

# **A Functional Analysis and Recommendations for Information Systems to Support the Department of Chemistry at Simon Fraser University**

by

**Shad Grunert**

B.Sc., University of British Columbia, 2006

Project Submitted in Partial Fulfillment of the  
Requirements for the Degree of  
Master of Business Administration

in the

Management of Technology Program  
Faculty of Business

**© Shad Grunert 2016**

**SIMON FRASER UNIVERSITY**

**Summer 2016**

All rights reserved.

However, in accordance with the *Copyright Act of Canada*, this work may be reproduced, without authorization, under the conditions for Fair Dealing. Therefore, limited reproduction of this work for the purposes of private study, research, education, satire, parody, criticism, review and news reporting is likely to be in accordance with the law, particularly if cited appropriately.

## Approval

**Name:** Shad Grunert  
**Degree:** Master of Business Administration  
**Title:** *A Functional Analysis and Recommendations  
for Information Systems to Support  
the Department of Chemistry  
at Simon Fraser University*

**Supervisory Committee:**

**Dr. Blaize Horner Reich**  
Senior Supervisor  
RBC Professor of Technology  
and Innovation



---

**Andrew Harries, MBA**  
Second Reader  
Tom Foord Professor  
of Practice in Entrepreneurship  
and Innovation



---

**Date Approved:**

August 8th, 2016

---

## **Abstract**

A functional analysis of the information systems used in support of the teaching program of the Department of Chemistry at Simon Fraser University was undertaken. The portfolio of applications was considered from the context of theoretical frameworks and models to facilitate better understanding of the current information technology environment of the department. Underlying management and operational processes supported by information systems are parsed out for comparison to process solutions across the Faculty of Science. Recommendations and an implementation plan for modernization of business processes and the supporting information systems are presented.

## **Dedication**

For my parents, Howie and Karen.

## **Acknowledgements**

The author would like to thank all of the staff, faculty, and students at the Department of Chemistry at Simon Fraser University for their support. The author would also like to thank the dozens of members of the university community across numerous academic and support departments for taking the time to explain how the rest of the university operates.

The author would especially like to thank Dr. Blaize Reich for her guidance and feedback over the course of this project.

# Table of Contents

Approval .....	ii
Abstract .....	iii
Dedication .....	iv
Acknowledgements .....	v
Table of Contents .....	vi
List of Tables .....	viii
List of Figures .....	ix
List of Acronyms .....	x
Glossary .....	xi
<b>Chapter 1. Introduction .....</b>	<b>1</b>
1.1. Organization Background .....	2
1.2. Purpose, Structure, and Scope .....	3
<b>Chapter 2. Research Method and Literature Review .....</b>	<b>5</b>
2.1. Research Method .....	5
2.2. Literature Review .....	6
2.2.1. Information Systems Strategy .....	6
2.2.2. Evaluation of Applications .....	10
2.2.3. Implementation Planning Tools .....	11
<b>Chapter 3. External Analysis .....</b>	<b>16</b>
3.1. Metro Vancouver Higher Education Institutions .....	17
3.2. Simon Fraser University Information Systems .....	18
3.3. Faculty of Science .....	23
3.3.1. FacSIMS and the Faculty of Science .....	24
3.3.2. Canvas and SIMS in the Faculty of Science .....	25
3.3.3. FileMaker in Biology .....	26
3.3.4. LON-CAPA in Mathematics .....	27
3.3.5. Innovative Systems .....	27
<b>Chapter 4. Internal Analysis .....</b>	<b>29</b>
4.1. Organizational Function .....	29
4.2. Functional Information Systems .....	30
4.2.1. FacSIMS .....	30
4.2.2. Marks Database .....	35
4.2.3. LON-CAPA .....	36
4.2.4. Canvas .....	37
4.2.5. Scantron .....	38
4.2.6. Excel .....	38
4.3. Strengths and Weaknesses of Current Systems .....	38
4.3.1. FacSIMS .....	39

4.3.2.	Marks Database .....	39
4.3.3.	Canvas .....	40
4.3.4.	LON-CAPA .....	40
4.3.5.	Scantron .....	42
4.3.6.	Excel.....	43
4.4.	Internal Analysis Summary .....	44
<b>Chapter 5.</b>	<b>Success Criteria, Options, and Implementation.....</b>	<b>47</b>
5.1.	Success Criteria .....	47
5.1.1.	Data Integrity .....	47
5.1.2.	Minimal Disruption.....	49
5.1.3.	Minimal Cost.....	49
5.1.4.	Value to Staff.....	50
5.1.5.	Value to Students .....	51
5.2.	Alternative Options .....	52
5.2.1.	Option #1: Adoption of Canvas-SIMS Grades Submission Process .....	52
5.2.2.	Full Replacement of LON-CAPA with Canvas .....	56
5.2.3.	Option #3: Replacement of FacSIMS.....	60
5.3.	Assessment of Options.....	64
5.4.	Strategic Impact.....	66
5.5.	Implementation .....	67
<b>Chapter 6.</b>	<b>Conclusion.....</b>	<b>72</b>
<b>References .....</b>		<b>74</b>
<b>Appendices .....</b>		<b>79</b>
Appendix A .....		80
University of British Columbia.....		80
Kwantlen Polytechnic University.....		81
Capilano University.....		81
Douglas College .....		81
Langara College .....		82
Appendix B .....		83
Biological Sciences.....		83
Physics 83		
Mathematics .....		85
Biomedical Physiology and Kinesiology .....		85
Earth Sciences .....		86
Molecular Biology and Biochemistry.....		86
Statistics and Actuarial Science .....		87
Appendix C.....		88

## List of Tables

Table 2.1.	Strategic Alignment Model perspectives .....	9
Table 2.2.	Major stages in proposed theory of change with unpacked steps .....	14
Table 3.1.	Metro Vancouver higher education institution information systems.....	18
Table 3.2.	Overview of central university information systems .....	23
Table 3.3.	Information system use in the Faculty of Science at SFU .....	24
Table 4.1.	Overview of information system functions, strengths, weaknesses.....	45
Table 5.1.	Assessment of the option to modify the grades submission process .....	55
Table 5.2.	Assessment of the option to replace LON-CAPA with Canvas.....	59
Table 5.3.	Assessment of the option to replace FacSIMS .....	64
Table 5.4.	Comparison of three options presented on meeting success criteria .....	65



## List of Figures

Figure 2.1.	IS Strategic Grid (McFarlan et al., 1983, modified by Author) .....	6
Figure 2.2.	Strategic alignment model (Henderson and Venkatraman, 1993, modified by Author).....	8
Figure 2.3.	TAM 2 with additional social influences (Venkatesh and Davis, 2000, modified by Author).....	12
Figure 3.1.	Levels of the external operating environment of the Department of Chemistry .....	16
Figure 3.2.	Historical flow of information between SIMON and FacSIMS.....	20
Figure 3.3.	Modern flow of information between SIMS and FacSIMS .....	21
Figure 3.4.	Grades approval process in other departments in the Faculty of Science .....	26
Figure 4.1.	Grades approval process in the Department of Chemistry .....	32
Figure 4.2.	TA and RA Application and Assignment Process .....	34
Figure 5.1.	Proposed three-semester change implementation timeline.....	68

## List of Acronyms

AFTE	Academic Full-Time Equivalent
BPK	Biomedical Physiology and Kinesiology
BPM	Business Process Management
CMS	Course Management System
CRM	Customer Relationship Management
ERP	Enterprise Resource Planning
FIPPA	Freedom of Information and Protection of Privacy Act
GPA	Grade Point Average
IS	Information System
IT	Information Technology
KPU	Kwantlen Polytechnic University
LMS	Learning Management System
MBB	Molecular Biology and Biochemistry
RA	Research Assistant
SaaS	Software as a Service
SFU	Simon Fraser University
SIS	Student Information Service
SQL	Structured Query Language
TA	Teaching Assistant
TAM	Technology Acceptance Model
UBC	University of British Columbia

## Glossary

AWS	Amazon Web Services
CourSys	Faculty of Applied Science student information and administrative planning and control system
CSV	Comma Separated Value file-type
FacSIMS	Faculty of Science student information and administrative planning and control system
FINS	Central university financial management enterprise system
HAP	Central university human resources enterprise system
LON-CAPA	Department of Chemistry online course management system
SIMS	Central university student information database enterprise system
TRACS	Beedie School of Business student information and administrative planning and control system
TXT	Text format file-type
XLS	Excel file-type

## **Chapter 1. Introduction**

The purpose of this paper is to provide a critical analysis of the information systems (IS) used in support of the undergraduate teaching program of the Department of Chemistry at Simon Fraser University (SFU). The current situation is a combination of decades-old incumbent systems and an ownership structure predisposing the department to severe service interruptions.

Over the past year, the department has experienced significant pains arising from a confluence of the above-mentioned systems ownership structure and unforeseen, yet likely expectable, human resources issues. Instructors and staff were often left scrambling to ensure that course management systems (CMS) were functional for student use, marking systems were in place for exam processing, and databases were at least minimally functional to allow for submission of final grades. This analysis seeks to explain how the weaknesses of the incumbent application portfolio and lack of strategic information technology (IT) planning precipitated these issues when they should have long been foreseen. An internal analysis of the information systems and business processes in place in the Department of Chemistry reveals significant shortfalls that were previously hidden from sight by the system ownership structure. An external analysis shows how the SFU operating environment has changed significantly while departmental processes have remained unchanged, creating new gaps in old approaches that were once entirely appropriate. An analysis of the business process approaches followed by other departments within and outside the Faculty of Science further supports the notion of a superannuated teaching program application portfolio in the Department of Chemistry. At the same time, this external analysis provides alternative operational models for study and possible implementation.

A series of structural and process changes are presented, each taking into consideration certain factors identified as being of critical importance to a successful

change plan implementation in the department. An implementation plan is suggested as part of a larger proposed realignment of the departmental approach to IS/IT strategy.

## **1.1. Organization Background**

SFU is the second largest university in British Columbia, with an enrolment of 29,591 part-time, full-time, and distance education undergraduate students across three campuses in Metro Vancouver in the 2015/16 academic year (Simon Fraser University, 2016). The university is organized into eight academic faculties and schools, one of which is the Faculty of Science. The Faculty of Science comprises eight departments, of which the Department of Chemistry is the fourth largest. With the dual mission of undergraduate instruction and novel scientific research, the Department of Chemistry employs 30 research faculty, nine teaching faculty, and 20 technicians and support staff.

The core purpose of the undergraduate teaching program in the Department of Chemistry is to educate students and to assess learning through administration of assignments and examinations. To be able to best serve the needs of students and provide prompt feedback on performance, reliable information systems need to be in place for the recording and tracking of grades over the course of a semester. Similarly, information systems must be effective in delivering complementary instructive and evaluative content for remote student access in the form of online reading materials and quizzes. Ultimately, the final grade a student receives in a given course must be submitted to the Student Services to be recorded on the student's official university transcript.

Support for both the teaching and research programs is provided by departmental administrative and managerial staff. Human capital, space management, and other resource planning and allocation activities are facilitated through use of information systems developed in-house.

As a public institution, the employees of the university are accountable to the government and taxpayers of British Columbia. Within the government mandate (Brewster, 2015), the university is expected to operate efficiently and in a cost-conscious

manner. The department can ill afford operational disruptions given the stringent scheduling of the academic semester. An informed analysis and selection of information technology in support of information systems and business processes will allow the department to increase cost-efficiency while minimizing downtime.

## **1.2. Purpose, Structure, and Scope**

An analysis of the current application portfolio in the Department of Chemistry can serve to inform a modernization drive, supplanting processes borne from an era when the external operating environment differed significantly from that of today. Through rationalization and modernization of business processes, the department can realize immediate efficiency gains. By undertaking this internal analysis and committing to change, the department can better prepare for expected externally-imposed change arising from the continued evolution of the IT environment of the university. Further, the department can prevent unrelated HR issues from spilling over to IS/IT issues through a strategic realignment and focus on core competencies.

This report provides a high-level overview of the information systems supporting the business processes of the Department of Chemistry. Conceptual frameworks are presented to facilitate understanding of the purposes the different information systems serve in the administrative and operational processes of the department. Through consideration of the external university operating environment, a series of recommendations are made to rationalize and modernize these information systems.

Chapter 2 of this report serves as a review of the pertinent literature around information systems theory, technology selection and acceptance in organizations, and change management. The interview method of data collection is described in this section.

Chapter 3 examines the external operating environment of the Department of Chemistry, considered for this analysis to be limited to the wider university. The approaches to similar business needs followed by peer organizations at the university

are presented for the sake of comparison. This is preceded by a brief overview of the information systems selections of local higher education institutions.

Chapter 4 provides a broad overview of key departmental information systems and the business needs they serve, followed by a brief discussion on issues arising from the use of these systems.

Chapter 5 presents success criteria derived from the above analyses and communicated to the author in interviews, followed by a series of alternative change plans. An assessment of the alternative options is followed by the recommended plan of action and a proposed implementation pathway.

This report is limited to the information systems in place to support the teaching program of the Department of Chemistry. The key academic processes concerned are educational content delivery, student assessment, and submission of student grades to the appropriate central university department. Administrative planning and control information systems that support academic instructional activities are also considered in this analysis as they are vital to the smooth operation of the teaching program.

While of significant relevance, the information systems in place to support the scientific research program of the department are outside the scope of this analysis. Though other departments in the Faculty of Science, and even across the university, might benefit from a broader functional analysis, this narrow analysis serves to examine gaps in the information systems portfolio solely within the Department of Chemistry.

## **Chapter 2. Research Method and Literature Review**

This section provides an overview of the research methodology employed in collection of information from faculty and staff in the department. This is followed by a brief overview of the theoretical models and frameworks applied in this analysis.

### **2.1. Research Method**

The fit and function of the application portfolio was elicited through a series of interviews across the full spectrum of departmental stakeholders. Approximately 25 individuals within the Chemistry department were interviewed, including support staff, administrative staff, instructors, teaching assistants (TAs), and current undergraduate students. The interview format was relatively informal and unstructured, with a friendly conversational approach taken in lieu of a rigid set of questions. Questioning focused primarily on the systems used by an individual and their experiences, positive or negative, with those systems. Approximately 15 individuals in other departments across the Faculty of Science were interviewed, with questioning focused both on user experience with faculty-wide systems and on approaches to business processes common across different departments. Another ten interviews were carried out with staff from a variety of functional divisions across the university, including multiple academic faculties and central university support groups. As far as possible, interview subject anonymity is preserved. There are instances where job titles or functions preclude absolute anonymity. The information gathered from these interviews is supplemented with the knowledge and experience of the author as an employee in the Department of Chemistry for approximately three years.



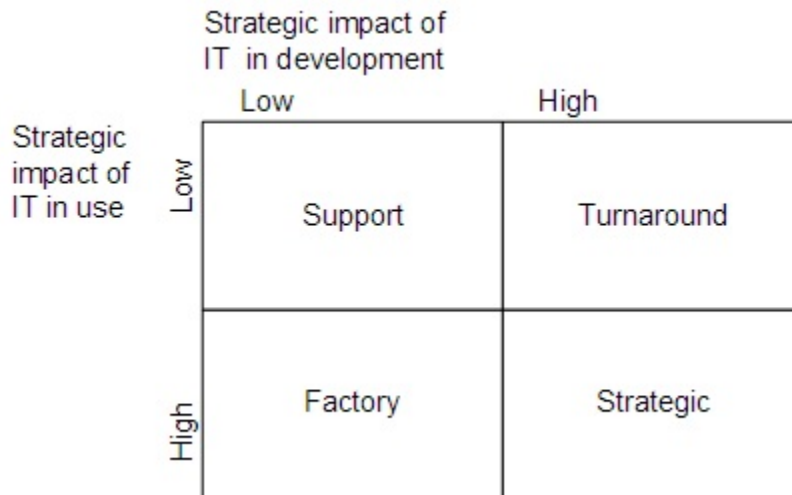
## 2.2. Literature Review

The following section provides an overview of the relevant research literature and theoretical models applied in this report.

### 2.2.1. Information Systems Strategy

McFarlan, McKenney, and Pyburn (1983) proposed that there are four general IS/IT environments: Support, Turnaround, Factory, and Strategic. A framework to organize these four environments relative to one another, presented below in Figure 2.1, considers the strategic impact of both existing operating systems and that of the applications in the development pipeline.

**Figure 2.1. IS Strategic Grid (McFarlan et al., 1983, modified by Author)**



McFarlan et al. suggest that this framework is useful for strategic planning as an introspective tool, affording management a better understanding of the role IS plays in the organization and if that role is aligned with the stated business strategy. As the organization perceives and responds to changes in the external environment, the strategic role of IS can move around the grid.

