mrs. Hill's questions.

Early on I noticed that Beth would often wait for Mrs. Hill to do a problem before she would attempt it. She was not 'doing' anything, but could have been thinking, or merely staring as she waited for Mrs. Hill to write down the solution. Once Mrs. Hill had written it on the board I saw that Beth copied it down and then tried it on her calculator. However, on one occasion when Mrs. Hill was about to provide the solution to one of these questions, Beth cried, "*Wait! I'm so close."* She wanted the opportunity to complete the question on her own. When she did try the examples, Beth often demonstrated that she was concerned about ensuring her answer was 'right' and it was common for her to ask Mrs. Hill for confirmation. For example, during a "now you try one" in the midst of a trigonometry lesson, Beth asked Mrs. Hill: "*Is the answer 70?"* Assured that her solution was correct, she then asked, "*And that's the only one?"*

Beth seemed to lack confidence, frequently seeking reassurance and confirmation. She requested help, stating, "*I just want to make sure I did this right*." With a lot of mathematics, it seemed Beth understood the process. She seemed to equate procedural fluency with understanding, yet sometimes she was not able to determine how to begin a problem. Occasionally she would look at the work of a peer to get some guidance for how to begin a task. She asked many questions while Mrs. Hill was demonstrating examples, often indicating she was unsure of what procedure she needed to carry out, or what she was being asked to find. During a trigonometry lesson she asked, "*What are we trying to find?,"* followed shortly thereafter by, "*So would we have to find the angle of C then?"* On another day, she raised her hand and waited until Mrs. Hill came over. When she did, Beth said, "*I just want to make sure I have this right*," wanting verification of her answer to a question about which trigonometric ratio was positive in a given quadrant. Beth was relying on a mnemonic, ASTC[125], to establish the answer. Mrs. Hill cautioned her against relying on her memory in favour of using her understanding of the coordinate plane and the signs of the x- and y- coordinates.

Beth shared her feelings about her learning of mathematics one day when I walked over to ask her how she was doing on a factoring problem. She said it was going "*alright*," but she was having some difficulty remembering how to do it. "*I remember doing this but I don't remember how I did it so I'm just trying to like see….get rid of the mental block*." She added that even though Mrs. Hill had just "*gone over it […] it does not click with me*." Beth struggled with math and often relied on memorization of rules to get by. She was not afraid to ask questions and seek help, from her teacher or her peers. Sometimes Beth tried the examples given during the lesson, but other times she waited to copy down the solution Mrs. Hill put on the board.

One day during class I had the opportunity to ask Beth about her reasons for taking notes. Primarily, the purpose was to use them for later reference. "*Like if I forget something or sitting here doing homework and I'm lost on something I go back to my notes and then I see 'oh, this is how you do it'*." Mrs. Hill's skeleton notes were "*good*" because they were organized and had blanks they could fill in with formulas and do examples, but Beth also found the act of writing helpful because she could "*remember it more than just looking at it*." However, she added that she had difficulty keeping up with the notes in some of her other classes so she missed some information and her writing got "*really messy*".

## Reviewing

Review days typically began with Mrs. Hill solving a few types of problems on the board and then allowing students to do practice or catch up on old assignments. During these sessions Beth paid attention to Mrs. Hill's explanations, sometimes trying the examples, sometimes waiting, and generally spent the remainder of the class working hard doing review and looking through her notes.

[125] All Students Take Calculus (ASTC) is a mnemonic often used to teach students how to remember which trigonometric ratios are positive in which quadrants.

For one review class, on sequences and series, Mrs. Hill decided to do something different. Each pair of students was given out a collection of triangles with an expression written on each edge. The goal was to create a hexagon with the pieces, where the statement on the edge of one triangle was of equivalent value to the statement on edge of the triangle it was touching. A few minutes into the task, I noticed that Beth and Chloe did not appear to be doing anything. After a brief conversation I surmised that Beth found the task a bit daunting. The sheer number of possibilities and number of calculations to be carried out was overwhelming. I began by asking her if she could tell me that they were doing. Her response conveyed that she understood what was required of the task: "*All these triangles are supposed to go together to make a hexagon, and like, these ones are the same, kind of thing, but it's like, these ones come together, these two connect*." Beth explained how the pieces were supposed to fit together or match up, where one triangle edge might have the terms of a sequence listed and another triangle edge might have the sum of that sequence, or another term, or the general term. She understood the task, but did not seem interested in working on it. I asked how she and Chloe were starting and she explained that they were trying to find the triangles that formed the perimeter of the hexagon (Mrs. Hill had written these on the board to assist the students). I commented that it looked challenging. Beth agreed, adding that she appreciated the hint Mrs. Hill had given (about the perimeter pieces). "*Yeah. So it was nice that she gave us the hint, this time*." At one point, Mrs. Hill had given the class two problems, telling them that one of them was impossible but not indicating which of the two. Beth found this unfair: "*So you could have wasted your time if you chose the one that was impossible while others did the possible one*." She continued, commenting on problem solving in general: "*So you know, it's fun, I guess, but if it were for marks it would be really frustrating. Especially when you're not getting told which one's possible and which one's not*." These statements suggest that Beth preferred mathematics when there were rules she could learn or memorize and procedures she could practice and follow.

With respect to the 'make a hexagon' task, Beth did not seem to see much point in trying it because she found it frustrating and it was not for marks. She also indicated in the initial survey[126] that she 'strongly disagreed' with the statement 'group work helps me learn

[126] See Appendix B.

mathematics.' She seemed to prefer the more usual review class wherein Mrs. Hill provided examples and Beth could do practice problems from her textbook. When doing this practice, Beth also specifically choose problems that she had found difficult in the past, during class or in her homework.

### Assignments and Assessments

Beth completed all of her homework, all the time, even when it was really tedious. In general the quantity of homework was not onerous, but she found some questions to be repetitive and time-consuming, for example those involving solving triangles. "*It's a good workload it's just that it's very tedious to do when you have to draw all the triangles and you have to get every angle, every side*." Though Beth felt she understood the material she still attempted every question.

When she had difficulty with her homework Beth was not afraid to ask for help from Mrs. Hill. She also asked her peers and often glanced at her seatmate's work to help her get started on a problem. She understood the need for homework, but was concerned with demands it placed on her time and other commitments. "*To be honest, I understand the concept of homework but […] what if you have extracurricular stuff or homework in other classes? […] You only have a few hours at home, depending on when you go to sleep*." Beth always completed her homework, not only to obtain the marks for submitting it, but also because those problems might appear on a test and she wanted to make sure she could solve them.

For Beth, studying math meant doing practice problems, repeatedly. She contrasted studying for Mathematics with studying for English: "*It's just when you get to math it's kind of like a more rigid subject […] the method that you study is doing all these problems over and over and over again.*" She stated that even when she knew what she was doing, she could get a bit confused. "*[S]ometimes I find if I'm studying […] everything I write just starts to look like gibberish to me. I know what I'm doing but it's so much stuff, I'm like, "what do these numbers mean, why are they here?"* For Beth, mathematics required more effort than her other subjects, and she sometimes found it tiring: "*I start to get a bit exhausted*."

In the minutes immediately before an assessment Beth was usually doing some last minute study, not because she had not prepared but because she liked to refresh her memory. She often asked Mrs. Hill specific questions about what they could expect on the test: "*Is there a way you can tell if something can be factored? Will we get ones that can't be factored?"* During one quiz I noticed Beth looking around at her neighbours, even turning around to look behind her, but more often beside her, at her seatmate's paper. When class ended and many were not finished the quiz, Mrs. Hill allowed them to stay, at which point her seatmate packed her stuff up and nudged her quiz closer to Beth. Although I did not ask her directly, my sense from Beth is that she felt cheating was wrong and would only do it if she was desperate. She held on to her quizzes until the last possible second, sitting and staring at the paper, though she said she was checking her answers.

### Beth's motive

Beth was an attentive and conscientious student. Mathematics did not come easily to her, but she was a hard worker, willing to put in the time and effort to complete all of her assignments, even tolerating repetitive practice. She relied largely on memorization and repetition of practice problems to help her do well on quizzes and tests. She wrote complete notes, sometimes trying the examples given during the lesson, and at other times waiting for the teacher to solve it before copying the solution down. In all aspects she demonstrated compliance with her understanding of the teacher's expectations. On the initial survey she 'somewhat agreed' with the statement that her goal in mathematics was to get a good grade.

Figure 7.2 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Beth's actions, her voiced and otherwise indicated goals, and, extrapolated from these, her motive.

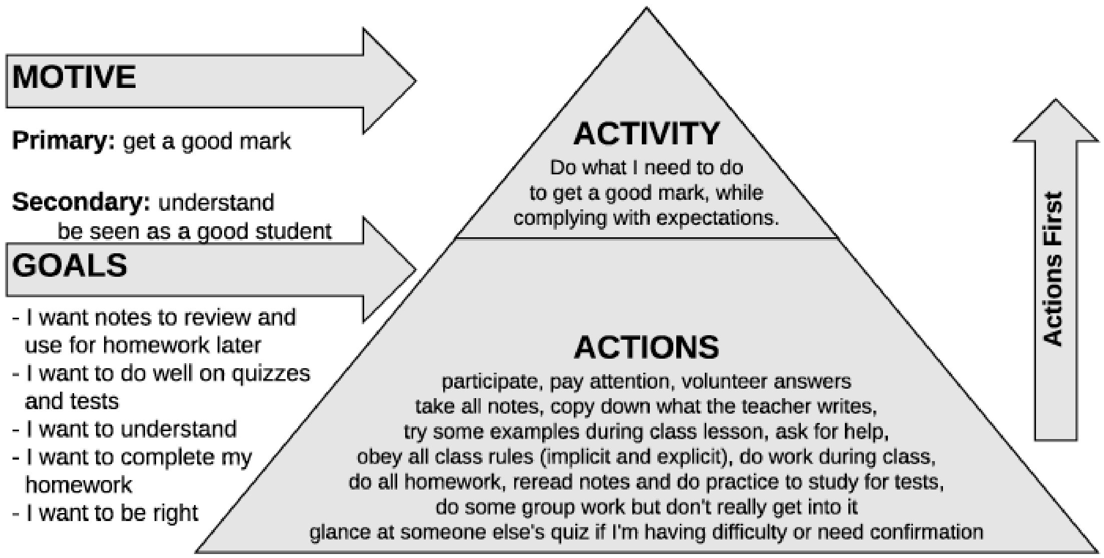


**Figure 7.2 Using an 'actions first' approach to determine Beth's motive(s)**

Beth wanted to understand mathematics and wants to be seen as a good student, but ultimately was concerned with getting it "right." Her actions in a variety of activity settings support this conclusion.

## 7.3 Summary

Both Toby and Beth had a primary motive of getting a good grade. However the actions they performed in achieving their goals were different. This is largely due to their individual, and different, secondary motives. For Toby, a motive of getting a good grade was mitigated slightly by his desire to minimize his effort, and was supported by a motive of understanding. For Beth, a motive of getting a good grade was supported by both a desire to be seen as a good student and a desire to understand. Both Toby and Beth wanted to understand, but this was at best a secondary motive.

# Chapter 8:

# Mr. Matthew's Students

> Review can look a number of different ways. If you haven't finished the assignments it might be best to go back and […] finish them up. But I'm going to direct you […] to the end of the chapter and then to some other areas as well. (Mr. Matthews, addressing class on a review day)

As in the previous chapter, here I offer a summary of the description of Mr. Grant Matthews and his classroom provided in Chapter 3. His school is located in a small city in Southwestern British Columbia and is the only high school in the area. A significant proportion of the population is First Nations, and a large number of citizens whose income falls below the poverty line. Mr. Matthews' teaching style was traditional, and he was friendly and approachable. He was enthusiastic about mathematics and wanted his students to have some interest for it, as well as to see relevance through the real world connections he introduces. His desire for students to understand was tempered by his realistic appreciation of the nature of the course and his clientele.

The course of mention is FoM 11, one of three courses students could take to fulfill the provincial mathematics requirement for graduation. It was largely perceived to be less difficult than PC 11, and more difficult than Apprenticeship and Workplace Mathematics 11 (AW 11); however, it satisfied the entry criteria for many university Arts and Social Sciences programs, whereas AW 11 did not. Sometimes students took this course as a bridge to PC 11, but for most[127] of Mr. Matthews' students it was their penultimate mathematics course at high school. This particular class was observed 14 times from September to the end of January, in clusters[128] of visits.

Four student case studies comprise this chapter. Each student's actions and comments, recorded over the 5-month period of study, are analysed herein to ultimately determine

[127] There were two students in Mr. Matthews' class who would also take PC 11; Melissa (taking both courses at the same time), and Stephen, who would take PC 11 in the subsequent semester.

[128] Six visits in two different weeks in September, four visits in two different weeks in October, two visits in late November, and two visits in late January.

the primary and secondary motives that drive each students' actions. The four students, presented in this randomly chosen order, are: Maria, Stephen, Tyrone, and Michelle.

## 8.1 Maria

"*I won't remember anything later if I don't write it down. […] So, yeah, I have to write it down and then look at it before the test and then I'll remember*."

Maria was a pleasant, conscientious, and hardworking young woman who I met in Mr. Matthews FoM 11 class. Although she was not particularly outgoing, she was approachable and we spoke informally a few times while I was in the classroom. Over the five-month period the class was visited I observed Maria in a variety of activity settings; some multiple times, others only once, such as group presentations or working with a TOC[129].

To analyze and understand Maria's behaviour better, it is useful to compare it in context with that of her peers. For example, Maria's class often took place first thing in the morning. Whereas many of her classmates walked in late, or had frequent absences, Maria was always present, on time, and prepared for class with the necessary tools, such as: paper, the textbook, a writing tool, and a calculator. While others skipped or paid little attention to a TOC (uncharacteristic behaviour when Mr. Matthews was present), I observed no change in Maria's attention or effort. When there was a transition between activity settings (Gallimore & Tharp, 1990), e.g., from a teacher directed lesson to a group activity or to individual seatwork, she moved swiftly to the new task, never dawdling or delaying starting. She was often the first to begin a new activity. In what follows I present a more comprehensive description of what Maria said and did, in three context groupings: direct instruction and note-taking; participation; assessments. I summarize by discussing her motives in mathematics.

[129] Observing students working with a TOC gives a glimpse of how students would act when there is little chance of repercussions for not complying with the expectations set by the regular classroom teacher. As described in Chapter 6, students often take advantage of a TOC to get out of work or get away with behaviour that would not normally be tolerated.

## Direct instruction and note-taking

Maria took comprehensive notes when there was a lesson, even if she had done the topic previously, and she wrote them in her own words, rather than exactly what the teacher said because, "*[it] helps me remember the notes.*" In addition to copying down what was written on the board, Maria also added notes about what Mr. Matthews said while explaining the lesson. If students were asked to try an example, and later Mr. Matthews went over the solution, she wrote that down as well.

On her questionnaire[130], Maria wrote that she took notes during class because it helped her "*pay attention to the lesson*" and it helped her "*to study later on when there is going to be a test*." Although Mr. Matthews did not explicitly tell students they had to take notes, and he explained to me that he did not make students take notes "*at this age*," it was apparent that Maria believed otherwise. Maria thinks her teachers expect her to take notes because they know it will be helpful to students in the future. However, even if she *did not* think that it was expected, I believe Maria would have taken notes for her own use. The basis of my belief lies in part on my overall analysis of Maria's learning preferences, and also more concretely on how Maria used her notes. She wanted notes to study from – she "*looks them over*" and read them to see if she can "*follow all the steps*."

During student presentations she also made notes, taking down the problems and the solutions that her peers provided. Wanting to better understand how and why she took notes, I approached her in class and asked her about taking notes. She responded:

> I won't remember anything later if I don't write it down […] yeah, I have to write it down and then look at it before the test and then I'll remember […] Like just the one that they gave me there[131], there was so many issues I didn't know how to do it […] And then it's easier if I have a sheet in front of me I can look at it 'cause I have trouble following it when it's so fast.

In this brief conversation Maria reveals two reasons she took notes. In her final comments she admits to having difficulty following the explanation sometimes because it went too fast, so having notes allowed her to review and make sense of the material at her own

[130] All students were given a questionnaire to complete prior to the first chapter test (within the first three weeks of the course. The purpose of the questionnaire was to determine note-taking practices, and how students used their notes (if they took them). See Appendix B.

[131] The students had been given some problems orally to work on in teams (part of Questions for Candy).

pace. Her earlier statements shed more light on her learning style: having notes helped her to "*remember*" the material better. Maria's note-taking practices and comments are indicative of an inability to discern what is relevant or important in-the-moment, and it is likely that she was not being mindful as she was taking notes.

Maria was extremely diligent about her assigned work. A few glances at Maria's workbook revealed that she tried every assigned homework question. She used her notes to help her, looking for similar examples. Given her statements about her need for and use of notes, it is likely she relied on 'mimicking' (Liljedahl & Allan, 2013a) to complete at least some of her homework. If she had difficulty with a question during class she sometimes sought help from one of her neighbouring peers, or put up her hand to ask Mr. Matthews. On occasion she asked a homework question at the beginning of the class, if Mr. Matthews provided opportunity. She came before class to ask Mr. Matthews questions and also stayed after class and through lunch about once a week to do extra review and finish homework.

### Participation

Maria was not particularly outgoing or attention seeking, but could often be relied on to supply answers (usually correct) if Mr. Matthews asked a question of the class during a lesson. However, she was not always the first to respond, and did not always volunteer. She followed along and checked the correctness of the teacher's solution, if asked, and if she was able, provided explanations when prompted to respond to 'why' an answer was what it was. When Mr. Matthews was doing examples during a lesson, Maria often asked questions of him such as, "*If you gave us those two roots, how would you graph it?"* The mathematical explanations she provided in response to Mr. Matthews and her classmates' queries were largely procedural. For example, when Chelsea asked how to find the measure of an interior angle of a regular polygon Maria explained, "*you have to use that formula thing,*" and told her what steps to do. "*You have to do 180 minus 140, then…"* She did not explain to Chelsea *why* she had to carry out these steps, but just told her *what* to do. When I asked Maria to explain it to me later, she was able to do so, and it appeared that she understood, but for some reason had not explained her reasoning to Chelsea.

Group work was not a frequent situation, but did occur a number of times in the term. Maria participated fully in response to each task, working hard to ensure the group completed the assigned exercise. Although she did not seek a leadership role, depending on the composition of the group members it often fell to her to take charge, as she wanted the group to succeed. If the group was required to present solutions to the class she often led the explanation while others wrote on the board or checked in with the class. When grouped with Scott and Emily, Maria led the presentation while Scott read the question and wrote on the board. Emily was tasked with checking in with the class to make sure they were following the explanation. Scott read out the question and Maria began to explain. Mr. Matthews intervened frequently.

> Maria: The first thing we had to do was find three consecutive odd integers so we did 2x plus 1, 2x plus 3 and 2x plus 5. And then it said the square of the largest so we had to square them all. (…) we got 4x squared plus 20x plus 58 and then we had to square the other ones…
>
> Mr. Matthews: Oh wait a second, wait a second. Where the heck did you get 58 from? I'm not saying that's wrong…but where did that come from? Because I get 25 when I square that.
>
> Maria: Oh…you have to add 33 because it said it was 33 less than the sum of the squares of the others

This pattern continued throughout the presentation as Maria proceeded to explain how they solved the problem, and Mr. Matthews interrupted to accomplish one or more of the following: slow Maria down and request more detail and explanations; restate and clarify what Maria had said; prompt Emily to check in with the class.

Maria's explanation was almost entirely procedural; she did not offer and no student asked for a rationale. Mr. Matthews intervened frequently to slow the explanation and to restate and elaborate for the rest of the class. He did this for most groups. In Maria's group, Scott was capable of taking on the role of explaining – it is not clear if did not want to, or if Maria chose to take the lead and he let her.

## Assessments

Maria's class was asked to respond to two short questionnaires[132] as part of the research study, on the topics of taking and using notes, and reviewing for tests. In what follows I summarize some Maria's written responses and provide selected excerpts of transcripts of informal interviews, as evidence and for further analysis.

During a quiz or test Maria remained focused throughout, her head down and attention on the task at hand. Her written work was complete, neat, and detailed. She never 'doodled' on her page; thus when she appeared to be working and writing, she was actually working on the task, not faking[133].

A common theme for Maria was her emphasis on "*remembering*". She explained that to review she looks at her notes and tries to remember how to do procedures and how to approach particular questions. Asked about her strategy for reviewing: trying problems in the order they were assigned, or targeting topics she knew she had struggled with, Maria replied, "*Well, I like doing the ones with the variables, cause I have a hard time with those ones, like number one I wouldn't do, I should know how to do it*." Despite her statement that she should do only those questions that she would have difficulty with, Maria typically completed every assigned question. Part of her rationale for doing this might be that she wanted to see every possible type of question in case something similar appeared on the test. Her comments and actions with respect to note-taking and other areas support this hypothesis, as she was concerned with remembering.

In a similar vein, to review for a chapter test Maria wrote that she used both her notes and her textbook to ensure she "*fully understands the subject/topic*." She "*looks over*" her notes both at home and in class, reading them "*to see if I can follow all the steps."* She did all the questions in the assigned textbook homework that she knew she would *"have trouble with,*" and also did "*some of each type of question."* This reinforces the hypothesis that Maria relies heavily on having a ready recall of as many types of questions as possible so that she can remember how to do any particular type that appears on an assessment.

[132] See Appendix B for blank copies of the questionnaires.

[133] Faking, as described in Liljedahl (2016b), refers to studenting behaviour wherein the student implements a façade to conceal from the teacher that he or she is not complying with expectations.

Typically there was a review block during the class preceding the test. During this block Maria worked on the assigned review, and if she ran into difficulty, she said, "*I'll ask someone who might understand*." The first survey took place immediately preceding the first chapter test, with one question completed following the test. When prompted by the question: "*What do you think you could have done to improve your understanding and success on the test*," Maria wrote, "[I] *should have done more practice on converting equations with the word problems."*

### Maria's motive

Maria's responses during the informal interviews indicate that she held particular goals and views about what it means to be a student, and about learning mathematics. Her actions align with these views; in all aspects Maria demonstrates qualities of what she perceives to be a 'good', and conscientious mathematics student. She always took notes and made sure to ask the teacher for help with any homework questions with which she struggled. She completed and submitted every assignment, paid attention and volunteered answers during lessons, participated in all tasks, and did all the assigned practice so that she was able to carry out procedures. To Maria, these actions should translate to learning; in fact, to Maria, this *is* learning. Yet, all of these stand in place of learning; they are mere proxies for it.

According to her teacher[134], Maria was the student who did every assignment, came for extra help, was always on-time, and always put in the effort, but when it came to the test did not seem to have fully understood the material. "*[S]he writes every question down, does everything perfectly on the assignments […] She should be pulling down like a 95 and man it's more like 60, 65 for her tests. It hurts every time you mark it*." According to her teacher, Maria "should" have been achieving a high 'A' in the class. Maria's actions seem to have (unintentionally) fooled Mr. Matthews into thinking she is a good mathematics student – yet she struggled with non-typical problems and relied significantly on 'remembering' how to do questions. Her actions aligned with all of the features that Mr.

[134] I did not formally interview Mr. Matthews. This excerpt comes from an informal conversation we had after class one day when he expressed interest in the questions I had been asking students during class.

Matthews appeared to consider a part of being a good mathematics student. With this perspective, Maria’s performance on assessments is puzzling.

Maria’s success seemed to hinge on her ‘remembering’ how to do problems, and doing copious amounts of practice. Her test results, and Mr. Matthews’ evaluation, show that she had difficulty adapting to new or unique formats or types of questions. Essentially, if Maria could not remember how to solve a problem, or had not seen that type before, or could not identify similarities between a given question and one she had done previously, she was stuck. This was one consequence of the way she often used her notes – as a reference to complete her homework; in essence, for mimicking. So how do we reconcile Maria’s actions and goals with her achievement? This perplexing situation could be understood by examining Maria’s actions to determine what is driving her behaviour.

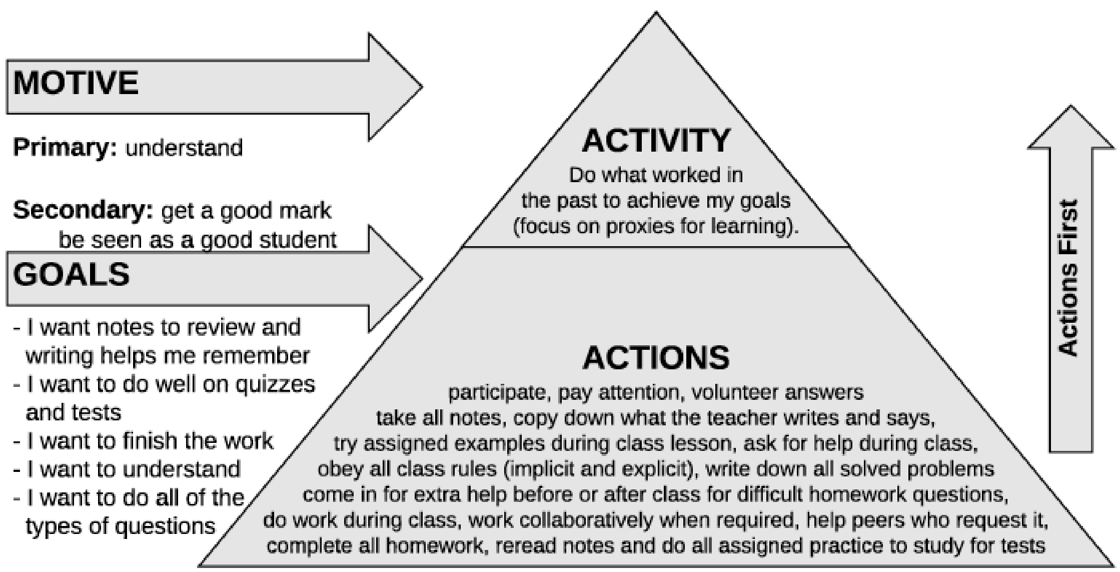


**Figure 8.1 Using an 'actions first' approach to determine Maria's motive**

Figure 8.1 (above) depicts the top two levels of Leontiev’s (1930/1974) triangle as applied to Maria’s actions; her voiced and indicated goals and, extrapolated from these, her motive.

Using an Activity Theory perspective based on Leontiev’s work (1978) and an ‘actions first’ approach (Kaptelinin & Nardi, 2012), it appears that Maria wanted to be seen as a good student and get a good grade, but ultimately she did want to learn and understand. This was her primary motive, though the outcome was not what one would anticipate, and her actions and rationale did not always parallel those of another student with an identical motive. Maria is representative of a cohort of students whose behaviours in mathematics are a consequence of several factors in their early years in mathematics.

Maria truly wanted to understand, but she did not know what this entailed. In earlier grades, she was able to achieve understanding through doing her homework, paying attention in class, taking notes, and asking questions if needed. This was her method of understanding and it was successful for her, for a few years (and I imagine it worked in other subjects too). She was one of many students, in my experience, who developed the notion that the path to understanding comes from paying attention in class, taking notes, and trying to do every question (and memorize it) so it can be remembered and reproduced on a test. This class of student also often demonstrate compliant behaviour. What happens for these students is that the path that once led to understanding no longer gets them there. Now it frequently leads to frustration, and the notion that they do not do well on tests, even though they ‘know’ the material.

## 8.2 Stephen

“*What I did for this one is […] I calculated velocity and acceleration due to gravity and the distance that they would fall and found the second velocity […] then I calculated the average velocity and used the distance to find the time*.”

Stephen was a mature and approachable young man taking FoM 11 with Mr. Matthews. He was one of the two students[135] in the class who was going to take PC 11 (with another teacher) in the semester following FoM 11. I begin with a general description of Stephen’s actions within the classroom, and then focus on three areas: group work; taking and using notes; review and assessments. A summary section with a determination of Stephen’s motives concludes the case study.

Stephen was a conscientious student; attentive and self-disciplined in all respects. He was studious, like Maria, but appeared more relaxed and not quite as intense. He engaged in activities, took notes, and participated in groups, usually ending up quietly taking the lead

[135] Melissa was the other.

if they had to present. The majority of the time he worked independently, by choice. He made good use of class time, doing his homework or work for other classes when the time was provided. Stephen never dawdled when transitioning to a new activity, although he would chat with others occasionally when it was not work time. He was always prepared for class with all necessities (paper, textbook, calculator, pen or pencil). During work time he often listened to music on his headphones.

In all the time I observed the class, I did not notice any time when Stephen was not paying attention to the teacher lesson, or not occupied with work (either for FoM 11 or for another class) when he was supposed to be doing so. His conduct in class was exemplary from a perspective of compliance. On one occasion Mr. Matthews was doing a proof that none of the students needed to know, and although Stephen did not appear to be interested, he was attentive[136]. Even when the teacher left the class and other students started chatting and using cell phones Stephen had his textbook open and continued working on his homework. He volunteered answers during Mr. Matthews' lessons, and sometimes even pointed out errors in the board work, always respectfully. More than once he introduced terminology not yet used in this class, but possibly learned in his other math class. When introducing transformations of parabolas, the teacher had students do some graphing. Seeing Stephen was almost finished, he walked over and asked, "*You done?*" Stephen replied, "*Almost*," then added, "*It's just going to be the same parabola just* translated *down four*" [my emphasis]. Mr. Matthews responded, "*Ooh, cool math word!"*

One day Mr. Matthews introduced a game "Questions for Candy". It was a novel way to get the students to review the material. I asked Stephen what he thought about the game, and he replied that he felt the game situation provided "*good incentive*" (to do the examples) but did not cover all the basics: "*I think if you covered the basics and went straight up, that would have been a bit nicer, but um, it was alright*."

Generally it appeared that Stephen preferred to do his work, in his own way, but he was willing to participate in group activities when Mr. Matthews asked them to do so. There

[136] There are several possible reasons for this, but most likely (based on all of his other actions), is that he felt he was being respectful (his own expectation) and that he might need it (as opposed to avoiding getting into trouble or complying with teacher expectations).

were two occasions I observed in which students were asked to present their solutions to assigned problems as a group: a description of one follows.

### Group work

Group work was not the norm in this classroom, but Mr. Matthews shared with me that he was trying different things when he felt they could work. In this case, students were given a question to work on in one class and asked to present their solution to the class on the following day (the presentations actually took two days and Stephen's group presented on the second). Each group was given a different quadratic functions problem (from the textbook although most of them didn't know that). They formed groups of three, the composition of each determined largely by Mr. Matthews (I was not present on the day students were given the problems). Keiran and Tiffany comprised the other two members in Stephen's trio.

On the first day of presentations Mr. Matthews gave the students some time to prepare, advising them to "*present as if YOU are the teacher*" [his emphasis]. During this preparation time I was able to circulate and see how the groups had done with solving the questions on the previous day. When I asked Keiran how his group was doing on the problem he admitted, "*We couldn't do it*." But then Stephen jumped in and explained that he had solved the problem, using methods from physics, and sharing that his answer did not exactly match that found in the textbook.

> I calculated velocity and acceleration due to gravity and the distance that they would fall and find the second velocity so when they get to the water what the second velocity was, then I calculated the average velocity and used the distance to find the time. And I found the time to be one point four. And then the actual, or, what the textbook says, is one point eight.

Stephen recognized that his answer was not exactly what the textbook said, but did not appear very interested in my suggestion that he try it the way they had learned in class, explaining that he had not tried it "*that way yet*" because he used the graphing calculator.

At the end of this class, following the other presentations I asked Keiran if they were going to let Stephen present it. He explained that while Stephen presented, he was going to write the solution up, and Tiffany had the job of checking with the audience to see if they were following along. Keiran and Tiffany still seemed to be unable to do the problem, so I asked what their plan was. Keiran said that he hoped Mr. Matthews would not put one like it on the test because they had never had a question like it before. Stephen agreed that their question was "*pretty difficult*". I asked how he would begin if he was going to use the methods taught in class. He correctly answered that "*you'd write down what the vertex is because you have that*," but did not seem interested in pursuing the procedure any further. Despite my hints, Stephen was reluctant to use what he had been taught in mathematics class, apparently satisfied with the methods he had employed[137], even though his answer was not exactly the same as that in the book. Mr. Matthews also attempted to dissuade him from using a physics analysis: "*If you want to do that, but, explain it in a way that you learned it in this class, because if you try to explain only in the in the physics way* [pause] *you can do that after, okay?"*

The presentation itself prompted many questions from a very small number of more engaged students and was punctuated by many interruptions from Mr. Matthews asking for clarity and offering explanation for the class. By the end Tiffany and Keiran still did not understand Stephen's solution (or any other solution to their given question). The written solution shown to the audience was very messy and not at all organized so that made it more difficult for the audience to follow. Eventually Mr. Matthews went to the board and rewrote the work as Stephen explained in a calm and well-paced manner. Even with Mr. Matthews' interventions, in the end there were probably fewer than five students in the audience who had any idea of what was going on. In comparison, the other presentations were not markedly more successful.