Ward (1990) extended this strategic grid framework to a portfolio approach for IS analysis and planning. He suggests that applications and key success measures must

be considered differently depending on where they fall in the IS application portfolio, with high potential Turnaround systems requiring a similar management as in R&D environments, Strategic systems being deployed in a full-firm strategy push, Factory systems properly integrated to maintain efficiency, and Support systems being carefully managed to not consume a disproportionate amount of scarce resources. This understanding of how applications in each quadrant of the strategic grid should be managed must also be extended to how the firm prioritizes development and support activities. Ward suggests the three most important factors to consider in assigning priorities are benefits expected, resources required, and potential risks. While applications in different quadrants require particular approaches to quantify benefits and risks, Ward (1990) suggests the whole IT portfolio be ranked and prioritized according to the following ratio:

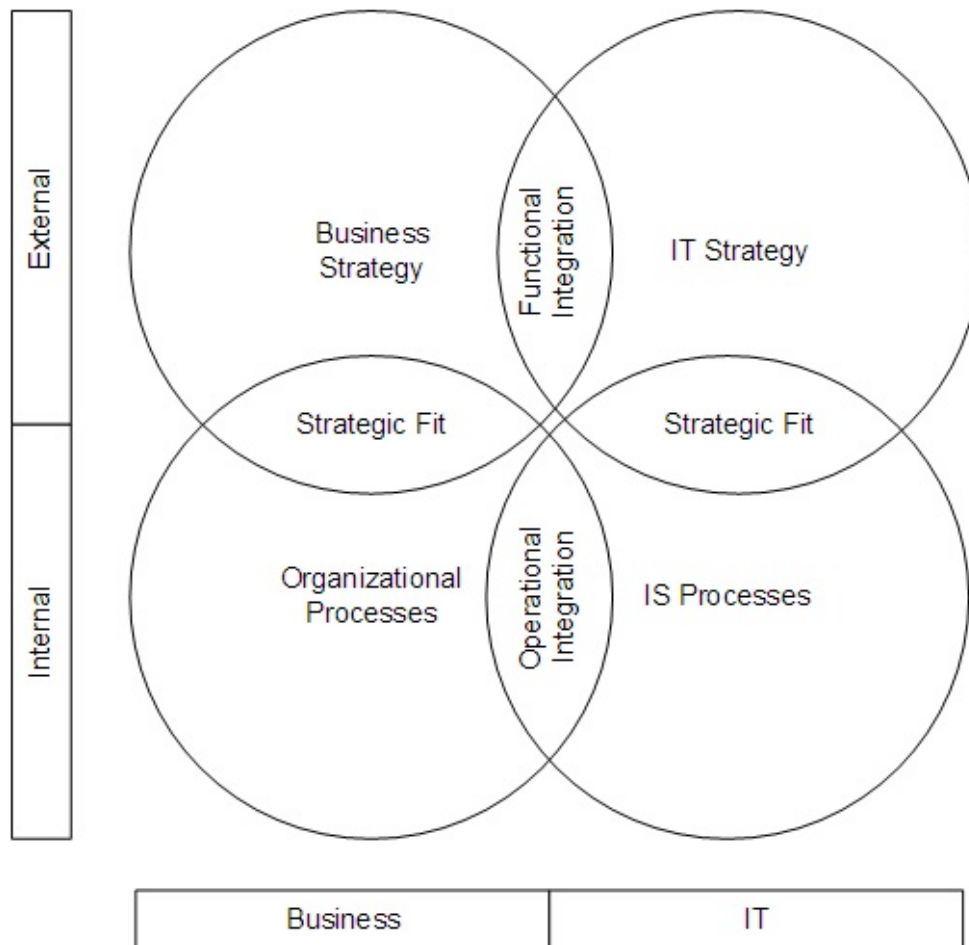
$$\frac{\textit{Benefits to be achieved (adjusted for risk)}}{\textit{Limiting resources consumed}}$$

In this analysis, the strategic grid model will be applied to facilitate an understanding of the current approach of the Department of Chemistry to IT. By connecting the application portfolio back to the organizational processes carried out, the strategic importance of those processes can be deduced. Any mismatch between the importance of the process and the reliability of supporting IT should then become clear. An example of such a mismatch would be the use of unreliable, faulty applications (that might be acceptable for the Support quadrant) for high-importance processes in the Factory quadrant. In addition to providing an understanding of IT in the department today, the strategic grid model will be used to suggest the approach the department should take moving forward. Ward's concepts of realizable benefits, required resources, and potential risk are used in generating criteria to be used in the evaluation of alternative change plans.

Whereas following a project prioritization model as shown above should allow for the most worthwhile applications to be developed and deployed, Henderson and Venkatraman (1993) evolved a more nuanced approach to understanding the role IS/IT plays in an organization with their Strategic Alignment Model (SAM). This model considers the internal and external components of both the business and IT. They

consider the external business aspect to be business strategy while the internal aspect is the combination of organizational structure and enabling business processes. The internal aspect of IT is then the IS in place to support the organizational structure and processes, while the external aspect is deployable technology to enact business strategy. This model can be visualized as shown in Figure 2.2 below.





**Figure 2.2. Strategic alignment model (Henderson and Venkatraman, 1993, modified by Author)**



Henderson and Venkatraman propose that IT is integrated in the business in two different ways: *strategic integration* is how IT supports and informs the strategic plans of the company, and *operational integration* is how internal IS supports the internal structure and processes of the company. They suggest that there are four major types of alignment perspectives, each with a driver from a given quadrant that leads to

dependencies on other quadrants. These perspectives can be represented visually by drawing an arrow from the quadrant that informs competitive approach through to how the company realizes that competitive strategy. A description of the four alignment perspectives is shown in Table 2.1 below.

**Table 2.1. Strategic Alignment Model perspectives**

SAM Quadrant Path	Alignment Perspective	Description
	Strategy Execution	Business strategy dictates organizational infrastructure, necessitating a given IS infrastructure
	Technology Transformation	Business strategy informs IT strategy, dictating IS infrastructure
	Competitive Potential	Available IT informs business strategy, dictating organizational infrastructure
	Service Level	Available IT dictates IS infrastructure, necessitating a given organizational infrastructure

Contemplation of strategic drivers through the lens of the SAM affords managers an understanding of the actual perspective of the firm. If it differs from the stated strategy, either strategy or the internal IS/IT environment can be modified to better align the two, ensuring that all divisions are following the same vision to the same ends.

In concert with the strategic grid model, the strategic alignment model will be applied in this analysis in order to deduce the IS strategy that the department appears to be following. The reasoning behind the strategic direction will be examined and suggestions made on realignment to a perspective that better suits the wants and needs of the department.

## 2.2.2. Evaluation of Applications

For user-facing technology, application interface design is an important consideration. In a 2013 edition of his seminal 1988 work *The Design of Everyday Things*, Norman deconstructs an individual's interaction with an object in their environment to seven separate steps in what he terms the action cycle (Norman, 2013). Beginning with a goal of what they want their action to achieve, such as making a set of lights go on, an individual goes through the steps of planning, specifying, and interacting with an object in their space. They then go through stages of perceiving, interpreting, and comparing the changed state of the space to what they had intended their goal to be, such as if the lights turned on or not. While this idea of the action cycle is fairly abstract, Norman suggests that it holds true for all user-object interactions. He realized that at each stage of the action cycle, an individual is searching for an answer to a question, such as what they want to do, how are they able to do it, did their action have the desired effect, and so on. Ultimately, this led him to propose his seven fundamental principles of design:

1. Discoverability: It is possible to determine what actions are possible and the current state of the device.
2. Feedback: There is full and continuous information about the results of actions and the current state of the product or service. After an action has been executed, it is easy to determine the new state.
3. Conceptual model: The design projects all the information needed to create a good conceptual model of the system, leading to understanding and a feeling of control. The conceptual model enhances both discoverability and evaluation of results.
4. Affordances: The proper affordances exist to make the desired actions possible.
5. Signifiers: Effective use of signifiers ensures discoverability and that the feedback is well communicated and intelligible.
6. Mappings: The relationship between controls and their actions follows the principles of good mapping, enhanced as much as possible through spatial layout and temporal contiguity.
7. Constraints: Providing physical, logical, semantic, and cultural constraints guides actions and eases interpretation. (Norman, 2013)

In this analysis, Norman's principles of good design will be used to evaluate and compare the design elements of IT applications and how they affect usability. Where the elements of good design are followed, the user is more likely to perceive a particular application as user-friendly and intuitive. These levels of user-friendliness and intuitiveness are considered as among the relative strengths and weaknesses of the existing departmental application portfolio and potential alternative systems available for use.

A concept that goes some way in explaining why a particular application embodies elements of good design is that of *core competence*, which Prahalad and Hamel (1990) outlined in their thinking as not necessarily being the strength of the firm in one particular product or offering, but as represented in the institutionalized learning and expertise in a particular field or process. Thus, one well-designed, user-friendly application does not a core competence make, but instead a core competence of user-centric design is manifest in every product. A key element of business strategy is recognition of the core competencies of the organization, with outsourcing of non-core functions to more capable suppliers thereby affording the firm a greater focus on doing what it does best. Whether strategic alignment is directed by available technology or business strategy, acting on strategic plans through technology acquisition can benefit from an understanding of the core competencies of the organization (Torkkeli and Tuominen, 2002). This introspective view helps the firm consider make-or-buy decisions in pursuit of technology and applications that reinforce core competencies, thereby providing or preserving competitive advantage.

While the concept of core competencies will be used in this analysis to infer the intuitiveness of IT application design, it also will be tied back to the larger discussion of the strategic direction of the Department of Chemistry.

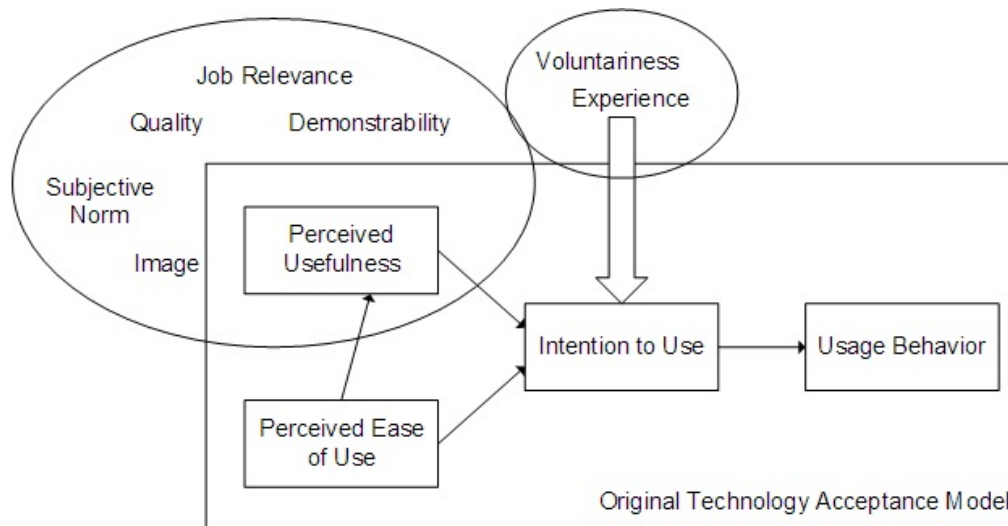
### **2.2.3. Implementation Planning Tools**

In his 1985 Ph.D. dissertation, Davis put forth his original Technology Acceptance Model (TAM). This first model is comprised of four constructs: "Perceived Ease of Use", "Perceived Usefulness", "Attitude Toward Using", and "Actual System

Use”. From this starting point, where user perceptions inform an individual’s attitude toward system use, Davis, Bagozzi, and Warshaw (1989) extended the TAM through incorporation of the additional construct “Behavioural Intention to Use” as proposed by Fishbein and Ajzen as part of their Theory of Reasoned Action model (1975). In the extended TAM, a positive or negative attitude toward technology use informs that behavioural intention to use, leading to either actual system usage or avoidance.

Noting social influences and situational factors that may compel an individual in an organization to use a particular application, Venkatesh and Davis elaborated on the extended original model with the TAM 2 (2000), shown in Figure 2.3.

**Figure 2.3. TAM 2 with additional social influences (Venkatesh and Davis, 2000, modified by Author)**



Regardless the number of external factors that are proposed to influence a user, the core TAM remains a powerful tool in explaining observed organizational acceptance of novel systems.

The concepts of TAM will be used in this analysis to extrapolate from interviews why some applications have gone relatively unused in the Department of Chemistry. Further, the external factors from TAM 2 will be used in proposed change implementation plans to suggest means by which the department can achieve high levels of usage of new and different applications.

In a purely economic world, rational actors within an organization would choose the application portfolio that provides the greatest benefit per unit of cost. They would then use those applications regardless their perceptions of ease of use, usefulness, and interface design. The field of behavioural economics provides a counterpoint to this economic world, where the psychologies of non-economic humans influence behaviour.

Samuelson and Zeckhauser (1988) carried out a series of experiments to show that on being presented with a decision, even one where a change option is objectively more beneficial than the norm, individuals exhibit a persistent status quo bias. Some of their proposed core components of this observed bias include

- lack of realization that there is even a decision that can be made
- expected benefits from change are less than perceived search and transition costs
- assumption that the reasoning of others in arriving at the current status quo was valid and well-considered, so there must be no reason to change
- deference to self in trusting own previous decision to select the current status quo must be correct, so there must be no reason to change (self-perception theory)
- downside risks arising from change perceived more acutely than potential upside gains, so change is avoided as a net negative (endowment effect)
- economically-irrational consideration of past expenditures on the status quo (sunk cost effect)

As with TAM, the concepts of status quo bias theory will be used to both explain why the application portfolio of the Department of Chemistry has remained unchanged for so long and how this inertia can be overcome moving forward.

In the event that an organization does decide on change over status quo, it must be remembered that an organization is comprised of individuals who may each be resistant to change. Schein (1996), building on the pioneering work of Kurt Lewin in the field of change theory, developed and proposed what he called an “unpacking” of the stages of change. He noted that while Lewin identified “unfreezing”, “changing”, and



“refreezing” as the three main stages in change, each of the stages can be further described by a series of psychological steps (Table 2.2).

**Table 2.2. Major stages in proposed theory of change with unpacked steps**

Stage 1: Unfreezing	Disconfirmation
	Creation of survival anxiety or guilt
	Creation of psychological safety to overcome learning anxiety
Stage 2: Changing	Imitation and identification with role models
	Scanning for solutions and trial and error learnings
Stage 2: Refreezing	Incorporating into self concept and identity
	Incorporating into ongoing relationships and groups

The disconfirmation step in unfreezing is the receipt and acceptance of some information that the current state is somehow not optimal, a step noted by Schein as crucial since disconfirming information can be easily dismissed, ignored, or blamed on external factors by the individual. Once it is accepted that the current state is not ideal, the individual can feel guilt that the situation is what it is and will therefore be driven to change. However, this guilt or anxiety may not be enough to overcome the restraint of learning anxiety, a feeling that undertaking change can be an admission that something was being done wrong but that any change can strip one of their formed sense of self in the new, changed paradigm. The third part of unfreezing then is being able to feel safe enough to overcome this anxiety. Once accepting that change is necessary, the individual can look to role models that exhibit the desired state of being. In addition to (or in the absence of) role models, the individual motivated to change can attempt to inhabit new behaviours and beliefs through trial and error until confirmatory signals are received. Finally, the individual comes to accept and internalize their new state as part of their identity. This leads to reinforcement through interaction and incorporation of the new behaviour or belief within the group or society.

While abstract in theory, Schein (2002) quotes case study showing how an understanding of the stages of change allowed a manager to smoothly transition to a new IT hardware infrastructure where once there had been great resistance to change.

Change theory will be considered in the implementation section of this analysis so as to craft a plan for the Department of Chemistry that has the best chance of meeting with success. A technically sound plan that does not receive buy-in from members of the organization is more likely than not to fall flat on implementation.

Among many management philosophies, including Six Sigma, Lean, and Agile, lies Business Process Management (BPM). BPM is an approach that emphasizes an introspective view of the processes that deliver value to the customer with an eye on constantly improving efficiency through the reasoned deployment of technology. . In order to make sense of the myriad BPM success and failure stories coming out of industry, Trkman (2010) sought to define some of what he perceived to be the theoretical underpinnings of the BPM movement. In doing so, he found that the factors most often associated with successful BPM programs could be classified into one of three broader organizational theory spaces:

- Contingency Theory: there is no perfect organizational structure, only optimal styles that are contingent on the particulars of the current operating environment
- Dynamic Capabilities: persistent competitive advantage depends upon the ability of the organization to reorganize and redeploy resources in response to constant changes in the operating environment
- Task-Technology Fit: the degree to which technology facilitates job tasks depends on the degree of alignment between the nature of the task, the skills of the individual, and the capabilities of the technology in use

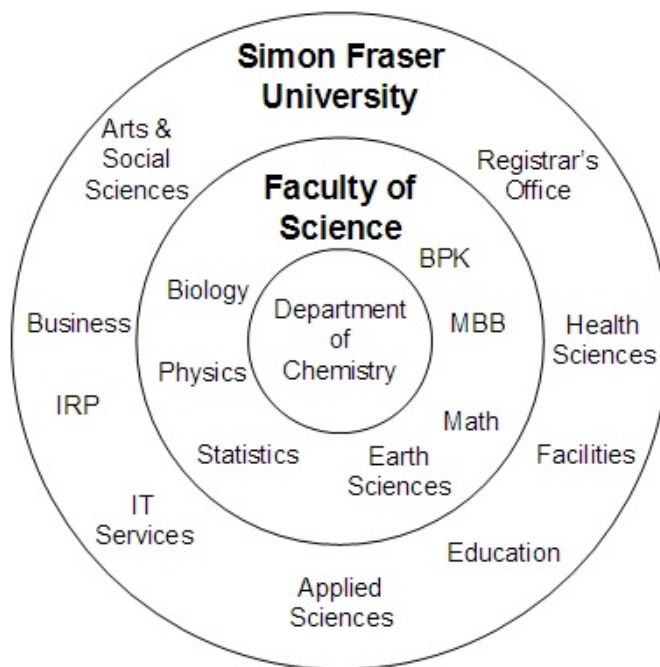
In a case study of a BPM program in the banking sector, Trkman identified the particular critical success factors of that situation and showed that they indeed could be classified according to the above organizational theory framework.

BPM will inform a great deal of the changes proposed in the options section of this analysis as part of a greater suggested realignment of IT strategy.

## Chapter 3. External Analysis

This section provides an analysis of the external environment in which the Department of Chemistry operates. Within the hierarchical structure of the university, the Department of Chemistry is but one of eight academic units in the Faculty of Science, itself but one of eight faculties at Simon Fraser University. In addition to the academic departments and faculties, there are numerous other operational and support divisions ensuring the smooth continued operations of the university. The relation of the Department of Chemistry to the rest of the university is represented graphically in Figure 3.1. There are many central university support divisions not included in this graphic.

**Figure 3.1. Levels of the external operating environment of the Department of Chemistry**



### **3.1. Metro Vancouver Higher Education Institutions**

Before an analysis of the operations and systems used at different divisions across SFU, it is instructive to look outside the university to the applications used at other local institutions of higher education. In addition to showing the breadth of systems in use in the Metro Vancouver area alone, this overview is meant to show that there are alternative systems the Department of Chemistry could look to use aside from those identified at SFU.

In the Metro Vancouver area, there are many community colleges, technical schools, art schools, colleges, and universities. From among this wide range of higher education institutions, there are five that share enough geographic and curricular similarities to be considered to operate in the same subspace of this sector as SFU: UBC, Kwantlen Polytechnic University, Capilano University, Douglas College, and Langara College. Though on the surface an arbitrary grouping unnecessarily excluding Trinity Western University, British Columbia Institute of Technology, and other apparently similar institutions in the area, there is experientially and anecdotally noted a significant degree of student flux between the five schools selected. Students often begin their studies at one of the colleges and transfer to a university to complete their degree. On completion of their studies at one university, students often apply to graduate school at the other in the area. Graduate students can even begin their teaching careers by seeking single-term instructional appointments at the local colleges.

A discussion on the history and information systems selection at each of the schools in this basket is provided in Appendix A. Summary information is presented below in Table 3.1. Enrolment numbers provided for UBC are for students in undergraduate programs while those for the remaining institutions are for students in all programs. For the sake of comparison, information for SFU has been added.

Table 3.1. Metro Vancouver higher education institution information systems

Institution	Annual Enrolment	SIS Provider	CMS Provider
SFU	29,591	Oracle PeopleSoft	Canvas
UBC	42,986	Developed in-house	Blackboard
KPU	19,000	SunGard Higher Education	Blackboard
Capilano University	7,000	Ellucian	Moodle
Douglas College	14,000	SunGard Higher Education	Blackboard
Langara College	20,615	Ellucian	Desire2Learn

What the above summary shows is that there is little consistency in student information system (SIS) or CMS selection across even the small subset of schools included in this study. Each institution must undertake an analysis of their needs and the costs of implementation to arrive at a suitable SIS or CMS decision; there is not one clear market leader that is synonymous with SIS or CMS in the same way the Microsoft Word is synonymous with word processing. The information system selection process for a higher education institution is apparently not as simple as identifying best of breed or benchmarking against the competition. An institution needs to look at the current application portfolio at the school to determine what other possible installations are even compatible, sensible, feasible, or cost effective. Regardless, there is a wide selection of software in use locally and a wider analysis yet of the Canadian or North American higher education sector would only grow this list. In making any decision on new IT deployments, the Department of Chemistry should include, but also look far outside, the confines of SFU.

### 3.2. Simon Fraser University Information Systems

In order to meet the student information, human capital, financial management, and other needs of all of the stakeholders at the university, SFU has three main enterprise system installations: SIMS (Student Information Management System), FINS (Financial Services), and HAP (Human Resources). Deployed in the early 2000's, all three systems are powered by Oracle PeopleSoft databases yet remain logically and functionally siloed. Over the past year the walls between these enterprise systems have become begun to crumble with limited synchronization of personnel information between

SIMS and HAP. This is but one example of how the university operating environment continues to evolve, ideally signalling to academic units the strong need to co-evolve. Where departmental processes depend on communication with one of these three central university systems, data transfer is typically effected through one of two pathways: direct synchronization for custom databases or shared network folders for manual file transfers. Automated synchronization jobs are scheduled to run as frequently as daily for time-sensitive information, such as for provision of up-to-date student lists during the fluid enrolment period at the beginning of a semester.

The antecedent to SIMS, SIMON, had a flat-file structure with limited functionality. Being so limited in functionality, SIMON could not meet the evolving needs of academic departments, such as requirements for grades queries for all students enrolled in a particular program. In order to better meet their own information needs, several departments undertook the in-house development of custom databases. With the rollout of SIMS, a new suite of online reporting and query tools rendered many of these departmental databases redundant. FacSIMS and Marks Database, two databases still in use in the Department of Chemistry (described in detail in section 4.2), provide a vivid example of this redundancy. Where the flow of grades information was once unidirectional from Marks Database through FacSIMS to SIMON, the new arrangement with regular back-synchronization from SIMS to FacSIMS ensures that the grades information in FacSIMS is unique for only a brief period. This evolution of the grades information flow in the SIMON and SIMS eras is shown in Figures 3.2 and 3.3. This suggests that the external operating environment of the Department of Chemistry has evolved over the past decades, suggesting that approaches and processes implemented in the era of SIMON are not necessarily efficient or appropriate today.

Figure 3.2. Historical flow of information between SIMON and FacSIMS

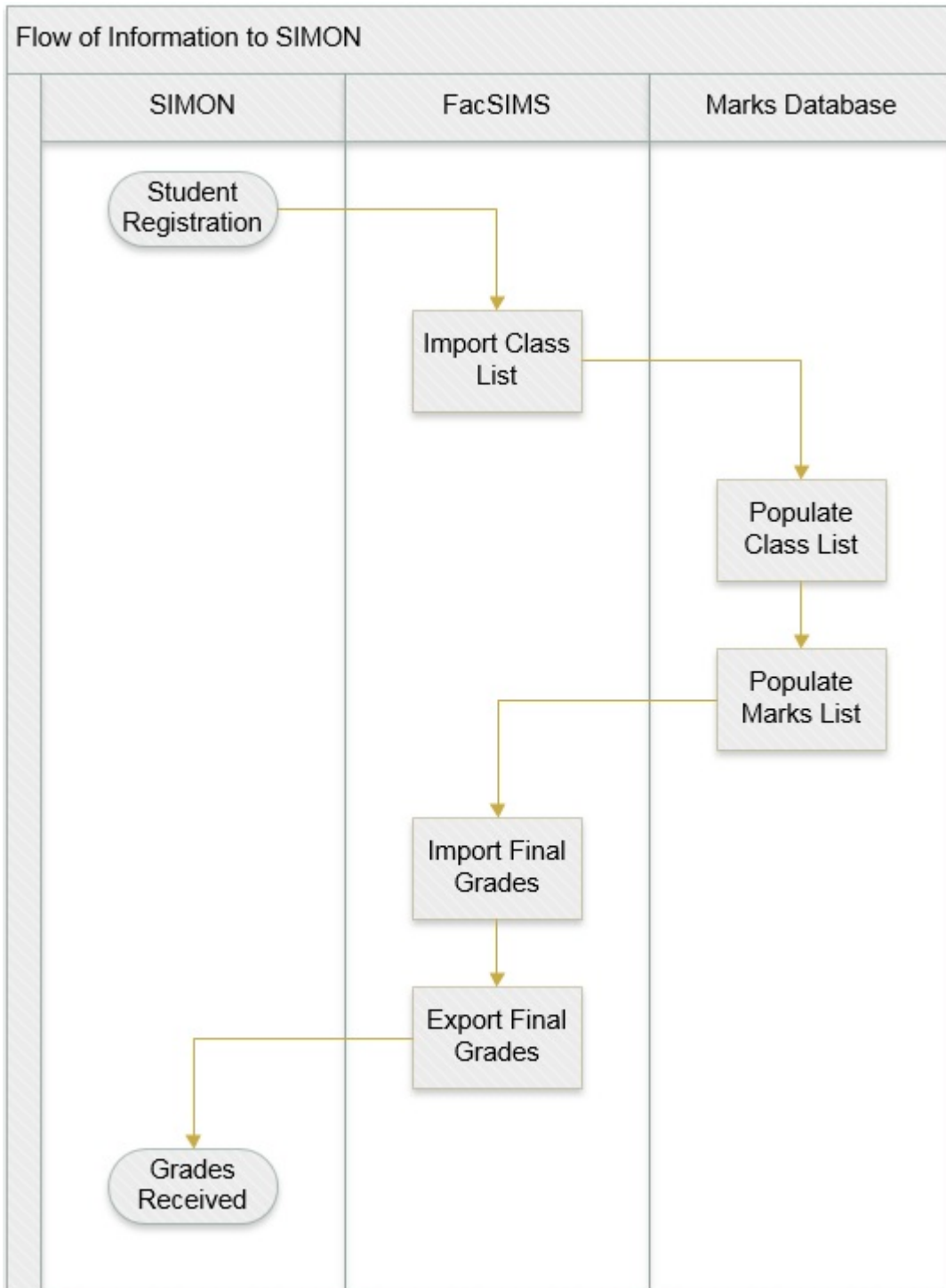
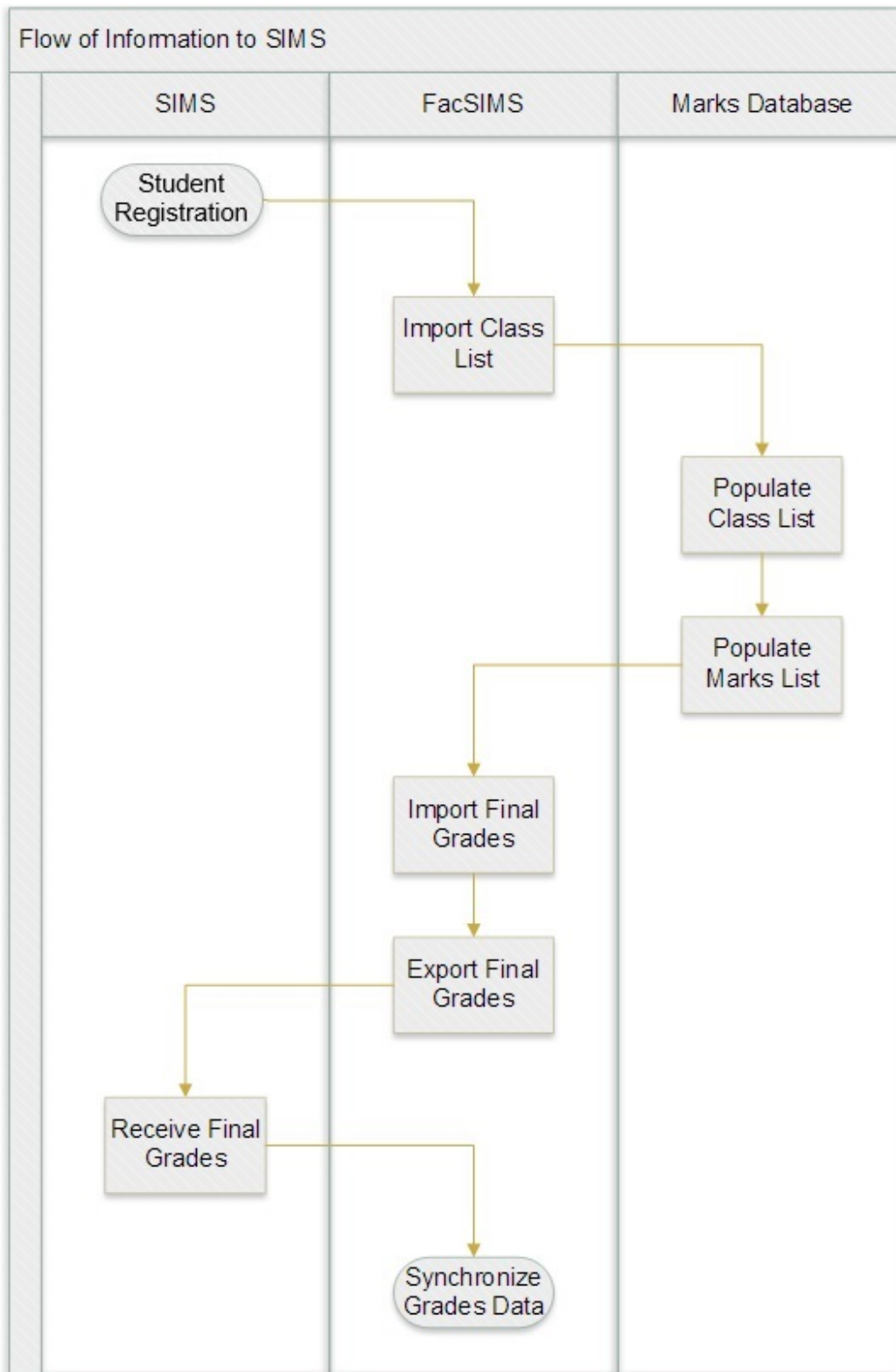


Figure 3.3. Modern flow of information between SIMS and FacSIMS





In order to make sense of the vast amount of information in SIMS, the university procured a license for the application Tableau, a modern application allowing for the graphical representation of data from a wide variety of database sources (Tableau, 2016). The data visualization capabilities of this system are limited only by the number of fields in the source database and the user's imagination. There is a dedicated Tableau support team at SFU, dedicated to programming common queries accessible to all departments. For example, a historical grade distribution query can be generated with the breadth of every grade assigned in every course since the founding of the university. Filters can then be applied to narrow displayed results down to a particular course over a given time range, and further as requested. Powerful queries can show the grades for an individual student in classes in a given faculty, a necessity for a science course grade point average (GPA) maintenance policy.

For those reporting needs that currently cannot be met by the current enterprise systems, there is a channel through which requests can be made to build out new functionalities in the Oracle database interfaces. The enterprise systems priority setting committee receives requests, considers the required resources and potential losses if denied, and decides on features to develop using the Oracle PeopleSoft application programming interface library. Interviews with university database support staff have suggested that this feature request pathway is inaccessible for minor requests. Tableau is a more agile tool than the Oracle database programming interface for leverage of the data as it currently exists. As such, the development timeline can be on the order of weeks instead of months and the business case need not be as convincing given the lower demand for resources in programming a Tableau query. Interviews and extended email communication with the Tableau group show that they are extremely willing and able to generate new queries to be able to provide as much value as possible to the rest of the university.

As SIMS, FINS, and HAP are all critical to the smooth operations of the university, these systems are all located on servers controlled by IT Services. This level of control allows for multiple layers of redundancy and security to be in place (collectively called the IT Firewall), guaranteeing to a high degree the integrity of mission-critical

data. Departmental shadow databases are often located on servers located in a department, and as such are not behind the IT firewall.

It is within this wider SFU environment that every faculty operates. While there are common requirements across departments, such as submitting grades to Student Services, there is no university policy dictating the process any group follows to meet those requirements. Thus, there has historically been a university-wide proliferation of systems designed to meet the same essential needs. Core SFU systems and their basic functions are summarized below in Table 3.2.