## On taking and using notes

Stephen was selected for a case study analysis largely because of the processes by which he took and used notes; and even more so because of how his actions and Stephen's explanations about his method indicate his purpose for activity. The data discussed here is taken both from a second questionnaire, regarding note-taking practices, and from my observations of, and discussions with, Stephen.

[137] It is likely that Stephen preferred his method because it made sense to him (and possibly because it was more 'real-world' whereas fitting a function to it may have seemed abstract.

Stephen wrote (and was observed to take) notes whenever Mr. Matthews wrote something on the board or brought something up on the projector, and also wrote notes based on what Mr. Matthews said. His rationale was, "*Writing notes makes me repeat all of the teachers notes through my head so even if I don't look at them again (which rarely happens) I still can vaguely remember what he said.*" The act of physically writing the notes helped Stephen to process and remember them. These notes were written verbatim so that "*nothing gets lost in translation*" and would help his understanding because "*that's how [Mr. Matthews] intended us to learn the material."* Stephen felt that Mr. Matthews would *like* students to take notes but that he would not *make* them. He added, "*It's our choice to learn*." These notes are only one part of Stephen's study regimen; he also uses old homework and his textbook to study. Of most interest to me was Stephen's comment that he uses a computer program "*at the end of the week to type in any vital examples or notes. It helps me run it through my brain again."* This response intrigued me so I engaged Stephen in conversation when I saw him working with his laptop in class. He was entering some Physics notes into a document, and explained that he would be done with it in an hour or so, at which point he would be doing his notes from Mathematics. I commented on the time it must take to enter them, and asked if he ended up using his notes very much.

> I think that the just refreshing them after, because there's one thing where you're just mindlessly copying down what the teacher says, but if you're doing it on your own time where you're taking the notes and you're writing them down again I find that I actually read them for the second time so I actually start to comprehend and stuff I didn't catch the first time around I might have caught once I put them back. When I take my notes I take them in complete, exactly, everything the teacher says and then some, and then I add my own things to them. And that's how I comprehend most of the stuff.

I asked what else he added to the notes, and he said he does not add that much more, "*just if I can think of a way to relate this to something else, or if there's just an easier way of me thinking about it, I'll put that up by the side*." Adding his own explanations to the notes he took verbatim from the teacher helped Stephen to make connections and comprehend the material. He said that he would often update his notes towards the end of the semester, right before finals, which "*counts a bit as my studying for it and it works out pretty well*." In addition to retyping notes he had already written, Stephen added his own thoughts and related concepts in the notes to other ideas from life or other courses so he could better make sense of them. Thus, for Stephen, the initial writing of notes was not a culminating activity.

### Review and assessments

A brief review day questionnaire[138] was given to students in the class to complete. The responses were compiled and Stephen's are discussed here. To prepare for a test, on review day Stephen copied down everything Mr. Matthews wrote on the board and what was said in class. For studying, Stephen wrote that he found doing it at home most effective, followed by reviewing in class, and then by studying at lunch. I asked if he did all of the assigned practice questions, and he said that he did not, explaining that he only does the ones that he thinks might be difficult. "*I don't go through all the questions; I go through just the units that I thought might be a bit difficult for me."* But he added that he would do one or two of each type anyway. He chose practice questions that ranged from those that did not look too easy to those that looked very difficult. As discussed previously, Stephen made significant use of his notes, initially in writing them, then by retyping and adding material. To study he reviewed all of his notes, retried the example questions and then looked for similar questions to practice in his textbook or worksheets.

During quizzes and tests Stephen remained focussed for the duration. When first handed an assessment of this type, he read through the questions and then began working through them methodically. When he had finished writing he looked back over his work and checked his answers before submitting his test, usually towards the end of class. He did not appear concerned with 'getting rid of it' or having free time to do other, more desirable activities once he had finished. After one particularly difficult quiz, he was one of only two students to copy down the explanation given later by Mr. Matthews. Several of the students made comments about not understanding how to do the problem, but they did not write anything down (though later said that they probably should have). Stephen really wanted to know how he did on the quiz (he and some other students misread a 200 as a 100) so he asked for another blank copy and rewrote the quiz to show to Mr. Matthews to see if he was correct.

[138] See Appendix B.

### Stephen's motive

In all his conduct, Stephen demonstrated himself to be an engaged and disciplined student, concerned with deeply understanding the topics presented to him, rather than merely focussing on achieving high scores. His compliance with classroom rules and expectations was not motivated by a desire to be seen as a good student, but instead, I believe, out of a sense of respect for the teacher.

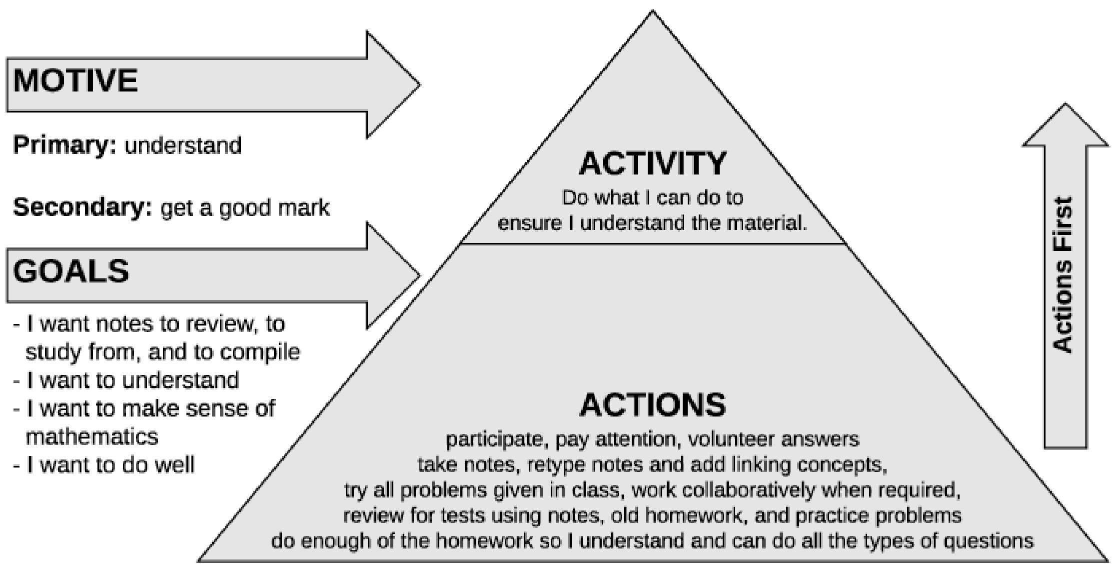


**Figure 8.2 Using an 'actions first' approach to determine Stephen's motive**

Figure 8.2 (above) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Stephen's actions; his voiced and indicated goals and, extrapolated from these, his motives. Stephen's activity was driven by a desire to fully comprehend the material he encountered in class, and he went to significant extra effort to help himself to draw connections and master the concepts. While he was interested in getting a good grade, it was secondary to his desire to understand.

## 8.3 Tyrone

"*I only write down the examples with formulas that I need […] I know how to do it once I get the formulas down*."

Tyrone, also in Mr. Matthews FoM 11 class, was capable young man, laid-back with a projected air of nonchalance. At all times he appeared relaxed, lounging in his desk and seemingly unconcerned with the nature of the lesson. At first glance his slouched posture and lack of note-taking seemed to indicate that he did not care about mathematics, but looking past this I realized that he was paying attention to the lesson. During the class he spent a good deal of time chatting with his seatmates, typically Morgan, Tiffany, Michelle, and Keiran. He collaborated with his peers and they often moved to work together when this was allowed. Tyrone was social with his peer group, and though friendly and polite he was not overly communicative with me or with Mr. Matthews.

I begin this case study with a description of Tyrone's general conduct in the classroom, and then discuss his actions in group tasks, and his behaviour with respect to reviewing and assessments. A summary section with a determination of Tyrone's motives concludes the case study.

## Observable classroom behaviour

Tyrone did not typically volunteer answers to Mr. Matthews' questions during a lesson, but did answer on the occasions when he was called on. However, instead of providing an answer he would sometimes respond, "*I don't know,*" or tried to avoid answering. For example, when Mr. Matthews was reviewing a problem he had solved on the board, he asked the students, "*What did we do?*" After waiting a few beats, he prompted, "*You know, Tyrone*." Tyrone shook his head, no, but Mr. Matthews persisted, saying, "*Yeah, you do. What did we do?"* Still, Tyrone maintained that he did not know. However, later that lesson Tyrone asked Mr. Matthews to go over the challenge question from the homework, suggesting that he had some interest in understanding it.

During a lesson it was rare for Tyrone to take notes. I questioned him about this practice, having observed him for a number of lessons. He responded that he "*understood everything*" and if he did not understand something he "*would have written it down and asked [the teacher].*" On the note-taking questionnaire[139] given to students in this class near the beginning of the course, Tyrone wrote that he took notes in class when he did

[139] See Appendix B.

not understand the concept being presented. His notes were written in his own words because it helped him understand and because he "*may think about things differently than others.*" He was not clear about whether he thought Mr. Matthews expected them to take notes, but if so, the reason would be that they have the notes if they did not understand and could use them to eventually learn the material. Tyrone indicated that he primarily used his notes to refresh his memory and to review to help him remember what they had done earlier in the course.

As mentioned earlier, most of the time Tyrone appeared to be attentive if a lesson was occurring, but he did not write much down, and did not always try the examples the students was asked to do. For example, when the class was given a handout and asked to work out the values in a table and then draw the graphs of quadratic functions, Tyrone's page was blank. He eventually filled in the information after Mr. Matthews had completed it on the board. In the same lesson, when the class was asked to, "*try the next two examples,*" Tyrone refrained, while many others in the class appeared to be finding points and checking their results with each other. At the end of the lesson Tyrone had not yet written any notes (other than copying examples once they had been completed) and did not write down the assignment. While Mr. Matthews was explaining how to do the homework assignment, Tyrone, Morgan, and Keiran were chatting, oblivious to what Mr. Matthews was saying. I seized the opportunity to ask them about why they would try certain examples but not others. Keiran stated that he had tried them all and had written them down (after Mr. Matthews had solved them). Tyrone agreed with Keiran, and explained that he would wait for the teacher to do the problem if he was "*not being so sure, so [he] could look [at what the teacher did]."* Morgan had said he would wait for the teacher if he did not understand how to do the question. Though Tyrone agreed with his friends here, he was the stronger student of the three and I think he likely did have an idea of what to do, but did not want to try.

Interested in discovering more about Tyrone's rationale for his conduct in mathematics class I asked him about why he wrote down some examples, but not others. He explained that he only wrote down the examples that had formulas that he needed. Once he had the formulas he would "*know how to do it*," and he wanted the formulas "*down to look at it so I can how to do it for the booklet*." I asked Tyrone how just having the formulas would help; how would he know which formula to use for which question? He explained that it depended "*on what way it's formed. So if it's like the quadratic, or it's the vertex form, you know*." Tyrone said he was able to read a question and determine which formula was needed, however this may not be true given his difficulty with the problem given to his group for the presentation (see below).

Later in the term, I had another opportunity to learn more about Tyrone's reasons for trying or not trying examples in class. Mr. Matthews was reviewing a unit on ratios and asked the students to try some questions he wrote on the board. I noticed Tyrone did not write anything down. When asked, he said that he had remembered how to do the problem. Wondering if this was actually the case, I tested him, asking him how he would solve it. He answered correctly, if a bit vaguely, "*Well, you just multiply it by the ratio kinda thing and it's really easy. I remember how to do it*." It appears that Tyrone copied down examples that he did not think he knew how to do, but did not try ones that he remembered.

When it came time to do seatwork, I often saw Tyrone and his seatmates with empty desks or books closed, at least at the beginning. Generally they were slow to transition to a new activity or new activity session. Tiffany was often on her phone and sometimes distracted Tyrone by showing him things on it. There tended to a lot of whispering between Tyrone and his neighbours. Finally, on the one day I observed a TOC take the class for Mr. Matthews, Tyrone was absent. When his name was called for attendance, Tiffany piped up, "*skipped*".

## Group tasks

Tyrone participated in group activities to a certain extent. During the logic and reasoning unit, the students were given manipulatives to play a game of strategy (similar to Nim[140]), Tyrone and his partner built towers while Mr. Matthews explained how to play. Like his peers, Tyrone was engaged with playing the game, and played a few rounds, and then tired of it. He was willing to play, but did not exert any effort, nor express any interest, in developing a winning strategy. There were a few group tasks during that particular unit,

[140] See Appendix D.

and Tyrone's actions varied little from those described above. The other type of group work the students were asked to do was a group presentation.

I was able to observe one set of group presentations for Tyrone. Each group was given a different problem using a quadratic function (from the textbook although most of the students did not know that). They formed groups of two or three, with Tyrone and Morgan pairing up. I was able to observe their preparations, but Tyrone and Morgan were away for the actual presentation day. As Tyrone was the more capable student, compared to his friends in the class, it could be expected that a leadership role would fall to him. However, Tyrone did not seem interested in taking on any such responsibility. When I arrived at Tyrone and Morgan's desks they appeared to be having difficulty with the question they had been given to solve and present to the class. Morgan was attempting it, but Tyrone did not seem to want to try anything and his behaviour was not greatly influenced by my mere presence. I tried to help them with the problem, beginning by asking what they tried thus far. Tyrone replied that he had tried "*[n]egative b over 2a but I was way off*." Tyrone seemed to be trying to apply a formula, but was unsuccessful. I asked if the given equation could be put into a different form, but Tyrone did not think so. Tyrone stated (incorrectly) that the equation was already in standard form. I did not correct him, instead trying a different tack, asking if they could find the x-intercepts. Tyrone somewhat hesitantly agreed that they could, and admitted that he was not really sure how to do it. I suggested they factor it, and Tyrone said he had; upon further questioning I realized that he did not know how to interpret his result once he had it in factored form (and also that he had not actually factored it correctly).

Tyrone seemed to be very dependent on formulas, but not always in command of the underlying concepts, such as in the example above. When Mr. Matthews checked in with Tyrone and Morgan he asked them to present their answer in a different way (and not rely on using the formula $x = \frac{-b}{2a}$ to find the vertex[141]) but since they were unwilling or unable to factor it and use the roots to find the vertex they could not or did not comply.

[141] This formula was not introduced by Mr. Matthews. It was shared by a student (Melissa) taking PC11 but its derivation was never explained. Some students latched on to it as a shortcut for finding the vertex, rather than the method of finding the roots and averaging them to find the x-coordinate of the vertex.

While I was not able to see Tyrone and Morgan present (they made it up on a different day), I was witness to their behaviour during the presentations of others. Mr. Matthews told his class, "*Okay, pay attention, make sure you get this down,*" as he reviewed the solutions presented by one group. The class was having difficulty following the student work as the writing was quite cramped. When Candace admitted to not remembering or knowing how to solve the problem, Mr. Matthews went through the steps again. During this time Tyrone and Morgan were talking to each other and not attending to the presentations or the teacher's review. When Mr. Matthews asked, "*Are you guys with me over there?*" they replied in the affirmative, but their actions indicated otherwise.

### Reviewing and assessments

Typically there was a review day prior to each of the nine chapter tests. On these days, most students appeared to work intermittently; brief bouts of work punctuated with a lot of chatter. It was common for the class to be given the latter half of the period to work, while Mr. Matthews led a review for the first half. This teacher-led review consisted of written board notes pertaining to important concepts and formulas from the unit and intermittent questions to try to involve students. The same few students tended to participate during these sessions, while others appeared to observe. On one occasion though, Mr. Matthews had to say, "*Tyrone, maybe it would work if you turned this way*." After that, Tyrone faced forward and sat quietly, but did not write anything, nor fake that he was. A glance at his workbook later showed that he had written down the formulas, but none of the other information. This behaviour was not atypical for Tyrone, during other review sessions he also would usually sit quietly and appear attentive, nothing on his desk. He rarely volunteered answers and was very selective in what he wrote down.

I had the opportunity to ask Tyrone and his friends what they thought about review days. Tyrone and Morgan both mentioned that they liked the game, questions for candy[142]. Tyrone actually got really into the game and was a fairly competitive, at one point shouting, "*He cheated! He looked at his test,*" when a fellow student offered a correct response. I

[142] This was a novel idea Mr. Matthews implemented on at least two occasions. Students worked in teams and answered questions posed by Mr. Matthews. Students put up a hand when they had a solution and Mr. Matthews waited until two or three hands from different groups were raised, then selected one (not always the first group to raise a hand).

suggested that candy was a good motivator, but Tyrone said they understood the material anyway. I wondered if they had learned anything new from the review, but Tyrone said they had understood it from doing the work earlier in the unit. Tyrone shared that it was typical for them to chat on review days. "*If we already understand it we usually just end up sitting here and talking…cause we already know what to do*." I was able to ask them again about review days on the last few days of the course, specifically about why so many people used review day for chatting. Tyrone said he did not know why, but agreed with Keiran that if it was "*hard*" unit they might actually do the work, but if the unit was "*not as difficult*" they might not.

Tyrone's class filled out a questionnaire about 'review day'. In his responses he indicated that on a typical review day he would "*do the questions I don't know and get help.*" To prepare for tests, Tyrone reviewed during lunchtimes and at home, and chose a variety of practice questions that looked neither too easy nor too hard. He indicated he would try the questions that he felt he would have trouble with. Tyrone also said he looked over his notes, seeing if the material was familiar and if he could follow the steps. In addition he also tried the examples in his notes without looking at the worked solution, and found similar examples to practice. This contradicts what he said on the earlier note-taking survey where he indicated that he only read his notes. After writing his first test of the semester he suggested that he could have done more word problems for practice because "*they give me trouble and I could have done more examples.*"

During a test Tyrone worked through the questions in the order they appeared on the test. He occasionally glanced around, not focussed on anything in particular, and then eventually returned to his test. During the first test he appeared to be whispering with Michelle, and had to be reminded by Mr. Matthews not to talk. He did not ask many questions during tests, except once to borrow a calculator and occasionally to get clarification about what a question was asking.

One test at the end of October was particularly long and a few students were unable to finish. As it was the first block of the day and they had to move on to another class, Mr.

Matthews allowed some to come back at lunch to finish[143] if they wished to do so. Tyrone elected to come back to finish. Mr. Matthews allowed students to rewrite quizzes or tests they had failed, provided they came for a review tutorial and showed some work. Tyrone took advantage of these opportunities, rewriting both a quiz and a test he had been unsuccessful with on his first attempt. He asked Mr. Matthews, "*What do I need to do to rewrite the test?*", and later, when I asked what he was working on he replied, "*4.1 because I failed the test so I've gotta redo it so I've got to make sure I know all the stuff".* Not only was he making the effort to retake the test, he was not just 'winging it' to try and get a better mark but was actually trying to learn the concepts to improve his result.

### Tyrone's motive

Tyrone appeared to be driven by many factors, two of which were efficiency and effort. This hypothesis is supported by Tyrone's formulaic approach to mathematics. He believed that if he knew the formulas he would be able to do the questions. He was clearly interested in doing well (which for him seemed to be having a decent grade), but with minimal effort. Tyrone was not particularly concerned with complying with teacher expectations, but did adjust his behaviour when he was specifically called out. He spent a good deal of time socializing, but also ensured he did enough of the work and paid enough attention so that he 'understood' the material (which to him meant being able to know which formula or procedure to apply and to carry it out). He seemed to want to give the impression that he did not care.

[143] "*You wanted to know who came back at lunch, it was Tyrone, Keiran and Morgan. It may be a little unorthodox to allow extra time that way as students can converse, but to be honest , that is part of what I, am looking for. They need to show work, so just writing down an answer won't really help them a whole lot. I am hoping that they might teach each other something before they finish the test*." (G. Matthews, personal communication, Nov. 1, 2016).

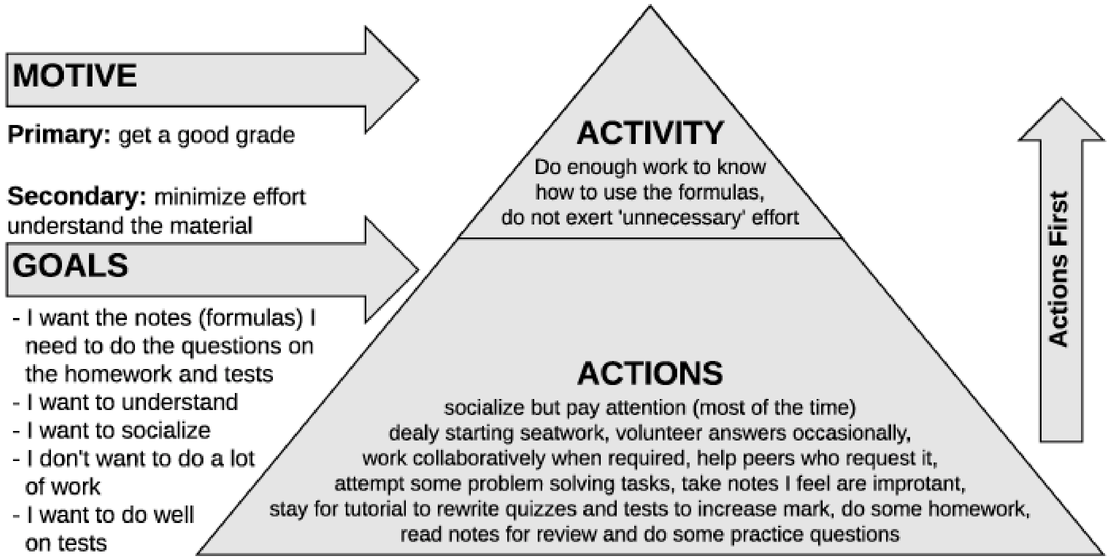


**Figure 8.3 Using an 'actions first' approach to determine Tyrone's motive**

Figure 8.3 depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Tyrone's actions, his voiced and indicated goals and, extrapolated from these, his motive. In all his observed and explained actions, Tyrone demonstrated himself to be an semi-engaged student, concerned with understanding the topics presented to him, apparently ultimately because he wants a decent mark, rather than for the innate knowledge of the material.

## 8.4 Michelle

"*I won twice, do I have to play again? […] I'm only doing one more, this is so easy*."

Michelle struck me as a confident and competent young woman, an impression that was largely borne out as my experience with her grew. On the first day of class Michelle positioned herself as a willing volunteer for answering Mr. Matthews' questions, and through this identified herself as one of the more capable students in the class. She was an active participant in class activities and appeared intrigued with the problems she was asked to work on in class. Given her early presentation as a relatively strong mathematics student, I asked her why she had chosen to take FoM 11, instead of PC 11. She replied that she had been recommended for PreCalculus but had chosen Foundations because "*it was easier*" and because she wanted to be a hairdresser and did not need PreCalculus.

The following is organized in a slightly different format as compared with the previous case studies, in part because I only observed Michelle for the first month of classes; approximately 5 lessons. After that she switched into another teacher's class. Thus I have categorized the analysis into a discussion of general classroom behaviour, followed by two themes that arose: noncompliant behaviours, and assessments, including results. Finally, I have provided a summary of a conversation with the teacher whose class Michelle switched to as further insight into Michelle's character and reasons for her conduct. I summarize with my conclusion regarding Michelle's motives in mathematics.

## Observable classroom behaviour

During the lesson and the beginning of group activities Michelle was an active participant. She volunteered answers, asked questions and exhibited self-confidence in her knowledge of mathematics. In one instance, when Mr. Matthews asked how to solve something, Michelle offered, "*solve by using inverse operations*." When Mr. Matthews repeated the explanation for the class, he used the term 'reciprocal,' at which point Michelle corrected him, asserting that she had said 'inverse' not 'reciprocal'. Michelle quickly became his 'go to' person for the correct answer – someone he could count on to speak up and not be afraid to take a risk. She appeared to take some notes, and I do not believe she attended any tutorials outside of class time.

Michelle asked the teacher about worksheet problems that she had struggled with, and asked questions of her peers. During one of Mr. Matthews' explanations to the class she whispered to Tyrone, "*how do you get 5y?"* She did not wait to see if Mr. Matthews would explain, but sought help from a classmate in her desire to understand. When there was group work, she participated, but tired of it quickly. Early in the term students were asked to play a version of "Nim[144]," with the hint that they look for a pattern and a strategy to win. Michelle paired up with Jake and shortly after beginning asked aloud, to no one in particular, "*I won twice, do I have to keep going?*" They kept playing and eventually

[144] See Appendix D.

Michelle explained the strategy to Mr. Matthews, and then the rest of the class. Later that same period each pair was given a different puzzle to work on. Michelle and Jake were given the most difficult one, and told that it was the trickiest. Michelle used her phone to take pictures of the different counterexamples[145] so that she did not have to draw each one out. At one point she announced, "*this is so easy, I'm only doing one more*." Shortly thereafter, Mr. Matthews came by to reiterate that they needed to find the pattern, not just a collection of several counterexamples. Michelle and Jake eventually found the pattern, and Michelle explained the solution and her thinking process to the class.

Michelle was sociable, chatting with Tiffany and Lindsay (neither of whom stayed in the course[146]), but not to the point where it impacted her learning, although the same can not be said of her peers. While Michelle appeared actively participate during lessons and group activities, she was less engaged and less focused during the homework time at the end of class.

### Noncompliant behaviours

One day, after the teacher had assigned problems for homework, I saw that Michelle was not making any progress on the assignment. When I asked her why she was not doing the work during class she replied that she usually went to a friend's house after school: "*It's better if someone else is doing it too. I help her."* Interestingly, after I moved away, Michelle went up to Mr. Matthews to explain to him why she was not doing the work and to ask if her plan for completing the assignment after school was okay with him. Asking for Mr. Matthews' approval of her homework routine suggests that Michelle was concerned with his opinion of her as a student.

Supporting the view that Michelle cared about being perceived as a 'good' student, the last class before the review day, Michelle arrived just after the bell. Rather than walk in quietly and explain her tardiness later, she interrupted the start of class. On entering she proclaimed, "*I'm not late,*" and announced that she did not have her homework done, explaining that she had been away all weekend. Mr. Matthews continued what he was

[145] The goal was to find the pattern for the counterexamples.

[146] Lindsay switched classes or dropped the course within the first week or two; Tiffany just stopped attending class during the third quarter of the semester.

doing and Michelle sat down at her desk. Michelle's explanation supports the view of being seen as a good student, the disruption suggests a possible concern that her peers also see her that way, or perhaps a desire for attention.

Michelle did not appear to like sitting still for long during the homework time. She found reasons to escape her desk or leave class, such as retrieving items from a locker, or she asked to go to the washroom. When permitted to leave, she took the hall-pass and disappeared to the washroom for 10-15 minutes, despite the fact that it was directly across the hall from the classroom. One day she asked to leave to get a pencil sharpener from her locker. Mr. Matthews pointed out the class pencil sharper, after which Michelle whispered complaints rather loudly to her peers about how poorly the sharpener worked.

The day before the first chapter test, a review day, Michelle plugged her cellphone into the outlet behind her desk to charge it. She proceeded to 'play' with her phone. Mr. Matthews approached and asked her to put her phone away and "*please don't use it*." His tone was sincere; my impression was that he thought she should respect his class rules regarding cell phone use, and it seemed to me that he did not want to have to take it away from her (his explicitly stated consequence for misuse of a cellphone during class). Michelle put her phone down and immediately asked Mr. Matthews about a particular question in the review assignment. However, it was more a clarification question than a mathematics question with which she was having difficulty. I found this interesting because she had not had her hand up earlier to ask a question, and it did not appear to be provoked by Mr. Matthews' proximity. I interpreted her action as a way to shift Mr. Matthews' role from disciplinarian back to teacher as helper. This also shifted Michelle's possible perception of herself from 'misbehaving or noncompliant student' to 'good, obedient, and engaged student'. It was not clear which shift was more important to her, or whether this was intentional at all, but it was something I found interesting and bears considering when inferring Michelle's motives.

Michelle was absent during the class when there was a TOC. I do not know whether this was because she intentionally skipped that class (I saw her in the school before class) because she heard Mr. Matthews was away, or whether she had another reason for her absence (legitimate or not).

## Assessments

During the first test of the year Michelle asked a question approximately every five minutes. Throughout the test she called Mr. Matthews over, or got up to approach him at his desk, a few times appearing frustrated with Mr. Matthews' response. Returning to her desk after one of her questions, she started muttering, visibly frustrated or angered by not receiving the answer she wanted. Later, she appeared to be communicating with Tyrone while each of them was still in possession of the test.

On my next visit to the class the test had been marked and returned to students. I had the opportunity to chat with Mr. Matthews prior to the start of the period so I inquired as to what Michelle was asking about during the test. His summation was, "*She was really trying to get me to give her the answers.*" I had heard his response to Michelle's queries during the test: "*you just have to do your best*." In his opinion, Michelle was frustrated with his replies, which coincides with my impressions as an observer. She was also displeased with Mr. Matthews' marking of her test. He shared with me that Michelle thought he had, "*marked the test wrong and should have given her more marks*."

After this test, Michelle switched to the other FoM 11 class. Mrs. Reynolds, the other teacher, had taught Michelle mathematics in the past and spoke with me briefly about Michelle's experiences and behaviour while in her class. I began by confirming that Michelle had switched into her class and commented that Michelle had seemed to be a bit upset with Mr. Matthews following the first test. Mrs. Reynolds felt that Michelle was "*a little high strung*" and that her behaviour was not unique to Mr. Matthews; she said she did not think "*it's anything he's done*." She shared that a similar situation had taken place when Michelle was in her grade 9 class. She felt that Michelle was reactionary: "*It's just that you get yourself into a situation and it's like calm yourself […] I think she just runs when there's a problem. Her first reaction is just to bolt*." Michelle entered Mrs. Reynolds class and wrote her test for the same unit, achieving a better score: "*she came in and she did my test write away and she did better – and she was happy*."

Mrs. Reynolds also commented that although Michelle tended to "*bolt with conflict*" she did struggle and did do work. I found this interesting and explained that Michelle had tried to avoid work in Mr. Matthews' class by finding opportunities to do other things, but Mrs. Reynolds said: "*Really, hey? Well, she'll work on stuff.*"

If Mrs. Reynolds is accurate in her assessment of Michelle's behaviour, then Michelle was more diligent about doing her homework during Mrs. Reynolds's class. Michelle may have felt more comfortable with Mrs. Reynolds given their prior history, and perhaps Michelle felt that she had a poor relationship with Mr. Matthews and would not be able to salvage it to appear as a 'good student'. Ultimately, together with her dissatisfaction with her achievement in Mr. Matthews' class, this provoked her departure from his class.

### Michelle's motive

Michelle did not stay in Mr. Matthews' class, thus it was not possible to observe her as many times, or in as many activity settings as her peers. Consequently, the results offered here are necessarily more tentative than those presented earlier for other students. With this proviso established, Michelle's behaviour was different from her peers and as such it is curious and compels analysis of her motive. Figure 8.4 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Michelle's actions, her voiced and otherwise indicated goals, and, extrapolated from these, her motive.

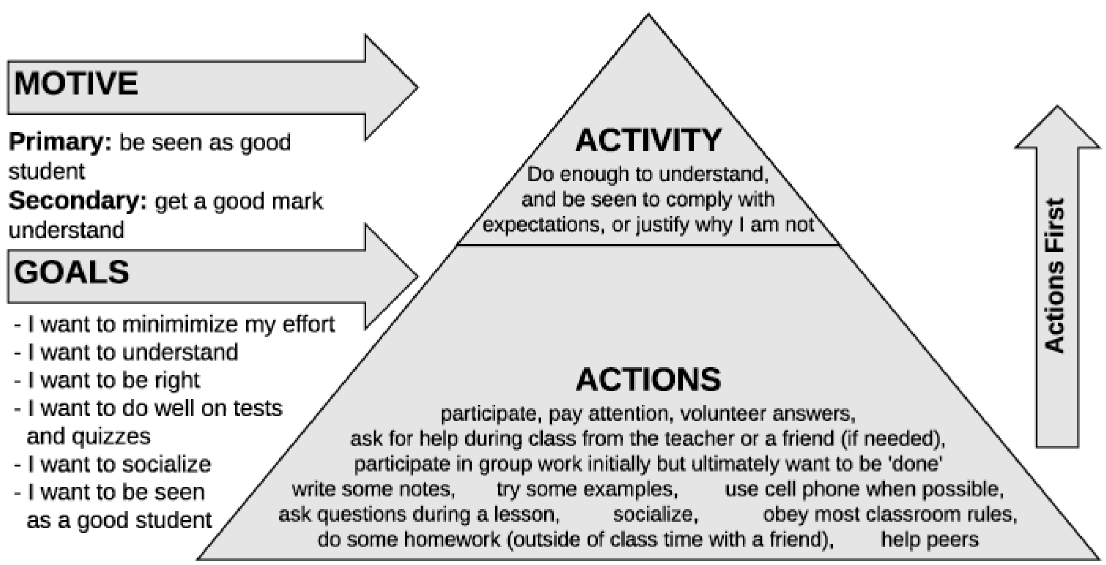


**Figure 8.4 Using an 'actions first' approach to determine Michelle's motive**

Michelle wanted to understand the material and was not afraid to ask questions and volunteer answers. She was concerned with how she was perceived; she wanted to be recognized as a ‘good’ student and went out of her way to put her actions in the best possible light, especially when they could be seen as non-compliant. When this was not possible, she attempted to shift the teacher’s focus, and as last resort took action to escape the situation. Given her actions, Michelle’s motive was to be seen as a good student, which for her includes getting a good mark by demonstrating understanding of the content. It is difficult to determine which motive ranks higher for Michelle – as her move to Mrs. Reynolds class could signal both: leaving Mr. Matthews’ class to get a better mark, and also because she may have felt she had sullied his view of her as a good student.