**Table 3.2. Overview of central university information systems**

Information System	Administrative Functionality
SIMS	Student registration, course scheduling, grades submission and release
FINS	Teaching and research grants administration, purchase order generation, payroll, central university financial management
HAP	Human resources database
Tableau	Database visualization tool

### 3.3. Faculty of Science

This section presents an overview of the information systems in use at the seven other departments alongside Chemistry comprising the Faculty of Science. The breadth of approaches across the faculty, as summarized in Table 3.3, suggest that there is great opportunity for each department to learn from the rest. The whole faculty would benefit from continued discussion moving past a recognition of the particular applications used in each department to a more thorough understanding of the departmental business processes these applications support. A deeper discussion on the particulars of each department and information on unique systems is provided in Appendix B. It is important to note that class sizes in other departments are similar to those in the Department of Chemistry, suggesting that there is no specific requirement for the systems in Chemistry arising from higher enrolment numbers than elsewhere.

**Table 3.3. Information system use in the Faculty of Science at SFU**

Department	Administrative Tasks System	CMS	Online Assessments	Grades Reporting
Chemistry	FacSIMS, FileMaker	Canvas, LON-CAPA	LON-CAPA	Marks Database, FacSIMS, Canvas, SIMS
Biology	FileMaker	Canvas	n/a	Canvas, SIMS
Physics	FacSIMS, FileMaker	Canvas	MasteringPhysics	Canvas, SIMS
Math	FacSIMS, FileMaker	Canvas, LON-CAPA	LON-CAPA, Stewart Calculus	Canvas, SIMS
BPK	FacSIMS, FileMaker	Canvas	n/a	Canvas, SIMS
Earth Sciences	FacSIMS, FileMaker	Canvas	n/a	Canvas, SIMS
MBB	FileMaker	Canvas	n/a	Canvas, SIMS
Statistics	FacSIMS, FileMaker	Canvas, CourSys	n/a	Canvas, CourSys, SIMS

Although the subject matter taught in each department varies widely, there is a remarkable consistency in the acceptance of Canvas, rejection of LON-CAPA, and simplification of the grades reporting process across the Faculty of Science. Both Canvas and LON-CAPA are discussed in more detail in section 4.2. The Department of Chemistry serves as the exception to this consistency.

### 3.3.1. FacSIMS and the Faculty of Science

The Dean's Office has assumed ownership and made available to all departments in the Faculty of Science the database originally developed in the Department of Chemistry, FacSIMS. The rationale behind this transition from a departmental to a faculty application is to be able to provide every department with the resources necessary to streamline everyday activities. The first departments using FacSIMS when it became a faculty offering were Chemistry, Earth Sciences, and Statistics and Actuarial Science. In the time since the departments of Math, Biomedical Physiology and Kinesiology, and Physics have opted to begin using FacSIMS. In order to continue adding features and fixing bugs, a developer was brought on at the Dean's Office. Much of the understanding of the operation of FacSIMS in the Department of

Chemistry and across the Faculty of Science was gained through interviews with this developer. This developer is also working on generating a set of user documentation, as infrequent users often require retraining every time they revisit FacSIMS. Some voiced unhappiness among users has led to upgrades and feature development, though this has proven a long process with some features not yet fully deployed after two years' work. A FacSIMS daughter database, Marks Database, is used only in the Department of Chemistry. It has proven to be much more problematic and replete with bugs than FacSIMS, and will require quite some time for the developer to rationalize and clean up.

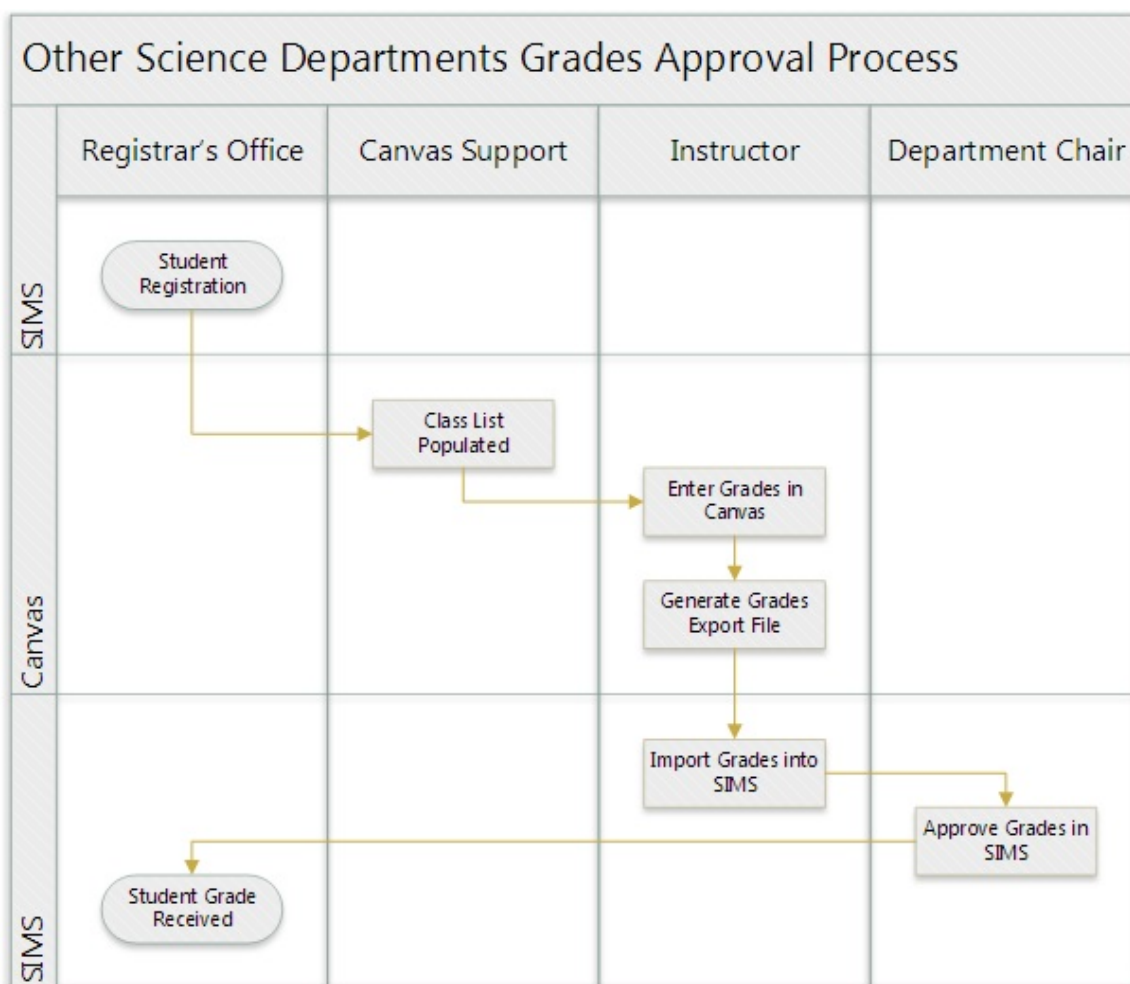
A mix of university culture and politics has led to variegated FacSIMS acceptance across the Faculty of Science. For example, the Department of Biology has chosen to continue use of their own systems instead of adopting FacSIMS. In some cases, this has led to an interdependency of different systems across different departments, as in the reliance of most other departments on bespoke systems in Biology for the TA and research assistant (RA) application process.

### **3.3.2. Canvas and SIMS in the Faculty of Science**

Almost all instructors for high-enrolment science courses outside the Department of Chemistry use the university-supported CMS, Canvas, as their principal course management and grade tracking tool. There is almost universal faculty acceptance of Canvas Gradebook, a tool for instructors to record and post marks in a detailed rubric for each assignment or exam. In generating these rubrics, instructors also enter a weighting for each component to automatically generate a final percent grade at the end of the semester. After export to Excel for determination of letter grade percentage cut-offs, grades information is merged into a class registration list generated by SIMS for submission of final grades to Student Services. Compared with an automated letter grade assignment script as found in Marks Database, this manual process allows for instructor consideration and reward of a students' improving performance over the course of the semester. On uploading the class list populated with final grades, the instructor clicks a button to generate a notification for the department Chair (or designate) that grades are ready for approval. The grades approval page presents the Chair with a histogram showing the letter grade distribution as submitted, allowing for

consideration and questioning of instructor rationale in assigning grades. On approval by the Chair, grades are released to Student Services. This cross-system process is represented graphically in Figure 3.4, shown below.

**Figure 3.4 Grades approval process in other departments in the Faculty of Science**



### 3.3.3. FileMaker in Biology

The Department of Biology has for many years used FileMaker, a proprietary web app and database development platform (FileMaker, 2016) to design a series of web portals for facilitation of numerous administrative tasks. As previously mentioned, multiple departments in the faculty depend on the TA and RA online application portal

hosted on the Biology FileMaker server. Because these departments (including Chemistry) use FacSIMS for administrative tasks, the TA and RA application data from FileMaker must be subsequently manually entered into FacSIMS for the application assessment process. The question remains on if the popularity of FileMaker stems from making forms web-accessible, or if there are other features that differentiate it from FacSIMS.

### **3.3.4. LON-CAPA in Mathematics**

Aside from the Departments of Chemistry and Mathematics, no other department at SFU is known to use LON-CAPA, a system providing for online homework assignments and instructional content access by students. However, as has been reported in Chemistry, Mathematics instructors say the system is very much despised by the very students who must use it. For numeric answer problems, LON-CAPA may demand input of a precise value that differs from what a student is trying to enter, owing to rounding differences or number of decimal places shown. For algebraic answers, instructors are frustrated that the system cannot distinguish between logically equivalent answers such as “ $a - b$ ” and “ $-(b - a)$ ”, never mind anything more complicated. Complaints fielded by instructors include the fact that the system is not scalable, it has a dated appearance, and that frustration with the above answer precision can push students to shortcut their learning, for instance by entering the question at hand into a web service such as Wolfram|Alpha to find the correct answer. There is little departmental support for LON-CAPA in Mathematics, with only a small subset of instructors using the system and a reported majority arguing in favour of discontinuation. This limited use profile and high negative perception suggests that LON-CAPA is very likely in the midst of, or well past, the point of decline on the product cycle.

### **3.3.5. Innovative Systems**

Over the past few semesters, an instructor in Mathematics has been trialing an innovative exam marking platform called Crowdmark. It is a tool allowing for near-automated upload of printed exams to an online portal, providing providing a collaborative grading environment for TAs and instructors (Crowdmark, 2016). Each

student is provided with a unique QR-coded exam booklet, electronically scanned by the instructor after the exam session, allowing the Crowdmark application to interpret the QR code and so associate each page of a particular booklet with the returning student. Instructors can then assign marking responsibilities by page, question number, or fraction of the students in the class. After collaborative marking, full Canvas integration allows for marks to be automatically entered into Gradebook, sparing a cross-system data translation step.

One definite benefit of this system is that students can only view their marked exam online, preventing cases where physically marked and returned exams are surreptitiously modified by the student, followed by a request to mark it again. In interviews it was reported that Crowdmark has reduced these re-grading requests in Mathematics by approximately 80%. At the moment, it is only being tested on a limited basis, reportedly costing on the order of \$100,000 for an annual institutional license. The Department of Chemistry could exhibit real options thinking by reaching out to the Crowdmark champion in Mathematics in order to establish a working relationship. If this system can be used by the Department of Chemistry on a trial basis at no cost, there is almost no downside risk. In the event that the university does procure a campus-wide license, the department would then be familiar with the new system and ready to scale up implementation without hesitation.

## **Chapter 4. Internal Analysis**

This section provides a description of the functionalities and uses of six major information systems in the Department of Chemistry. This is followed by a summary of the strengths and weaknesses of the different applications and the impact they have on the smooth operation of the teaching program in the Department of Chemistry.

### **4.1. Organizational Function**

Within the department, the dual purposes of education and research necessitate three main categories of information systems: administrative, instructional, and research computing. This analysis focuses only on the administrative and instructional systems.

Courses offered to undergraduate students have two major components, lectures and laboratories. Both share a similar set of IT requirements, including online delivery of content, student evaluation via online quizzes, high-speed exam marking, student grades tracking, and a means of electronically submitting final grades to Student Services.

The classical instruction of students in a formal lecture setting has changed little over the past decades. Students are expected to attend lectures and complete all quizzes, midterms, and exams. Laboratory sessions are required for students to learn and practice the specialized skills required of a chemist. While the above-described IT requirements are the same for lecture and laboratory components, the online student-facing systems are effectively less consequential for lectures. Students attend one four-hour long laboratory session once every one or two weeks, depending on the course. If students are not able access online materials to prepare themselves for the coming laboratory session, they may not fully understand what they are supposed to do and so cannot effectively complete the experiment. Lectures are less time-sensitive, requiring



students to be more self-motivated to stay on schedule with course content and so be able to perform well on exams. Both lecture and laboratory components have the same requirements for entry and tracking of student grades over the course of a semester. There is a common need for all academic units at the university to have in place a system for submission of final grades through an online portal to Student Services.

There are two ancillary systems that are considered out of scope for this analysis: LabPro and iClicker. While these systems are critical to the delivery of course content to students, they either do not serve a direct function in the evaluation of students or are only a minor component of the grade, mainly to promote lecture attendance.

## **4.2. Functional Information Systems**

There are six main information systems employed by the Department of Chemistry for the functions of student evaluation, grade tracking, and grade reporting. This section presents an overview of each system and the function served in the department.

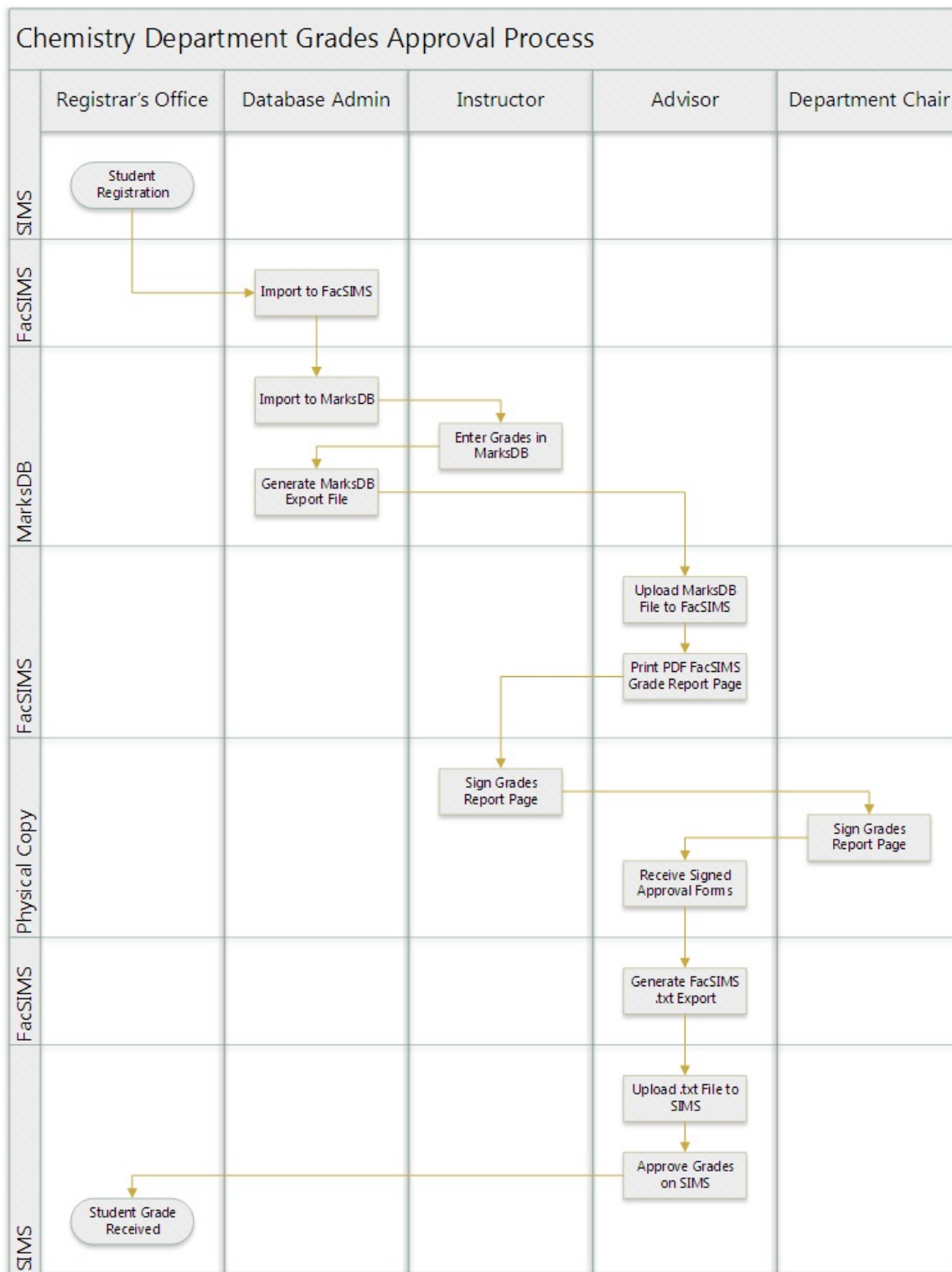
### **4.2.1. FacSIMS**

In 1996, the Chair of the Department of Chemistry combined a collection of smaller database tools that they had previously developed into the Faculty Student Information Management System (FacSIMS). Over the intervening twenty years, this combined database has been continually modified and small functionalities have been added to meet the growing needs of the department. The core system remains a structured query language (SQL) relational database, one of among many industry standard database formats. There are four central functions that FacSIMS currently serves in the department: student grade tracking, instructor assignments, TA and RA assignments, and research grants tracking. These four functions require import and export of data from the three central university enterprise database systems, SIMS, FINS, and HAP. As it does not concern the teaching program, research grants tracking is not discussed in this analysis.

For the purposes of student grades tracking and reporting, an automated script runs daily to synchronize FacSIMS with SIMS. To minimize server demands, given that pretty well every other faculty at the university has similarly scheduled synchronization events, only current semester registration information is updated on FacSIMS daily. Full FacSIMS-SIMS database synchronizations are manually scheduled once per semester.

Registration information in FacSIMS is exported to a daughter application, Marks Database, for use by instructors in entering and tracking grades over the course of a semester. After all grades have been entered into Marks Database, an internal script is run to automatically generate an XLS file with final grades for import into FacSIMS where a histogram function allows department administration to compare the grades distribution for a course in the current semester to the historical norm. Once the Chair of the department grants final approval for grades to be released, an XLS export file is generated in FacSIMS and copied to a transfer folder for import by Student Services into SIMS. The process flow for the grades submission process followed by the Department of Chemistry is shown in Figure 4.1. Note that in this process, printed hard copies of final grades, including a grades histogram, must be signed by the instructor and an administrator and retained by the department.

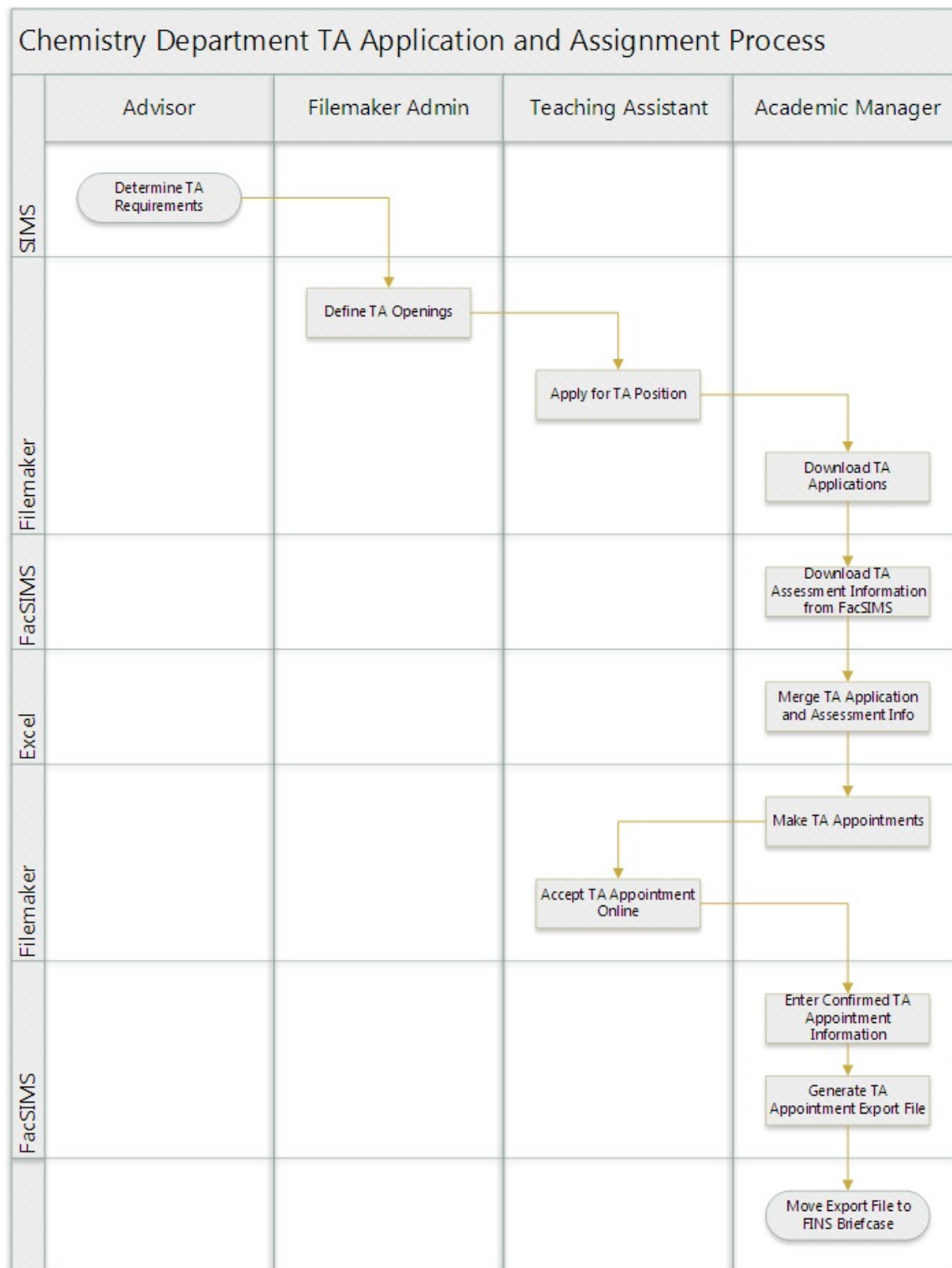
**Figure 4.1. Grades approval process in the Department of Chemistry**



For administrative purposes, FacSIMS has human resource tracking and allocation functions. It is intended to be used as a central repository of personnel information for faculty, staff, and graduate students in the department. In addition to contact information and addresses, the teaching assignments for instructors each semester are recorded. When the department administration is planning course assignments for upcoming semesters, this historical data is useful for determining which instructors have experience in teaching a particular course or for tracking when an instructor or faculty member is scheduled for a development, research, or sabbatical semester.

To similar administrative ends, FacSIMS is used in TA and RA appointments. The department currently relies on yet another cross-system process, owing to the fact that there are no for online applications forms available for FacSIMS, only for the Biology-hosted FileMaker system. Data from completed online applications from FileMaker is manually combined in Excel with graduate student career information from FacSIMS for consideration by the TA assignment committee. Agreed-upon TA assignments must then be entered into FacSIMS again for generation and submission of HR and payroll forms to HAP and FINS. Current TA appointment information is exported from FacSIMS to Marks Database, alongside class registration lists, allowing for further tracking in that system. The TA and RA application process in the department has proven to be a pain point for administrative staff (Figure 4.2).

**Figure 4.2. TA and RA Application and Assignment Process**



### **4.2.2. Marks Database**

Similar to FacSIMS, Marks Database was developed by the former Chair of the department in 1996. It is similarly an SQL database but it is a logically separate system from FacSIMS. Marks Database was intended to be used as the principal instructor-facing classroom management tool, providing for generation of class registration lists and acting as a grades entry tool. For laboratory technicians, the principal use of Marks Database is to generate laboratory space assignment charts and nametag labels for students to attach to their lab manual and report sheets. Marks Database is mainly used for high-enrolment classes such as first year introductory chemistry courses.

At the advent of the semester, the developer at the Dean's Office runs a Marks Database script daily for the first few weeks to query FacSIMS for updated class lists, FacSIMS itself being synchronized with SIMS daily. While this population of standard course templates with class lists is good enough to ready Marks Database for lecture use, for laboratory components there are additional steps required. A laboratory technician must make bench space assignments and weekly print the aforementioned identification labels. Several other seating assignment forms are also printed daily for the first few weeks of the new semester during which registration is relatively fluid. Between ensuring that class lists are up to date, generating label sheets, and printing new seating charts, technicians should absolutely be able to depend on Marks Database being stable and available. At the end of the semester, after all grades have been entered into the system, a script is run to automatically assign letter grades based on instructor-determined final percent grade ranges. This grades-populated class list is exported to FacSIMS for submission to SIMS, as previously described.

One of the stand-out features of Marks Database is final exam forms generation, allowing instructors to select the pre-programmed lecture theatre space where the exam will be held for printing of a seating assignment chart. This chart is an invigilator aid to prevent cheating by ensuring an empty seat between students, also preventing friends from deciding to sit together to share answers. In addition to the seating chart, Marks Database generates a sign-in sheet. When Scantron answer sheets are used (described in section 4.2.5), Marks Database can be used to print the student name, identification number, class section information, and even an identifying picture (all

information pulled from SIMS) directly on each student's sheet. As will be discussed below, the department currently relies upon Marks Database for marking of Scantron exams.

### **4.2.3. LON-CAPA**

Learning Online Network with a Computer-Assisted Personalized Approach (LON-CAPA) is an academia-developed open source learning management system (LMS) in use at over 60 universities worldwide (LON-CAPA, 2013a) including six in Canada (LON-CAPA, 2013b). For the purposes of this analysis, an LMS and CMS are treated as functionally synonymous, both providing an online tool for instructors to host course content, track grades, and administer student assessments via quizzes and exams. Where LON-CAPA differs from other available CMS platforms is in the distributed network nature of the system. On joining the LON-CAPA network, an institution becomes part of the global group of participating high schools and universities wherein every school in the group has access to the complete pool of sample problems generated by every other school. Further, the network allows for sharing of server resources for load balancing and system optimization (CampusSource, 2010). As an open source system, there is little cost to deploy beyond setup and maintenance of a local server. The Department of Chemistry first began using LON-CAPA over a decade ago.

The Personalized Approach in the LON-CAPA name is represented by the ability of the system to generate unique problem sets for each student through use of random number generation for variable values in a given question framework. This feature requires significant input on the part of the system administrator to define the appropriate limits and statistical distribution of random variables to ensure the problem is both sensible and applicable in the context of the course material. Aside from numerical answers, the system allows for multiple choice questions where incorrect answers are randomly drawn from a previously-generated pool of responses. Together, these randomization features are intended to reduce students' rote copying of answers from one another when completing online assignments.

In addition to hosting online quizzes, LON-CAPA has other CMS functionalities including grade tracking and posting of course material files for students to download. Within the Department of Chemistry, LON-CAPA is used almost exclusively as an assessment tool to ensure that students have completed the assigned readings before a class or laboratory session. The nature and format of the system is such that educational installations have tended towards the sciences and mathematics (LON-CAPA, 2013c).

#### **4.2.4. Canvas**

Canvas by Instructure is a cross-platform, mobile-friendly CMS marketed as a leading educational resource (Instructure, 2016a) in use at over 2,000 institutions worldwide, from K-12 through to higher education (Instructure, 2016b). Behind a customizable graphical user interface is a plethora of features for instructors and students, including but not limited to: course materials posting; activity/usage tracking, online submission and grading of assignments, grades tracking and reporting, discussion boards, online quizzes, and data analytics for instructors

Following extensive consultation and research on modern CMS products for replacement of the aging centrally-supported CMS (a product called WebCT) in use at the time, SFU first deployed Canvas in early 2013 (Simon Fraser University, n.d.a). While the Canvas launch product was offered by Instructure as software as a service (SaaS), with data residing on Instructure-contracted Amazon Web Services (AWS) servers rather than at the facility of the licensee (Instructure, 2016c), in 2011 the company announced the release of the Canvas source code for free adoption by educational institutions (Instructure, 2011). It was this open-source product that was selected for use by SFU. As the university is required to abide by the British Columbia Freedom of Information and Protection of Privacy Act (FIPPA), personal information of students cannot be stored on international servers. As such, were student information located on the international cloud-based servers of AWS, the university could not guarantee FIPPA compliance (Simon Fraser University, n.d.b). The SFU central support divisions IT Services and the Teaching and Learning Centre (TLC) work together to



maintain the system, prepare course spaces for instructor use, and provide training as requested.

#### **4.2.5. Scantron**

Scantron is a ubiquitous test system in use across a wide range of sectors for the past five decades (Scantron, 2016). The Scantron system has two main components: the pencil-filled Scantron answer form and the Scantron scanner hardware. The nature of the Scantron form and scanning technology limits the format of possible exam questions to either multiple choice or numerical answer. For questions demanding a written answer, or where the instructor chooses to assign marks for (and thus expects to see) written, detailed calculations, a supplementary written exam booklet must be provided. These written answers must then be marked manually by TAs and instructors. In this case, the score from the Scantron component is combined with the written answer score to arrive at a total exam score. While the Scantron system does offer the benefit high-speed grading, it is not a comprehensive solution for thorough assessment of student learning.

#### **4.2.6. Excel**

Microsoft Excel is an exceptionally powerful spreadsheet program widely used around the world as part of the Microsoft Office suite of productivity tools. While the core function of the spreadsheet program is the ability to carry out complex calculations on numerical datasets, the layout of the workspace gives Excel some functionality as a database. Native formulas and features of the software can be used to provide limited sorting and search functions as might be required of a database application.

### **4.3. Strengths and Weaknesses of Current Systems**

In this section, some of the major benefits offered by, and issues arising from, the current portfolio of information systems are discussed. It is the persistence of these issues under a centralized systems ownership structure in the department that led to the operational disruption that forms the impetus behind this report.

#### **4.3.1. FacSIMS**

FacSIMS, depended upon by the department for many years, unfortunately suffers from idiosyncrasies and a lack of user discoverability (Norman, 2013). To a new user, the series of steps and button clicks required to perform simple processes can be difficult to remember, resulting in the common situation where infrequent users regularly require retraining. This background level of support requests very much distracts the IT staff from focusing on development of new features or even novel systems.

#### **4.3.2. Marks Database**

Marks Database suffers from the same usability issues as FacSIMS, only to a much worse degree. It is a common occurrence for the beginning of a new semester to be stressful as Marks Database proves unstable and unreliable, with staff regularly in contact with the database administrator and departmental super user to report that data is either corrupted or altogether inaccessible, requiring a reversion to a stable backup copy of the database.

There is little logic in the series of steps that must be carried out to accomplish basic tasks in Marks Database. Again, button labels are mostly cryptic and the database suffers from a significant lack of user discoverability (Norman, 2013). The Marks Database user interface is not very user friendly or intuitive, leading to a sort of learned helplessness for users. Because troubleshooting of minor issues is almost impossible for anyone except the administrator, a technician required to use the system once per semester must rely heavily on external support. This necessarily reduces the functional efficiency of both parties, leading to a reported dissatisfaction with Marks Database on the part of department support staff.

During the expected window of system instability at the beginning of one semester, the system owner at the time advised that Marks Database might not function at all and that a back-up plan should be devised. Over two days, the author designed an Excel template that meets all of the needs of laboratory technicians with none of the pain points of Marks Database. This workaround has proven so user-friendly that it is still in use despite Marks Database once again appearing stable.

### **4.3.3. Canvas**

To date, there has been limited use of Canvas in the Department of Chemistry. In large part, this is not due to any shortcomings of the system but because instructors have grown to rely on the LON-CAPA system owner to prepare and manage their online course spaces. With little apparent interest in departure from the status quo of legacy systems, there has been no impetus within the department to investigate or educate instructors on the potential benefits offered by Canvas. Where there has been interest and use, instructors have either taken it upon themselves to learn how to use Canvas or referred to TLC for training and support.

A definite strength of Canvas is the rich GUI of the system, allowing for a high level of user discoverability (Norman, 2013). On the other hand, new users in the department have been so intimidated by the deep feature set as to not know where to begin. With historical LON-CAPA course pages still available and a perceived high level of effort required to rebuild those same pages in Canvas, many instructors in the department have chosen to all but ignore Canvas for now.

### **4.3.4. LON-CAPA**

The level of resources devoted to supporting a system used only in the six first-year introductory courses and a single second-year analytical chemistry course is significant. The senior lecturer position for full-time LON-CAPA development and maintenance comes at an annual cost of at least \$70,000 (Simon Fraser University, 2013). The department also hires up to three additional sessional instructors per year (one per semester) at a cost of \$6,000 per semester, to make up for the teaching power otherwise devoted by the senior lecturer on a full-time basis to LON-CAPA upkeep. Thus, maintenance of this system costs the department, directly and indirectly, at least \$88,000 annually.