## 8.5 Summary

Each of the four students profiled here have a desire to get a good grade and to understand. They also have other motives, and the hierarchy of their motives differs. For example, Stephen’s desire to understand was paramount, whereas for Tyrone, it was secondary to getting a good mark and minimizing his effort. Likewise, Maria wanted to understand, but to achieve this she was relying on methods that were more likely to accomplish being seen as a good student. Michelle’s desire to be seen as a good student and to get a good mark outweighed her motive of understanding. The priority given to different motives drove each student’s conduct within the classroom, and is the root cause of the differences seen in their actions. Stephen would work on other material during mathematics class, not concerned with showing that he was attending to what Mr. Matthews had given him. Maria worked diligently at every task she was given, and always remained focused on mathematics. Tyrone paid attention during lessons, but projected an attitude that he did not care overmuch how he was perceived. He was respectful, but took advantage of any situation in which he could socialize and not do much work. Michelle was highly concerned with appearances; she prioritized this and getting a good grade above understanding the material.

# Chapter 9:

# Mr. Johannson's Students

> [F]ind the slope, find the y-intercept, but the most important part of this question is, what does it mean? What does the slope mean in terms of the story? What does the y-intercept mean in terms of the story? (Mr. Johannson, addressing the class)

Like Mrs. Hill's school, Mr. Johannson's is located in the Greater Vancouver area. He is an experienced and caring teacher, whose enthusiasm for teaching mathematics was demonstrated daily, as was his desire for students to think about the mathematics they were introduced to, rather than attempt to memorize formulas and processes. To achieve this he actively cultivated a community of learners, carefully choosing and posing his problems and tasks. He had high expectations, and recognized that learning occurs over time, a belief evidenced by his classroom practices.

The students observed were taking FMP 10 with Mr. Johannson. FMP 10 is one of two mathematics courses at the grade 10 level, and is considered to be the 'mainstream' choice[147]. After successful completion of FMP 10, students can choose to take PC 11 or FoM 11 depending on their post-secondary aspirations (and sometimes determined by the grade achieved in FMP 10). This particular class was observed 9 times from February to the end of April, on a weekly[148] basis. One focus group interview was held in May. Five students volunteered for the focus group interview.

The actions and comments of four students were used to create the case studies for this chapter. This data was used to ultimately determine each student's primary and secondary motive with respect to mathematics class. In the order they appear below, the four students are: Kyle; Jineane; Xander; Todd.

[147] The other choice is Apprenticeship and Workplace 10 (AW 10), a prerequisite to AW 11, which is generally sufficient only for graduation and to satisfy trade school requirements.

[148] There was a two-week hiatus for Spring Break and two other missed weeks (1 in March and 1 in April) due to scheduling conflicts.

## 9.1 Kyle

"*I'm probably just going to study it a bit at home, but I have more important things for other classes that actually change my mark*."

Kyle was a relatively quiet, easygoing young man taking FMP 10 with Mr. Johannson. He was sociable, and occasionally animated, but most often occupied himself with doodling or working on a given task. His conduct in class could best be described as 'going with the flow' without exerting too much effort; he did what they were asked to do, to a certain extent, and then started to chat or doodle. Inconsistencies in his behaviour both across and within activity settings make Kyle's an interesting case, as does the perspective and rationale he provided in conversation. Additionally, there was a sincerity and genuineness to all of his interactions with me.

In the following two sections I will discuss Kyle's observed actions and his explanations, organized by everyday classroom settings and assessments. These descriptions are followed by a brief summary and analysis of his motive.

### Observable classroom behaviour

Mr. Johannson began each class with a starter problem, unrelated to the current topic. Students worked in pairs, sometimes with manipulatives, to try and solve the problem while Mr. Johannson circulated, sometimes providing hints or asking questions. Kyle always tried these problems, but rarely got deeply involved with them. Asked, "*Do you typically do the problems that [Mr. Johannson] gives out?",* he responded, "*Yeah, I tried it once but couldn't….a few times actually but I didn't get it*." I probed a bit further, explaining that sometimes I saw that other people were "*shut off*" and "*not interested*" in the problem. Kyle agreed with some of his nearby classmates that sometimes you just "*give up if it gets too hard*." Generally he seemed to make a half-hearted attempt at these initial tasks, but gave up quickly and occupied himself by chatting or doodling.

Following the initial problem, students were tasked with solving a question that typically related to the previous day's topic, but also pushed them a little bit further. Students were expected to do these problems in partners on the vertical boards or on the smaller boards[149] that they brought to their desks. Kyle was often the student who wrote on the board and carried out the work, depending on who he was partnered with. If they were stuck, he might look at other pairs' work[150] to try to get an idea or figure out the problem, but on other occasions he would just wait. Seeing him apparently waiting one day, I invited them to tell me about what they were doing. Kyle confirmed my thoughts, replying that they were, "*waiting for the explanation*". They had already asked a classmate for some help, but were still stuck, so I asked them to walk me through what they had done up to that point. They made a little more progress, finding an error in their work, but ultimately ended up waiting for Mr. Johannson to debrief the solution with the class[151]. Kyle found that it was hard to get involved in these partner problems because often it became a race to see who could finish first, and then "*go back to their desks and sit down for the longest time while not doing anything."* It was also problematic if one partner could not follow the others' solution, or if they were both stuck. "*It's difficult to get involved too because […] you can take over if you know what you're doing but if both of you don't know what you're doing … you got, well, you're stopped*."

Other days Kyle just seemed more interested in socializing. I joined his group one day to see what they were doing. They were chatting about social media and stopped when I arrived. I told them that they did not have to stop, stating that I was not there to make them work, but they felt it was awkward chatting while I was there so they made an attempt to solve the problem they had been given. Kyle had found the previous day's material difficult, and had sought help, but was still having trouble with the topic. His group had managed to get partway through the question, but ultimately got stuck and were not able to finish. With another, similar problem in the same unit (systems of linear equations), Kyle was not able to solve it algebraically, but did use some strategic guessing and checking to come close to the answer.

[149] One interesting note is that when the students were on the vertical boards they tended to be more talkative (and slightly more productive) than their peers who were seated, working on the horizontal boards. This finding confirms Liljedahl's work on building thinking classrooms (2015).

[150] This was not only allowed, but encouraged.

[151] As described in Chapter 4, this involved selecting one group's work, projecting it on the screen and then having a discussion about what they did, and why. They also looked for errors as it was not always the "best" work that Mr. Johannson chose.

Although Kyle sometimes chatted, he was rarely the source of distraction for others. More commonly he was a victim, albeit a willing one. Only once did I note that Mr. Johannson had to move Kyle because he was too distracted where he was sitting. The shift to seatwork time following the lesson predicated another shift in Kyle's behaviour. Kyle rarely accomplished any part of his assignments during class time. Instead he delayed or avoided starting his homework. He occupied his time chatting with any of his peers (he seemed happy to chat with anyone), wandering the class with a semi-legitimate alternative (looking for paper towels to clean the marker off his desk), or doodling in his book. Towards the end of the course, Kyle shared that if he was allowed to use headphones he would actually "*do work during class,*" indicating that distractions were a significant factor influencing Kyle's behaviour.

Seeing that Kyle did not appear to complete any homework in class, I broached the topic of homework with him to get some more information, beginning by inquiring if homework was collected. Kyle explained that it was only collected four times per term (three terms per year), and said that he mostly did homework at home, qualifying that the only time he really did "*hardcore homework*" was before a test. To prepare he would do the questions in the back of the book, and for final exams he would do approximately "*half the questions in the entire book*." If there was material he did not understand he would focus on those chapters and do "*all of those*." After this I returned to the homework he had just been assigned, asking if he would do it. He said he wrote it down, and implied that he might not do it, since it was "*mostly for review.*" However, he then said that he usually did the homework: "*I usually do it because I have a tutor and I do most of my stuff with a tutor*." I explored this topic a bit more. When Kyle arrived home from school he had a Skype call with his tutor to help him make a plan of what he would do for the rest of the night, and Kyle could then follow through on the plan on his own. He explained, "*I understand most things at school. I don't have a problem with understanding*," but he has difficulty planning and organizing, as well as losing assignments and materials.

Returning to the topic of the current homework assignment, I asked Kyle again if he would do the homework, given that he seemed to understand the topic (based on his success with the board problems). He said he would probably study it "*a bit at home*" but that it was "*not a main priority*" because he had "*more important things for other classes that actually change my mark*." Kyle did not usually do homework in class because he did not feel obligated to do it. Also, he said it was "*easy and difficult at the same time*" and "*it's the same thing so once you get it you can do it forever*." My interpretation of these final statements is that Kyle did not see a point in doing the homework questions he found easy, and did not want to put the effort into trying to figure out the more difficult ones, nor ask for help.

### Assessments

Mr. Johannson allowed students to do corrections on their quizzes and tests[152], so to further probe Kyle's feelings about marks I inquired about Kyle's actions when a quiz was returned. Kyle answered: "*Ah, you keep it and you do corrections and then you hand it back. If you don't get something you ask him I guess. But I usually do pretty good on quizzes*." Mika, his seatmate that day, added that the corrections had to prove to Mr. Johannson that they knew the material. Although he said he usually did well on quizzes, Kyle had done poorly on one particular quiz because he did not study; he was studying for a Socials test instead. I asked him if he was going to do corrections, as he did not seem to be doing anything with his quiz other than doodling on it. I suggested that it might not be worth the effort to do the corrections. Kyle did not agree, stating: "*Well actually it is worth it so I'll probably just correct it, like show the equation and what not, and then get like, six I guess*[153]." Regarding test rewrites, Kyle stated that for one test, which he had only just passed, he would "*probably redo it and get a higher mark*." Redoing did not guarantee an improvement in understanding. At one point, Kyle boasted to Mika that he was able to raise his mark on a test from "*60% up to 70% just by guessing*" (on the multiple choice).

While Kyle clearly used some strategies to improve his test mark when he did not understand the material, cheating was not one of them. Cheating on a test appeared to be quite difficult in Mr. Johannson's class, given the configuration of the desks and other measures taken to reduce or eliminate the behaviour. Although it did not appear to be an

[152] Mr. Johannson had not initially allowed rewrites but changed his policy midyear. Allowing rewrites substantiates my claim that he believes learning occurs over time.

[153] Kyle scored 4 or 5 out of 8 on the quiz.

issue, I asked students during a focus group interview what they thought about it. Kyle's response gives some insight into his behaviours.

> Um, I think that, ah, well, personally I don't cheat, just for self […] I'm probably like the one person in the school. But um, I think that the reason people do cheat is because of, for example me, I can't do a test. And for example my final exams, I can't do them in a big room with lots of people. I have to be in a room with just myself or me and like three other people in the room, otherwise I can't focus. And well, I think people cheat is because of temptation and also well, ah, if you really want to get something right I guess.

Kyle himself did not cheat, but recognized that others might if they were tempted and needed to get an answer correct. Kyle also seemed to imply that test anxiety was a factor as well as distractions. If a student felt that they knew the material but could not focus then he or she might 'even the odds' by cheating. Kyle did not write tests in Mr. Johannson's classroom as he had an accommodation allowing him to write tests in a separate setting. He laughed at the ease at which cheating was accomplished in this other room, claiming that the teachers would give the students answers, but also repeating that he did not cheat. Asked why he would not do so, Kyle simply replied, "*moral values*."

### Kyle's motive

Kyle's actions and verbalizations are interesting in light of what he professed his goals to be. Towards the end of the course I conducted a focus group interview, for which Kyle volunteered. I asked whether the students felt understanding was more important, or whether they were more concerned with getting the marks they needed to pass the course. Kyle initially said that understanding was more important, but then expanded on his response.

> Well, for me, it's about 75-25. Seventy-five percent understanding it, twenty-five percent marks because I do care about marks because it's what's going to let me go to, for example, university or college or institution, and with that said the understanding is much more important to me than the marks themselves because if I understand something then, first of all it would lead to better marks and second of all, in the future instead of having to redo everything I'd rather just get it through now so I don't have to do everything again later, for example, ten years from now.

Although Kyle seems to think that it is more about understanding, he did make some effort to get extra marks by doing quiz corrections and rewriting tests. He also indicated that he would not cheat because he had a moral belief against it, not because he did not want the marks if he did not understand the material. Kyle's comment regarding the relative importance of understanding versus marks, then, appears quite accurate in light of his behaviour. He cared about understanding, did not cheat due to his moral values, but marks did hold some importance for him. He did not indicate that he ever came for extra help, and although he had a tutor it was primarily for organization, not understanding.

Figure 9.1 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Kyle's actions, his voiced and otherwise indicated goals, and, extrapolated from these, his motive.

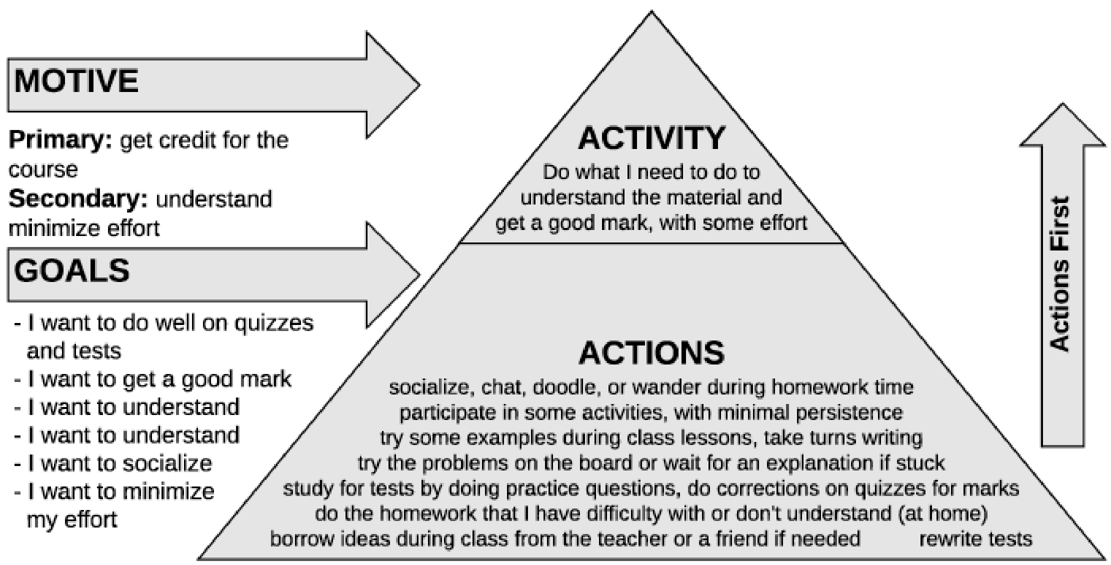


**Figure 9.1 Using an 'actions first' approach to determine Kyle's motive**

Kyle wanted to understand, and he was willing to make some effort (do practice questions to study for tests) but he was only willing to do certain things. He did not attend tutorials or go out of his way to ask for help during class, instead waiting for an explanation to be offered, or else he tried to figure something out by observing his peers. Given his actions and what he said, one of Kyle's motives was understanding, but this is mitigated by the amount of effort he is willing to devote to the endeavour and is only marginally more important than getting marks. Thus, his primary motive is to get credit for the course.

## 9.2 Jineane

"*[…] one thing that I know is that the score doesn't really represent what happened in the game, so I guess you can have a really good score but your game could have been really crappy. Right?*"

Jineane was a friendly and honest young woman taking Mr. Johannson's FMP 10 class. She was a willing interviewee and I spoke with her a number of times over the observation period. In our conversations and through her conduct Jineane did not exhibit any particular interest in mathematics, and in fact often appeared disinterested and disengaged. She shared her thoughts in one of our early conversations, stating that the work she had been asked to do was kind of boring, "*I mean, I'm never going to use this again*." I asked what her future plans were and why she chose to take FMP 10. She explained that she did not want to do "*A and W math*" and supposed that this was "*the default math course*." When I asked if AW 10 was just too easy, she replied, "*I guess*" and added that FMP 10 was just "*better to have*." Her goal was to be a physiotherapist, which she thought required "*more biology and physics*" as opposed to mathematics.

This case study has two sections: the first describes my observations of her conduct in certain activity settings, with some commentary from Jineane, and the second section contains Jineane's views on other aspects of classroom life, gleaned from the informal interviews.

### Observable classroom behaviour

Jineane engaged with the problem-solving tasks given at the start of every class, but did not exhibit extreme emotion regarding them or any particular drive to solve these types of tasks. She did get caught up in Todd's enthusiasm when they were struggling to solve the one problem Todd was unable to conquer[154]. For other problems (like the "Die Hard Problem[155]") Jineane's attention wavered. Like many of her peers, she initially did not understand the problem. I overheard her say "*I don't even know what we're doing.*" Despite

[154] The leap-frog problem. See Todd's case study, below.
[155] See Appendix D.

attempts my attempts to engage her group and provide assistance they could not be induced to do more than try it half-heartedly. This is very different from her actions with the "Pen Caps Problem[156];" Mika and Jineane were greatly excited to have found a solution, and eventually demonstrated it to the class. When I asked about participation in these tasks, sharing that I sometimes saw people who were not interested or were not really trying the task Jineane explained: "*some people just give up* … *if it gets too frustrating.*"

On the first day I visited the class I noticed Jineane, primarily because she appeared to be letting her partner do all the work and also because she was chatting with Todd about getting braces. This was not always the case, as she did frequently take part in the pair work on the boards, and also took her turn writing. She was just not consistent. For example, when they were doing slope questions on the vertical boards, Jineane finished the problem quite quickly, after first spending about a minute doodling on the board. Yet on the second task[157], Jineane's board was blank, a fact she blamed on her partner, Jackson, because he had the marker. They eventually completed the task, although my presence was likely a factor.

I asked Jineane and some peers how they felt about working on the whiteboards. Jineane felt that having a partner was helpful if you did not understand something. She gave an example:

> Well, what my group did today is we were doing this question and nobody knew what to do so I was like, oh, you do like, inverse, or whatever and they're like, "okay, that makes sense" so one person writes it and if they don't get what to write next then another person takes it, and "okay, that makes sense" and everyone kind of collaborates.

When the activity setting shifted from the 'lesson' portion (most often in the form of a class discussion about a sample of student work), to time for homework, Jineane's level of participation shifted as well. Seatwork time was a time to take a break. Jineane employed various tactics to delay and avoid starting homework, usually with great success. On one occasion, Jineane had no textbook and next to her Trevor had no paper, but had his

[156] See Appendix D.

[157] They happened to be seated at the desks with a board for this task, whereas for the first task they were standing. This again confirms Liljedahl's research on building thinking classrooms (2015).

textbook out in front of him. Neither of them was doing homework. Trevor was flipping pages in the textbook and Jineane was just sitting. Mr. Johannson suggested they share the textbook and paper, but the suggestion was ignored. Earlier Jineane had told me that the material was "*boring*" and that it "*made sense*." Asked if that was her reason for not doing the work, she said, "*well, I don't have my textbook*." Perhaps for Jineane this was a more 'legitimate' reason for not doing the work, as compared to not doing the work because she understood it. Whether she understood it or not, lack of the textbook was her excuse for not doing the work at that time. In direct contradiction to the actions of many of her peers, Jineane agreed that math classes should be shorter because homework time was wasted time, stating, "*no one does the homework when given time in class.*"

Another class, after having assigned homework, Mr. Johannson spoke to Jineane at least twice about starting her homework. Jineane managed to delay starting the homework task for at least 20 minutes, until class was dismissed. During this time she flipped through the textbook, paged through her binder, and generally avoided doing any work. When I asked her, "*I noticed that you took a little bit of time to get started today. Is that, do you go somewhere later to do your homework?",* she replied, "*Yeah, I have a tutor so I go over it with her then*." She further elaborated that she had a spare block the following afternoon so she could go home and spend that time with her tutor to "*go over all my homework.*" She explained that she found doing that "easier" than sitting in class and trying to do the work, adding that she just "*liked her tutor more."*

For Jineane, it was easier to do the work with her tutor than to attempt it on her own during class. In this case "easier" means more efficient, as Jineane was capable of doing the homework in class, with some occasional assistance from Mr. Johannson. A month later I noticed her doing some work in class. Interested, I asked, "*What's making you start your homework today?*"; she responded, "*It's easy*." Yet during an earlier conversation Jineane had said she probably would not do the homework because it was easy and made sense. Like this example, there were other times when Jineane's statements contradicted her conduct.

## Jineane's comments

Mr. Johannson neither required, nor gave notes, but posted them online. I explored this topic with Jineane to enhance my understanding of her note-taking practices, which appeared to be non-existent. Jineane explained that Mr. Johannson's class included "*everything […] We do homework and then we do questions together and sometimes notes. So I guess everyone gets happy, in a way*." She said that Mr. Johannson did not "*make*" them take notes, and that she would look at the online notes "*only when I really need to."* Here, Jineane implied that she did go online to look at the notes occasionally, but a later conversation revealed that Jineane did not use the online notes at all. We had been talking about notes in the focus group interview and Jineane gave an example from her socials class in which the teacher gave copious notes, "*so basically all we're doing is we're writing this down – we're not even paying attention to what we're writing down because he's talking at the same time.*" She compared that experience to Mr. Johannson's class: "*But then we have this class – we have no notes and I never look at the notes online. Come on let's be honest here –I never look at them*." Yet she followed that by saying, "*Yeah. If we have a test and I'm confused then you go dig it up*." It is difficult to tell from Jineane's statements whether she has actually ever gone online to look at the notes. She says she never does, but then says she would if she needed to and if she was confused. To reconcile these contradictions, we can consider the shift from "*I*" to "*you*" in her final statement about being confused. It is possible that Jineane means that if she is confused she should go dig it up, but she does not say "*I*" because she does not actually do it.

Jineane was one of the students who expressed dislike for Mr. Johannson's policy regarding test submission[158]. She explained how she felt in a focus group interview towards the end of the course, saying that she finished tests really quickly and then had to sit there "*for an hour*." She said the test sitting on her desk was "*mocking*" her, 'saying' "*'ha ha, you've got something wrong, fix it' and you're just like, 'what did I get wrong'? And it's like 'find out.*'" Handing it in finally was "*like getting a weight off your chest*" and she felt "*satisfied*." Jineane did not appear to see much benefit in taking time to check her work,

[158] Students were not permitted to hand in tests and do alternate activities until the end of the class period.

or taking more time to think about a question. She preferred to hand in her test and then listen to music, because it passed the time more quickly.

Although cheating would have been very difficult in this class, Jineane thought that someone might ask a friend to "*feel more comfortable with it*" or cheat because they were "*desperate*." Some of her peers stated that they would not cheat because they would feel guilty or were morally against it. Jineane, however, declared that she would cheat, if she needed to.

### Jineane's motive

At one point I asked Jineane what was of greater concern to her; getting a good grade to pass the course, or understanding the material. She said that it depended on the course. Understanding was more important in some courses, but did not really matter in a "*random course like psychology or foods*." She then made a rather insightful comment:

> "[O]ne thing that I know is that the score doesn't really represent what happened in the game, so I guess you can have a really good score but your game could have been really crappy. Right? And so people look at the score and go "oh, wow, that game looked so good" and you're like "but I played so badly" but it's like "obviously not, you won" but it's like that's not exactly true.

In Jineane's metaphor, she explains that a good score (grade) does not mean you have good skills (understand the material), you may have just been lucky. Jineane's version is particularly remarkable because it contrasts what the majority of students would say: that they understand the material, but they just got a poor mark. Most students appear to be more concerned with getting a good mark, regardless of how they feel about their command of the concepts.

Jineane seemed to have a maturity that some of her peers did not. This did not mean that she was a dedicated mathematics student, but more that she was self-aware. Figure 9.2 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Jineane's actions, her voiced and otherwise indicated goals, and, extrapolated from these, her motive.

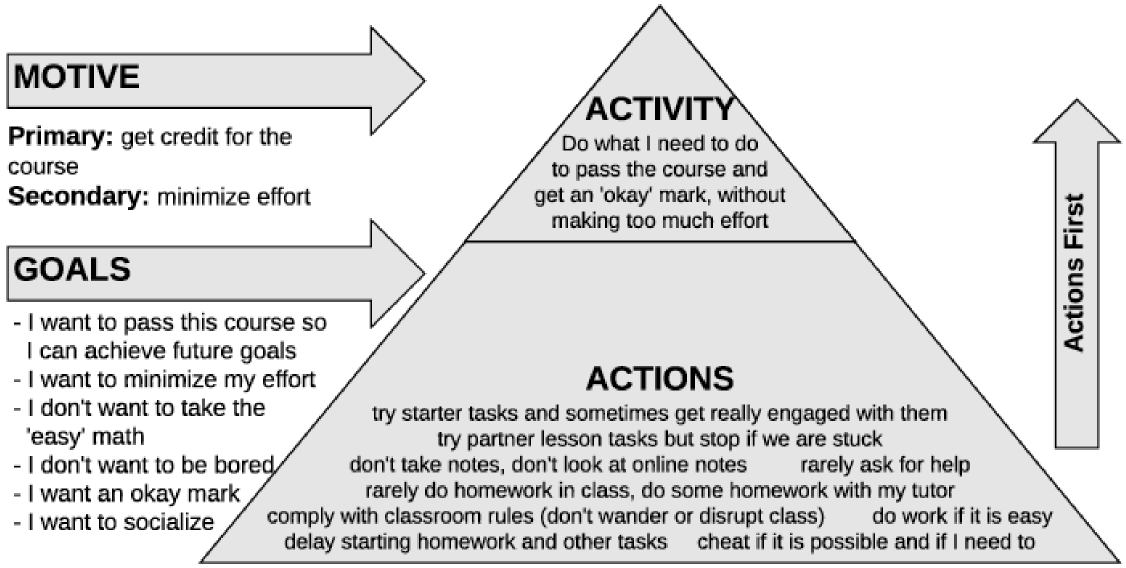


**Figure 9.2 Using an 'actions first' approach to determine Jineane's motive**

Jineane wanted a good mark, but this was not highest on her list of priorities. She needed FMP 10 to get into the future courses that she had to take to achieve her goal of being a physiotherapist. Beyond that, she was not concerned with attaining a high grade or mastering the content. In class, Jineane participated in group activities, to the extent that she could be expected to do so, and until she and her group mates got stuck. She did not like to be bored and she liked to socialize so her participation and effort were guided by these desires. She avoided doing homework during class, but was never disruptive. Given an analysis of her actions and the content of what she said, Jineane's motive was to get credit for the course.

## 9.3 Xander

"*[…] there's multiple intelligences, like everyone's smart in a different way, everyone thinks in a different way, and that's why I think that teachers should be more open in the ways they teach. Like, 'you can do it this way, you can do it this way'*"

Xander was a capable, personable, and intelligent young man. He appeared very comfortable interacting with his peers, and also conversing with Mr. Johannson and with me as I visited his FMP 10 class. In our conversations and in the focus group discussion, which Xander volunteered to attend, he shared his thoughts on topics such as cheating, taking notes, and writing tests.

I have chosen Xander for a case study for two primary reasons: his conduct varied with respect to activity setting, and he often provided ‘reasons’ for his behaviour when it was not compliant with perceived teacher or researcher expectations. Thus, I consider Xander an interesting student because of how he seemed to want to be seen. In our interactions he appeared to want to be perceived as intelligent and mature. If one were to look at his actions alone, he could be categorized as a delayer and sometimes a reluctant participant in group tasks. Yet unlike Todd, whose case study comes later in this chapter, Xander employed a façade, albeit a weak one, to mask his non-compliant behaviours. He also made excuses when the issue of his delaying was raised.

In what follows I describe Xander’s behaviour and the content of our conversations to support an analysis of Xander’ motives in mathematics class. The following is organized into three sections: a ‘sketch’ of Xander from his thoughts about different aspects of mathematics class, followed by two themes. The two themes arising from analysis of Xander’s conduct during class are changes in behaviour across activity settings, and Xander’s rationale for his conduct. Finally, I offer a brief summary and discuss Xander’s motives in mathematics class.

### Observable classroom behaviour

I had many opportunities to converse with Xander during class; he was often willing to stop what he was doing (or not doing) to converse. As a result I was able to assess Xander’s views on many topics, such as notes, cheating, and test writing.

Xander felt notes were useful to look over, and that the main purpose for having them was to help with the homework and to review something if you forget it. “*I think that notes help with math because like if you forget how to do a problem you can refer to it over and over until you get it*.” Few students in the class took notes, as it was not required and they were posted online for students[159]. However, nothing prevented students from taking notes.

[159] As explained in Chapter 3, Mr. Johansson provided a full record of the notes and audio-recording of his lesson on his course website for students to access.

Xander occasionally wrote things in his notebook, but not much, though he said he would prefer to have notes as, "*he understood it more,*" when he had them. He added that he would like some notes, enough to "*figure out the steps and then to be able to learn that at home*." I asked if the textbook was of any use, since it had examples. Xander felt that textbooks were more difficult because you had to interpret them: "*the teacher's words are different from the words that people wrote. So you have to really read between the lines and take your time consuming it*."

Xander found notes useful to the extent that they could be used to help him do his homework and to refer to if he had difficulty with a particular problem or topic. He preferred having notes for this reason, and mentioned that he "*understood*[160]" it more last year when he took notes. I observed that Xander occasionally wrote some things down in class, but he did not make use of the notes provided online. He alluded to reading the textbook and making sense of it, and I noticed that he did this occasionally, but his primary purpose in this was to follow the steps in a similar worked problem - doing what Liljedahl calls 'mimicking' (2013a). Xander was capable and intelligent; he was able to explain his thinking and often shared his thoughts during class discussions following the board work. In fact, Mr. Johannson dubbed the process of finding x- and y-intercepts "Xander's Law[161]", based on Xander's explanation of how to find the two values.

One of the topics we discussed in the focus group was cheating. Xander shared his thoughts on why he would not cheat on a quiz or test. I had asked the focus group why they would not or did not cheat on a quiz or test, even if they had the opportunity to do so. Xander replied: "*guilt*." I probed: "*So it's more important to you not to cheat than to get the marks? Even if you really need the marks?"* Xander claimed he had never cheated, even if he really needed to. He explained: "*I'd rather fail [a quiz] than cheat 'cause […] failing a quiz isn't going to haunt me in a few years, but knowing that I did something that my own personal beliefs and I broke that – that wouldn't be as good*." Xander claimed to have a strong moral compass with respect to cheating, or it seems at least a strong avoidance of the negative feelings of guilt.

[160] It is not clear what Xander means by "understand", but considering his other statements it seems that for him, understanding is akin to being able to 'do' a given question/procedure.

[161] To find the intercepts, Xander explained, "*cross off x to find out what y is, cross off y to find out what x is*."

With tests, Xander was not fond of Mr. Johannson's policy that students were not allowed to hand in their tests until the end of the period. He would have preferred to do something else, stating that it should be "*customary for everyone to just be able to check over their answers for 30 seconds*" and be able to hand it in early. Xander, like many others when it came to test taking, seemed to want to 'get rid of it'.

### Theme 1: Shifts in behaviour

In many activity settings, Xander was engaged[162] and worked well. In others, he was disengaged and delayed starting tasks. This supports the idea that context is critical to student engagement. Often his engagement with tasks showed a predictable pattern, which will be discussed in the summary, below. In what follows, I describe some instances of Xander's observed behaviour in different activity settings in the sequence that they would occur in a typical class period.

At the start of almost every class period students were given a problem-solving task unrelated to the current mathematics topic. During this time, Xander often disengaged and, when questioned, made excuses for not trying it. There were several instances of this, one occurring when the class was given the 'seven rings' problem[163]. When I noticed that Xander did not appear to be trying the problem, but his partner was, I asked them what they were doing. Xander responded, "*I don't even know the problem.*" He did not seek clarification about the task, nor did he embrace the help that was offered.

Yet later, in the same class, Xander appeared to be quite attentive during the teacher-led portion of the lesson, even voluntarily responding to a request for responses/suggestions to questions posed by Mr. Johannson about the current topic (slope of a line). In fact, Xander was usually attentive during the teacher-led portion of a lesson and, while he was not always the first to respond, often contributed his answers or ideas to discussions.

When students were asked to carry out a topic-relevant task that Xander understood or with which he had some initial success, I saw that he contributed to the partner work and

[162] As previously stated, I use the term 'engagement' or 'engaged' in it's common sense, as opposed to a theorized one.