A timesaving tool for high-enrolment classes, LON-CAPA is used in the department as a knowledge check to ensure student preparation for laboratory sessions. Ironically, where instructors like LON-CAPA for its ability to prevent answer sharing among students (owing to random-variable problem sets), the written laboratory report

structure is a sieve for plagiarism. Report sheets, the in-lab assignments students complete in lieu of a formal write-up, are standardized to facilitate marking by instructors and TAs. The bulk of the final grade is calculated from the marks students receive on report sheets. Because these report sheets are little changed between semesters, students are not allowed to remove them from the lab so as to prevent passing along the answers to their friends in later sections or semesters. Despite the measures in place to combat this plagiarism, it is commonly accepted among instructors that photographs and copies of report sheets are available should students seek them out.

As noted above, the contribution of report sheets to the total student grade is many times higher than that of LON-CAPA quizzes, yet the department expends more effort in maintaining LON-CAPA than overhauling a report sheet system that lends itself to cheating. Even though the LON-CAPA grade contribution is low (~5%), past students have taken it upon themselves to post worked answers for almost any question from the decade-old problem sets (Yahoo! Answers, 2011), defeating the Personalized Approach feature of the system; even with random variable questions, a posted answer comprising the series of mathematical steps robs the student of learning the underlying chemical principles behind the calculations. Any benefits arising from the cooperative network nature of LON-CAPA also go unrealized, as instructors do not consider the online external reservoir of problems to be up to the standards of the department. Despite the situational failure of the department to realize benefit from those unique features of the system, it seems that there is little appetite for change because LON-CAPA is already in the toolbox, ready to use every semester with a known factor of upkeep effort.

During consultation with the undergraduate student end users of LON-CAPA, overwhelmingly negative feedback was received. The first challenge students face is finding a LON-CAPA server that is accessible from among the four linked on the Department of Chemistry web page, a capacity limitation issue that immediately instills in students both frustration and a sense that the system is an anachronism. This feeling is strengthened by a plain text interface that has been described simply as “ugly”, leading to an overall unfavourable impression and lack of student engagement.

As previously described, on attempting to answer quiz questions students can have the correct answer yet a bug, numerical rounding convention, or other specific limit on the variable answer can result in the correct answer not being accepted by the system. Students often use up all of the available attempts afforded them in trying to guess exactly what the answer needs to be in order to be accepted. This leads less to learning and conceptual understanding than it does sheer frustration. Guiding hints, as originally programmed by the Ph.D. chemist departmental system owner, prove far more confusing than helpful for stuck students as these hints follow the logic of the programmer, not necessarily that of a student learning the material for the first time. The logic of the programmed hints is not necessarily a weakness of LON-CAPA, but an approach to any online assignments that must be modified moving forward.

The overall frustrating experience of being forced to use LON-CAPA is perhaps why students search the internet for worked answers, or even post their own answers to alleviate the aggravation of future students. The final obligatory interaction with LON-CAPA has been described by many students as cause for celebration. Unfortunately, interviewed instructors predominantly meet the above criticisms of the system with the reflexive response that students do not like LON-CAPA simply because they are lazy and do not want to do any extra work outside of class. Another common rationalization of this negative feedback is that the department is trying to instill good study habits and a level of accuracy in solving problems that students find onerous. This is considered by instructors to be a weakness of the students, not LON-CAPA. There is an overall perception that instructors feel students are complaining about the pedagogical nature of the problem sets. Though there is likely some truth to that, it leads to the case that instructors dismiss all complaints outright, even those legitimate ones around system usability and design.

#### **4.3.5. Scantron**

The very design of the Scantron system for high-speed marking predisposes it to time-consuming problems. If students do not completely fill in or erase an answer bubble, or even use a pen instead of pencil, the scanning hardware and Windows 3.1 software interface often cannot correctly register an answer. These common issues

force instructors to undertake an examination of each completed and graded Scantron form to ensure that there are no questions where an improper score has been assigned.

The dated Scantron system used by the department is limited in functionality, essentially translating completed Scantron forms to a digital file; the system does not automatically grade the forms as they are scanned. Rather, an answer key is scanned and a Marks Database script is run to automate marking. The Department of Mathematics previously attempted to follow this grading process but found it to be so troublesome that they have instead written a simple comparison script in Python programming language, altogether avoiding Marks Database.

#### **4.3.6. Excel**

One of the key strengths of Excel is that data from a wide variety of sources can be imported, notably CSV and ASCII text data (TXT). However, the process of importing data is far from automated or foolproof, often resulting in the department in value-offset or other errors in class registration list manipulation.

As an industry standard spreadsheet program, Excel benefits from a very wide installed base where most users have at least limited experience. The interface is relatively user-friendly, though the sheer power of the calculation engine leads to low discoverability for more advanced functions. There is a vast amount of vendor- and user-generated guidance documentation available online and in print. By the nature of their field of study in the physical sciences, staff and faculty in the Department of Chemistry are likely to have significant experience using at least the basic features of Excel.

Because Excel is at its core a spreadsheet program, it is in many ways unsuited for use as a database. Regardless this weakness, many instructors persist in generating and using Excel databases. Within the department, Excel is widely used for tracking of student grades for low-enrolment, upper division courses and there is no standard format that instructors must adhere to in using a spreadsheet for this purpose. There is limited tracking of user actions in the form of an audit trail, allowing for data manipulation and destruction by almost anyone with access to the XLS file.

Although many of the above weaknesses could be perceived to be inherent to Excel, they in fact stem from the reliance of the other departmental information systems on Excel as a translational file type. Excel has very few weaknesses as a spreadsheet program.

#### **4.4. Internal Analysis Summary**

Table 4.1, presented below, provides a summary of the key information systems in use in the Department of Chemistry. The primary function of each system is shown alongside reported strengths and weaknesses in department use cases.

**Table 4.1. Overview of information system functions, strengths, weaknesses**

Information System	Instructional Functionality	Strengths	Weaknesses
FacSIMS	Grades database, grades submission, TA assignment, instructional resource planning	Student information queries useful to department easily done, already populated with all pertinent data	Limited user documentation, “tired”, unintuitive user interface, largely redundant with the advent of university enterprise systems, limited support group
Marks Database	Marks tracking, grades calculation, exam grading, exam seating chart generation	Generation of exam seating charts and sign-in sheets is “killer app”, printing student information on Scantron forms	Extremely unintuitive user interface, replete with bugs leading to persistent system instability
Canvas	Instructional content delivery, grades tracking, online assessment, online assignment submission	Widely adaptable, large, central university support department, variety of plug-ins available	Some bugs are visible to students and are thus particularly frustrating to instructors, range of functions requires time investment to learn
LON-CAPA	Online assessments, instructional content delivery, exam grading, assignment uploading, problem set repository	Generation of exams from problem set repository, online assignment questions are pseudo-randomized	“Tired” user interface, problem sets are dated with answers widely available online, server capacity is limited, students hate it
Scantron	In-class exam administration	High-throughput exam marking, Marks Database allows for forms to be printed with student information prefilled	Current marking process requires import of data to Marks Database, improperly filled bubbles on sheet cause problems, marking software only runs on Windows 3.1
Excel	Used as an intermediary format for transfer of information between different databases	Flexible enough to meet most calculation and pseudo-database needs	Intrinsic flexibility and lack of standard use guidelines has led to confusion and data processing errors

To be able to locate the information systems in the department on McFarlan’s strategic grid (McFarlan et al., 1983), it is instructive to consider the whether or not there is even an application development pipeline in the department. Though there are plans to develop additional functionalities in FacSIMS, there is no true pipeline of new applications that will be strategically important in the future. This suggests that the department operates in either a Factory or Support mode. The strategic impact of the current application portfolio is low; there are many ways the department can continue to



function should a system do down. This suggests that departmental IT straddles the Factory and Support boundary in the strategic grid. This is a realistic assessment in that current business processes rely on the proper functioning of IT applications (as in a Factory mode) yet those business processes are not uniformly followed across the department, relegating IT much more to the Support quadrant. As there is some departmental reliance on FacSIMS (as in a Factory mode), the application portfolio should be robust, stable, and reliable. Several interviews across the Faculty of Science suggest that FacSIMS and Marks Database do not meet the needs of a Factory-mode application.

## **Chapter 5. Success Criteria, Options, and Implementation**

A comprehensive discussion of success criteria precedes the presentation of three alternative change plans for how the department can update the application portfolio. Success criteria are used in assessment of the viability and inherent risk of each alternative option presented. A recommendation presenting the lowest level of risk with the highest level of reward is presented alongside an implementation pathway.

### **5.1. Success Criteria**

Over dozens of interviews across the Department of Chemistry, five key success criteria repeatedly were revealed to be important in any decision making process on the future of critical information systems. Any proposal for change that does not consider these success criteria is not likely to meet with success. These success criteria are partially informed by Ward's (1990) suggestion that benefits expected, resources required, and potential risks are the most important factors to be considered in deciding on changes to the application portfolio.

For each success criterion there are multiple factors to consider, and each of the proposed change plans will be assessed individually on their ability to address these contributing factors.

#### **5.1.1. Data Integrity**

For the continued smooth operation of the administrative and teaching processes in the department, data integrity is of utmost importance. Three components of data integrity are important within the Department – IT security, data transfer integrity, and FIPPA compliance.

The first component of data integrity is IT security. Departmental IT support staff have indicated that data integrity is the most important consideration for any system in use, aside perhaps from the basic level of uptime required to be able to complete critical tasks. Where academic dishonesty meets information technology, there is the possibility that a student may try to gain access to systems to modify their grades. Though there have not been significant breaches reported, any systems used should have safeguards in place to prevent unauthorized access and should be able to log all user actions for forensic analysis when suspicion warrants. Interviewees reported enough elaborate attempts by students to cheat on in-class assignments and exams that IT security concerns cannot be ignored. Web-accessible systems present a conundrum of convenience and potential attack vectors at the same time, requiring an added level of vigilance on the part of administrators. Both preventative access restriction methods and forensic activity logging have been stated as essential for the department to be able to trust the information in a given system.

Data flow rationality is the second component of data integrity. The number of systems that information must be passed between in carrying out a particular process, the format of the data as transferred, and the manner by which information is ported into or out of a system can all factor into data trust issues. Every transfer action presents an opportunity for data loss, corruption, or other effective mistranslation of information. For example, when student grades data must pass through three different systems on the way to submission to Student Services via the transfer medium of an XLS file, there are four separate instances when a manual (or even automated) import or export event can go awry. When information is added to the XLS file between systems, such as in adding grades, there are yet two more opportunities where a user innocently changing formatting or layouts can inadvertently change how the data is handled by the next system.

The third component of data integrity is connected to FIPPA. Any information system in use at the university needs to be fully FIPPA-compliant, with personal information stored only on hardware inside Canadian borders. Information systems that require storage of data across national borders leads to a sort of loss of data integrity as the act of transmitting and storing that data becomes legally questionable. A FIPPA

complaint could lead to enforced deletion of information from international servers, constituting legally-obliged data loss.

### **5.1.2. Minimal Disruption**

The second success criterion is the minimization of disruption at both the individual task and wider organizational levels.

The first type of disruption is operational disruption. This occurs when an IT application proves faulty and unreliable, interfering with the ability of an individual to carry out a task. When considering changes to an application portfolio, a minimum of operational disruption is desirable, as frustration at having to struggle with substandard software drags on the productivity of the individual.

The second component, called organizational disruption, is manifest in the initial, transient reduction of efficiency in an organization when new technology replaces old. In his explanation of this perceived phenomenon, Downes formalized his law of disruption, stating that "...technology changes exponentially, but social, economic, and legal systems change incrementally." (Downes, 2009) An interpretation of this concept at the level of the organization suggests that when new applications and processes are brought in, there is a period of disruption as the expectations of users and even the operational norms of the group slowly adapt to the new means of doing business.

### **5.1.3. Minimal Cost**

The university has a fiduciary responsibility to the taxpayers of the province of British Columbia to operate in as cost-efficient a manner as possible (Brewster, 2015). As a success criterion, cost covers much more than just the purchase price for a product. A more appropriate concept, Total Cost of Ownership (TCO), presents management with a realistic appraisal of costs over the serviceable life of a product. While many elaborate TCO models are in use, each applicable within a given sector or for a particular class of product, a published developer article provides an excellent broad overview of the different factors in IT TCO estimation (Ghazizadeh, 2009). She suggests that there are two major cost classes: tangible and intangible. Tangible costs

include the purchase price as well as installation costs, routine maintenance, and fixed operating costs. Intangible costs include risk mitigation, data conversion, integration, and system usability costs. For this analysis, three broad cost classes are presented – start-up cost, migration cost, and operational cost.

Start-up cost is the up-front purchase price for a system as well as the hardware on which it will run. Any infrastructure changes that are required to make the system minimally functional from a technical point of view are included in this cost component.

Migration cost is the set of costs incurred in porting data from old systems to new, modifying applications and processes to fully integrate new systems into workflows, and training users on these new systems and processes.

Operational cost is comprised of the expenditures to maintain and provide support for a system that has been fully integrated into workflows. Ghazizadeh (2009) uses the initialism RASM, referring to Reliability, Availability, Serviceability, and Manageability. An unreliable system with low uptime that is not serviceable yet requires extensive management is very expensive over its lifetime.

#### **5.1.4. Value to Staff**

Following extensive discussions with faculty and staff in the Department of Chemistry, three broad categories of perceivable employee value became clear: extrinsic, intrinsic, and job satisfaction. Were there no upside value gains for the department, there would be little motivation to pursue change.

To make a difference in the life of a student, to bring understanding and see them succeed, is what drives an educator. Thus, the first level of value is termed intrinsic value. Any system or process change that frees an instructor from administrative bureaucracy and allows them to be a more effective educator provides intrinsic value. One instructor even commented that nothing would make them happier in their role than for every one of their students to earn an A+ in their class. For administrative and support staff, the idea of being freed from inefficient systems and processes to be able to excel at one's actual job provides a level of intrinsic value.

For tenure-track instructors, there are also extrinsic motivators that better information systems might impact. Efficient administrative processes afford more valuable time to focus on teaching and research, leading to positive teaching reviews and more publications, both of which are looked for by the promotion and tenure committees. For staff, the same concept of being free to focus on their actual job is a source of extrinsic value as it leads to increased productivity and thus potentially better job reviews.

If new information systems and processes can minimize stress and frustration, the individual experiences a higher level of job satisfaction. As job stress can negatively impact an employee's personal life, it is not a stretch to say that more job satisfaction can lead to a better quality of life overall. Key interviewees have reported that some identified changes in the department would make them very happy.

While it is individuals realizing value from change, the cumulative effect for the department is an overall higher level and quality of production. The department, and even university as a whole, benefit when the above gains are realizable.

### **5.1.5. Value to Students**

Multiple discussions with students suggest that their primary concern lies with immediately perceivable benefits. There are also long-term benefits for students' academic and professional careers arising from a provision of a higher quality of education. Thus, there are two proposed components of value to students: current and future value.

Current value is any benefit that immediately improves the educational experience of students. Receipt of timely feedback on assignments and exams is a definite positive, allowing for a readjustment of efforts where need be. When student-facing systems are simplified, students experience less frustration and stress. Even those changes that allow an instructor to better focus on effective education provide current value to students as they have a better opportunity to learn the material presented and so perform well on exams. Similarly, when the academic advisor can

focus more on advising-related tasks and not on shuffling paper, students realize a higher quality of advising service.

Future value for students is that which will be realized after graduation and so may not be immediately apparent today. For example, if the quality of the education provided to students increases, they are better prepared for the job market and thus are better positioned to succeed. As SFU graduates prove to be highly employable, the stature of the department in the eyes of employers can increase. Positive perceptions by employers and ratings groups can drive program enrolment, thereby increasing funding for the department. That increased funding can be reinvested in the teaching program, spurring a virtuous cycle that benefits all.

## **5.2. Alternative Options**

In this section are presented three options for how the department can modify business processes, IT applications, or both in order to improve the overall state of information systems relied upon for continued success.

### **5.2.1. Option #1: Adoption of Canvas-SIMS Grades Submission Process**

Among the simplest of process changes for the department is to adopt the final grades submission process followed by the rest of the Faculty of Science (shown in Figure 3.4). This would entail a discontinuation of Marks Database and adoption of Canvas as the operational grades entry tool. As Marks Database is not used, there is no need to import grades into FacSIMS for generation of an output file to upload to SIMS. Rather, grades data will be exported from Canvas and merged with student information from a SIMS-generated class list for upload to Student Services. Instructors will be completely responsible for submitting grades for their own classes, freeing the academic advisor to focus on other tasks. Should the department administration require historical grades data visualization, query design requests will be sent to the Tableau support group.