[163] See Appendix D for the problem. Xander's interaction with this task was also discussed in Chapter 5.

worked hard on the assigned task. For example, when asked to find the domain and range of a given situation, he and his partner showed them in three different formats (set, interval, and number line), and later that day the teacher had to convince Xander and his partners to sit down and stop working on the story they were writing to accompany a given graph. Some days Xander needed a little prodding (when Mr. Johannson asked Paul to let Xander write (problem about slope) and Xander was chatting with Todd), later Xander and Paul's work was used to demonstrate the problem. When he did not understand or had difficulty, Xander was reluctant to make an effort to try, even when offered peer help.

When the student work and teacher-led portion of the lesson reached its conclusion, and homework was assigned, Xander's engagement and attention typically waned. A typical observation of Xander during this time proceeded as follows. Homework was assigned and Xander slowly took out his books, then chatted with his nearby peers for a bit, before he got up and went to sharpen a pencil, after which he meandered back to his seat. Arriving there, he opened his book, and proceeded to chat with another classmate, then with his seatmate, then with Todd. Fifteen minutes after the task (homework) had been assigned, and having only just started the first few questions, Xander attempted to draw me into conversation.

As can been seen above, Xander's engagement across activity settings waxed and waned with some degree of predictability, based on the value he placed on what was occurring, and on other situational factors (i.e., availability and 'legitimacy' of an alternative). Clearly Xander valued the teacher-led portion, where ideas were discussed, answers were arrived at, and where his contributions could be 'seen', as this was the activity setting in which he demonstrated the greatest levels of attention and participation.

### Theme 2: Xander's rationales

The second theme that appeared, in addition to Xander's pattern of engagement in different activity settings, was his habit of providing a particular type of rationale for his conduct. Whenever Xander was not engaged in the task, or not interested in it, he made an attempt to find a “seems legitimate” substitute activity (such as talking with me), or made other excuses for his ‘non-compliant[164]’ behaviour.

When approached, Xander embraced the opportunity to answer my questions, and in fact there were also times when he initiated the questioning. As described in the preceding section, after homework had been assigned one day Xander spent fifteen minutes delaying doing his homework, then attempted to draw me into conversation, asking, “*What kinds of questions do you ask?”* Another instance of this occurred during a problem-solving task (the ‘seven rings’ problem). As described earlier, I approached Xander and Paul because the two partners did not appear to be doing anything, after having ‘had’ the problem for a few minutes. I prompted: “*Are you guys listening, or thinking, or what?”* Paul started to explain the part he was thinking about, “*We have to make a really small cut*”, whereas Xander turned to me and said: “*I’m wondering what you’re observing right now*.” Xander had again tried to turn the conversation away from what he was doing or not doing to another, ‘legitimate’ occupation.

When he could not use talking with me as a legitimate substitute for doing a task, Xander either provided rationales involving other semi-legitimate substitutes, or he said that he did not hear or understand the task. The first example I provide took place in the same ‘seven rings’ problem solving setting. After Xander had asked me what I was observing I attempted to get them to refocus, stating that I was most interested in the problem they were working on. At that point Xander claimed he did not even know what the problem was: “*I don’t even know what the problem is. I don’t get it. Like, they’re interconnected; you’re trying to pay the person.*” Paul started to explain the problem to Xander but he resisted. He seemed determined not to think about the problem, at one point managing to involve some others in his deliberations about whether or how you could cut gold, and if you could make rings from meteorites. Later he told me that he did not really understand the problem and claimed he was, “*trying to understand it as best I can.*” I asked if he was waiting for Mr. Johannson to come around to explain it. Xander replied that he was “*sort of*” waiting, and that he was wishing the teacher would repeat it, “*because I was throwing*

[164] I use ‘non’-compliant to refer to student conduct that is not in accord with the student’s perception of teacher or researcher expectations. Teacher’s expectations are discussed to some extent in Chapter 3, and can also be reasonably deduced from the teacher and classroom descriptions provided in Chapter 3.

*the marker out and I didn't really catch it… the first part really. And ah, it's not necessarily an easy question, you know?"*

At first, Xander said he does not even know what the problem is, because he did not hear it. Then, he seems to resist others' efforts to help him understand, followed by trying to divert the conversation from the task, and finally, he says that the task is not easy and that he is trying his best. This episode is typical of many of my interactions with Xander. He is intelligent, and wants to be seen that way, but he did not really like doing work, whether it was easy or challenging for him.

In a latter class, I again asked Xander why he had not started when ten minutes had passed since the homework had been assigned. Xander claimed that he had started. "*I'm working on it right now. […] I'm on number four*." Having had some experience with Xander and seeing that he had not yet even started that particular question, I rebutted, "*Number four is the first question*." Xander then said he gets distracted easily sometimes, and started to hypothesize: "*[S]ome people work better at home. Some people think that if they're alone they work better, some people think that if they have the ambience of a group of people […]*." Other than his first sentence wherein he refers to himself being easily distracted, the rest of his statement appears to be rambling. I reminded Xander that I was not there to get anyone in trouble, and that I just wanted to know why people chose not to work in class, if there was time. I gave examples of reasons that others had provided: doing it with a tutor, not able to focus in class, working better at home, etc. Xander said, "*Yeah, I just can't focus*." But then he added something about distracting his partner: "*I just like distracting Trevor because it's a hobby of mine*," making a joke that he would put it on his resume. I then attempted to depart, saying that I would "*stop distracting him*," but he said I was not distracting them, "*[b]ecause it's research*."

In this interaction, Xander first claimed that he is working, and then explained that he was distracted and had difficulty focusing, repeating one of the justifications I listed as being given from other students. His final statement supports my claim that Xander viewed talking to me as a legitimate, and more desirable, substitute to doing the assigned task.

During the lesson Xander was usually attentive and involved. He volunteered at times when the teacher asked for suggestions during the discussion portion of the lesson, but was not the first, and was not always correct in his observations and responses. Typically Xander was active in the pair or quartet work part of the lesson (board problems), but on at least two occasions he was not. Two final examples, both from a board problem giving during the lesson setting, follow.

I approached a group of four, noticing that Todd and Xander were allowing Sabine and Nicole to do all of the work on the board, and the two boys did not seem to contributing in any way. I asked why they were letting the girls do all of the work. Todd replied, "*uh, sorry*," but Xander stated that it was a "*one-person job*". I was a little taken aback by his statement and said: "*Xander!*" He then changed tack, claiming: "*I don't know. I have no idea because […] so I don't know what I'm doing*." I pointed out to Xander that he had not really missed any part of this session, and had only missed the starter puzzle (which was entirely unrelated). I called him on it, saying, "*excuses, excuses*" in a joking manner. He then claimed to be "*in the middle of substitution*[165]".

The second board task example began with my observation of a peer approaching Xander and his partner to tell them how to start the given board task. Thinking they might be stuck, I went over to investigate. Xander and his partner were having difficulty, and when I asked them about the task, Xander explained that he had not completed the homework, because, even though he 'followed the steps in the textbook' he "*got the wrong answer for x and no answer for y.*" He seemed to be frustrated with the difficulty he had with the homework, and since this problem was of a similar type, it seemed to me that Xander was implying that he had tried and had been frustrated so that excused him from trying at the moment.

### Xander's motive

Xander was interested in socializing, but also with appearing intelligent. He delayed starting tasks such as homework or starter problems, but engaged in the lesson portion of the class, contributing his efforts and volunteering answers. He rationalized and tried to justify his behaviour when he was not doing what is 'expected', or attempted to find a 'legitimate' substitute, such as talking to the researcher. Xander said he did some of his

[165] They were working on systems of linear equations.

homework, at home, and would try and use his notes and the textbook to help him with some of the questions.

Figure 9.3 (below) depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Xander's actions; his voiced and indicated goals and, extrapolated from these, his motive.

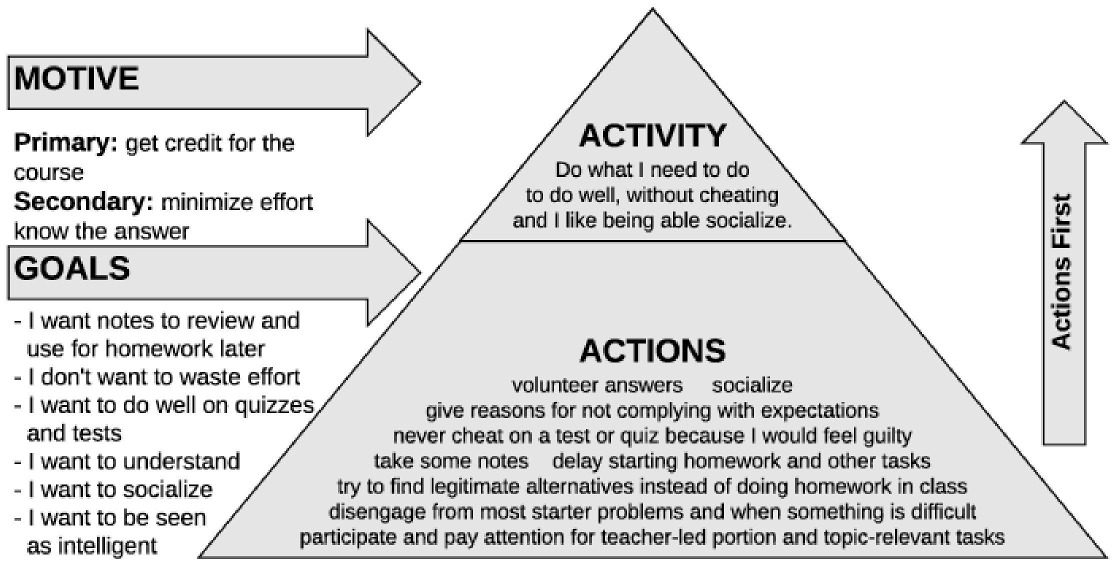


**Figure 9.3 Using an 'actions first' approach to determine Xander's motive**

Xander's primary motive was to get credit for the course. This determination is arrived at through consideration of what Xander appeared to value (being seen as intelligent, the teacher-led lesson, socializing, having notes to refer to) and to not value (problem solving, getting time to do work in class, getting help from the teacher). Although at some level he wanted to know the material, this was not drove the majority of his actions. He liked to socialize, he did not like to put in a lot of effort, and he did not always participate in activities that he saw as consequential to his grade (such as doing corrections or completing homework). He wanted to get a good grade, but it was not his primary motivation as he is was not always willing to put in the effort.

## 9.4 Todd

"*Honestly, I think, at the end of the scales I don't really care about understanding […] I'm just worried about getting it over with*."

Todd was a personable and approachable young man in Mr. Johannson's FMP 10 class. He was an incorrigible social butterfly, and incredibly honest, almost to a fault. Todd was also a highly skilled delayer, and from day one I was intrigued by his conduct. In particular, Todd stood out in comparison with that of most of his peers because he never tried to justify or excuse his behaviour. Whereas others tried to delay doing work by substituting tasks such as going to sharpen pencils, going to the washroom, looking for paper or a textbook, going to borrow something from a peer, or waiting to ask the teacher a question - activities that appear to conform, or put up a façade - Todd never bothered to hide his non-compliance. He was not particularly blatant, nor did he flaunt his nonconformity; instead it was somehow accepted, 'that's just Todd'. That said, there was a subtlety and a fluidity to his delaying that was almost masterful.

Todd's conduct varied within different activity settings, and to some extent actually swung between two extremes. When the object of the activity setting had to do with the FMP 10 curriculum, Todd minimally engaged with tasks, if at all, and tended to delay. In stark contrast, when the object of the activity setting was not curriculum based, or was a novel task, Todd could hardly be more focused. In the following sections I elaborate on his actions and his comments in three parts: curriculum based settings; non-curricular and novel tasks; further insights. Following these is an analysis of Todd's activity and motives.

### Curriculum based settings

Todd had difficulty focussing during direct instruction, board work, and homework time. He rarely did any homework or paper and pencil tasks during the class time provided. As I noticed this early on, Todd was one of the first students I approached. I began by commenting that I had noticed it was taking him a bit of time to get started that day, to which he responded: "*oh no, that's normal*," and laughed. I was a little surprised by his response, having had more experience with students who made excuses about lack of materials, being tired, or provided some other rationale if asked about not doing a task.

So I asked Todd if he had a tutor, thinking that he might just ‘save’ the work to do later, or if he did it at home because he could not focus in class. Todd again surprised me with his honesty, explaining he had a learning disability, though he did not like to blame his actions on it. Having been diagnosed with a learning disability meant that Todd had the opportunity to write his tests in a separate setting, the LAC[166], which he called the ‘Special Ed Room’. Although this room was not quieter, Todd explained that he could “*focus a little better*” because it was “*less distracting*.” He also admitted to being “*just a little bit lazy*” and added “*I could probably just do stuff*.” Todd said that when he did do work, it was at home. He found it easier to focus in a quieter setting because he was distracted by loud noises and conversation and he had difficulty resisting the temptation to join conversations. He experienced this in all of his classes, not just mathematics. I followed up by asking if he was able to do the work at home, and what he did if he ran into difficulty. Todd said that there were distractions at home too, but if he took the time to get “*zoned in*” he was usually able to get his work done. His dad was able to help him with his work, and Todd added that tutorials [with the teacher] are good too, but did not actually say whether he ever attended, and I did not ask Mr. Johannson.

In this class, Mr. Johannson had worked to instil a culture of community – when students had difficulty they were expected to use each other as resources rather than wait for the teacher to help them. It was generally easier to ask for help or borrow an idea because the students were doing their work on the vertical whiteboards and could easily see what others were trying. They also knew (from experience) that Mr. Johannson would not tell them directly what to do, but would instead provide a hint or ask a question to provoke them to think some more. I asked Todd what he thought about this practice of doing the work on the vertical surfaces and asking others for help. He felt that it was more like one person did the work than it being a group effort. “*I personally think that, also when we’re up on the boards it kind of feels like one person is doing it, than another*.” I asked Todd if he was able to follow what the ‘leader’ of the group was doing. He felt that a great deal of the time he did not understand, and was holding the group back.

> I feel for me it doesn’t really feel like that. Personally. I’m kinda, not gonna lie, I’m kinda hard to work with because I don’t really understand the stuff that much […] I wanna do it, but everyone wants to finish it, definitely, everybody kind of wants to finish it so it’s… especially the way they’re set

[166] Learning Assistance Centre.

> up it’s kind of hard for people who are kind of slower with this stuff too…kind of keep up.

Kyle had likened the group work to a race, where everyone tried to finish first so they could sit down for the longest time. Todd agreed with this, and added that in a race, people also lose:

> I kind of feel like if you’re the slower group you also lose because [the teacher] sees a bunch of people going and sitting down and there’s that one group that just can’t do it. They have to get sped along because all the rest of the class [is done].

I brought up the fact that Mr. Johannson would usually go over the problem and discuss it with the class, but Todd felt it might not be enough to catch him up. He was of two minds about the group work. He liked it because you could get help, but felt that the questions they were asked to do were too big: “*I feel like instead of doing like two or three big questions we should do a bunch of little questions. Like maybe every class just have a little quiz or something like that*.” Todd said he would rather have a little bit of individual practice, because in the group setting it was easier to get lost if, “*if you don’t quite know*.” It seemed that Todd liked the format of group work in general but there was also some tension because he felt a need to ‘keep up’ with the group and the class in general. Todd’s feeling that he was ‘holding the group back’ could be one reason why, in the excerpt discussed earlier, Todd hesitantly said he “*gets it*” but did not really seem to. His comment about preferring individual practice is a bit contradictory, given that he did not generally try homework or seek help when the situation permitted. I also found it interesting that Todd said he had difficulty working on the vertical surfaces because he was distracted when there was “*too much movement*”. For Todd, the vertical surfaces and activity of his classmates was more of a distraction than a motivator.

Distractions were a common theme for Todd. He found it difficult to focus when there was too much going on. However, as described above, he was not any more likely to focus when the class was quieter and students were expected to sit and practice homework questions. In one lesson, the class had been tasked with solving a problem related to the content area they are working on in class (linear equations). Each group of four was working at a board or at a set of desks. When I approached the their desks, Todd and Kyle were chatting about social media. But noticing my presence, they stopped talking and began performing actions indicating they were ‘getting to work’. On this occasion, Todd felt a need to at least appear to conform to his perceived teacher or researcher expectations (that he do the work when he is asked to).

In this class the students were not required (nor was there any implied expectation) to take notes. Mr. Johannson provided an audio and written record of each lesson online for students to access at any time they chose to do so. The topic of taking and using notes arose in a conversation with Jineane and Todd. Todd felt that it was "*awesome*" that they did not have to take notes in the class, because "*notes suck*." I asked them if they went online to look at the notes Mr. Johannson posted. Todd said that he had, but "*not enough*." He felt that he 'should' look at them more often to help him figure out what is going on, but did not clarify why he did not. It is possible that he did not find the notes useful or that it is too much effort to try and follow them. We talked about taking notes in other classes, and Todd shared that he really liked the 'fill in the blanks' style of note taking.

> I know that really worked for me. Because when it's too little [writing] my mind isn't even engaged enough and when it's too much I feel like, I'm just not going to do this because this is just way too much work. […] Personally, for me, that's like way better. And I learn more because it has a little bit of reading but it also kind of keeps me engaged because I have to fill in a couple things. I learn way more off stuff like that.

Todd felt like he was learning[167] because he was paying enough attention to follow the lesson and fill in the blank sections. Learning mathematics did not come easily to Todd, a fact that was made clear in both his actions and comments.

For example, at a later point in the course I observed Mika and Todd trying to solve a question involving systems of linear equations. They got an idea from Mr. Johannson when he gave a suggestion to the class at large, and made some progress. I watched them work through the problem and saw that Mika did most of the talking and writing, so I asked Todd it made sense to him. He responded: "*Yeah, it makes sense, yeah – I get it*." Todd's response was, to me, hesitant, and even if he could follow what Mika did, I doubt that at the time he could successfully complete a similar question. What is not clear is whether he did not understand, but felt he should say he did, or whether he actually felt

[167] It is not clear what Todd thinks learning 'is'. The fact that he was actually attending to the lesson is certainly much more *likely* to result in Todd learning (as opposed to Todd not paying attention), but filling in the blanks does not necessarily correspond to learning. It may be a useful tactic for memorizing terminology or facts, but is unlikely to result in much understanding of mathematics.

he ‘got’ it. Todd wavered back and forth between admitting he had difficulty with mathematics and claiming he just needed to try. Through conversations with Todd it became apparent that he believed there was such a thing as a ‘math brain’ that some people had, and he did not, “*Some people are just naturally good at it* [math].” I countered, “*There’s no such thing as a math brain*” adding that “*some people just work at it*”. Todd then asserted, “*Even if they work at it some people are awful at math*.” He followed this by stating that he did not care, but quickly recanted, “*I care, I just need to try*.” He had difficulty, however, explicating why he was not able to try. This issue arose a number of times in conversations, which I initiated when I saw opportunity.

When asked if he understood a question he was not trying, Todd claimed: “*I got it but I don’t want to do the work*.” When pushed to tell me what he would do with the question he had been given, however, Todd hedged: “*I’m not really good with word questions but if I had this I could probably work my way through*.” He started to try, and struggled with the terminology[168] and finally conceded, “ *ah…I don’t usually do this [the work]*.” A peer suggested he did not know what he was doing, but Todd contended: “*I half know*.” Asked if it was too much effort to try to do the questions, at first Todd said: “*Nah, nah, no, it’s not just too much effort.*” But as he continued to speak he realized that he was not really able to pinpoint the reason, *“No it’s not too much….I don’t know, that’s a hard question. Ahh, I’m not sure, probably not enough effort.*” At this point Todd seemed to feel what was for him a rare need to justify his actions. “*But it’s really hard though. The material’s super hard. Like I can’t… I can’t really comprehend… Cause it’s kind of theoretical and it’s not really like, like, I don’t really actually see it.*” So while initially Todd would say that he understood the material, but just needed to try it, he seemed to either realize or be willing to admit that he did have difficulty with a lot of it. On one occasion I observed that he and his partner were ‘stuck’ on a question with linear equations and when I asked what the specific difficulty was he replied, “*I don’t really get it*,” to which I responded, “*which part?”.* He laughed and said, “*everything*.” This was not entirely true because Todd was capable of doing at least some of the material. During one class Todd said he remembered the material from before, although I recalled he had difficulty with it in the previous lesson. Todd said he knew it now because he had studied it. Surprised at his initiative I asked if

[168] A peer volunteered the term ‘intersect’ and I offered ‘slope’ – the question involved finding the equation of a line.

he had a tutor help him. But he had not; he said he "*just did it*," and that he was studying and "*just worked*" on it.

On another occasion, when they were working in a group of four, only Sabine and Nicole were working, whereas Xander and Todd were chatting. Xander made excuses but Todd responded differently, saying, "*I don't have any excuses, I just hate math*." He followed this by telling me not to worry because he was going to get tutored and it should be better. He explained that the tutor was not going to help him like math, but would make him "*better*" in it. I suggested that he was relying on his tutor to do everything with him and was making the tutor's job harder. Todd explained that his tutor helps him to get a better sense of "*what's going on*," but what he said after was enlightening for me. Todd thought that if he tried to learn how to do it himself that he would "*screw [himself] up learning how to do it wrong*" and then he would "*have to relearn it*." This is an interesting justification, whether it was true or not. Todd's contention that if he tried it during class and learned it 'wrong' it would make it more difficult trying to learn it 'right' with his tutor later is intriguing.

Despite his difficulties with the topics, Todd's actions indicated he obviously found other parts of the class fascinating, which is why he makes such an intriguing case study. Given his avoidance or inability to do work during class, it was interesting to observe that Todd would engage deeply in certain activity settings and with some novel tasks.

### Non-curricular settings and novel tasks

There was one activity setting and one novel task where Todd showed deep engagement and significant interest. One of these 'special' topics or novel tasks was a project assigned to students. When the class was given a graphing project assignment using the online software *Desmos* I approached Todd after seeing that he was absorbed in task. I expressed my surprise at his behaviour (starting before anyone else) and he explained why. "*Um, yeah, because this is cool. It's fun stuff to do. I find the other stuff kinda boring. Like, stuff that I can do visibly see and stuff like that. Understand and see how it works. Then I like it."* He had some fairly elaborate plans and was very excited about the design. In this case, Todd was so involved with his assignment that he stayed past the end of class to work on it.

The activity setting in which Todd displayed high levels of engagement and affect was during the problem-solving tasks given at the start of each class. He exhibited significant interest in the problems and worked very well with his peers to try to solve them. When I asked about this difference in his engagement, Todd explained that they were different than the usual tasks they were asked to do. He said he hated numbers, and that the questions they were asked to do as part of the lesson and homework were "*just a jumble; it's just a bunch of numbers written on a board – that's all that I see*." But with respect to the problem-solving tasks, Todd explained, "*it's actually like, theoretically and you're doing stuff – with the skyscraper thing, that was awesome because we actually got to see, like physically see what was going on*." I dug deeper, asking if he ever gave up because the problems did not matter, as they were not 'for marks'. His response was an unequivocal "*no*." This was the exact opposite response to many of his peers. Todd explained: "*[p]eople have different mindsets. Some people think stuff like that doesn't matter, 'oh, it's extra credit' it doesn't really matter at all, plus this is like, frustrating me, so why should I do something that really frustrates me?"* Todd however, felt that it did not matter whether it was for marks or not, because, "*some people like really enjoy having their mind worked that kind of way*."

Todd was proud of his accomplishments with these problems, and displayed significant frustration when he was unable to solve one particular task (the leap frog problem[169]). When time was running short, and another group announced they had 'got it' Todd announced, "*Oh I hate you! I hate you. I've finished more equations than all you guys put together*." He and his group members expressed extreme angst with respect to the task. Todd went so far as to pronounce that he was "*going to have a heart attack*" because the situation was "*too stressful*." Todd said he "*need[ed] to figure it out […] because [he had] a perfect record so far*." Of all the problems they had been given, Todd claimed he had never been unable to finish one. Having tried a number of strategies (simplifying the problem, etc.), at this point they were just "*hail-marying it*" and Todd did not think they were going to be able to figure it out.

[169] See Appendix D.

Engagement with these problem-solving tasks was not typical of every student in the class, nor were other students engaged with every task – in this respect Todd was an anomaly. Not only because of his consistent engagement with the problem-solving tasks, but also because of the contrast between his behaviour in this activity setting and his actions in other classroom activity settings, such as the curriculum based settings reviewed above and some other areas, which are discussed below.

### Further insights

In this section I provide excerpts of Todd's actions in, and our conversations about, other aspects of classroom life, such as his attitudes with respect to cheating and (lack of) confidence, and his future plans for math courses and for life.

To paint a more detailed portrait of Todd, I have included here an excerpt of a focus group conversation about cheating in mathematics class. I asked the students why a student who was 'good' in mathematics would 'cheat' and look at her neighbour's quiz. Todd shared the following:

> It's a natural thing to do. Because you feel…in test situations you kind of feel like, you always second guess yourself and double guess yourself because you want to get the question right so much, so like you're always going to…You feel like when you have the freedom to kind of like, look over, so it can either help or hinder your thought in your mind.

I followed Todd's response by asking whether cheating or not cheated was influenced by the consequences of getting caught. Todd replied that he would probably still cheat, even risking getting caught. He added: "*Like, honestly, most of my tests I've cheated at least once. In this section*." Writing tests in a classroom setting was nerve-wracking for Todd. He explained, "*Sometimes when you're writing a test just blocks go up in your mind, like you know you know it, like, everybody has that feeling; you know you know it but you just can't write it down. You just start freaking out and stuff like that and go into a cold sweat and just start shaking – like, every single test*." However, Todd said he did not cheat when he was writing tests in a separate setting.

> Honestly, when I'm in the LAC room I've never cheated, ever. I've gotten some clarification from teachers but nobody's ever told me an answer. It's just a better working environment for me. Nobody's ever told me the answer in the LAC – they've clarified for me, they've told me what I was maybe

> missing, but I've never actually been told an answer and I've never actually went and looked at somebody and cheated off them.

It was not clear whether Todd did not cheat in the LAC because he had less anxiety and felt more confident, or if there was less opportunity, so I asked Todd about why he would not cheat, even if he had the opportunity to do so. He indicated that it was a matter of confidence. If he felt confident, if he felt like he could do it, then he did not need to cheat. This supports the hypothesis that he did not cheat in the LAC because he felt more confident for whatever reason, whether it is the separate setting or the feeling like support was there if needed.

Confidence was a recurring theme for Todd, especially with respect to tests. As noted in Chapters 3 and 5, Mr. Johannson did not give many tests (there were only four tests throughout the course), and each test took an entire class block. He did not permit students to hand in the test early because he wanted them to take their time and check their work[170]. This practice was frustrating for Todd because he lacked confidence in his initial answers: "*I don't really agree with it at all […] I think one lookover is enough because you don't want to start second and triple and quadruple guessing yourself*." He felt that having to sit with the test in front of you after you were 'finished' was not in his best interest. Todd identified with Jineane's statement that the test was "*mocking you*" and explained that he had trouble with 'second-guessing'.

> You don't want to sit with it too long because then – I once finished a test super fast because I knew the material but I second-guessed myself so hard that I ended up getting like, a 32 on the test […] it would have been like 93 percent and I ended up getting 32 because I went and changed everything in the test.

Confidence in his knowledge was clearly a factor influencing Todd's decision to cheat, or not. With further probing, it emerged that the morality of cheating was not a significant deterrent for Todd, although he expressed some tension about it.

> It's kind of confusing for me because you're told, growing up you're told two controversial things: do whatever you can to do the best that you can do, but also stick morally, don't cheat, don't do stuff that's bad to get to …so you're told two contradictory things, personally, for me, so it's kinda you're thinking about both. I'm not sure, you don't want to cheat because it's wrong to cheat, but also you do because you're told to do basically

[170] I established this fact with Mr. Johannson following one test block.

> whatever is needed to do the best you can. And that the world isn't fair either.

I asked Todd about his plans for future courses, and for life in general to get some perspective on his goals and reasons for doing (or not doing) mathematics. At the time I asked it was near the end of the course, and he was passing. According to Todd, if he wrote a retest and did well his mark would be in the high sixties. Given this, and being curious, I asked about his plans for his next math course. He said he would be taking Foundations (FoM 11) because it was more "*realistic math*" and more suited to a different path, adding, "*I don't really want to be an engineer or something […] I've never really had a numbers brain."* Todd mentioned this earlier in the course and again here. He felt there was such a thing as a 'math brain' or a 'numbers brain', and he did not have it. He wanted to take FoM 11[171] as his next math course in part because he saw himself as 'not good at math' (although he really enjoyed and succeeded with the problem-solving tasks and puzzles), and this may have influenced his career choices.

Finally, I share the following excerpt to shed more light onto Todd's perspective on high school in general.

> Being completely honest here, I personally think that, basically all of high school, just getting it done. Just getting, doing the best you can and just getting it over with and then moving on with our life after it. Honestly, I think, at the end of the scales I don't really care about understanding. If I really want to understand something I'll go in a couple a few years I kind of have a recollection in my brain of doing it from here. And just work on it more to understand it. Honestly, I'm just worried about getting it over with.

### Todd's motive

Todd's conduct shows a pattern of disengagement with everyday, content-based tasks, but engagement in problem-solving activities and project-based assignments. This supports Liljedahl's research on 'building thinking classrooms' (2016a). He delayed starting and avoided work whenever possible, and while he did not want to get in trouble, he made little effort to hide. For Todd, a task was 'work' if it did not interest him.

[171] As described in Chapter 3, Foundations of Mathematics 11 is a course that typically leads to non-science based careers (anything that doesn't require Calculus).

Figure 9.4, below, depicts the top two levels of Leontiev's (1930/1974) triangle as applied to Todd's actions; his voiced and indicated goals and, extrapolated from these, his motive.

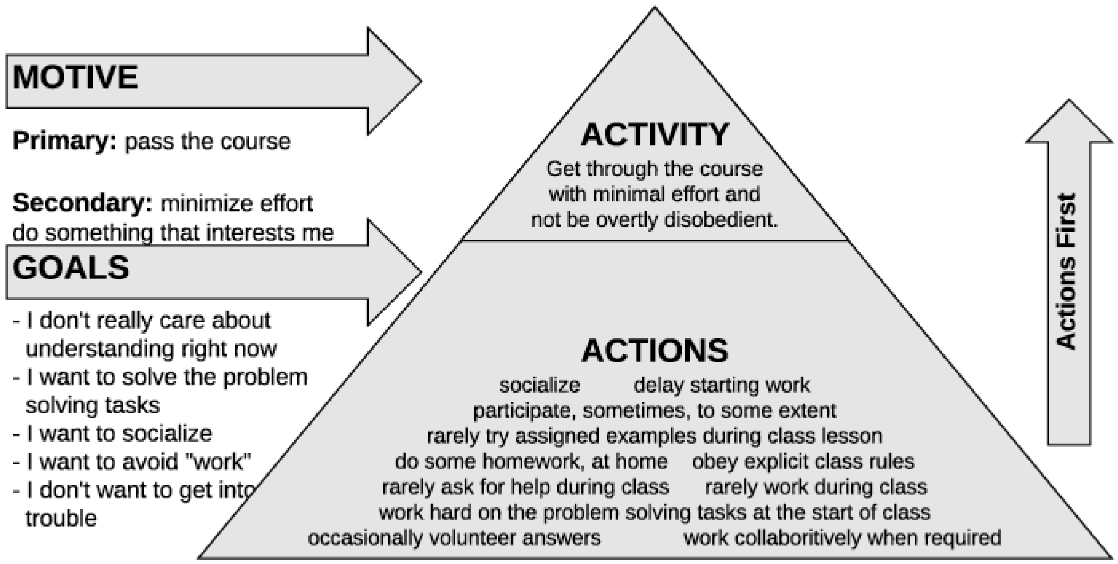


**Figure 9.4 Using an 'actions first' approach to determine Todd's motive**

Todd seemed to have the general feeling that school was just something to 'get through'. He would do his 'best', but it was clear that there was a limit to what he would do and he was not overly concerned with understanding. According to Todd, once he decides what he wants to do with his life he will apply himself to learning what he needs to know to achieve his goal. Ultimately his motive appeared to be to get through the class, and school, with minimal effort and without getting into trouble.

## 9.5 Summary

The case studies of Kyle, Jineane, Xander, and Todd support and extend the case study analyses from Chapters 7 and 8. At some level, they desired to know or understand the mathematics they encountered in class, but each approached it in a different manner, according to other motives they held. For Kyle, understanding ranked highly, but minimizing effort held equal, or more, influence. Jineane did not appear to care as much about understanding, only needing credit for the course to obtain a future goal of becoming a physiotherapist. Neither she nor Kyle were particularly concerned about getting a good mark in the course; this was not a high-ranking goal for either of them. Thus they both were determined to have had a primary motive of getting credit for the course. Likewise, Xander held a primary motive of getting credit for the course as understanding did not rank highly enough to be primary, and his actions did not always coincide with getting good grades. Jineane, Kyle, and Xander wanted to minimize their effort. Xander did not value certain aspects of classroom life (such as problem solving and doing homework or practice) and given some of his other actions it cannot be said that grades were his primary motivator. He wanted to be seen as intelligent, and to know the material, but there is a subtle difference between achieving that, and being motivated to understand. All three of these students wanted to minimize effort and ultimately get credit for the course, yet their actions differed.