Although this proposal is primarily a process change, it involves replacing Marks Database with Canvas and so will require the department to organize some user training. The downside of discontinuation of Marks Database would be the loss of the ability to generate exam invigilation forms. However, resources that are now focused on supporting Marks Database could be re-directed towards development of a lightweight, web-accessible exam forms generation system. In essence, this change could help move the department from the Support to the Factory quadrant of McFarlan's strategic grid (1983).

IT security is improved given that there are fewer, but more robust, applications in the data flow pathway. Further, migration of a process from the faculty systems of Marks Database and FacSIMS to those controlled and maintained by IT Services increases security owing to the IT firewall. In the modern grades submission process proposed for implementation, there are fewer data transfers between systems, increasing data flow rationality. As the SFU Canvas installation is on-campus, there are no FIPPA concerns.

There will be some operational disruption as instructors learn how to use Canvas. An amount of organizational disruption is expected as instructors come to accept responsibility for submitting their own grades after years of relying on the academic advisor to do so.

As previously discussed, Marks Database demands a significant amount of system administrator input to provide even a basic level of usability. Under the incumbent organizational paradigm where the senior lecturer responsible for LON-CAPA also had ownership of Marks Database, it is estimated through interviews and the author's experience that as much of 20% of their time was devoted to Marks Database. At a minimum senior lecturer salary of \$70,000 (Simon Fraser University, 2013), it is reasonable to suggest that maintaining Marks Database indirectly costs the department approximately \$14,000 annually. This is an opportunity cost more than a budget line item in that the time spent on Marks Database could be better spent on new systems development or even on teaching activities.



As the systems used in the modern grades submission process are already installed and maintained by IT Services and the TLC, there are no installation and minimal (if any) running costs. Training on Canvas is arranged through the TLC at no cost to the department. TLC staff have indicated that groups of 5 – 10 instructors can be easily accommodated for basic Canvas training sessions lasting approximately 2.5 hours, so the cost to the department is the opportunity cost of approximately 20 instructor-hours. Training can be scheduled during semester breaks so as to avoid distraction from current teaching duties. Follow-up assistance is provided on-demand, with TLC staff even coming to the instructor's office to provide support.

From a broader cost viewpoint, IT Services and the TLC are support divisions that do not directly generate tuition revenue. The tuition and government operating grant revenue generated by academic units, including the Department of Chemistry, provides for the budgets of these cost centres. In effect, the Department of Chemistry is already paying for the services without making good use of them. Thus, the return on investment for CMS and database systems in use is necessarily reduced when the department is not using (and so not realizing benefits from) a centrally-supported system such as Canvas. Referring to Ward's suggestion on the ratio of risk-adjusted benefits to resources consumed, the department is currently funding multiple systems but only benefiting from those used.

$$\frac{\textit{benefits realized from departmental systems}}{\textit{cost of operating departmental systems + funding assigned to IT Services and TLC}}$$

By using and realizing benefits from centrally-supported systems, including SIMS and Canvas, the numerator in the above expression increases while the denominator is unchanged, thereby increasing the value of the ratio. The department should not view increased use of Canvas for grades tracking as an added cost, but rather as realization of benefits from costs already incurred.

There is little in the way of value to teaching staff, either intrinsic or extrinsic, and job satisfaction might even suffer if they perceive it as a waste of their time to now be responsible for submitting final grades to SIMS. From the academic advisor there was a

resounding response that all three components of value would increase, as the modern grades submission process frees them to focus on their own specialized job tasks.

When Canvas Gradebook is used by instructors, grades are promptly visible to students, affording them a timely opportunity to gauge their own performance in a course. Marks Database has no student-facing component, so students would often have to wait until the beginning of a laboratory session to see their mark from the previous experiment on a returned report sheet. Interviews with students suggest that this prompt feedback provided by Gradebook is quite valuable to them. Future value is realized only if the time liberated for instructors to spend on teaching instead of bureaucracy truly increases the quality of education the student receives.

From the above discussion, an assessment of how well this option meets the success criteria is given in Table 5.1.

**Table 5.1. Assessment of the option to modify the grades submission process**

<b>Expected Level of Data Integrity</b>	<b>High</b>
IT Security	High
Data Flow Rationality	High
FIPPA Compliance	High
<b>Overall Minimization of Disruption</b>	<b>Medium</b>
Minimization of Operational Disruption	Medium
Minimization of Organizational Disruption	Medium
<b>Desirability of Cost Position</b>	<b>High</b>
Start-up Cost	Low
Migration Cost	Low
Running Cost	Low
<b>Total Value to Staff</b>	<b>Medium</b>
Intrinsic Value	Low
Extrinsic Value	Low
Job Satisfaction	Medium
<b>Total Value to Students</b>	<b>Low</b>
Current Value	Medium
Future Value	Low

## 5.2.2. Full Replacement of LON-CAPA with Canvas

This option suggests that the department altogether abandon LON-CAPA as an online learning tool. Canvas will be the standard CMS and online quiz tool, and new problem sets will be designed with a focus on learning instead of assessment. This proposal is very much informed by the concept of core competencies, in that the department should outsource CMS services to specialized divisions at the university while focusing only on how to best teach students the science of chemistry.

Canvas has a full-featured quiz component, including the ability to generate questions with random variables. With this replication of the Personalized Approach feature, little differentiates LON-CAPA from Canvas so there is no reason why the former need be used instead of the latter. In interviews with students, past and present, the immediate criticism of LON-CAPA was almost universally the fact that answers to all of the existing problems are freely available online. There is clearly a need to generate novel problem sets, but there is no need to continue to use LON-CAPA for this purpose. The department has continued with the status quo because the questions are already programmed and there is a fear that all of the effort expended in doing so will be wasted if a switch is made. Especially considering the answers being posted online, this expended effort is very much a sunk cost. If new problem sets are needed, why not use Canvas? The absence of the departmental LON-CAPA administrator and the presence of the Canvas experts at the TLC make Canvas the more attractive CMS.

The Canvas interface is much more attractive and user friendly than LON-CAPA, even providing a rich content editor for instructors to be able to incorporate graphics, videos, or other material into problem sets. Most importantly, Canvas quizzes allow for triggered events, whereby material only becomes visible after the student completes a certain action. This is the feature that is recommended be used in generating effective learning tools for students. The evaluative form of LON-CAPA questions, much as would be seen on an exam, does not help students learn how to approach a problem.

It is recommended that deconstructed problems, guiding the students through each step to the solution, be designed for use in Canvas. For example, the first step in solving a chemistry problem is often determining the constants to be used, and so the

first part of the problem can be a multiple choice question to select the proper constant for the question at hand. A feature of Canvas quizzes is to show a note when an incorrect answer is entered, so an explanation for why a particular constant is not applicable can help students learn. Completion of the first part of the question is the trigger that reveals the next logical step in the problem solving process, prompting student input. Subsequent steps in the deconstructed problem can include calculations, rearrangement of an equation, conversions, and much more. The idea is to walk the student through the individual steps required to arrive at the final answer, explaining the rationale at every point, rather than the current situation in LON-CAPA of simply demanding the correct final answer. The random value generator function can be used to generate hundreds of different questions in a question bank for students to practice on once they have gone through the initial learning steps of solving the problem. Through this cycle of learning and practice, students will be much better prepared to solve similar problems on an exam than they are when sourcing the calculator button sequence online to answer LON-CAPA questions.

Some interviewees have suggested that the completion of online problem sets should not be rewarded with marks, but rather that the reward is for the students to be prepared to perform well on the final exam and so receive a high final grade. When online problem sets contribute even 5% to the final grade, students can be motivated to search out answers on the internet to prevent needlessly falling behind their peers. The alternative is to incentivize students to complete the online assignments by telling them that the questions in a problem set are almost the same as will be on the exam. The full data analytics capabilities of Canvas can show the instructor which students spent the longest on the system and practiced as much as possible. The instructor can then tell students that those who show the most effort and do the most work are more likely to be rewarded with consideration of their final letter grade when it is on the bubble.

As part of this option, instructors will be expected to take more ownership of their online Canvas material instead of relying on the existing system ownership arrangement. However, it is proposed that a departmental Canvas user group be formed to provide a support network, perhaps even extending across the whole of the Faculty of Science.

The TLC remains available as always to provide guidance and assistance when requested.

When measured on the level of data integrity provided, this option is attractive. IT Security is high as Canvas ownership remains with the TLC and IT Service. Data flow rationality is high, especially in those cases where Canvas is already used as the course CMS but LON-CAPA is used for online problem sets; when Canvas is used for both, there is no need to transfer grades information between systems. As discussed in the internal analysis, the SFU Canvas installation is on a local server, affording full FIPPA compliance.

Unfortunately, this option will prove operationally disruptive to those instructors who currently rely upon the availability of LON-CAPA. This will extend to a high level of organizational disruption as it represents a major sea change in the way the department delivers online content to students. It is not just a move to Canvas, but a reimagining of the purpose and structure of online assignments.

From a cost perspective, there is no installation cost as Canvas has long been offered by the university. As previously discussed, training costs will only be the opportunity cost for instructor time. However, there are high anticipated data migration costs realizable in the time it will take to generate new problem sets in Canvas. One option to mitigate this cost is to assign the task of problem set generation to an instructor on leave for a development semester. Once the new material is in place, there will be some running costs. Though system maintenance at the infrastructure level will be covered at no new cost by support divisions outside the department, the expectation that instructors take a more active role in designing and modifying their own problem sets (as opposed to relying on a single faculty member to do so) contributes to this running cost measure.

The intrinsic value to instructors is high when a more effective means of online education allows their students to better master the theory and practice of the material at hand. An increase in student satisfaction can lead to better teaching reviews, providing some extrinsic value to instructors. On the other hand, job satisfaction may be lower

than the status quo when instructors are expected to have more of a hand in the generation and renewal of their online course components.

Students are likely to perceive the highest level of value under this proposal. Realizable current value includes a decrease in stress and frustration at not having to use LON-CAPA anymore. A system that proves more engaging and educationally effective will help students actually master concepts rather than defer to the internet for solutions. Almost every student interviewed expressed a similar sentiment along the lines of LON-CAPA being pointless when worked answers are available online for every question. Students so claim that they learn nothing from those exercises. Future value arises from actually learning and mastering the material, allowing students to be better equipped to succeed in their future studies and careers.

A summary of the components of the success criteria is shown in Table 5.2.

**Table 5.2. Assessment of the option to replace LON-CAPA with Canvas**

<b>Expected Level of Data Integrity</b>	<b>Medium</b>
IT Security	High
Data Flow Rationality	High
FIPPA Compliance	High
<b>Overall Minimization of Disruption</b>	<b>Low</b>
Minimization of Operational Disruption	Low
Minimization of Organizational Disruption	Low
<b>Desirability of Cost Position</b>	<b>Medium</b>
Start-up Cost	Low
Migration Cost	High
Running Cost	Medium
<b>Total Value to Staff</b>	<b>Low</b>
Intrinsic Value	Medium
Extrinsic Value	Low
Job Satisfaction	Low
<b>Total Value to Students</b>	<b>High</b>
Current Value	High
Future Value	High

### **5.2.3. Option #3: Replacement of FacSIMS**

This option presents perhaps the most significant change that the department could undertake. Given the plethora of identified issues with FacSIMS, this option recommends that the Department of Chemistry completely discontinue use of that system. There are a number of different products available on the market and at the university that may be suitable. The first part of this analysis examines the possibility of procuring new enterprise solutions. The second part evaluates two alternative systems already in use at other departments at the university.

What at first appear to be wildly different sectors – education and industry – actually share quite similar needs. To be competitive in the modern marketplace, a large firm can make use of an array of customer relationship management (CRM), materials tracking, human capital management, and financial management systems. Many of the systems requirements of industry mirror those of higher education, in particular-student relationship tracking, human resources planning, and financial planning. It is no surprise then that firms producing enterprise CRM products have sought to extend their market reach by presenting offerings for the education sector. An overview of the higher education CRM products offered by market leaders is presented in Appendix C.

In reality, it is far beyond the purview of a single department at a university to purchase a license for an enterprise system. The level of analysis of product features, user requirements, hardware installations, training, and support required for an enterprise solution are cost-prohibitive for a department, and perhaps even so for a faculty. While there are products on the market that may meet the needs of the Department of Chemistry, the suggestion is to look to other sources for a more cost-effective solution. Should the Faculty of Science eventually choose to enter into an analysis of new systems to replace FacSIMS, this enterprise systems overview should be revisited.

There are at least two other products identified at SFU that both serve the same administrative function as FacSIMS: TRACS and CourSys.

Beedie School of Business has developed an internal database called TRACS, a web-accessible MySQL database housing essentially all of the operational data of the faculty. As one of the needs of Beedie School of Business is to track and retain information required for accreditation, this database is particularly tailored for that purpose. Between a web portal for online applications and the full longitudinal database of graduate student careers, the TA and RA application and assignment process is vastly simplified in TRACS as compared to FacSIMS.

The faculty and staff at Beedie School of Business report in interviews that, for the most part, they are very happy with the features and performance of the TRACS database. It has a modern look and feel, is web accessible, has a responsive internal support team, and basically does a great job of streamlining the everyday administrative tasks of the school. Although it is designed for the needs of Beedie School of Business, the Faculty of Arts and Social Sciences and Health Sciences have both seen the value that TRACS offers and proceeded with installations. The source code for these installations was provided at no charge by the TRACS development team.

Faculty members in the School of Computing Science, experts in application development and coding, developed a MySQL database system called CourSys. It is this faculty database that is recommended for use by the Department of Chemistry. In common with other faculty databases, CourSys is populated with all of the personal and academic information for faculty, staff, and graduate students. The TA and RA application and assignment process is just as painless as in TRACS. Faculty activity tracking gives the academic manager a snapshot of the teaching power available in a term, indicating a need to hire sessional instructors when there is a shortfall.

A valuable feature of CourSys is a walkthrough of all the steps for an academic dishonesty report. There is a very well defined series of steps demanded by university policy, from first suspicion through final report of academic dishonesty, that an instructor must follow. CourSys has a form that provides prompts for every one of these steps and a space to scan in notes or other files, essentially guaranteeing that every step required by the administration is precisely followed. There is also a well-designed academic



advising portal with space for advising notes to be scanned or otherwise appended, a feature that the academic advisor in the Department of Chemistry reported as desirable.

Referring to Prahalad and Hamel's discussion on core competencies, the Department of Chemistry should recognize that the core competencies of the School of Computing Science necessarily include application design and programming. The smooth integration of computer scientist-programmed CourSys with university enterprise solutions provides a seamless user experience.

The developers have made this system open source, freely available on github.com. Further, they have already implemented features that pull data from enterprise systems for every other department at SFU. Should another department request access, the developers have only to make a few modifications and grant permissions; there is no need for a separate installation on a local server. The CourSys server is not physically located at IT Services, leading to a potential security concern. Otherwise, the success criteria components of IT security and data flow rationality are well addressed with CourSys. There are no FIPPA concerns with the CourSys as it remains on campus.

Switching from the known with FacSIMS to the relatively unknown with CourSys will likely prove both operationally disruptive for the small group of five or so staff that currently rely on the incumbent system for administrative tasks. The phased implementation plan for CourSys seeks to minimize this disruption. Given that much of the department is unaware of these administrative tasks, organizational disruption is not expected to be high. Graduate students will be directed to a different online application portal but have little knowledge of what transpires beyond that page.

The proposed migration to CourSys as a departmental database is an attractive option from a cost perspective. Whereas there is a large upfront cost with an industry product, and even server hardware costs for a "free" TRACS installation, there is no need to procure and commission a new server for CourSys. Rather, the CourSys administrators need only set permissions and new synchronization rules for the existing system to be marginally useable by the department; installation costs are low to non-existent. Some training will be required for new users, but as the core user group is a

small subset of the department the total training costs as part of migration costs would be low. The CourSys administrators indicate that they are happy to provide some training at no cost. In order to reduce the burden on the administrators, the department can send one individual to receive high-level training and so act as the departmental super user. Internal training would then be provided on an ad hoc basis at no additional cost except for the opportunity cost for time spent in training. There should be discussions with CourSys managers to examine the possibility of automating the import of data from FacSIMS. If this is not realistic, migration costs will increase with the time required to port data to the new system. Running costs will be low to non-existent as the system is operated and managed by a different department. Again, this benefits the department by freeing resources that can be better directed to development of new systems that meet more specialized needs of Chemistry.

For staff users of FacSIMS, there is little intrinsic value in moving to CourSys. There is some extrinsic value, in that simplification of routine jobs provides more time for users to focus on higher-value-added tasks. An increase in productivity and quality of work done will benefit staff in job reviews. There is an expected increase in job satisfaction from the resulting decrease in stress and frustration at not having to follow inefficient processes anymore, similar to the grades submission process redesign option presented above.