Todd too wanted to minimize his effort, and though at times he seemed to want to understand, it was low in his goal hierarchy. He even said that if he needed to understand something he would learn it later. Todd also cared little about grades, seemingly only making enough effort to pass the course so that he could take FoM 11 and satisfy his graduation requirements so he could get on with his life. High school held little importance for Todd, and he was quite matter of fact about that. Yet Todd invested significant effort into the problem-solving tasks and the project based tasks – things that interested him, and possibly things that involved more application of critical thinking and less memorization of topics that Todd saw as not relevant to his future.

Additionally, these students shared an environment that differed in many ways from the classrooms of Mrs. Hill and Mr. Matthews, yet their actions in particular settings did not vary significantly from many of the other students in those classes. At the same time, in the absence of the problem solving setting and the project task, Todd might not have engaged in any aspect of classroom life. So while I can suggest that the different classroom environments would not affect the conduct of some students overmuch, I contend that for some students, teacher practices could have had a significant impact on their experience of mathematics class.

## Summary of Part III

These ten students comprise only a small subset of the 70[172] students I observed. They were selected because they said or did something, or several things, that intrigued, interested, or confused me. I could have chosen many more, but time, space, and scope compel me to stop here. In Chapter 7, I introduced two students from Mrs. Hill's PC 11 class; Toby and Beth. Though they were determined to share the same primary motive, understanding, their actions within the classroom differed, in part due to their different secondary motives. Four of Mr. Matthews' FoM 11 students were profiled in Chapter 8: Maria, Stephen, Tyrone, and Michelle. They all wanted to get a good grade and to understand, along with other motives. The hierarchy of these motives significantly impacted the actions of each student within the mathematics classroom. Chapter 9 contained case studies for Xander, Kyle, Jineane, and Todd, four students in Mr. Johannson's FMP 10 class. These four students shared a motive of wanting to minimize effort, and also held other, different motives, such as understanding, getting a good grade, and passing the course. What I have found, in these ten stories, is that these students, while singular, demonstrate both similarities and differences in their actions and, ultimately, their motives. This warrants further analysis, which is one aim of Part IV.

[172] There were 28 in the PC 11 class, 26 in the FMP 10, and 15 in the FoM 11. One student in the FMP 10 class chose not to participate.

# PART IV

> Researchers […] do not have access to the same information that teachers have as they confront real students in the context of real lessons with real learning goals. For researchers to improve teaching, they must guess at many of the things that are readily perceivable by teachers. (Stigler & Hiebert, 1999/2009, p. 126)

In Parts II and III of this dissertation, I reported and analysed the data I collected from the three different mathematics classrooms. In doing so, I answered questions about types of behaviour in different activity settings and the motives driving student actions. I was also left with more questions with respect to the similarities and differences in the actions I observed and the motives I deduced. The purpose of the first of the two chapters in Part IV is to investigate these themes. The conclusion to this thesis is the second, and final chapter of Part IV.

In Chapter 10 I consider particular similar actions in and across activity settings. Using the student motives arrived at in Part III, and informed by the types of behaviour identified in Part II, I look at actions and motives in different activity settings, doing this from two perspectives. First, I consider similar student actions in a given activity setting and compare the students' motives, which were arrived at through a comprehensive analysis of their behaviour across all activity settings. Then, I approach the data from the opposite direction: looking first at similar student motives and then comparing these students' actions in different activity settings. This 'cross-over' reveals further insights about student behaviour and motives.

The second chapter in Part IV, Chapter 11, concludes my dissertation. In it, I summarize my findings, discuss their implications and limitations, and suggest future directions for researchers and educators, in light of what I have found.

# Chapter 10:

# Viewing actions and goals through different lenses

> Caleb Gattegno (1987) emphasised that stressing some features and ignoring others is how we generalise and abstract. Thus changing our point of view […] may lead to different generalisations. (Mason, 2002, p. 120)

The process of sifting through data and organizing it in particular ways creates a domino effect as new insights bubble to the surface. The findings discussed in this chapter arose directly from the analysis and writing of the previous sections. The analyses and discussion that follow draw from the student motives derived using the 'actions-first' approach in Part III, which in turn drew from the data presented in Part II and from other data collected in the study.

Two diametrically opposite perspectives are taken herein, with an ultimate goal of highlighting similarities and differences in student actions and students motives. This involves looking at the data through two different starting lenses: motive and activity setting. These two lenses reveal different patterns in student actions and provide additional results. Figure 10.1, below, depicts the initial lens and the organization of the data.

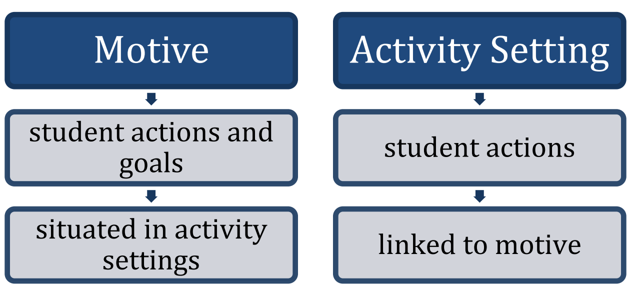


**Figure 10.1 Two different lenses for viewing data**

First beginning with motive, I present the range of student actions exhibited in varied activity settings. Taking in turn each of five identified primary motives, I examine the assemblage of student actions in different activity settings and with respect to specific aspects of classroom life. In placing a spotlight on the actions of students jointly holding one particular motive, I hope to identify similarities and differences in the actions performed by students who held that motive. Secondary motives were also identified, and the relative strength of the secondary motive was a significant factor in differentiating among primary motives. Following the identification and examination of each of the five motives, I discuss some key findings with respect to the differences between the motives and how they drove different student activity.

In the second part of this chapter, I take activity setting as the initial lens and list the range and types of student actions observed in each setting. The five respective motives are then attached to each of these actions, using the motives previously ascribed to students performing those actions. Each action may be linked to only one motive or to several. This provides a structure from which to examine student behaviour and motive in particular activity settings. Thus, it is similar in some respects to Part II, with the exception that students' goals were not considered in the construction of the diagram. Thus, the analysis offers a snapshot of student behaviour, with the additional information of student motive; the student motive helped to differentiate and discuss rationales behind the actions. However, it is important to emphasize that the student motive was not known while the actions were viewed. I discuss this analysis at greater length in the latter half of this chapter.

## 10.1 Motive driving activity and actions

The analysis that follows draws largely from the case studies presented in the previous three chapters. Supplemental data is drawn also from the actions of students who were not profiled in Part III, but whose motives were determined using an identical process and with the same degree of thoroughness. Students' motives were ascertained by considering their actions and goals in all settings, though not all settings are represented in the diagrams presented below.

Overall, five distinct primary motives emerged through the use of the 'actions-first' analysis. These are: understanding; get a good grade; get credit for the course; pass the course/get through it; avoid work and/or attention (from the teacher or class). Each of these motives is addressed in turn below. Two diagrams of student behaviour and a discussion of distinguishing features are offered for each motive. These diagrams do not differ in content, only in perspective. The first provides a ‘satellite view’, where activity settings and some specific types of behaviour[173] are arranged around a circle; the inner region of the circle holds actions of students who did not participate in the setting, and the outer region those who did. The second diagram presents the same data arranged in a format that makes it easier to read the student actions, but those participating and those not are not as immediately visible as in the first diagram.

For each motive, both diagrams portray the actions and goals of students who held one of these five particular motives with respect to mathematics class. For example, the first pair of diagrams represents the activity of students who held the motive of understanding. Several activity settings and significant facets of mathematics class comprise the core of the diagrams; they are the hubs from which the range of students’ actions branch. When zooming in on one hub, for example the activity setting ‘taking notes’, I have noted all the observed actions of students who held the motive of understanding.

For each motive, I discuss some conspicuous differences in comparison with the actions of students holding other motives, but I do not discuss every action nor each activity setting represented in the diagrams (in the interest of space and relative importance with respect to contribution to the findings).

To reiterate, the motives identified in each subsection below are not the motives that drove student activity in all situations; instead, these represent the most often dominant motive driving the student’s activity with respect to the particular mathematics course under observation. Thus, this is the primary mathematics-related motive that led to their activity.

### Understanding

The number of high school students who were identified as wanting to understand mathematics was small. Looking first at the satellite view provided on a following page in Figure 10.2, there are a number of immediately obvious features of the behaviour of a student who held a primary motive of understanding mathematics.

[173] Student actions with regard to these types of behaviour are useful in ascertaining motive, but are not activity settings in themselves. They include: cheating; asking for help; reviewing for assessment; paying attention; volunteering.

First, there is significant blank space in the inner region. There are very few activity settings, or aspects of classroom life, in which these students choose not to participate. Some notable exceptions are the item 'do homework in class'. However, if these students were not doing homework in class, they communicated that it was because they knew how to do the topic already and did not need to waste effort practicing more or because they prioritized other work (from other classes or from mathematics class). Another activity setting where students demonstrated behaviour that might not comply with expectations is 'now you try one'. Possible explanations for a student appearing not to do it included that she: did it in her head; did not do it because sufficient time was not provided; did not do it because she already knew how. Finally, it is perhaps unsurprising to see that none of the students entertained cheating as a course of action. To a student with a motive of understanding mathematics, there is no upside to cheating. When students displayed behaviour that might indicate non-compliance with (perceived) expectations[174], there was usually a 'rational' reason, such as not asking for help because it was not needed or not doing homework or taking notes when the material was well known.

Figure 10.3 displays the same information as Figure 10.2, but it is presented in a manner easier to read the student actions. Activity settings and facets are in darker rectangles with associated actions branching off. In this representation, student actions that signify participating in the activity are presented in ellipses and the actions of those who did not participate are in lightly shaded 'kite'-shaped containers.

Looking at the actions coinciding with participating (ellipses in Figure 10.3 and the outer region in 10.2) now, there are some goals or reasons that appear quite frequently. One of these is, "*I want to learn*". Notes were taken because they were useful for review, they could be used to build from and make connections with other material at a later date, and they could be taken verbatim or in one's own words, depending on the student.

Students with a motive of understanding engaged with the problem-solving tasks. For some, it was a challenge and several stated that they enjoyed doing puzzles. Another interesting action to note is the students' resourcefulness – several reported using the

[174] 'Expectations', as used here, refers to those of the teacher, the researcher or the student themselves.

internet[175] or other external sources[176] to build and enhance their understanding. Finally, though this is not evident in the diagrams, students with a motive of understanding rarely, if ever, procrastinated or delayed starting tasks.

There are some statements in this diagram that do not necessarily fit with what one might think corresponds to a student who had a motive of understanding. Most of these relate to Maria, an outlier, whose actions and motives were discussed in detail in Chapter 8.

[175] Both Khan Academy and YouTube were mentioned.

[176] External to the classroom and classroom resources (e.g., textbook, teacher). Most commonly a person: friend; parent; sibling; another relative; family friend.

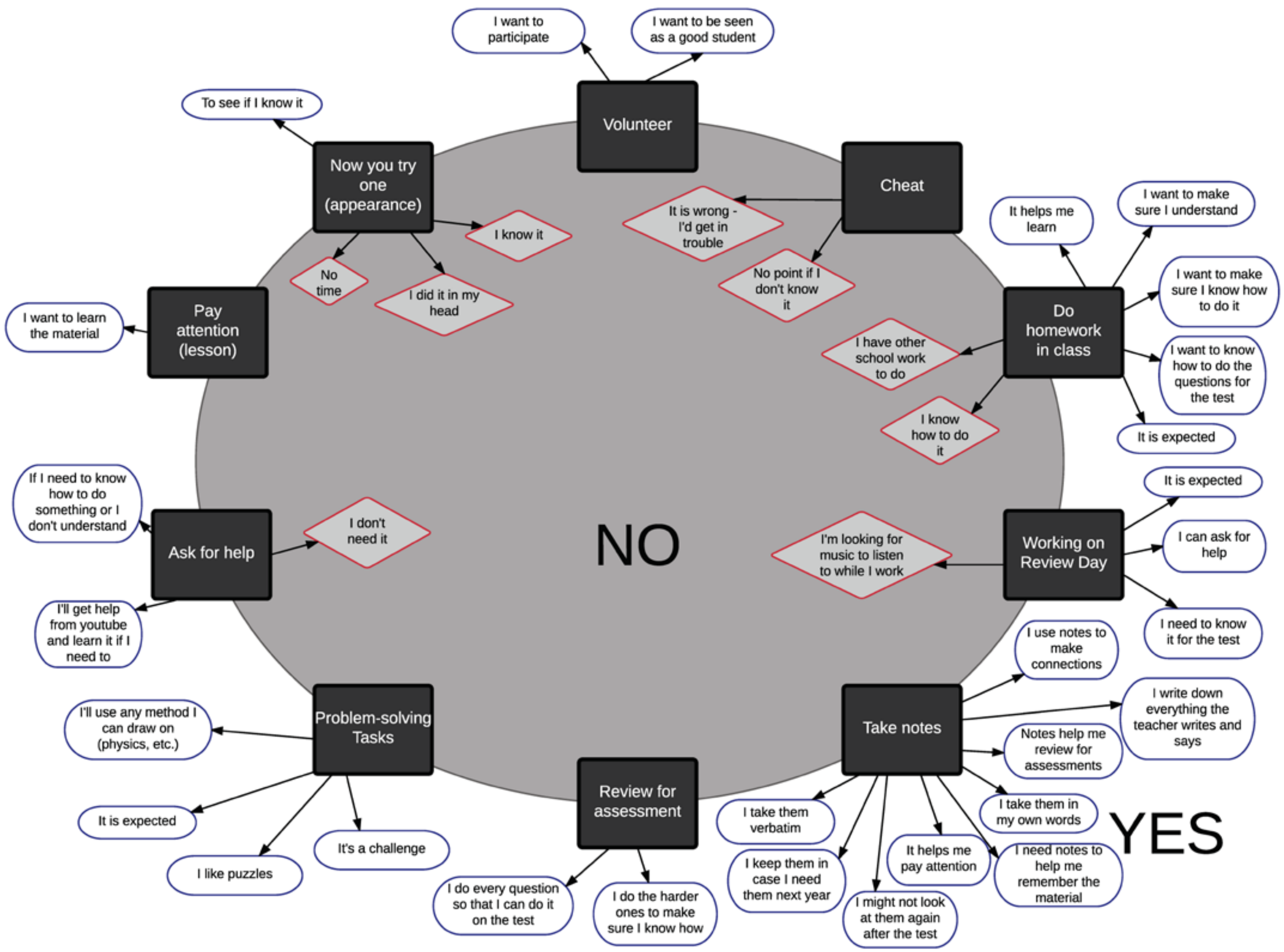


**Figure 10.2 Activity of students with a motive of understanding**

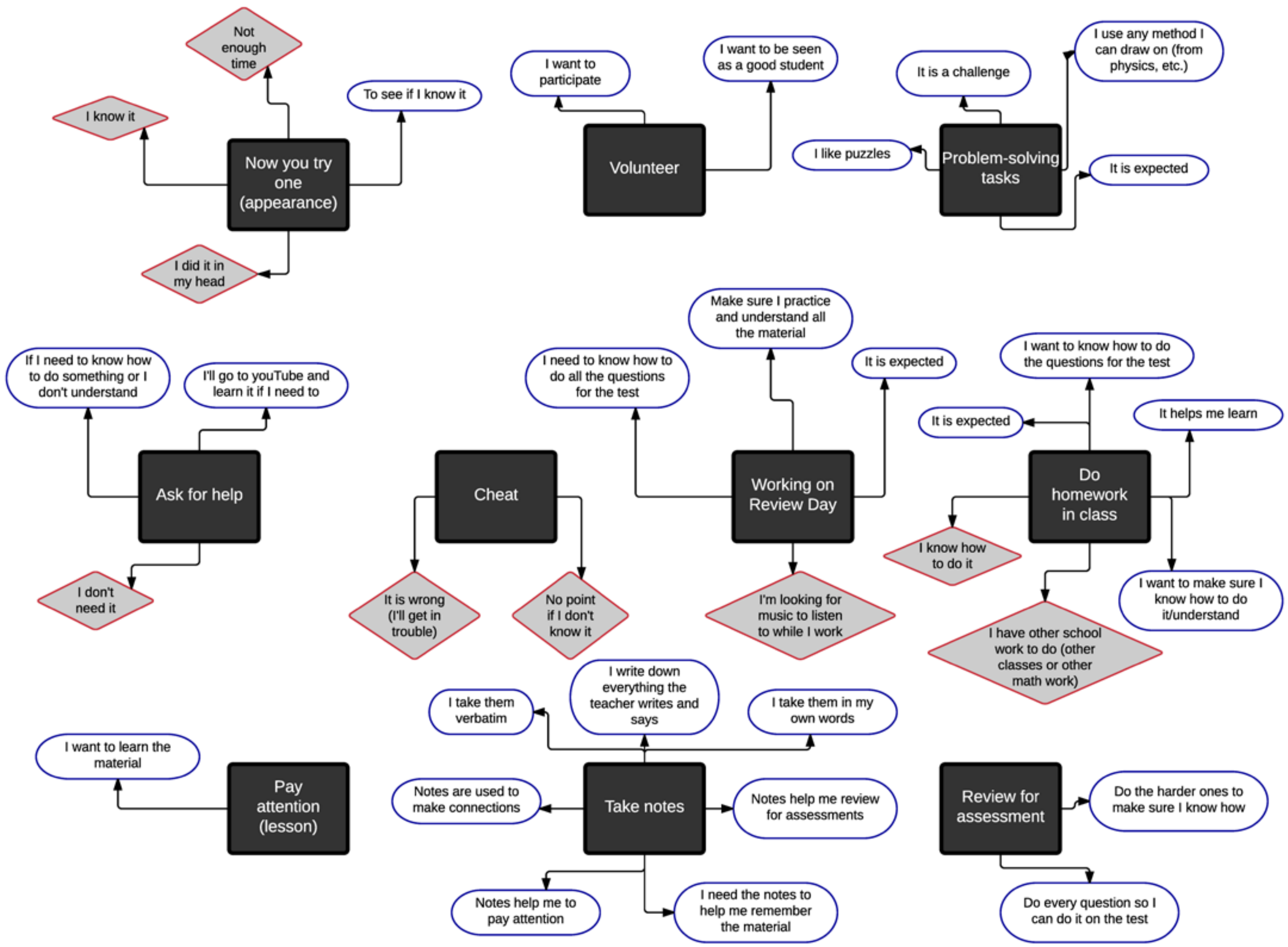


**Figure 10.3 Activity of students with a motive of understanding**

### Get a good grade

The second primary motive identified is 'get a good grade'. Figure 10.4, on a following page, represents the activity of students holding this motive. Although the diagram itself does not necessarily imply this, there was a significantly greater number of students who held this motive compared with those holding a motive of understanding.

At first glance, there are two things that are immediately clear. First, there are not only a great number more actions performed by students with a motive of getting a good grade, there is also substantially more variety within those actions, as compared with students who held a motive of understanding. Second, the center region of the diagram is significantly more populated in comparison with the first two diagrams; there are a greater number of actions that do not comply with expectations.

Delving into the actual content represented in the diagram, one can see that although the center region is heavily populated with reasons such as distracted, lazy, not worth marks, and the like, there are also many 'valid' reasons for not exerting effort to pay attention to a lesson, do homework in class or attempt the 'now you try one' examples. Some of these include: "*I know it*", "*I'm doing work for another class*", "*I'm doing an assignment that needs to be completed for this class*", "*not enough time is given*" and "*I'll do the work with my tutor later*" or "*I'll do it at home*."' These actions are easier to read as represented in Figure 10.5.

Another point of interest is the appearance of cheating as an admitted or potential action. Students confessed to cheating as a means to confirm answers, to get a hint to help remember or because the marks were needed. Still, as with the motive of understanding, there were those who would not cheat, but their reasons differed. Rather than not cheating because there was no point if they did not understand it, students with a motive of getting a good grade indicated that they would not cheat if it was too difficult and they would get caught; if they would feel guilt; if it was not worth the risk of getting caught if the gain in marks was not at a certain threshold; if it was not worth it because they would still have to learn the material later. Even considering only this one type of behaviour it is clear that there was great variety in the students who held a primary motive of getting a good grade.

It is notable too that there were a greater number of students who would not engage with the problem-solving tasks (as compared with those students with a motive of understanding). Reasons included: frustration from not understanding; it was not worth marks so there was no purpose in making the effort; the student was working on something else that was worth marks. Also, as compared with students with a motive of understanding, there were a greater number of students whose actions complied with expectations *because* it was expected.


**Figure 10.4 Activity of students with a motive of getting a good grade**

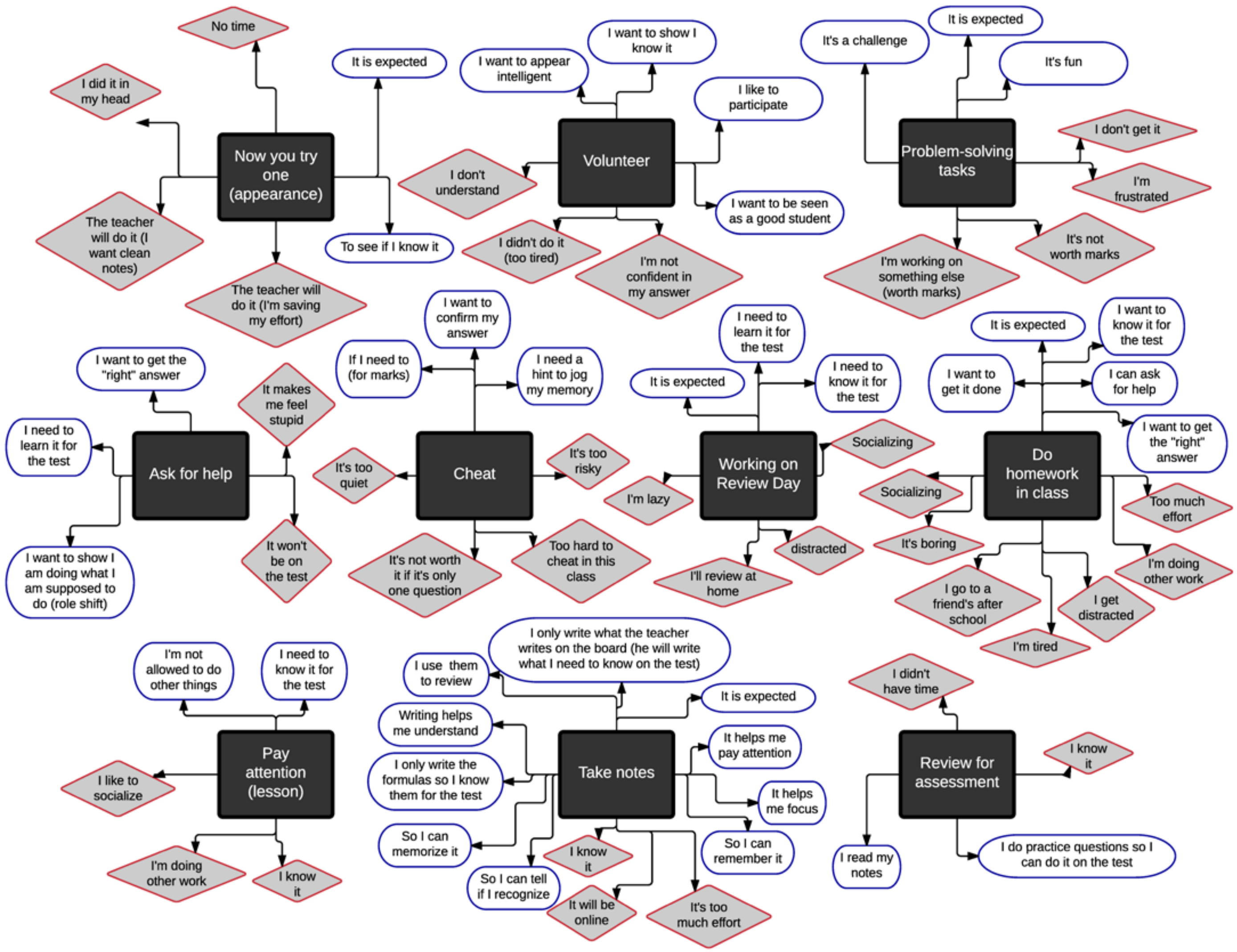


**Figure 10.5 Activity of students with a motive of getting a good grade**

### Get credit for the course

The third identified motive, getting credit for the course, is closely linked to a motive of getting a good grade: in fact, this was a secondary motive for many of the students identified with this primary motive. A typical student in this situation was one who needed the course for entrance to a desired program or future course, where there was a certain prerequisite mark to be obtained. While students who were motivated to get a good grade also desired credit in the course, the relative importance of these two motives is reversed in this scenario.

The differences between getting a good grade and getting credit for the course are not as conspicuous when looking at the satellite view presented in Figure 10.6, following. The distinction between students with a primary motive of getting credit as compared with those driven by wanting a good grade is very fine and is most apparent in their actions around homework and assessments. This is much easier to see in Figure 10.7.

When getting credit is the primary driver, a student may not study for every assessment and may not complete all assignments (unless they fall below a certain percentage grade). In essence, current performance and percentage in the course was a very good indicator of whether or not a student would study and complete any work for marks. Jineane and Cara are two very good examples: Jineane did homework when it was “*easy*” and Cara did homework after missing a number of classes. Both were selective about when they did work – when it was necessary to maintain or achieve a certain standing. Their aim was not their ‘best’, as they were satisfied with ‘good enough’.

As compared with students who held a motive of getting a good grade, the exchange rate of effort for marks was a more significant factor in determining whether a student would attempt or complete a given task.

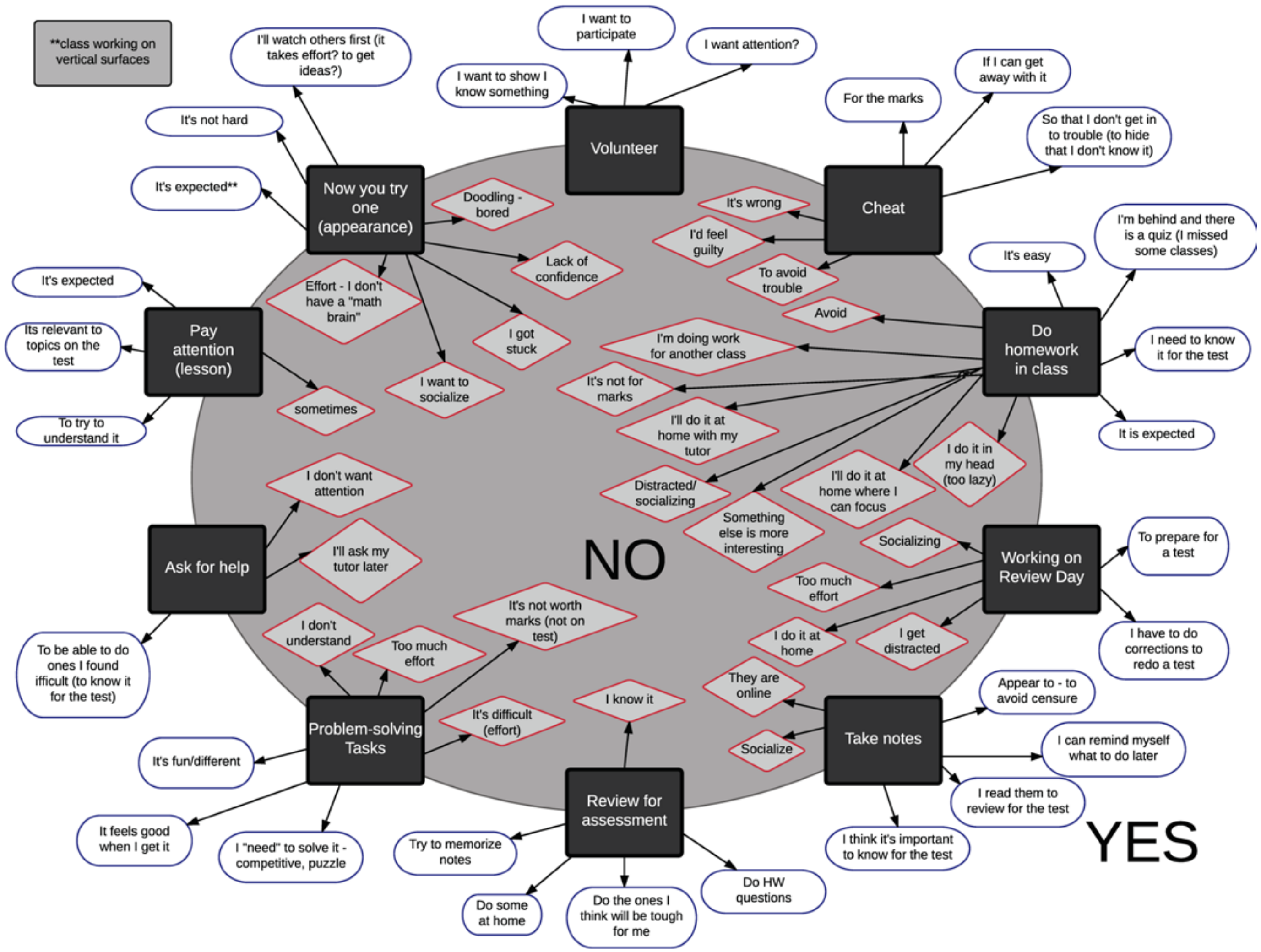


**Figure 10.6 Activity of students with a motive of getting credit for the course**

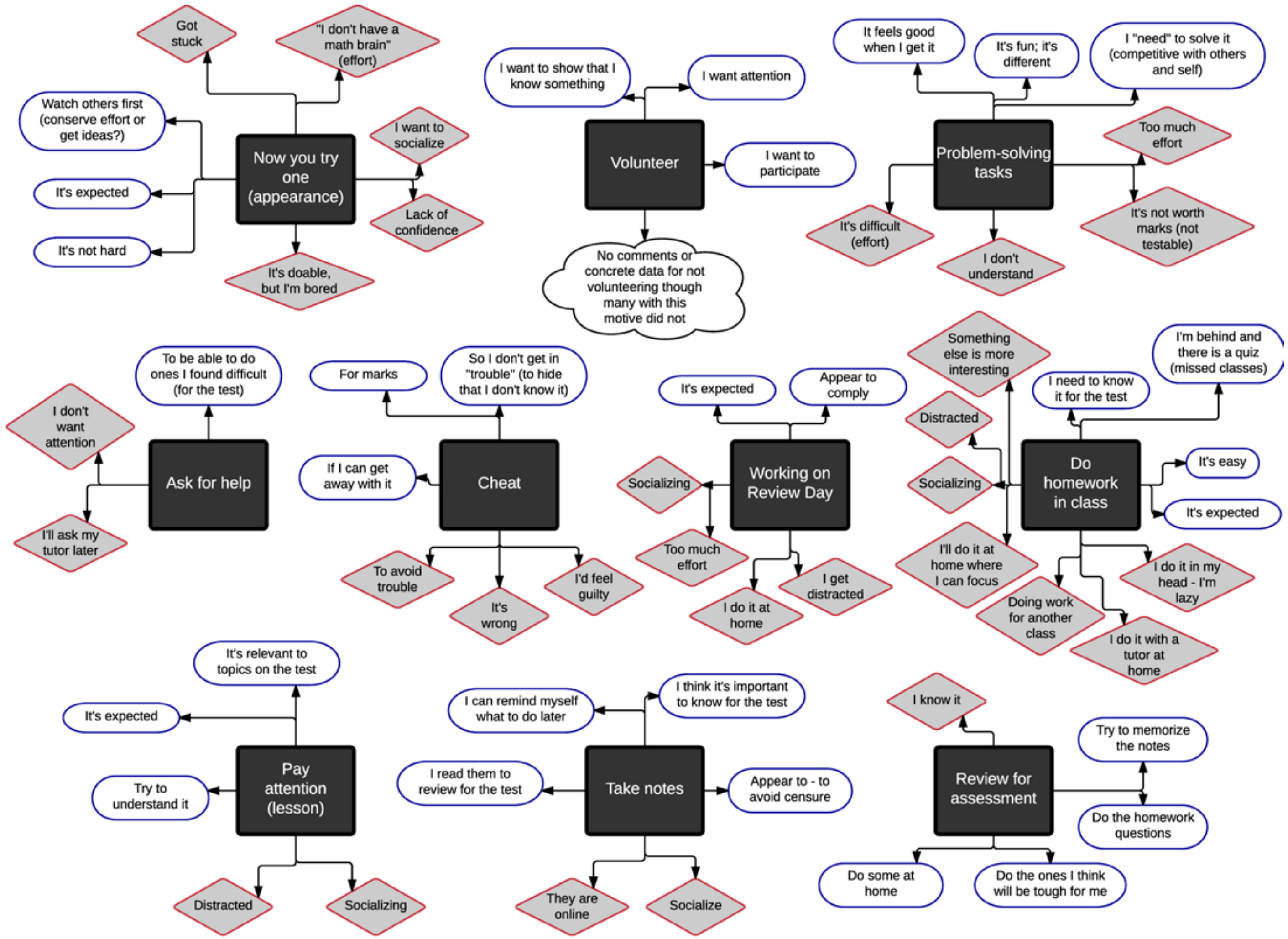


**Figure 10.7 Activity of students with a motive of getting credit for the course**

## Get through it

Wanting to 'get through' or 'pass' the course differed in a few minor ways from 'getting credit for the course' – primarily with respect to the magnitude of the influence of a secondary motive, 'getting a certain mark'[177] in the course. For students who just wanted to get through it, or pass, the motive of getting a good grade was much further down on their priority lists. Minimizing effort was likewise often higher on their lists of goals. Figures 10.8 and 10.9 depict the actions of students with this primary motive.

Differences in behaviour here are again most noticeable in the categories of homework and assessment. For example, in comparison with getting a good grade and getting credit, task participation appeared to be less dependent on a desire for marks and more on easiness of the task for students with a motive of getting through the course. Teacher proximity also played a larger factor in student behaviour, suggesting that there was recognition that getting through the course required some level of compliance with teacher expectations.

Reviewing for assessments and doing homework was often delayed and only attempted or completed when the assessment or due date was imminent. Maya's comments regarding homework support this. She said that if homework were collected all the time, her mark would suffer. Maya rarely completed her homework and often only did any of it immediately before a test or quiz. Or, if homework were worked on in class, it was the 'fun' or easy questions that she attempted.

Likewise, volunteering or responding to teacher questions might occur if the question were easy or did not relate directly to any mathematical computation. Continuing on the theme of participation, student involvement and engagement in 'now you try one' and problem-solving tasks were largely dependent on and driven by the motivation of the partner. For example, when Todd was a member of Trevor's group, Todd was the driving force and

[177] This 'certain mark' depended on the student. It was more than merely passing the course, but less than wanting it to be 'good'. Sometimes there was a benchmark to be reached for external reasons (parental pressure, school requirements) while at other times the student wanted to keep a certain average for their own personal reasons.

Trevor participated in problem solving activity. When paired with someone else, Trevor rarely did more than make a weak initial attempt.

Another notable behaviour that cropped up in this category of motive was that a few students only really began to study for a test once the initial test had resulted in an insufficient grade and a retest was necessary (if this were an available option). Corrections were often completed only in order to earn the right to a rewrite – and only if the overall course grade were judged too close to a fail. Thus, work and productivity were strongly linked to urgency and immediacy; students ‘crammed’ for tests or only made an effort to complete assignments at the last minute (which sometimes involved copying). Tasks were commonly delayed or deferred until a later time as students often chose to do something that was more desirable or more important to them ‘in the moment’, such as socializing or just relaxing.


**Figure 10.8 Activity of students with a motive of getting through the course**

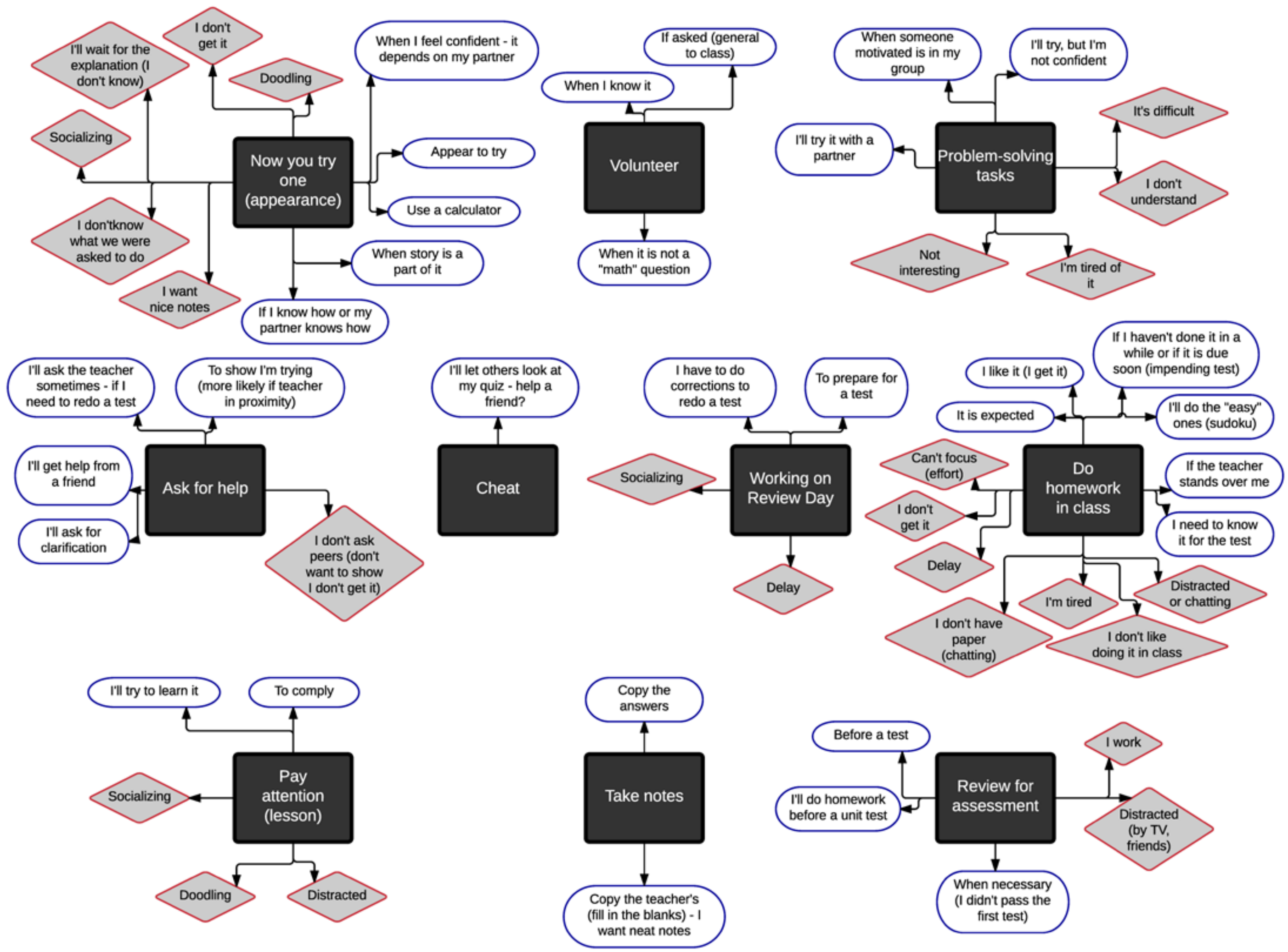


**Figure 10.9 Activity of students with a motive of getting through the course**

### Avoid attention/work

Interestingly, this fifth category of motive is in some ways much more similar to understanding when one looks at the variety of actions. There were only a small number of students who were identified with this motive, and, like understanding, behaviour in this category had less variation. Students' behaviour appeared to be less susceptible to other environmental or contextual factors, and thus proved more predictable. Overall, there was a sense that these students felt they had little choice or control over any situation. Mathematics was 'done' to them, as opposed to them 'doing' mathematics. They often elected to remove themselves from any mathematical situation, if not physically, then mentally. They chose not to engage. On a following page, Figure 10.10 provides a satellite view, and further on Figure 10.11 offers the same data in a more readable format.

This choice is apparent when looking for patterns in the actions described in the diagram. Students delayed getting books out, faked doing work or just did not do it. They chose not to try problems and tasks or, if a student with this motive participated in problem solving or any other activity, it was for social reasons only; there was little or no mathematical thinking done.

It was rare for a student to ask for help; this occurred only were the teacher in proximity and should the student feel it was necessary[178]. These questions were often clarification questions, probing questions (looking for a hint), or queries about the homework assignment: "*what questions am I supposed to do?"*

Continuing in this vein, a student might admit that he or she did not understand a concept or question, but it was clear that help was not really desired. For example, Jackson told me that he did not really "*get*" how to do a question his group was tasked with, but he was not asking for help, nor was he receptive when it was offered. In general, students with this motive tried to avoid getting in trouble and hoped that somehow they would pass the

[178] There are certain situations in which a background motive of compliance and meeting expectations comes to the fore. Students seem to try to maintain a careful balance to avoid negative teacher attention. Therefore, a student may engage and ask a question to prevent the teacher from thinking that he or she is not trying and thus avoid any potential consequences.

course, but overall felt little control over the outcome. They made few attempts to comply with expectations and only did so to avoid attention and its negative consequences.

By nature of the course and self-selection (and other selection) – no students in the PC 11 course held a primary motive of avoiding attention or work.

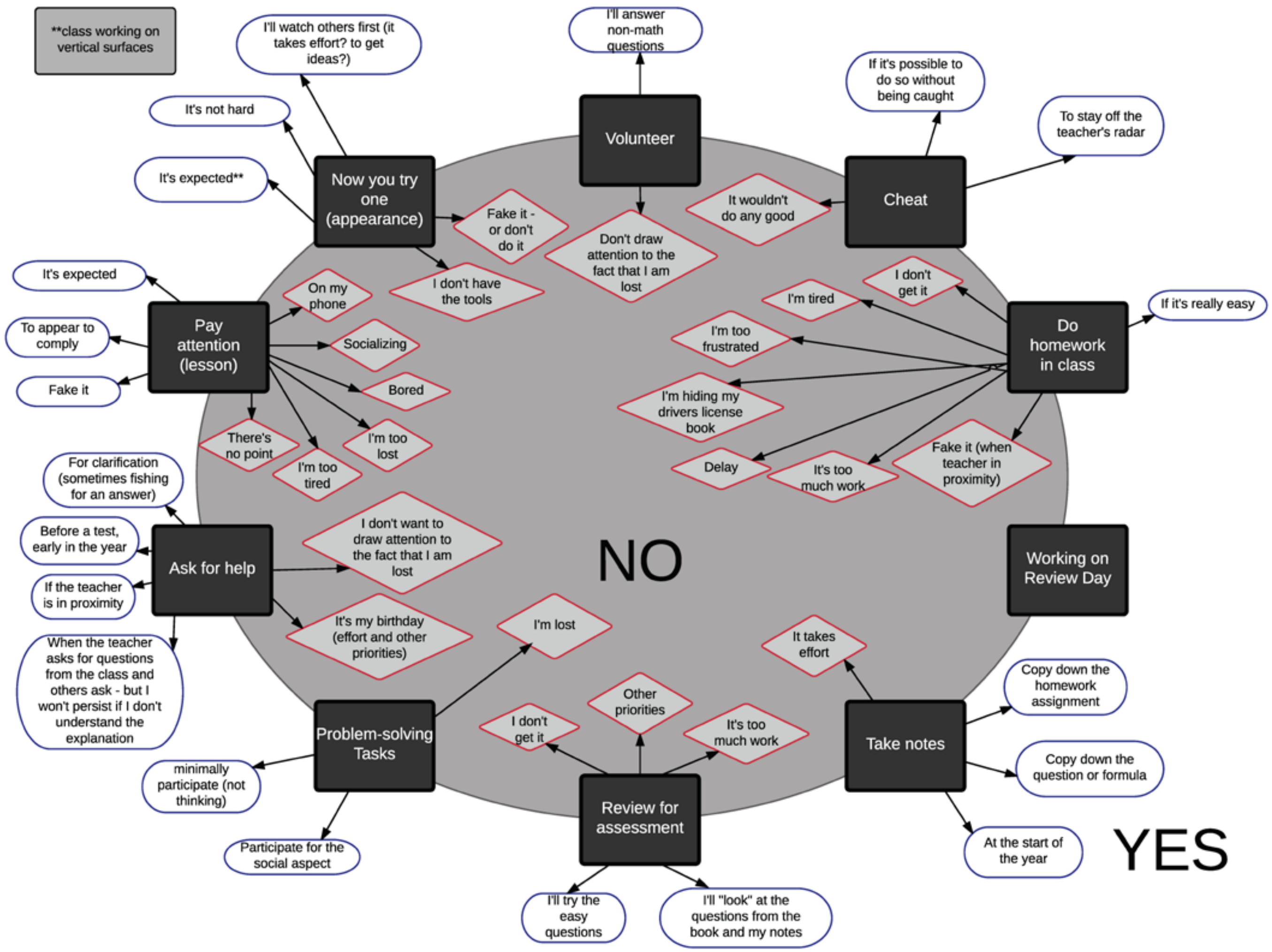


**Figure 10.10 Activity of students with a motive of avoiding**

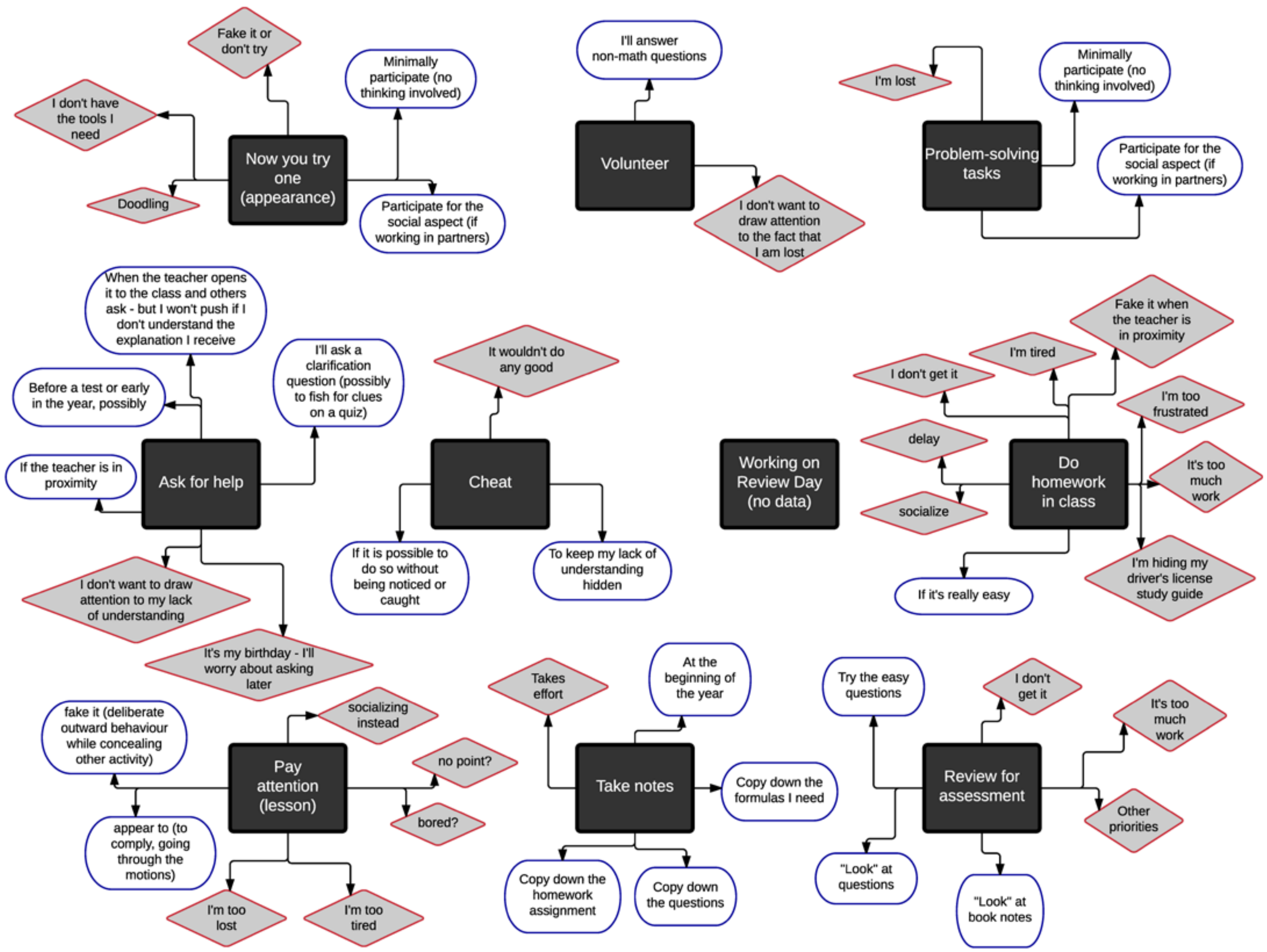


**Figure 10.11 Activity of students with a motive of avoiding**

## Themes

There are three significant themes that can be discerned from looking at the actions of different students with same primary motive. The first concerns the exchange of effort, while the second and third are stability of the motive and its continuity. These last two findings are related, but differ with respect to scope: the former is local, whereas the latter is global.

First, students with a motive of understanding tended to put in effort as ‘payment’ for understanding the topic. Students with a motive of getting a good grade tended to see effort as an exchange for marks; if the payoff were not high enough, then it was judged not worth putting in the work. This view appeared to be shared by students with a motive of getting credit and passing. Those with a motive of avoiding attention or work faced an interesting trade-off: avoiding attention often required some effort, whether it was directed towards actual work or merely faking it.

Second, viewing the data through this lens reveals that the primary motives of understanding and avoidance are more stable than other primary motives. Stability, as it is used here, refers to the ‘sticking power’ of the motive within *localized* activity settings. For example, in a problem-solving activity setting, a student with a motive of getting a good grade may try the problem initially, but then choose to finish his homework. Or a student with a motive of getting credit may start the homework during class, but then choose to socialize with friends. Referring to Kaptelinin’s (2005) conclusions regarding conflicting motives discussed in Chapter 2[179], the motives of *getting a good grade*, *getting credit* and *getting through the course* are more susceptible to being displaced or influenced by factors in the social environment or other conditions under which the student operates. These conditions are often internal, such as being tired or hungry, but are just as frequently external, when other assignments or interests take precedence. But when a student holds a motive of understanding (or avoidance), that motive is pervasive. It is the driving force throughout the activity setting, almost all the time. Referring to the various figures above,

[179] Kaptelinin explains that conflicting motives (e.g. a motive to get a good grade and a motive to avoid work) can drive activity. The nature of this activity (and which motive achieves dominance) is influenced by the social context, the conditions under which the student operates and the means available to the student.

there is far greater variance in students' behaviour when they have a motive of getting a good grade or getting credit for the course, as opposed to in the actions of students who primarily want to avoid or understand.

Finally, looking now across activity setting and over time, from a *global* perspective understanding and avoidance as primary motives are *continuous*, as opposed to discrete. For a student with a motive of understanding, the actions that are consistent with this motive occur continuously, as opposed to only at certain intervals or times. On any particular day a student's actions will coincide with her or his primary motive in each activity setting. Further, if we look across multiple days, the same patterns of behaviour can be seen and the continuity of the motive applies. 'Discrete', then, describes motives wherein the actions that are consistent with them occur more sporadically. Across activity settings and over time, there is more variability in activity and more tension or conflict between motives. Despite this, there is some predictability in student behaviour. The difference between continuous and discrete is better explained by example.

Consider two composite[180] students, Jenna and Lisa. Jenna has a primary motive of getting a good grade. That motive holds dominance when assignments (for marks) are due and in the lead-up to an assessment, such as a test or a quiz. At other times, Jenna may defer her learning to another time, or not see participation in certain activities as important, such as problem solving. Thus, a secondary motive such as socializing or relaxing takes precedence.  Jenna's attention may waver during a lesson and she may not try the examples because she can learn from them later or because she already knows. In contrast, Lisa holds a primary motive of understanding. She sees opportunities for understanding at all times, not just before an assessment or when an assignment is due. She may not always do her homework in class or try every example, but understanding is always Lisa's primary motive and her actions almost always align with this motive.

Deepening my analysis, I can further differentiate motives that are less stable. Getting a good grade, getting credit or getting through the course are more susceptible to being displaced by other motives and, as such, they are 'discrete'. Where the actions of students

[180] Though Jenna and Lisa themselves do not exist, they are composites of students whose actions are represented in the data.

holding these motives differ is in *when* the primary motive (related to mathematics) takes precedence.

For example, students concerned with getting a good grade act consistently with this motive when assignments are due or when an assessment is imminent. In comparison, the actions of students with a motive of getting credit for the course may be less consistent with regard to completing assignments. Further, they may only exhibit behaviour consistent with mathematics motives for ‘big’ assessments, such as chapter or unit tests, or when they are in danger of dropping below a particular grade threshold. Finally, behaviour consistent with a primary motive of passing the course may appear in flurries of effort, preceding some chapter tests and before the final exam.

Having looked at the actions of students with particular motives, the following section uses a different lens, both compressing and then extending the work of Part II, as student actions in selected activity settings are subjected to analysis by student motive.

## 10.2 Actions in activity settings linked to motives

Taking a revised version of the spectrum of actions for each identified activity setting from Part II, I now attach the motive ascribed to each student who performed each action. For example, in the activity setting ‘taking notes’, the observed student actions included: *taking notes*, *faking taking notes* and *not taking notes*. The action *not taking notes* was exhibited by students with the following motives: get a good grade, get credit for the course, and avoid attention or work. A more detailed explanation of the complete process follows.

Five activity settings are explored. These were strategically chosen to accentuate the similarities and differences in the behaviour of students with different motives and are a sufficient number to establish a pattern. In each setting, I consider two levels of observation: level one represents what the teacher is likely to observe about students’ behaviour, while level two adds the perspective of the researcher–observer. The contents at the first level represent my judgement of what the teacher would see, and how I believe he or she would interpret the students’ actions. I did not collect any formal data from the classroom teachers. Thus, the analysis is based purely on my observations of each teacher’s classroom and is grounded in my own experience as a classroom teacher. The five motives at the bottom are linked to the observed actions, but the arrow does not point from action to motive. I want to underscore that all of the theory and analysis (and surrounding context) is invisible in these diagrams. Determining motive required an analysis of actions in multiple activity settings and over time. The connections between motives and actions in the diagrams included here were only determined long after the actual action was observed, and was possible only after the a full analysis had been conducted. I *cannot* overemphasize that it is not possible to determine motive in one viewing or even with observations over time in one activity setting.

Figure 10.12 below, depicts the general form of the diagram.

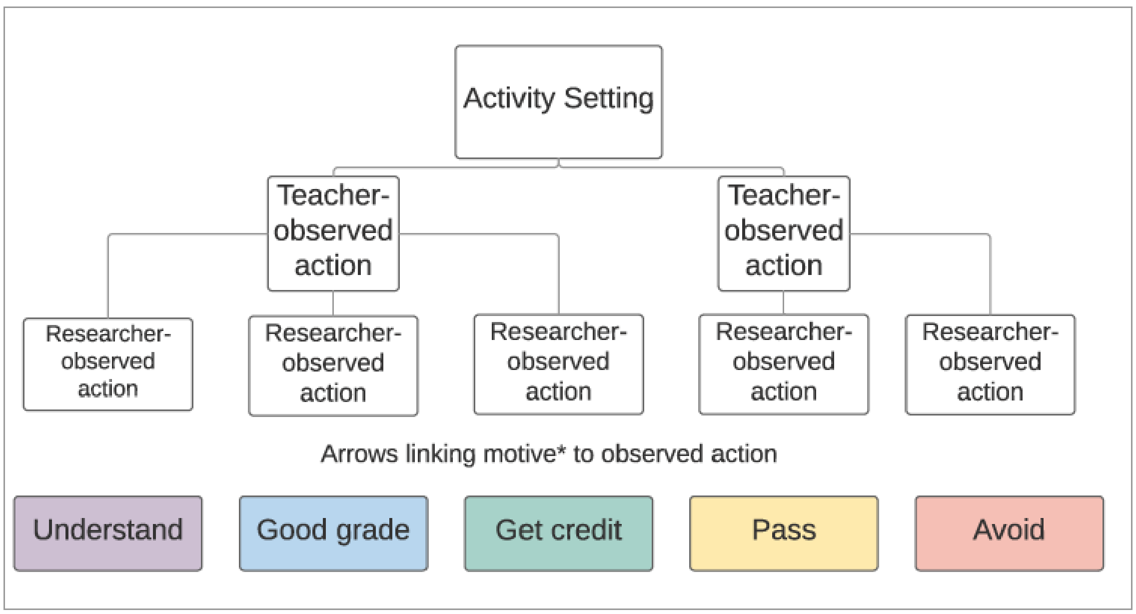


**Figure 10.12  Explanatory diagram for motives linked to observed action**
* Motives were determined long after the actions were observed and links can only be made after a complete analysis is conducted.

Representing the information in this way highlights the distinction between what the teacher saw and what was revealed from another (physical) perspective. Although these were the primary motives, it was not necessarily a primary motive that drove the act that it was linked to. For example, a student who wanted to get a good grade may have chosen not to take notes during a lesson. In this case, wanting to get a good grade was not the driver of that particular action; a secondary motive had taken precedence, such as minimizing effort, socializing or just taking a break. The arrows point from motive to action (and not in the other direction) to emphasize the fact that a particular action does not necessarily link to a given motive, so not participating in note-taking does not indicate any particular motive, at the time. The motives had to be determined *before* a link could be made.

The five activity settings explored here are actually three: problem-solving tasks, homework during class time and lessons. However, the setting of lessons is quite broad: thus, it is further subdivided into the student actions of note-taking, now you try one and paying attention. Rationales for student actions are provided, when appropriate.

## Problem-solving tasks

Problem-solving tasks, as outlined in Part II, are problems that are generally not linked to the current topic being taught in class and are intended to create a space for students to think, play and engage with mathematics. There was no assessment of these tasks in any of the three classes. Figure 10.13, below, depicts the types of actions that were performed by students within the setting of problem-solving tasks.

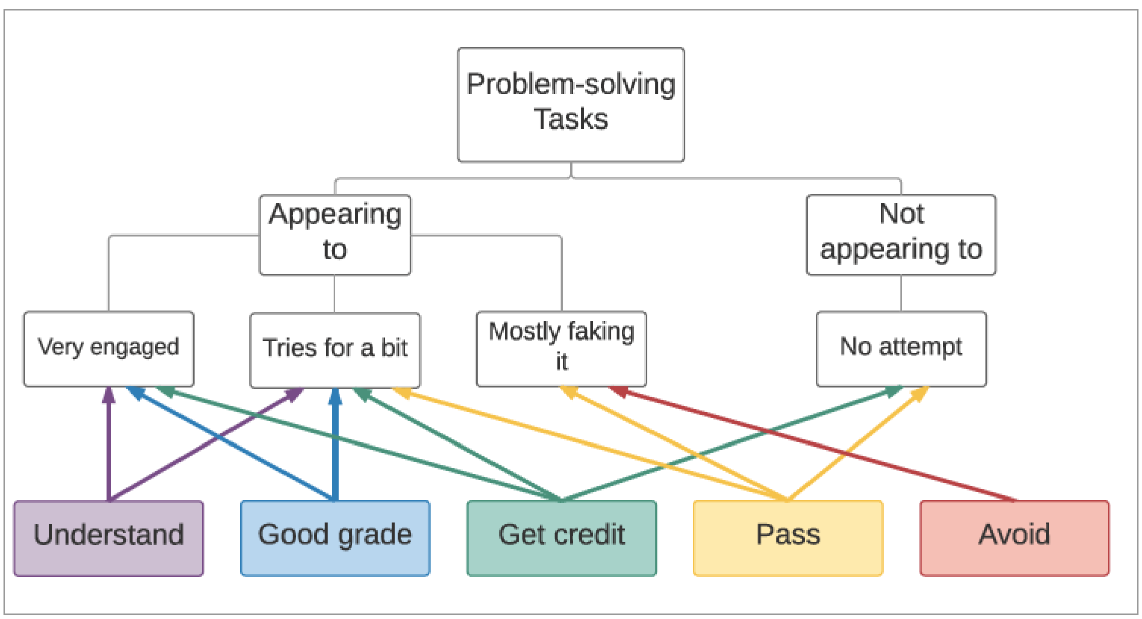


**Figure 10.13  Motives linked to actions during problem-solving tasks**

To explain the diagram a little more, looking at the motive ‘understand’, there are two arrows; this indicates that there was at least one student with a motive of understanding who was very engaged in the task and at least one who only tried for a bit. The 'noise' (crossing arrows) here obscures the data, but there remain a few notable differences.

Although the arrows point from motive to action, this analysis was conducted first from the perspective of actions (not motives), because these were what can be seen in the classroom. For example, when looking at students who authentically attempted the problem-solving task, for at least a short while, it is apparent that they held one of four motives. This does not seem to offer much information, except it does confirm that we cannot determine a student's motive from their participation in a problem-solving task.

The only students who did not try (this includes those faking) were those with an avoidance motive. Yet none of the students with an avoidance motive completely abstained from the task. They all faked it. While this is interesting, it is not entirely surprising when one considers that typically it required little effort to fake engagement and the student thereby avoided any negative attention received as a result of not being seen as participating in the task at all. Thus, from a cost–benefit analysis, faking was a good option.

### Homework in class

Class time for assigned homework was not a feature of every class period, but it occurred often enough to afford collection of a large range of behaviour (represented in Figure 10.14, below).

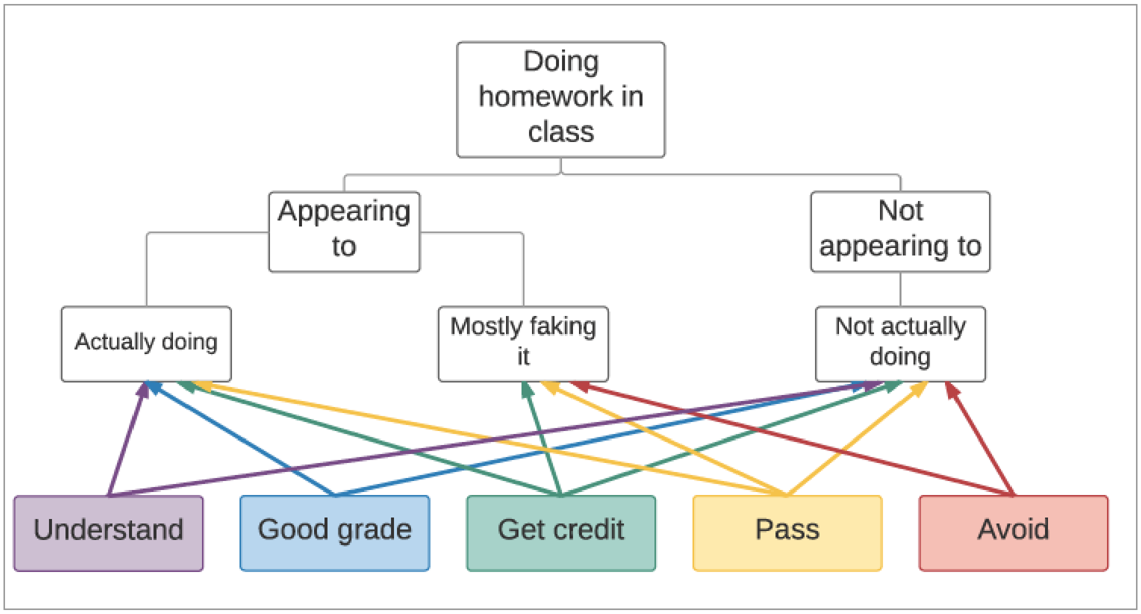


**Figure 10.14  Motives linked to actions during homework in class**

In this diagram, “actually doing” does not mean that a particular student was doing their homework every time they were observed, but that he or she was observed to be doing work during class on *at least* one occasion. So, if ‘Giles’ did homework one day, but not the next, both of these actions would link to his motive. Also, many students opted to do their homework at home because they had difficulty focussing in class, or may have chosen to use class time for other activities, such as socializing. Homework that was completed at home was beyond the scope of this study, as I did not check it and thus cannot differentiate between a student who said that he or she did or would complete it at home and one who actually did that.

For these reasons, the spectrum of student behaviour and motives is a little more jumbled here, due to this variety in the behaviour of students with any given motive and the scope of the study. This minimizes the notable findings, but there are two that can be discussed.

First, students with any of the five motives were observed not to do homework on multiple occasions – thus, not doing homework in class cannot be tied to any particular motive, nor does it eliminate the possibility of a given motive. Second, students who faked doing work held a motive of getting credit, passing or avoiding attention. Students with a motive of understanding and getting a good grade did not fake doing homework; they either did it, or did not do it, for various reasons sometimes legitimate, sometimes not.

The next three activity settings or potentials for student action occur within the broader setting of lessons. The first of these concerns the attentiveness of students.

### During lessons: Paying attention

Students knew that teachers expect them to pay attention during a lesson. While it can be obvious to a teacher and observer alike that a student is not paying attention, it is not so clear whether a student who appears to be paying attention is actually doing so. Hence, the distinction at the second level (the observer's view) between those paying attention and those faking it, in Figure 10.15, below.

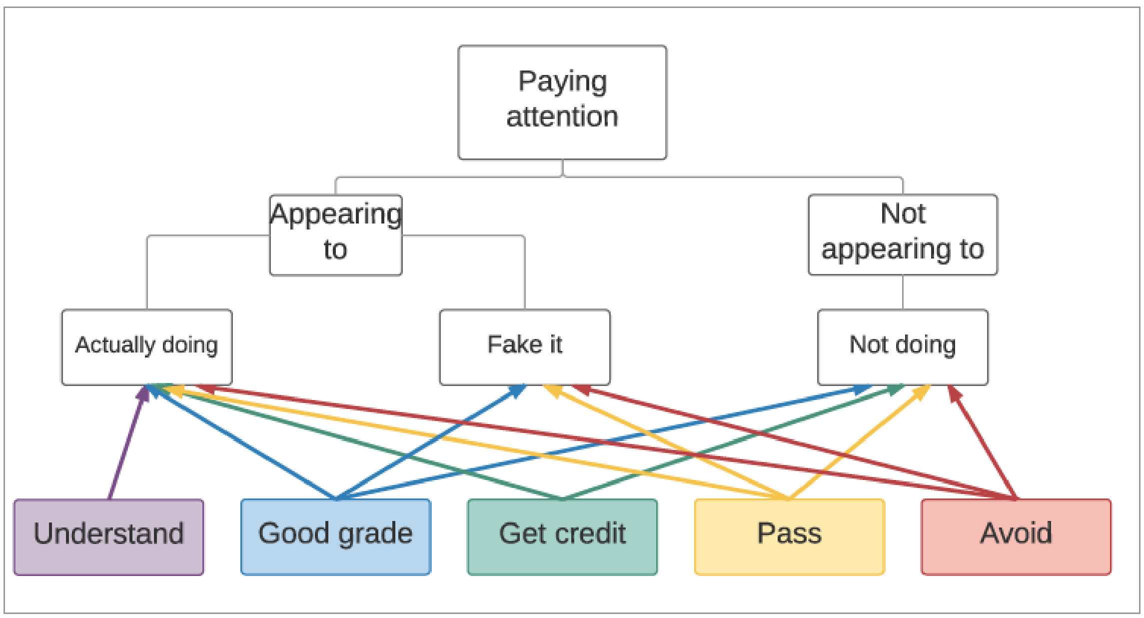


**Figure 10.15  Motives linked to actions during lessons - paying attention**

What this diagram shows is that it is virtually impossible to determine a student's motive based purely on his or her actions during a lesson. The only clear conclusion is that any student who held a motive of understanding was paying attention during the lesson. However, from the teacher's perspective, students who were paying attention could have held any of the five motives.

## During lessons: Taking notes

Taking notes during class is an expectation of some teachers (even if unstated), whereas others allow students more discretion or choice. Figure 10.16 represents the actions of students when notes could be taken during a lesson.

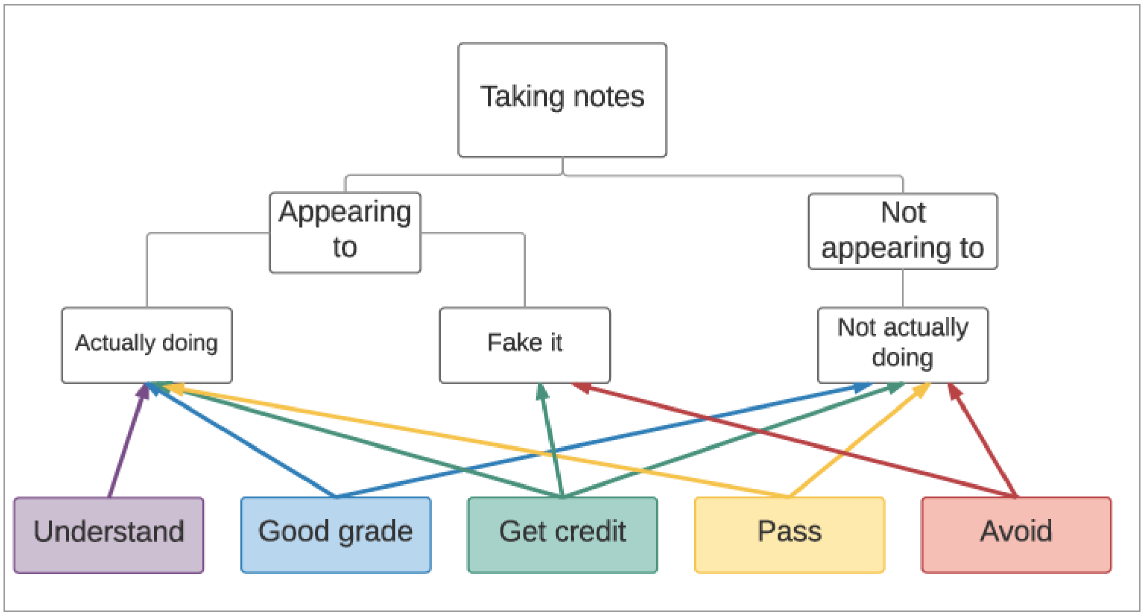


**Figure 10.16 Motives linked to actions during lessons - taking notes**

Interestingly, of the students who faked it, none were members of the class where taking notes appeared to be an expectation. And only those students who held motives of getting credit for the course or wanting to avoid attention or work faked taking them. Students who took notes had one of four motives, while only students who were driven to understand took some notes all the time. This is likely because they thought something might be relevant at a later date (they seemed to find something of potential use in every lesson and task).

Students with a motive of avoiding either faked taking notes or just did not take them. If students took no notes, reasons could include: the notes are online; I know this already. Reasons offered for taking notes included: using them to complete homework; using notes to review for assessments; using them to maintain focus. Some students only appeared to take notes – thus appearing to comply (such as Tiffany). These were discussed at length in Chapter 4.

### During lessons: Now you try one

Trying examples during class is viewed by teachers as a valuable part of learning mathematics. Often, however, contextual factors (such as time pressure) can limit participation, when students might otherwise be predicted to do so. Instances of students who did not try due to lack of time provided have not been included in Figure 10.17 below. Also omitted is the option of "faking it", for reasons discussed below.

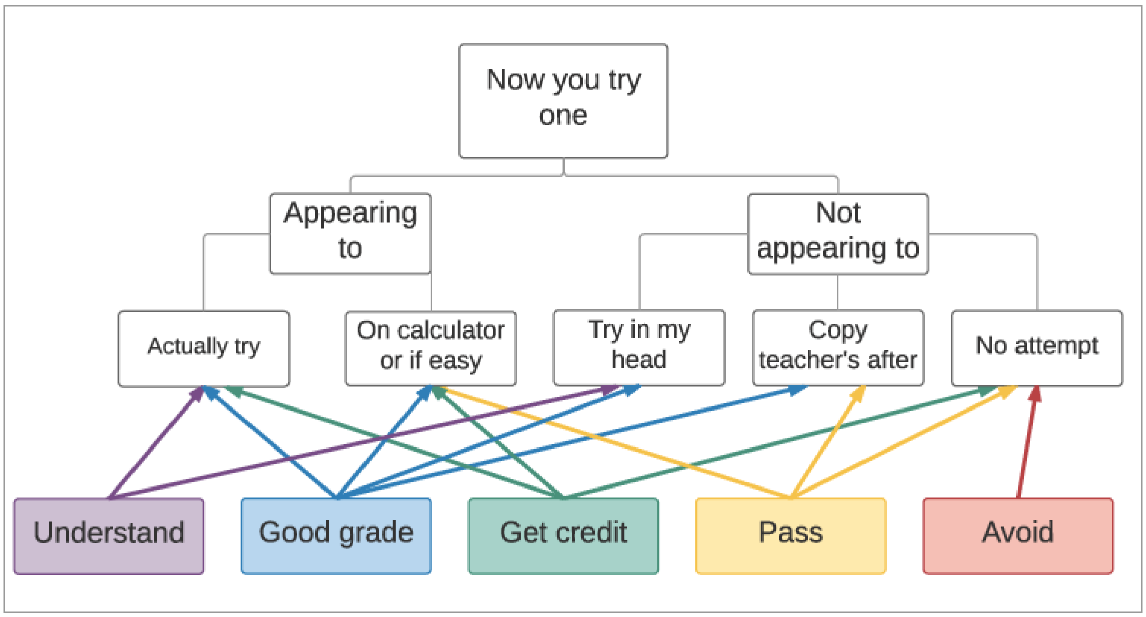


**Figure 10.17 Motives linked to actions during lessons - now you try one**

Students rarely faked trying examples. This could be due to the time factor (so it was not 'necessary' to fake it) or because 'trying' could mean looking at the problem and being stuck, at which point in many classes it was acceptable to wait for the teacher. In one class, students were standing up at a vertical surface and thus it was more difficult to fake participation. Another reason students might not fake it was because if the teacher asked why they were not trying a problem, it was acceptable to say – "*I don't get it*." A few students said they were waiting for the teacher to do it, so they could write the solution neatly in their books.

### Results of motives linked to actions

There are few conclusions one can reach when the data is viewed through this lens. However, I will briefly highlight two findings here: the first concerns faking it, while the second is a more general conclusion. One point of interest that merits some discussion is the notion of 'faking it'. Particularly, who fakes it? What is their motive? In which activity settings is putting up a façade deemed necessary? Faking it was linked to *getting a good grade*, *getting credit*, *passing*, and *avoiding*. The notable absence here is *understanding*. Putting up a façade was more commonly linked to the motives *getting credit*, *passing* and *avoiding attention or work*. The purpose of putting up a façade is to avoid negative attention, which is interesting when one considers students with a motive of avoiding. There was a trade-off for these students as they had to put in work in order to avoid attention. Finally, of the five activity settings examined here, faking was observed in all but one: *now you try one*. The possible reasons for this were discussed above and include: teacher acceptance of not trying it and it being too difficult to fake participation.

There is great variability in the actions linked to motives and in which motives drove particular actions. If, however, one focuses on what *cannot* be found from viewing the data in this manner, there is a significant finding. The main conclusion that can be drawn is that in this setting it is not possible to identify a student's motive accurately by studying his or her actions. There are too simply many factors influencing their behaviour. For example, students who did homework in class may have held a motive of understanding, getting a good grade, getting credit or passing the course.

## 10.3 Summary

In this chapter, I looked at student actions through two different lenses: first through their primary motive and then through the various activity settings, linked to motive. These perspectives revealed some significant findings, which I will summarize here.

Looking at student actions through motives, I found that students with a motive of understanding would exchange effort in a pursuit of understanding, while those with a motive of avoiding attention or work would exchange effort to avoid attention and those with a motive of getting a good grade, getting credit or passing the course would exchange effort for getting marks.

Still using motive as the lens, I established that students' motives could be described in terms of stability (local) and continuity (global). Within particular activity settings, the motive of understanding was less likely to be displaced by a secondary or tertiary motive, whereas the motives of getting a good grade, getting credit or passing evidenced more susceptibility to contextual conditions. Looking across activity settings and over time, understanding and avoiding can be described as continuous, whereas the motives of getting a good grade, getting credit and passing are discrete, due to their variability and timing of actions consistent with the primary motive (namely closer to assessment).

The second part of this chapter employed activity setting as a lens. The findings here involved the use of faking it as a strategy to avoid attention. In particular, it was found that students with a motive of understanding did not fake participation in any activity setting, whereas students with all other motives evidenced faking it. The exception to this was the setting *now you try one*, where putting up a façade did not appear, likely because it was either too difficult or thought unnecessary.

Comparing actions of students with different motives, the lens used in the latter half of this chapter brought to the surface findings that, while present, were not as apparent when viewing actions through the lens of student motive. Looking at this chapter holistically, both perspectives show that the same motive held by different students can be manifested in different actions in a given activity setting. These findings clearly show that student classroom activity is not a good metric for ascertaining motive. This is of significant importance for classroom teachers. Also, these findings really challenge the notion that students and teachers have the same goals. These and other results, their implications and suggestions for future avenues of research will be discussed in the concluding chapter.

# Chapter 11:

# Conclusion

> [T]o survive in the marketplace of ideas, a theory of learning has to be situated in a theory of schooling. Otherwise, it may leave its mark on archival journals, but leave the world of classrooms virtually untouched. (Wineburg, 1989, p. 9)

It is an incontestable fact that human behaviour is complex. Acknowledging this, I find resonance with Mason's assertion that, "*it is important to maintain and work with complexity rather than reduce it to isolated simplicities*" (2002, p. 251). At the same time, he writes that, "*dwelling in chaos* […] *denies the way human beings operate in the world*" (p. 252). In striving to achieve a balance between chaos and simplicity, I looked to activity theory to shape and guide my investigation, including the research questions themselves. As stated at the end of Chapter 2, my aim was to answer the following two questions:

*1) Using activity theory as a lens, how can we better understand the motivations that drive student actions in the mathematics classroom?*

*2) Which forms of behaviour do students exhibit within and across activity settings in the mathematics classroom?*

To respond to these questions, I first summarize the approach and findings of Part II, Part III, and Chapter 10. In Part II, I held the activity setting constant and studied the variance and consistency of student conduct within each setting. In Part III, I took the student as the constant, and looked at individual student's behaviour across multiple activity settings. Finally, in Chapter 10, the findings from Part II and Part III were viewed from two different perspectives: first holding motive constant and searching for patterns across activity settings, and second holding activity setting constant and looking for consistencies in motives and actions. Holding these four separate, but related, entities constant brought to light different patterns in the data, and also revealed that sometimes no apparent patterns existed, contrary to what one might expect. Here, I begin by revisiting the findings from each of these perspectives, which, when woven together, form a cohesive response to my research questions.

Beginning with Part II (Chapters 4–6), I established that students exhibit a broad spectrum of behaviour within the high school mathematics classroom. Over time, patterns emerged within and across the different activity settings. I highlight some of these patterns here (including delaying, compliance and use of vertical surfaces) and discuss the conditions under which they occurred. This leads to some observations and questions about the nature of such behaviour, as well as comments about how the data suggests particular student goals.

Some actions were context dependent, such as volunteering or taking notes, while others persisted across settings (e.g. delaying, faking)[181]. This latter type of behaviour, together with the shifts in student conduct that occurred during transitions from one activity setting to another (e.g. from taking notes to homework time), were most interesting and most informative because they helped to determine student motive when it was previously inconclusive based on their behaviour in isolated settings. Another notable pattern, though not particularly surprising, was that there was a fairly high level of compliance, or apparent compliance, with perceived teacher expectations – particularly during lessons and in the more traditional classroom setting.

It is also significant to note that these persistent patterns of student behaviour occurred in multiple classrooms and in different mathematics courses, suggesting that sometimes the teacher may not be such a significant factor influencing student conduct. Additionally, or alternatively, it suggests that student patterns of interaction with mathematics are firmly entrenched and may prove difficult to shift. However, other findings suggest the opposite. Student engagement with ‘now you try one’ tasks and with problem-solving tasks proved, in some cases, significantly different when compared across the three classes I visited. Students in the class working on vertical surfaces participated in the ‘now you try one’ tasks more frequently than students who stayed seated at their desks, who did not always

[181] Delaying and faking occurred in multiple settings for many students, but was also noted to occur more commonly in certain activity settings, such as homework time and ‘now you try one’ tasks.

undertake these tasks (for various reasons). It was not that the teachers had different expectations, but sometimes the enactment of these expectations deviated from what the teachers intended and expressed them to be. For example, in one class, it was clear to students that the teacher expected them to try these tasks, but teacher practice and student experience sometimes conflicted with this expectation, such as students not being given sufficient time or students waiting because they knew the teacher would supply the answer. Problem-solving tasks were more frequent in the class working on vertical surfaces, and student participation in these tasks appeared higher than in the other classes. Though it was not a focus of this study, it is interesting to consider the impact that problem solving had on students' views of mathematics and their affective relationships with the subject. Todd, for example, may never have engaged with any aspect of the mathematics classroom were it not for the problem solving and projects that his teacher introduced to the students.

Students displayed a wide range of behaviour across and within activity settings; the similarities and differences in behaviour revealed particular themes. The results of Part II, then, both engaged with my second research question and serves as a foundation for responding to my first. Certain student actions, in particular settings, pointed to the student's goal and, ultimately, his or her motive. For example, the choice only to write down formulas that would be "needed" is heavily suggestive of a particular, procedural view of mathematics, and also indicative of a motive that is something other than understanding. Additionally, situations that students knew were not formally assessed, such as problem solving, revealed significant information about their goals. Comparison of student action with that of their peers (over time and over multiple viewings) was also suggestive of a particular motive in mathematics class. For example, while many of her peers opted to relax rather than do work when there was a TOC, Maria exhibited no change in behaviour. This, and other similar instances of persistence – that is, student actions that did not vary significantly according to contextual factors – suggests that those particular students entertain certain proclivities or stances towards mathematics and the mathematics classroom. In short, it helps to reveal their goals. These findings are helpful in engaging with my first research question, with the contributions of Part III and Chapter 10 providing the bulk of the response.

In Part III, student motives were determined using activity theory and the 'actions-first' approach. Activity theory proved to be a useful and successful framework to use to establish students' motives within the mathematics classroom. Five primary motives were identified: understanding, getting a good grade, getting credit for the course, passing the course and avoiding. Secondary motives also arose in the analysis, and it was the complex interplay among these primary and secondary motives that proved highly revealing. These multiple motives, their interaction and the relative importance of each were found to have the most impact on student conduct in and across activity settings. The student motives identified in Part III, and those of other students in the study, were compared and contrasted in Chapter 10, first by examining student actions through the lens of their motive, and then by looking at motives through student actions in activity settings. Viewing the data through each of these perspectives brought to the surface different themes.

For example, when the primary motive was understanding and the secondary motive was getting a good grade, the student approached mathematics, and mathematical tasks, in a particular way. Problem-solving tasks were engaged with because they were interesting or might help the student gain insight. In contrast, when the motives were reversed and getting a good grade was a student's primary motive, the problem-solving task might not even be attempted, or, if it was, it was to satisfy a tertiary motive of being seen as a good student (i.e. complying with teacher expectations). In addition to the interplay between primary and secondary motives, my research showed that the number of students who hold a primary motive of understanding mathematics is very small. And, when understanding is the primary motive, students' actions are less swayed by external conditions, such as distractions or alternative tasks, as compared with their peers with other primary motives.

Further, considering one primary motive at a time, it was evident that the same motives drove different actions within activity settings. This was most apparent for motives such as getting a good grade, getting credit and getting through the course, but still occurred from students with a primary motive of understanding. Comparing motives, at first locally (within any particular activity setting), the range seen in the actions of students holding the same motive is indicative of the relative stability of the motive. For example, understanding is a particularly stable motive; it is not easily displaced in any given setting, whereas a primary motive of getting credit or even getting a good grade is more likely to lose precedence to secondary or tertiary motives, such as socializing or doing work for other courses. These motives are more susceptible to particular social conditions.

Comparing motives again, but this time globally (across activity settings and over time), it appears that motives can be differentiated as continuous or discrete. Understanding and avoiding are continuous, in that they are almost always the primary motive in every activity setting and at all times. The distinction between continuity and stability is easier to see when taking a motive such as ‘getting a credit for the course’. In a local sense, this motive is not particularly stable because it is relatively easy to shift it out of primary position depending on the particular activity setting and the options available to the student as alternatives (whether legitimate or not). In a global sense, this motive is discrete, because of *when* it takes precedence. Getting credit for the course assumes the top spot in the motive hierarchy when a test or assessment is imminent, whereas it is more susceptible to losing that position when there are no forms of assessment on the immediate horizon.

Finally, just as the same motive can manifest in different actions, identical or similar actions performed by different students in the same activity setting does not necessarily point to the same motive. This was made abundantly clear in the second half of Chapter 10, where I showed that in many settings the same action was performed by students who held different primary motives.

The findings discussed above also make contributions to the literature on mathematics student behaviour, and have implications for the teaching and learning of mathematics. I discuss these in more detail in the next section.

## 11.1 Contributions to the literature (and some implications)

In Chapter 1, I considered several well-known educational and psychological approaches to studying student mathematical classroom behaviour: *didactique* (including the didactic contract); social and sociomathematical norms; breaches of norms and rationality; gaming and game theory. Then, in Chapter 2, I described several versions of activity theory, from its origins in the work of Lev Vygotsky and German psychology, through Leontiev’s work, Engeström’s formulation of his Activity System, and a brief introduction to CHAT. For each of the approaches overviewed in Chapter 1 and Chapter 2, I discussed how they have been applied in educational research, and (when possible) their specific usage in mathematics education. I concluded Chapter 2 with the decision that I would be using activity theory because of what it offered, namely, what I viewed as an appropriate balance between the reality of the chaotic complexity of human behaviour, and a simplified, but less informative or accurate approach to studying behaviour. Given my results, I now revisit these other approaches and explain why, in the light of my findings, they were ill-suited for the purposes of this study.

### Revisiting approaches to student behaviour

First, I reconsider *didactique* and the didactic contract. There are a number of problems that arise when trying to apply this approach. Above and beyond the difficulties anglophones have in fully comprehending Brousseau's account, partly due to translation and partly due to the vagaries of metaphor, there is an underlying issue that lies in the extent of the application of the 'contract': it is confined to the student's *learning*. According to Brousseau, the primary obligation of the student is to learn. The data presented in my study shows that, for the student at this age at least, learning is rarely seen as his or her primary obligation. Furthermore, the contract seems to concern only the individual student's interaction with the teacher in isolation from his peers. As this research clearly shows, peers constitute a significant influence on the actions of the majority of students. Moreover, student conduct encompasses a much broader range of interaction and behaviour, including that not directly connected to learning. In fact, in light of the data collected and analysed throughout this study, only a small proportion of the observed student behaviour pertained to the learning of mathematics. Thus, *didactique* and the didactical contract would only serve to describe a small segment of student conduct in the mathematics classroom, albeit a significant one.

Social and sociomathematical norms and, in particular, classroom norms were explored as a possible approach. Social norms are the informal (unwritten) 'rules' that govern the behaviour of members of a society. Classroom norms, therefore, are the implicit or explicit expectations for behaviour in the class. Classes are differentiated by the nature of the norms that exist (rather than by the presence or absence of them). Conformity (compliance) with explicit rules and implicit norms serves to explain a broader range of classroom behaviour than merely the actions that coincide with the learning of mathematics. But they still fall short. For example, compliance with norms explains much of the faking behaviour observed in the study, but not delaying, cheating or socializing. Nor does it help to understand the variances in student behaviour, such as why one student writes complete notes while another writes down only formulas, or even why one student does not do work during class except on the day before a test. Most importantly, norms do not shed light on student motives in the mathematics classroom (other than, perhaps, a motive of being seen to be a good student). Norms certainly have value in explaining many influences on student behaviour, and could contribute to a response to the second research question by providing a rationale for student action in certain situations[182], but even here their utility is limited, and they cannot provide enough information to determine the motivation driving student action.

Breaches of norms extend the usefulness of classroom norms in explaining student behaviour. Using breaches to prompt student responses can reveal students' views of, and dispositions towards, mathematics. It can also reveal their interpretation of their perceived obligations in relation to the didactic contract. Use of these breaching experiments forms the basis of practical rationality, conceptualized and developed by Herbst and Chazan (2003) with respect to teachers, and later broadened to students by Aaron (2011). As previously discussed, Webel (2013) then extended Aaron's work by considering the practical rationality of studenting with respect to student goals for working in groups. Practical rationality has certain merits for explaining student behaviour within the mathematics classroom, particularly as it incorporates some of the other approaches mentioned above (e.g. norms, the didactic contract), and it also considers the individual's personal resources, acknowledging that each person comes with their own experiences, values, beliefs, and in particular, goals. Webel (2013) showed substantial variety in students' goals for group work and provided a finer-grained analysis with respect to types of goals (i.e. beyond performance or mastery). Practical rationality adds a perspective that helps to explain behaviour that deviates from norms (breaches), but the scope is restricted to instructional situations. Webel's work comprises a significant departure from much of the other related literature, in that it highlights the diversity of individual student goals (as opposed to group goals), as well as considering non-mathematical goals. With the

[182] Such as student compliance with perceived expectations when that particular action did not coincide with the students' goals.

exception of Webel's study, the bulk of research conducted in this realm has been concentrated on direct instructional situations, whereas the approach taken my this study includes activity settings such as homework time, problem-solving tasks, 'now you try one' tasks and review day.

Finally, while interesting to explore and valid in very specific situations, frameworks like game theory operate under the assumption of certain conditions that just do not exist in the high school mathematics classroom. In the classroom, students do not behave according to set rules or operate in ideal situations – therefore assumptions of consistent behaviour are incorrect.

Undeniably, the aforementioned theories have produced valuable contributions to mathematics education. I do not argue against their utility, yet I deemed them unsuitable for the purposes of my study for several reasons. First, no single theory was broad enough in scope to apply to all potential activity settings within a single classroom period. They are applicable in specific situations or under certain conditions or have underlying fundamental assumptions about student motives. Theories of learning (such as *didactique*) are only relevant if the motive of schooling is learning. Some theories assume a shared group goal[183], but this too is not the case. Students are individuals and act as such, even though they may appear to have a common objective. Thus, in many cases, these theories do not account for student behaviour that is exhibited in the actual classroom and subsequently not suitable to achieve the aims of this study. I did not seek to understand particular responses or answers, or breaches; rather, I took a broader, more holistic perspective on behaviour. Also, any simplified model necessarily neglects some of the complexity of human behaviour – and thus diminishes real-world applicability.

Activity theory proved to be a highly adaptable and functional approach for my purposes. It can be applied over a broad range of activity settings and, when paired with Kaptelinin and Nardi's (2012) "*actions first*" strategy, proved a productive means for determining student motive. The framework and the process have provided theoretical and practical results that have implications for both researchers and educators.

[183] It is common for research using Engeström's activity system to assume the collective has a common goal, and that individuals within the group share the common goal (whether they are aware of it or not) (e.g. Fitzsimons, 2005 and Williams, Wake & Boreham, 2001).

First, it was clear from early on in my research process that theories that are commonly used in educational research could not be applied to examining the entirety of student behaviour within the mathematics classroom. Leontiev's activity theory proved to be successful in achieving this end, which suggests that there are benefits to be reaped by applying his version of activity theory to future studies.

It is not a new idea that students do not exist in isolation. The influences of community and context are recognized and represented in many theories. When studying student behaviour and goals with a desire to determine motive, I suggest not only that student motives should be examined in context, but that it is also of value to compare and contrast them by means of one student's actions with that of his or her peers. Viewing multiple students in the same context helps to make sense of what a particular student is doing in that setting. This provides insight into student rationales for behaviour.

Activity theory holds that students have a hierarchy of motives in the mathematics classroom, and further, that students are not capable of articulating their own motives. I identified both primary and secondary motives for students in this study, and then used them to examine the links between motive and student action, from two perspectives. My main findings – namely that the same action performed by different students does not imply the same motive, and further, that two students having the same motive will not necessarily perform the same action in any given activity setting – have significant implications.

Although the actions of different students in the mathematics classroom often appear similar, this analysis shows that they are driven by very different motives, arguably with significant consequences for potential learning. It is common for teachers to use indicators such as apparent compliance with expectations (such as paying attention, note-taking, etc.) as proxies for learning. In light of these findings, I contend that teachers must re-examine the way they make inferences from observations of student behaviour. Further, since student behaviour in school is largely formed by students' prior experiences in school, teachers at all levels of education need to consider the impact of their policies and procedures on the development of student motives and goals. In particular, traditional assessment practices value grades and achievement, which pushes the motive of getting a good grade. What this research suggests is that traditional assessment practices should be reconsidered in light of supporting the motive of understanding.

My findings regarding the stability of different motives support my recommendation that teachers interrogate their practices. I found that many students hold motives that are less stable and more discrete (determined by their susceptibility to the social environment and the conditions and means available to the student). This suggests that there may be some way to influence the actions of students whose motives *are* less stable, which supports my contention that teachers need to question the effects their policies and practices have on student action, and ultimately the result students' actions have on their own learning.

## 11.2 Contributions to method

In the first part of Chapter 3, I discussed the uses of ethnographic methods in the mathematics classroom. I concluded that ethnography is well suited to this type of investigation, and that it has a history of use in the literature. In accordance with ethnographic studies, I conducted my research *in situ*. I used semi-informal interviews, within the classroom and in the moment, to glean information about student rationales and goals. So, while my use of ethnography to orient and guide my investigation into student behaviour in the mathematics classroom is not a new contribution, it does add to what already exists. Nor is my contribution new in pairing ethnography with activity theory (Johansson, 2006). What I offer that is new with respect to method is the cross-over analysis I conducted in Chapter 10.

I used Kaptelinin and Nardi's (2012) "*actions first*" strategy to determine students' motives, which could only be achieved through conducting multiple observations, in the classroom, and over a range of activity settings. I then analyzed their motives and actions from two different perspectives. First, I held constant the primary motive, and looked at the variation in student action. Then, I began with specific activity settings and examined the links between primary motive and actions within that setting. This singular approach revealed significant findings, discussed in the previous section. It was only through taking both of these two different perspectives that the patterns became apparent. I believe this to be a valuable methodological contribution in that I have not seen previous instances of this type of approach in the literature.

## 11.3 Questions and future directions

Observations I made during my data collection and analysis have raised some questions for me. They are not findings in themselves, but are things about which I continue to wonder, and constitute possible directions for future research.

Research has shown, and my data supports, that students asked to work at vertical surfaces are more likely to participate in tasks (Liljedahl, 2016a). I wonder about the particular implications this has for student learning and understanding. I also have questions about affect – does working at vertical surfaces make students enjoy mathematics more? Does this practice change their attitudes towards mathematics, and possibly affect their motives? I am thinking as well about problem-solving situations, which I found to be the setting in which students showed the greatest levels of affect. Todd, for example, appeared to derive great satisfaction from solving these problems, and demonstrated high levels of excitement and also frustration during his work on the tasks.

I also have questions about 'understanding'. I am thinking about my observations of Maria's actions and my analysis of her primary motive. Although many students say (and possibly believe) that they are motivated to try to understand mathematics, few of them actually hold that as a primary motive, and we do not know what they think 'understanding' means[184]. Maria, however, really did want to understand mathematics and that was what drove her activity. The problem was that Maria did not know how to go about achieving it. She relied on strategies that had worked for her in the past, such as completing the assigned homework, asking questions, paying attention and taking notes. Yet, at some point along the way, these methods became insufficient, leading to frustration both for Maria and for her teacher. What recourse does a teacher have when a student really does want to understand, but does not know how to achieve this?

[184] Some students seem to think that understanding means getting every question 'right' on the test.

Finally, the responses to my research questions have raised more questions. How does one go about influencing student motives in mathematics? If teachers realize that they need to change their practices, how can they achieve this? What support do they need? Ultimately, how does the culture of mathematics education in schools change?

## 11.4 What I would do differently

In any research project there are many decisions to make. In my research, I made choices regarding method, theoretical framework and innumerable choices ‘in the moment’ during data collection and throughout the analysis. These choices necessarily limit what I am able to say and what generalizations can be made. I regret none of these decisions as I feel some were almost unavoidable given my own beliefs and values (such as my selection of an ethnographic approach and activity theory). That said, such decisions have consequences, and there are improvements that could have been made, or could be included as part of a future study.

There are always more questions to ask students and teachers. In hindsight, I wonder if I had asked more students more direct questions I could have learned more about their goals. Part of the reason I did not was that I could have improved my interviewing technique and been more comfortable asking potentially ‘uncomfortable’ questions (such as “*Why aren’t you trying the example?*”). I could also have formally interviewed the teachers to get more details about their perspectives – but likewise this also could have shifted my perspective.

With respect to my analysis, I chose three different classes, taught by three different teachers. This necessarily significantly limits the generalizations that can be made and raises questions about whether individual students’ actions might or would have been different in another classroom or with another teacher. The answer to those questions, from my theoretical perspective, is yes. Perhaps they would not have been radically different, but different nonetheless. I could have chosen instead to look at the same teacher teaching different mathematics courses and different students or selected different teachers’ classes from the same school or observed classes of the same course taught by different teachers. Making any of these choices would have changed my data, potentially leading to other findings, but perhaps also missing what I have found here. It would have been impossible for me to conduct an in-depth study that included all of these possibilities. Thus, choices were made, and I am pleased with the results because I achieved my goals and discovered more than I could have hoped for.

## 11.5 Final words

The goal for my research is that it create a disturbance. I use this term in the sense of Mason (2002): for Mason, the only way that perceptions can change is for there to be a recognition of a disturbance. In the process of collecting and analysing my data, I learned a lot about myself and my own teaching. Observing other classrooms, and students' responses to other teachers' practices, caused me to question my own practice, and the impact my choices have on student action.

My hope is for my findings to provoke others to look explicitly and at length at student actions, and at teaching, with a different perspective, as they have caused me to do. In reading this dissertation, if some aspect strikes a chord, finds resonance and brings new awareness, then I will have achieved my aim. I encourage both researchers and teachers to question their assumptions about compliant and non-compliant behaviour – and what compliance really means. I hope it illuminates the assumptions that we (both teachers and researchers) hold, raising questions about common practices, their uses and, particularly, whether our commitment to certain practices, particularly regarding assessment and measurement tools, actually achieves the outcomes we intend them to.

Ultimately, I am asking researchers and teachers to do what I will do: interrogate the effectiveness of my practices and the effects my practices have on student motives and actions.

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# Appendix A.

# More on Ethnography

### What is culture?

At this point it seems wise to define culture, as interpreting it is the primary goal of ethnographers. What is culture? Although there is no universally agreed upon definition, Whitehead (2005) describes it as "*a 'holistic' flexible and non-constant system with continuities between its interrelated components*" which comprises "*shared ideational systems and preferred behaviour and structural (social) relationships*" (p. 5):

> human individuals live their lives in wider social contexts (e.g., family, peers, etc.) of shared ideational systems (beliefs, attitudes, values, etc.) and preferred behaviour, that help to meet a range of human needs, and that are influenced by significant historical events and processes. Thus the specific ideas and behaviour of an individual member of the cultural system can be influenced by any of these components of that system (social structure, shared ideas, and preferred behaviour) and the broader issues that have some influence on that system (physical environment, history, and real and perceived human needs). (p. 5)

Culture is seen as growing and changing. It is manifested at different depths, affects behaviour and interpretations of behaviour and is different from both human nature and individual personality. Additionally, for practitioners cultural expressions may exist as real, ideal, explicit or tacit. Ideal cultural expressions refer to those that people think exist or would like to exist. Explicit culture can be identified and discussed, whereas tacit culture is that which "*motivates particular ideational or behavioural patterns, but about which people may not be able to directly speak*" (Whitehead, 2005, p. 6). This is important because what cultural expressions people perceive to exist or be true is not always a true reflection of reality. In other words, what people say they do and what they actually do often differ. This highlights the importance of multiple methods of data collection to ensure validity.

### What is Ethnography?

Even experts in the field sometimes have difficulty conveying the essence of the ethnographic method; in fact, there is debate about what type of research can be called 'real' ethnography (Agar, 2006). One point of contention exists around whether 'area' must be geographical or if it can be institutional, particularly with respect to the question of whether *educational ethnography* actually deserved that title. A second area of debate concerns what Agar calls the "*emic versus etic distinction"* (2006). After much thought, Agar concludes that there is not one 'real' ethnography; *"[m]ore than one type is possible, but not all ethnographies are acceptable*" (para. 31). There is a boundary, Agar claims, but it is neither crisp nor clear.

Wolcott admits that ethnography can appear "*maddeningly ambiguous*" (1980, pp. 47-48). In fact, after having spoken at a graduate student seminar at the University of Alberta, Wolcott himself fell into the trap of describing ethnography by what it is not. This was not Wolcott's intention and after reading a report of the proceedings (Jefferson, 1981) Wolcott found himself dissatisfied and commented on this in a later book chapter. In that chapter Wolcott addresses each of four statements[185] regarding what ethnography is not: 1) a field technique; 2) a length of time in the field; 3) created through gaining and maintaining rapport with subjects; 4) simply good description. Wolcott's expanded four-part definition will be used here to describe what ethnography is.

1) Ethnography is not field technique. That is, "*field techniques in and of themselves do not an ethnography make*" (Wolcott, 1987, p. 38). The use of participant observation, interviewing or any other technique used by ethnographers does not it in itself qualify a study as ethnography. Spindler and Spindler (1987) explain that a study is "*not ethnography unless it uses some model of cultural or social process in both the gathering and interpretation of data*" (p. 3).

2) Nor does time spent in the field qualify a study as ethnographic. Wolcott describes time as a "*necessary but not sufficient*" (p. 39) element of ethnography. How much time is 'enough'? According to Wolcott, there is a general consensus among ethnographers that one must remain in the field at least a year, but he also notes that twelve months in a setting as complex as a contemporary school, even if focused on only one teacher or student, may amount to a 'blitzkrieg ethnography'. Blitzkrieg ethnographies (Rist, 1980) involve impressionistic accounts and very short periods of observation, resulting in superficial caricaturisation rather than characterization of the learning setting (Watson-

[185] I have addressed them in a slightly different order from the one Wolcott presented them in in the chapter.

Gegeo, 1997). In general, one must spend enough time to come to know the setting thoroughly. Conversely, Wolcott (1978) cautions against staying too long, noting that detachment is as important to the ethnographic process as is involvement. This aspect of ethnography is thus a difficult one to determine accurately.

3) Third, ethnography is not created through gaining and maintaining rapport with subjects. Building relationships, forming a level of trust and being a confidante are not necessarily factors that preclude a good ethnography. In some respect, a level of distance is needed. Wolcott points out that some ethnographers' work is compromised by humanitarian, ethical and personal considerations – and, in fact, never gets written. He notes (1987) that even arrogant, self-centred and inconsiderate ethnographers have managed to produce satisfactory ethnographic accounts.

4) Although it is a significant element, ethnography is not simply good description. The depth of reporting is often the basis on which studies are erroneously labelled 'ethnography' (Wolcott, 1990). Beyond good description an ethnographer must be able to recognize the elements that require attention – not just describe all elements in depth. Wolcott criticizes what he calls 'neophyte' fieldworkers for attempting to record and report everything at their site. Judicious decision must be made to determine which data should be featured and that which must be sacrificed.

A good ethnographer must be able to discriminate and discern what details are important to describe when ethnography is the goal, rather than some other outcome (Wolcott, 1978). Observation and the reporting thereof is a subjective endeavour and must be recognized as such. There is no such thing as 'pure observation', thus it is critical that the ethnographer's perspective is acknowledged. Further, in a ethnography, data and interpretation are intertwined rather than existing as separate steps – it is a dialectic process. The judgement and 'sense' of the ethnographer is critical to the success of the ethnography, as her task lies in "*rendering a theory of cultural behaviour*" (p. 41) rather than merely recounting events:

> There is a difference between culture as perceived by any member of a group and culture as attributed to that same group by the ethnographer. The ethnographer attempts to make explicit and to portray in terms of social interaction among many individuals […] what its various members know only tacitly and understand individually. Ethnographers are rightly accused of making the obvious obvious […] because, quite literally, their task is to

> describe what everybody already knows. The catch is, of course, that no one individual, ethnographer included, ever knows it all or understands it all. Ethnographers recognize that they do not have to describe it all, either. (pp. 41-42)

An ethnographer must find a way to describe the key elements of a culture, which are not necessarily even apparent to the individuals in the culture. Of course, if done well, the ethnographer's careful analysis and synthesis of observations and other data results in a description of culture that appears obvious to the members of the group of that particular culture.

Ethnography requires an "*iterative, recursive, abductive logic*", and is thus more than just description. Agar talks of 'rich points', "*the raw material of ethnographic research*" (2006, para. 64). A rich point could be something surprising, a departure from expectations or a problem with a data set. He states that making sense of these requires imagination and the creation of new concepts (abductive logic), rather than reliance on old ones (deductive or inductive logic). Abduction, claims Agar, is one key element differentiating acceptable from unacceptable ethnography. However, he continues, while logic is static, ethnography is dynamic. Therefore abduction is iterative, and also recursive.

Other key features of acceptable ethnography concern the question of context and meaning. Agar maintains that being an ethnographer requires enjoying *not* knowing what is going on around you – a state of discomfort for most people. The ethnographer must constantly question the correctness of his interpretation of what is going on: *Is there another point of view? Will someone else see something the same way I see it?* According to Agar the ethnographer is always on the lookout for evidence to falsify his understanding. Regarding context, in contrast to traditional social scientists who look to isolate and measure phenomena (i.e., variables) ethnographers look for co-occurrences with other phenomena (i.e., patterns).

Frederick Erickson described ethnography as a "*deliberate inquiry process, guided by a point of view*" (1973/1984, p.51). Ethnography is not, he says, a "*reporting process guided by a standard technique or set of techniques, or a totally intuitive process that does not involve reflection*" (p. 51). The fact that the techniques used shift and evolve throughout the process is one reason why ethnographers find it so difficult to describe what they do. Ethnographers learn by experience and their questions are situation-based, developing in response to the answers they receive from previous questions. The existing literature also plays a role in framing the questions. An analogy is offered by Tony Whitehead (2005), who is a senior professor at the University of Maryland with a lengthy and successful career in the field of anthropology.

Whitehead uses the young child as an ethnographic model. In order to learn their culture, he explains, children use the same processes ethnographers use: observations, asking questions, making interpretations and participant observation. Toddlers carefully observe their parents and the world around them, soaking up information and beginning to learn rules and routines. They explore and experiment once they begin to crawl and then walk, and climb, and copy actions they see others do. Soon after they begin to talk they start to formulate questions. And then they ask them – all of them. Throughout this process the child is making and refining interpretations. The ethnographer takes a similar path, albeit with less (or possibly more) fumbling. The child's parents and others they rely on to provide information are the ethnographers 'informants'; people observe and interview in order to glean understanding about the culture. One advantage young children have over ethnographers is that they have no pre-existing cultural framework to act as a potential barrier to interpretation. But like the ethnographer, the child moves through a cycle of interpreting and re-interpreting data as more, and possibly conflicting, data is added. This process continues *"until the child achieves a level of satisfactory coherence regarding the phenomena about which data were collected*" (Whitehead, 2005, p. 10). Wolcott echoes this statement, claiming that the true test of an ethnography, is the "*satisfactoriness of the completed account"* (1978, p. 42).

Wolcott's belief of the importance of fieldwork to the ethnographic approach is shared by Whitehead. He also notes the importance of secondary data analysis and shares his views on certain fundamental elements of ethnography. Whitehead contends that ethnography is grounded in particular ontological and epistemological perspectives, that is, perspectives on the nature of what is being studied, and on research findings.

## General Ethnography Methods

Once ethnography is chosen as the methodology for a study there are still many choices to be made – there is not one set path or one recipe to follow. There are a multitude of methods from which the researcher can select. Whitehead classifies ethnographic methods as *classical* and *non-classical*, further differentiating classical methods into *core*, and *other classical*.

*Classical* methods are those "*traditionally used by anthropologists, such as* secondary data analysis*,* fieldwork*, observing* activities of interest*,* recording fieldnotes *and observations,* participating in activities during observations *(participant observation), and carrying out various forms* of informal and semi-structured ethnographic interviewing" (author emphasis) (p. 2). These are also referred to as basic classical or core, to differentiate them from other classical methods.

*Non-core classical* methods may involve household census collection and genealogies, physical mapping of the study setting, and use of audio/visual methods, including video and photography. Basic classical methods are a subcategory of classical, differentiated by the social setting under study. These methods are used like other classical methods in the study of communities and populations, but unlike other classical methods, basic classical ones are also applied to settings like organizations, institutions and other, smaller, social settings. *Non-classical* methods include focus and other group interviews, use of computer assisted technologies, and highly structured interview techniques (sometimes involving psychometric scales and other similar methods) (Whitehead, 2005).

Irrespective of the particular methods, the purpose of ethnographic research is to describe and interpret cultural behaviour. In order to fully grasp the reasons for why certain behaviour exist and persist, "*we must understand the socio-cultural contexts in which these behaviour occur, the socio-cultural processes of behavioural contexts, and the socio-cultural meanings that these contexts and processes have for those who practice them*" (Whitehead, 2005, p. 9). Achieving this end requires direct observation and immersion in the field situation, as well as ongoing interviewing in varying degrees of formality. The interviews, taken together with observations, elicit the native view of reality as well as the meaning ascribed to events, consequences, and intentions by the subjects. Then this view of reality must be described using the vernacular of the reader, having been analyzed and framed according to the theories from a particular professional discipline (Spindler & Spindler, 1987). The goal is to make the culture "*intelligible as seen from within, and to portray the actors in the situation as humans – not as stick figures or* *monsters*" (Erickson, 1973/1984, p. 61). Ultimately, it is the final account that determines the legitimacy of the ethnography.

The methods employed in my study are most closely aligned with basic classical methods because of the context: the classroom.

## Concerns and Limitations

Several issues regarding classroom ethnographies are brought forth for discussion by Watson-Gegeo. He identifies four such issues, and Erickson adds a fifth. I describe these here.

The first issue Watson-Gegeo cites is the aforementioned 'blitzkrieg ethnography' – a superficial caricature of the learning setting rather than an in-depth and considered analysis. Erickson describes caricature as "*systemic distortion – abstracting what the artist perceives to be the most salient features of his subject and presenting those features in exaggerated form*" (1973/1984, p. 58). Although the ethnographer's perception is also an issue in 'real' ethnography, the caricature is the result when the study is too brief and grasps at the first plausible explanation. This may result in overgeneralizing on the basis of a small amount of data, or selecting to present only those details that support a slanted description. At the same time, it is impossible to study everything. "*Too much is there to monitor holistically, yet holism cannot be eliminated, or caricatures based on tunnel vision may result*" (Erickson, 1973/1984, p. 60).

This leaves me in a bit of a quandary; how long is 'long enough'? How much data should be collected? What is 'sufficient depth'? In general, the appropriate duration for a classroom ethnography is one semester or cycle. Most importantly, emphasizes Erickson, the researcher must really *be there*, experiencing strong relationships with the members, not merely being involved at 'arm's length'. Adequate description requires immersion in the field until the behaviour one is seeing makes sense. Frequent reflection by the ethnographer is necessary; about the methods chosen, the lens used, and the reasons for these choices. Additionally, the ethnographer should be careful to note her rationale for selecting the data to be included and discussed, and that which is omitted (since it is impossible to include everything). One should also be explicit about the extent of the study, the decisions made, and the methods utilized so that the reader can make an independent assessment of the appropriateness of the results. In other words, the ethnographer needs to provide evidence that supports her results and also supports independent analysis.

The second problem is ‘within data sampling’. Watson-Gegeo describes this as the selection of a particular instance or scenario within the data for analysis, rather than consideration of the entire corpus of data. Often the issue is too much data rather than too little and the real problem is choosing which data to present. All contexts and activities must be examined and considered in the analysis of a particular event to preserve the integrity of the ethnography.

Thirdly, Watson-Gegeo (1997) contends that some studies identified as classroom ethnographies have a tendency towards reductionism and avoidance of complexity. Awareness together with careful and in-depth analysis as well as openness about methods for data collection and analysis are sufficient to guard against this pitfall.

Another concern about classroom ethnographies raised by Watson-Gegeo is the problem of perspective. “*Although each study is guided by existing theory, analytic categories in classroom ethnography are in large part emic (derived from teachers’ and students’ own concepts and categories) rather than etic (imposed from the analytic language of the social sciences)*” (1997, p. 136). ‘Emic’ refers to the insider’s view of reality whereas ‘etic’ represents the outsider’s perspective. It is critical that ethnography addresses the emic view, yet it is impossible to completely remove the etic one. Ethnographer Frances Reimer emphasizes that because everything we see is “*filtered through our own lens* … *the ethnographer is never able to completely write him or herself out of the ethnography*” (2009, p. 205). Consequently it is imperative not only that the ethnographer is cognizant of his or her theoretical perspective and approach but also that this information is provided to the reader.

Also regarding perspective, although with respect to a different problem, Erickson (1973/1984) questions how the point of view of ethnographers who are members of that society is affected by their thoughts and feelings about their society. Wolcott shares this concern. Inherently the people interested in classroom ethnography are those who are deeply familiar with and encultured in school life. Therefore, it is nigh impossible for the researcher to ‘discover’ school culture. “*These hopelessly enculturated insiders accept as natural and proper the very things an ethnographer from another society – or even an* *ethnographer from our own society not so totally familiar with schools – might want to question*" (1987, p. 51). Insiders don not question what is second-nature to them – things like why teachers do work in full view (classrooms) but administrators have offices, why school is held Monday through Friday, why it is preferred that teachers stay after school to do work than come early, and why evaluators of educators do not necessarily have classroom experience or responsibility (Wolcott, 1987).

Despite these concerns, there is often an advantage to being an insider. Wolcott acknowledges that the insider has a unique perspective and can best understand the complexity of the system under study. The affordances that the insider perspective offers can outweigh considerations if the ethnographer makes a conscious effort to pull back, distance himself from the setting, and to make conscious and really question his assumptions. Although the ultimate goal is to understand the situation as a member of the group sees it, an important exercise for the ethnographer is to step back and try to see it from an outsider perspective. "*Especially in doing ethnography in our own society, it is important to keep in mind the oddness and arbitrary nature of the ordinary everyday behaviour that we, as members, take for granted*" (Erickson, 1973/1984, p. 62). This view may elicit questions and realizations about unconscious acceptance and assumptions of classroom practices. Consider not only what happens, but also what *doesn't* happen? *Why* doesn't it happen? Additionally, for the purpose of clarity, the ethnographer should make explicit to the reader the point of view at the beginning of the fieldwork, during the fieldwork, and at the point of departure.

Ethnography is descriptive – it describes and interprets cultural behaviour but it is meant to end there. Good ethnographic accounts help us understand how social systems work but are not intended, nor do they contain the necessary information, for making value judgements such as 'good or bad', or decisions on efficacy of the system, with the exception of those being voiced by those within the group under study (Wolcott, 1978). It does not suggest a cause and effect explanation but only describes a particular set of circumstances. Often, however, educational ethnography leans towards efforts at improvement. "*In and of themselves, ethnographic studies do not point the way to how things can or ought to be improved*" (p. 52).

# Appendix B.

# Surveys

**Mathematics Note-taking Survey – Pre-Chapter 1 Test**

**When do you take notes in this mathematics class? (Under what circumstances?)**

**How does taking notes during class help you? (eg. Keeps you focused, helps understanding, etc.?)**

**Do you think your teacher expects you to take notes? Why do you think this?**

**Do you take them down verbatim (as they are written on the board) or do you paraphrase (write it in your own words)?**

**Why do you prefer this method?**

**Does it aid your understanding? How?**

**Do you intend to use your notes to review for the chapter test? Why or why not? (Will you use some other source? Textbook, etc.)**

**What are other different ways in which you use your notes, if any?**

This information will NOT be used in any way in this course – for your grade or otherwise. It is used for the purpose of research only and will not reflect on you in any way.

## Review Survey

What do YOU normally do during a review day (IN CLASS)? (Be honest – if you usually just chat just say so – Mr. Matthews won't hear it from me!)

What did you do for review/prepare for THIS test? Give specifics please! (What, and where – in class/at home/during lunch etc.)

When you do practice questions do you: (Check the ones that apply – you may choose more than one)

- Do all the questions
- Do the questions that look easy
- Do the questions don't look too easy but don't look really hard
- Do only the questions that look really hard
- Do the questions that you know you will have trouble with
- Do some of the questions until you give up
- Do some of each type of question
- Don't do any questions

When you look over your notes do you: (Check the ones that apply – you may choose more than one)

- Just read
- Read and see if it seems familiar
- Read and see if you can follow all the steps
- Read and see if you can do the questions without looking at your notes
- Try and find questions like the ones in the notes to practice

How did you think you would do before you wrote the test? (Give a percentage)

What do you think you could have done to improve your understanding and success on the test? (don't say "study more" – be more specific – for example "I needed to do more practice on the word problems", or "I could have reviewed the equations and tried to understand them better")

How do you think you will do now that you have written the test? (Give a percentage)

## Mathematics Student Survey

| | Please respond to each statement | Strongly agree | Some-what agree | Neither agree or disagree | Some-what disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| 1. | When the teacher tells us to try an example I wait until she explains all the steps. | ○ | ○ | ○ | ○ | ○ |
| 2. | Group work helps me learn mathematics. | ○ | ○ | ○ | ○ | ○ |
| 3. | Mathematics learning is mainly memorizing. | ○ | ○ | ○ | ○ | ○ |
| 4. | Writing notes helps me to learn the material. | ○ | ○ | ○ | ○ | ○ |
| 5. | There are several ways to find the correct solution of a mathematical problem. | ○ | ○ | ○ | ○ | ○ |
| 6. | I don’t like to try the problems in class because I don’t like to be wrong. | ○ | ○ | ○ | ○ | ○ |
| 7. | If I follow all of the same steps as the example I should be able to solve a given problem. | ○ | ○ | ○ | ○ | ○ |
| 8. | I write notes during class so that I can study from them later. | ○ | ○ | ○ | ○ | ○ |
| 9. | I do my homework because it is worth marks. | ○ | ○ | ○ | ○ | ○ |
| 10. | I like doing problem solving. | ○ | ○ | ○ | ○ | ○ |
| 11. | Writing notes is a waste of time because I never look at them again. | ○ | ○ | ○ | ○ | ○ |
| 12. | I prefer mathematics tasks for which I have to exert myself in order to find the solution. | ○ | ○ | ○ | ○ | ○ |
| 13. | I do my homework because it helps me to learn. | ○ | ○ | ○ | ○ | ○ |
| 14. | I am good at problem solving. | ○ | ○ | ○ | ○ | ○ |

| | Please respond to each statement | Strongly agree | Some-what agree | Neither agree or disagree | Some-what disagree | Strongly disagree |
|---|---|---|---|---|---|---|
| 15. | Those who are good in mathematics can solve problems in a few minutes. | ○ | ○ | ○ | ○ | ○ |
| 16. | The teacher knows the right answer and will give it to us eventually. | ○ | ○ | ○ | ○ | ○ |
| 17. | I take notes because the teacher tells me to. | ○ | ○ | ○ | ○ | ○ |
| 18. | Mathematics is a mechanical and boring subject. | ○ | ○ | ○ | ○ | ○ |
| 19. | I do my homework so that I don't get into trouble with my parents. | ○ | ○ | ○ | ○ | ○ |
| 20. | My major concern when learning mathematics is to get a good grade. | ○ | ○ | ○ | ○ | ○ |
| 21. | I like mathematics because the teacher shows me how to do it and I do it. | ○ | ○ | ○ | ○ | ○ |
| 22. | Instead of doing the homework I just copy the answers from the back of the book or someone else. | ○ | ○ | ○ | ○ | ○ |
| 23. | In mathematics on a review day before a test I… ... mostly just chat with my friends. | ○ | ○ | ○ | ○ | ○ |
| 24 | ... try the easy problems because I know I can do them. | ○ | ○ | ○ | ○ | ○ |
| 25 | ... just read over the notes because if I can follow them I think I can do the problems. | ○ | ○ | ○ | ○ | ○ |
| 26 | ... try the problems I had difficulty with before. | ○ | ○ | ○ | ○ | ○ |
| 27 | My teacher is not teaching me mathematics the way ... ... I am used to. | ○ | ○ | ○ | ○ | ○ |
| 28 | ... I like to be taught. | ○ | ○ | ○ | ○ | ○ |
| 29 | ... in a way that will allow me to be successful. | ○ | ○ | ○ | ○ | ○ |

**Mathematics Anxiety Rating Scale – revised**[186]

| **When I am … I feel ANXIOUS** | Not at all | A little | A fair amount | Much | Very much |
|---|---|---|---|---|---|
| Looking through the pages in a math text | 1 | 2 | 3 | 4 | 5 |
| Walking into a math class | 1 | 2 | 3 | 4 | 5 |
| Reading a formula in a science text | 1 | 2 | 3 | 4 | 5 |
| Thinking about an upcoming math test one day before | 1 | 2 | 3 | 4 | 5 |
| Watching a teacher explain a problem on the whiteboard | 1 | 2 | 3 | 4 | 5 |
| Being told how to interpret algebraic statements | 1 | 2 | 3 | 4 | 5 |
| Picking up a math textbook to begin working on a homework assignment | 1 | 2 | 3 | 4 | 5 |
| Taking an test in a math course | 1 | 2 | 3 | 4 | 5 |
| Reading and interpreting graphs or charts | 1 | 2 | 3 | 4 | 5 |
| Starting a new math problem | 1 | 2 | 3 | 4 | 5 |
| Being given a homework assignment of many difficult problems | 1 | 2 | 3 | 4 | 5 |
| Waiting to get a math test returned in which you expected to do well | 1 | 2 | 3 | 4 | 5 |
| Getting stuck in a math problem | 1 | 2 | 3 | 4 | 5 |
| Starting a new chapter in a math book | 1 | 2 | 3 | 4 | 5 |
| Listening to another student explain a math formula | 1 | 2 | 3 | 4 | 5 |

[186] The revision of the revised scale is based upon the work of Derek R. Hopko **Confirmatory Factor Analysis Of The Math Anxiety Rating Scale–Revised,** *Educational and Psychological Measurement* 2003; 63; 336

# Appendix C.

# NVivo codes and number of references

| | | | |
|---|---|---|---|
| Ability | 2 | Distracted or Focus | 62 |
| Activity setting transition | 99 | Division of Labour | 5 |
| Affect | 53 | Doesn't like the teacher | 6 |
| Excited about math - student | 4 | Doing work during class | 137 |
| Answering - I don't know | 4 | Doodling | 16 |
| Answering a question during a presentation | 3 | EXPLAINING | 22 |
| Appearing to conform | 77 | Explaining a problem to a peer | 29 |
| Assigning a task | 146 | Explaining or suggesting procedure | 99 |
| Attendance | 58 | Explaining reasoning | 29 |
| Avoiding | 31 | Explaining task to researcher | 6 |
| Delaying starting | 77 | Teacher explaining the solution to a class | 36 |
| Calculator | 42 | Efficiency | 14 |
| Calling on students | 46 | Effort | 39 |
| Cell-phone | 89 | Excuses | 90 |
| Chatting | 121 | Extra Practice | 3 |
| Checking Answers | 81 | Feedback | 20 |
| Checking for understanding | 51 | Formulas | 25 |
| Classroom agenda or foreshadowing | 35 | Game | 23 |
| Common Errors | 19 | Gaming | 2 |
| Confidence | 9 | General Classroom Details | 9 |
| Copying or Cheating | 44 | Class Description | 16 |
| Correcting Students | 14 | Marks breakdown | 1 |
| Corrections | 25 | Getting Help | 29 |
| Dana | 1 | Asking peers for help | 20 |
| Developing Rapport | 4 | Asking researcher for help | 12 |
| Disagreement with textbook | 1 | Asking the teacher for help | 34 |
| Discipline | 48 | Getting help from a family member | 4 |
| Consequences | 9 | Getting help from a tutor | 6 |

| | |
|---|---|
| Offering help outside of class | 5 |
| Student getting help from a peer | 33 |
| Teacher going to help a student | 18 |
| Giving a similar example | 2 |
| Giving reasons or explanation | 18 |
| Goals | 10 |
| Going over homework questions | 30 |
| Grades or Marks | 48 |
| Group work | 53 |
| Guess and test | 6 |
| Guessing | 10 |
| Handouts | 20 |
| Homework - talking about | 78 |
| Housekeeping tasks | 1 |
| Incentives | 1 |
| Intentions | 10 |
| Learning | 7 |
| Leaving the room - student | 13 |
| Making connections | 10 |
| Math in future courses | 2 |
| Mismatch | 24 |
| Mistakes | 30 |
| Needy | 2 |
| Norms | 4 |
| Not Working | 176 |
| Not doing what is expected | 316 |
| Not understanding | 110 |
| Not wanting to make an error | 15 |

| | |
|---|---|
| Oral explanation (no written) | 4 |
| Pace of class | 38 |
| Packing up | 25 |
| Paige | 1 |
| Parent reactions | 2 |
| Participation | 46 |
| Paying Attention | 74 |
| Pedagogical Choice | 38 |
| Peer corrects peer | 2 |
| Performance on assessments | 53 |
| Persistence | 8 |
| Preparedness for Class | 19 |
| Prerequisite Knowledge | 3 |
| Presenting to peers | 10 |
| Pressure | 16 |
| Priorities | 11 |
| Problem Solving Problem Posing | 44 |
| Puzzles | 6 |
| Project | 2 |
| Proof | 4 |
| Proper Course Placement | 5 |
| QUESTIONS | 12 |
| Answering Questions | 14 |
| Answering Correctly | 94 |
| Incorrect or no response | 34 |
| Responding to teacher question (non- | 10 |
| Asking another student about a problem | 11 |
| Declining to answer teacher request | 4 |

| | |
|---|---|
| Proximity Question | 7 |
| Questions about teacher practice | 8 |
| Relying on a peer to answer teacher | 7 |
| Student asking a question | 100 |
| Teacher Questions | 4 |
| Teacher asking how or why | 40 |
| Teacher asking if an answer is correct | 12 |
| Teacher asking questions of class | 118 |
| Questioning technique | 36 |
| Quizzes | 64 |
| Real world or real life | 4 |
| Reasons for taking a course | 9 |
| Recognition | 2 |
| Relatedness | 2 |
| Remembering | 65 |
| Researcher Comments | 30 |
| Researcher asking a question about why | 16 |
| Researcher chatting with student | 25 |
| Response to poor result | 2 |
| Review Day | 11 |
| Reviewing old material | 104 |
| Rewrites and Makeups | 31 |
| Role Shift | 4 |
| Self-regulation or will power | 1 |
| Showing work | 10 |
| Specific Topics | 11 |
| Speed of explanation | 13 |
| Story | 8 |

| | |
|---|---|
| Strategy (or lack of) | 82 |
| How to start a question | 14 |
| Student Responsibility for Learning | 24 |
| Student choice or autonomy | 14 |
| Student explaining solution to class | 5 |
| Student likes and dislikes | 25 |
| Student observing the teacher helping a peer | 1 |
| Student preferences | 38 |
| Students commenting on peers' work | 5 |
| Students getting bored or restless | 24 |
| Students getting up | 37 |
| Students having difficulty | 121 |
| Student being confused | 21 |
| Students looking at other students | 33 |
| Students volunteering information | 12 |
| Studying | 12 |
| Doing Practice Questions | 37 |
| Reading Notes | 15 |
| Submitting assignments | 45 |
| Suggesting strategy for studying | 25 |
| Surveys | 8 |
| TOC | 14 |
| Taking Notes | 121 |
| Talking about math with peers | 22 |
| Talking about other students | 5 |
| Talking about what is hard or easy | 27 |
| Talking through a problem | 16 |
| Talking to another teacher about a student | 1 |

| | | | | |
|---|---|---|---|---|
| Teacher Expectations | 35 | | Tests | 109 |
| Rules | 11 | | Textbook | 41 |
| Teacher Humour | 16 | | Thinking | 4 |
| Teacher Solving | 71 | | Time | 58 |
| Teacher circulating | 26 | | Trying questions | 97 |
| Teacher comment on student question | 1 | | Understanding | 66 |
| Teacher didn't hear or see student | 8 | | Using Notes | 37 |
| Teacher error | 8 | | Using manipulatives | 10 |
| Teacher gets distracted or goes off-topic | 3 | | Using student work | 17 |
| Teacher giving a lesson | 30 | | Values | 7 |
| Teacher giving info about test | 24 | | Videos | 5 |
| Teacher interrupting | 44 | | Volunteering Answers | 64 |
| Teacher leaves room | 8 | | Wait Time | 4 |
| Teacher mood or affect | 22 | | Waiting for the teacher to do it | 21 |
| Teacher prompt or hint | 29 | | Wanting 'perfect' notes | 5 |
| Teacher providing rationale | 23 | | Wanting the teacher to provide the answer | 5 |
| Teacher restating student explanation | 15 | | Wanting to finish | 13 |
| Teacher suggesting a method | 30 | | What is Math about | 2 |
| Teacher talking to researcher | 22 | | What is important for life | 2 |
| Technology | 32 | | Whispering answers | 4 |
| Telling Mathematical Rules | 10 | | Whispering to another student | 33 |
| Test - getting extra time | 9 | | Workload | 5 |

# Appendix D.

# Problem-solving tasks

### The 'Frogs' Problem

The leap frog problem. There are three red frogs and three green frogs  and 7 lily pads. The green frogs are at one end and the red frogs are at the other and there is one empty lily pad between them. The goal is to get each group of three frogs to the opposite side by either jumping over one frog, or sliding one spot onto an empty lily pad. The frogs can only move in one direction (towards the opposite side from where they started. The students used whiteboard maker caps to represent the frogs.

### The 'Seven Rings' Problem

You have to stay in a hotel for 7 nights outside your city, but you will not have money until your brother arrives at the end of the 7 days. You have a valuable gold chain formed by 7 linked rings. The manager at the hotel agrees to let you stay for the price of one link per day, but you must pay him every day (he does not trust you to pay at the end and you do not trust him to honour your deal if you give him the chain in advance). At the end of your stay the manager has agreed to let you trade the money your brother is bringing to get your chain back. The chain decreases in value with every cut. What is the minimum number of cuts that need to be made?

### The 'Checkers' Problem

You have ten pen caps in a row. The goal is to stack them two high. You can jump two pen caps at a time (two singles or one double) to land on another cap. Once stacked, you can't unstack.

### The 'Die Hard' Problem

You have an 8 cup measure full of water, an empty 3 cup measure and an empty 5 cup measure. How do you get exactly 4 cups of water?

### The ‘Two Mathematicians’ Problem

Two mathematicians are each assigned a positive integer. They are told that the product of the two numbers is either 8 or 16. Neither knows the other's number. This is their conversation:

| | |
|---|---|
| First mathematician: | "I don't know your number." |
| Second mathematician: | "I don't know your number." |
| First mathematician: | "Give me a hint." |
| Second mathematician: | "No, you give me a hint." |

At this point, one of the mathematicians knows the other's number. Assuming that they always tell the truth and do not guess, what is the number and who has it?

### The ‘Nim’ Problem

You and a partner have a pile of 21 counters between you. You take turns removing counters from the pile. On each turn, you can take 1, 2, or 3 counters. The winner is the player who takes the last counter. (You can also switch it so that the loser is the one who takes the last counter)