There is not much in the way of perceivable value to students, either current or future, arising from a migration to CourSys. As this option focuses only on the administrative aspects of FacSIMS and not on any student-facing system, there is little expectation that students would even be aware of the change. The one possible exception is that students can receive a higher quality of advising service when the advisor has access to the student's full history with the department at their fingertips in a single system, relating much more to current value for students than future value. A more granular view of an undergraduate academic career allows the advisor to see red flags or other issues that can then be brought to the attention of the student. If these red flags suggest that the advisor not grant permission for the student to enroll in a course when they are likely going to fail, the student realizes value in tuition savings while the stress, anxiety, and turmoil of struggling in a course is forestalled.

A summary of how well the FacSIMS replacement option meets the range of success criteria is shown in Table 5.3 below.

**Table 5.3. Assessment of the option to replace FacSIMS**

<b>Expected Level of Data Integrity</b>	<b>High</b>
IT Security	Medium
Data Flow Rationality	High
FIPPA Compliance	High
<b>Overall Minimization of Disruption</b>	<b>Medium</b>
Minimization of Operational Disruption	Medium
Minimization of Organizational Disruption	Medium
<b>Desirability of Cost Position</b>	<b>Medium</b>
Start-up Cost	Low
Migration Cost	Medium
Running Cost	Low
<b>Total Value to Staff</b>	<b>Medium</b>
Intrinsic Value	Low
Extrinsic Value	Medium
Job Satisfaction	Medium
<b>Total Value to Students</b>	<b>Low</b>
Current Value	Low
Future Value	Low

### 5.3. Assessment of Options

An assessment of the options through the lens of the defined success criteria provides for a comparison of relative merits and risks. Table 5.4 below shows a summary of this analysis, derived from the previous discussion of the options.

**Table 5.4. Comparison of three options presented on meeting success criteria**

Proposal	Expected Level of Data Integrity	Overall Minimization of Disruption	Desirability of Cost Position	Total Value to Staff	Total Value to Students
Adoption of Canvas-SIMS Grades Submission Process	High	Medium	High	High	Low
Replacement of LON-CAPA with Canvas	Medium	Low	Medium	Low	High
Replacement of FacSIMS with CourSys	High	Medium	Medium	Medium	Low

What can be seen from this analysis is that the option of the Canvas-SIMS grades approval process provides high levels of data integrity and value to staff with low levels of cost and pernicious disruption. As such, the recommendation is that the Department of Chemistry implements this process modification as soon as possible.

While the selected change option is the initial recommendation, there is significant value to be found in implementation of the remaining options. Thus, the extended recommendation is to only begin with the grades submission process change, followed by implementation of the other suggested system changes. The first steps for this replacement of LON-CAPA as a CMS and online quiz tool are necessitated by the greater adoption of Canvas for grades reporting. Once the new grades submission process for the Department of Chemistry is completely updated to be in line with every other department and there is full buy-in from all instructors and staff, the momentum of process change should be maintained by migrating the TA and RA application and assignment process to CourSys. This migration is the first step of a full FacSIMS replacement, as suggested in the third option.

Through the above recommendations, the application portfolio in the department will be rationalized along operational boundaries of teaching, reporting, and administrative activities. Where previously a FacSIMS outage could potentially impair the ability of the department to run a course (from assigning instructors and TAs to

setting up class lists to submitting grades), in the future a CourSys outage will only have an impact on resource planning processes. There remains some functional overlap, in that Canvas is used in both the recording and reporting of grades. However, as a central university system, Canvas is depended upon by multiple faculties and so receives mission-critical support from IT Services and the TLC. Thus, the small continued risk arising from this process regime overlap is mitigated through outsourcing to groups with specific core competencies around Canvas management.

## **5.4. Strategic Impact**

Migration from FacSIMS to a proven, stable system such as CourSys can serve to free the department, and potentially the faculty, from dedicating an inordinate level of resources to an application that really should be more appropriate for a Factory operating mode (McFarlan et al., 1983) - the department needs a tank, not a Yugo.

A similar conclusion arises from consideration of the strategic alignment of the department (Henderson and Venkatraman, 1993). Long ago, the previous management in the department may have developed a business strategy that depended on the IT available at the time, dictating the IS processes currently in place (“technology transformation” perspective). The implementation of electronic databases and online quiz platforms in the mid-1990’s very much speaks to a decision to transform education through the application of technology. However, years of complacency have resulted in the current situation where the deployed technology dictates IS processes, relegating strategy to that of maintaining business as usual. This would be symptomatic of a “service perspective” if not for the fact that this SAM perspective is one of competing on quality of customer service offered; the perceived departmental perspective represents more of a basic support level for IT.

Evaluation of this transformation using the strategic grid framework suggests that the department started in the Turnaround quadrant as the systems in development, FacSIMS and Marks Database, held promise in transforming the way courses were managed and grades information accessed. As there was nothing else in the development pipeline after that, the department moved firmly to the Factory quadrant.

While the operating environment continued to change with the university-wide deployment of SIMS, the strategic impact of FacSIMS and Marks Database diminished with their increasing redundancy, moving the department to the Support quadrant. The department needs to put business strategy back in the driver's seat and move back to the Factory quadrant. Time, attention, and other resources freed from maintaining the incumbent systems can be focused on development of new uses of technology for the benefit of students.

As a five-year term for the position of Chair is long enough to be able to effect real change in the department, there should be a renewed push from the top down to embrace a reversion to business strategy informing technology selection. Even the remaining three years of the current Chair appointment is more than enough time to both address the major issues with the application portfolio and lead an IT strategic planning charge. In order to stay relevant and competitive, an additional recommendation for the department is to undertake an IT strategic planning process wherein no technology is sacred. Ingrained complacency should give way to an internalized drive to enact the new strategy with an eye always on the next opportunity to improve. Once a cycle of planning and implementation gains traction, the transitory nature of the position of Chair will not limit the ability of the department to change.

## **5.5. Implementation**

In this section, change implementation plans are proposed. The repeating academic semester offers a natural series of four-month planning and production cycles in which all business processes are carried out. So as to minimize the possible negative impact of change, stemming from either impaired productivity as systems proficiency is gained or from tepid acceptance or rejection of new systems, a phased change implementation over three semesters is proposed. The three-semester plan broadly mirrors the three phases of change theory, “unfreezing”, “changing”, “and refreezing” and is represented below in Figure 5.1.

**Figure 5.1. Proposed three-semester change implementation timeline**

	Semester One “Unfreezing”	Semester Two “Changing”	Semester Three “Refreezing”
Departmental Expectations & Cultural Norms	<ul style="list-style-type: none"> <li>Grades submission process has changed</li> <li>Canvas will fully replace LON-CAPA next semester</li> <li>Exploring TA/RA features of CourSys</li> </ul>	<ul style="list-style-type: none"> <li>All instructors must follow new grades submission process</li> <li>First semester with only Canvas</li> <li>TA/RA feature of CourSys used by department</li> </ul>	<ul style="list-style-type: none"> <li>Grades reporting only done through the Canvas-Excel-SIMS pathway</li> <li>LON-CAPA is fully discontinued</li> <li>Migration of other FacSIMS tasks to CourSys</li> </ul>
Training & Development	<ul style="list-style-type: none"> <li>Departmental Canvas experts fully trained, provide training to rest</li> <li>Ad hoc training from TLC</li> <li>Generation of new problem sets in Canvas</li> </ul>	<ul style="list-style-type: none"> <li>Growth of Canvas user network</li> <li>Refinement of Canvas course pages</li> <li>Full deployment of Canvas problem sets</li> </ul>	<ul style="list-style-type: none"> <li>Continued support from TLC</li> <li>Gaining mastery of Canvas</li> </ul>
Legacy Systems Status	<ul style="list-style-type: none"> <li>FacSIMS and Marks Database set up, in place as backup</li> <li>LON-CAPA still in use</li> <li>FacSIMS is core administrative tasks database</li> </ul>	<ul style="list-style-type: none"> <li>FacSIMS and Marks Database not set up but can be as final contingency</li> <li>LON-CAPA fully discontinued</li> <li>FacSIMS administrative tasks limited</li> </ul>	<ul style="list-style-type: none"> <li>FacSIMS and Marks Database fully discontinued</li> <li>LON-CAPA fully discontinued</li> <li>FacSIMS administrative functionalities discontinued</li> </ul>

The above implementation timeline can be accepted as a rough starting point to begin moving the department in the direction of change. The initial development of FacSIMS and Marks Database in the 1990’s shows that the Chair at the time had the vision and drive to transform the way the department operates. What were at the time innovative systems have since grown stale as the operating environment evolved around the Department of Chemistry. Following through with the changes proposed in this analysis is nothing more than another instance in a history of punctuated modernization.

Fruitful discussions with the staff at the TLC have led to the development of a Canvas training timeline that provides for a high chance of success. First, the teaching faculty should discuss internally their experiences with Canvas and their ideal vision of the CMS as a student engagement tool. With these positive and negative experiences and CMS visions in mind, three to five teaching faculty for high-enrolment lower-division courses will attend a two-hour initial training session to provide them with the tools to be able to create a course page and be able function in the Canvas space. Two weeks later, after instructors have had the opportunity to practice and explore the tools in the unpublished course page, they attend another two-hour training session where advanced user questions and requests are fielded. Following this, ad hoc support is provided as requested. These trained faculty members will become the trainers for the rest of the department, providing departmental peer education and support that is more likely to be accepted than that from outside Chemistry.

The phased implementation of Canvas, first as the primary CMS for grades tracking, followed by full replacement of LON-CAPA as the online assignments and learning tool, provides a high chance of success for the latter change to succeed. By first giving instructors a full semester to familiarize themselves with Canvas, as required from the change in the grades submission process flow, they will be well-positioned to be able to incorporate assignments into their online course space when LON-CAPA is shut down.

As Canvas use gains traction, the department should operate with the understanding that any tool used should be for the benefit of the student. It is proposed that a mandatory student survey is issued at the end of a course, similar to teaching reviews but instead serving as a sort of learning technology review. Students will be given the opportunity to provide feedback on what they like or dislike about Canvas, LON-CAPA, or any other student-facing system. Based on this feedback, changes can be implemented in the course spaces or other tools used. This is a process of continual improvement, keeping the department up to date on the current attitudes of students toward online learning and allows for fine tuning of approaches to better serve their needs. As the TLC already functions in report generation for teaching reviews, this learning tools feedback system can be developed cooperatively to maximize value for



both groups. Analytics data, including system usage time per student, can be combined with this feedback to serve as a performance metric. Without paying due attention to the feedback and engagement of the student-as-customer, the department risks the relevance of its teaching approaches.

What is clear from this analysis is that a culture shift is required in the Department of Chemistry. This shift needs a change champion imbued with the drive to innovate, capacity to develop a vision, and determination to relentlessly push the department towards operational excellence. Ideally, this change champion would be an instructor with the respect of their peers, the full support of the Chair, and an authority legitimizing their role. The change champion will be appointed to the department IT committee but should also be expected to attend departmental faculty meetings to be given a valid platform from which to preach change. Further, in creating this role, the Chair should expect the change champion to attend, and even initiate, IT-focused meetings with the Faculty of Science, IT Services, the TLC, Student Services, and even further afield. By paying active attention to the constantly evolving university operating environment, the champion is well positioned to keep the Department of Chemistry at the forefront of change. Updates and directives from the change champion on the changing face of university IT should become as natural to the department as Friday morning coffee.

To drive the above proposed implementation plan, the change champion should take full ownership of the first suggested proposal of grades submission process reengineering. They should brief the IT committee on the new process and ensure that the committee is fully equipped with the training and knowledge to be able to provide the support the rest of the teaching faculty may need to be able to effectively follow the new process. They should also liaise with the TLC and IT Services to organize training as required. With this support system in place, at the very next faculty meeting the change champion can inform the department that the grades submission process is being modified. In this same meeting, the seed of the idea of LON-CAPA replacement should be planted to get the faculty members thinking on potential new approaches to online assignment structure. For the administrative functions of FacSIMS, the change

champion need only work with the smaller group of staff and faculty that perform planning and administrative job tasks to drive implementation of CourSys.

In order to not shock all of the employees in the department with three massive changes at once, each semester in the timeline is devoted to implementation of only one of the proposed changes. In the future, as new IS opportunities are identified, this restriction of taking on one change project at a time should be adhered to. This is not to say that change projects need be self-contained and serialized. Rather, brainstorming and discussions should constantly be taking place to build buy-in for adaptation. “Change for the sake of change” should be avoided, but instead change should be informed by the strategic plan of the department. Thus, the change champion should play a key role in the strategic planning process.

One of the main goals of the change champion, and by extension the department, should be to ensure that systems ownership is decentralized or outsourced as far as possible. It makes little sense for the department to remain a self-contained functional silo in the modern university operating environment. This analysis is very much necessitated by the pains and disruptions wrought by the unexpected absence of the previous departmental applications keystone individual. The department can ill afford to revert to the previous systems ownership structure. Decentralizing ownership and outsourcing to the support groups at the university ensures that individual HR issues do not threaten operations.

## Chapter 6. Conclusion

This analysis suggests that many processes in the Department of Chemistry have gone relatively unchanged over the past twenty years while the university operating environment has never stopped evolving. The department was once at the leading edge of leveraging technology to improve the teaching program, as evidenced by the development of FacSIMS and Marks Database, and deployment of LON-CAPA. However, as the university evolved technologically the department did not. As more and more system upkeep responsibilities were taken on by a single keystone individual in the department, they became less and less free to explore new technology and push change. By outsourcing these upkeep tasks by migrating to either centrally- or externally-supported systems, the department can refocus on the strategy of leveraging IT to the benefit of the students.

It is not suggested that this report solves all of the information systems problems that might be present in the Department of Chemistry. Rather, it seeks to provide an analytical framework and set of tools for the department to use in understanding information systems. More importantly, it reveals a troublesome gap in IT strategy. A strategic realignment can demand change, showing that there are immediate efficiency gains to be found with relatively little pain. With the view that generation of this report constitutes a consultative process, "... activities such as observations, interviews, and questionnaires are already powerful interventions and that the process of learning about a system and changing the system are, in fact, one and the same." (Schein, 1996)

While a full-scale BPM project is not being proposed, and in fact the academic organizational structure almost all but precludes such an idea, much of the proposed change is encompassed by the organizational theories informing BPM.

An overarching theme revealed over the course of this analysis is that the department's IT strategy has not been responsive to change in the operating

environment, both internal and external. Contingency theory suggests that, while the development and deployment of FacSIMS and Marks Database was critical to the success of the department in 1996, the external pressures necessitating those departmental databases are no longer the same today as they were then. The Chair, instructors, and staff in the department need to realize that change has happened and will continue to do so regardless any action or inaction on the part of Chemistry. There has also been significant internal change, with developers and system owners coming and going, taking with them the knowledge and expertise required to best leverage IT for success. Importantly, the students of today are no longer the students of ten years ago - they have grown up with technology, experience it differently, and have expectations on how it fits in to their lives. The effect of these unstoppable changes in the internal and external environment have left the department trying ever-harder to squeeze a square peg into a hole that has been getting rounder and rounder for years. Underlying this analysis is a presentation of the facts of those accumulated changes; the proposed changes and implementation plan attempt to set the department on a strategic direction better informed by contingency theory rather than effecting a one-time modernization.

A significant factor in the ability of the department to find success in this new strategic direction is the ability to respond to perceived changes, as suggested by dynamic capabilities theory. Business process reengineering combined with an outsourcing of Factory systems (grades reporting, CMS) to specialized university support divisions unburdens the department, allowing for a greater agility in responding to a changing operating environment. The suggestions for the Chair to appoint a change champion and instill in the department a culture of adaptability do more than simply fix the current issues, they prime the faculty to be able to move as nimbly as the environment demands.

## References

- Brewster, K. (2015). Simon Fraser University Budget and Mandate Letter [PDF file]. Retrieved from [http://www.aved.gov.bc.ca/budget/15\\_16/budget\\_letters/SFU.pdf](http://www.aved.gov.bc.ca/budget/15_16/budget_letters/SFU.pdf)
- CampusSource.(2010). LON-CAPA. Retrieved from <http://www.campussource.de/org/software/loncapa/>
- Capilano University. (n.d.a). Student Enrolment Statistics – Capilano University. Retrieved from <https://www.capilanou.ca/about/Student-Enrolment-Statistics/>
- Capilano University. (n.d.b). A – Z List of Programs – Capilano Univeristy. Retrieved from <https://www.capilanou.ca/programs/A-Z-List-of-Programs-Courses/>
- Crowdmark. (2016). Higher Ed | Crowdmark. Retrieved from <https://crowdmark.com/higher-ed/>
- Davis, F. D. (1985). A technology acceptance model for empirically testing new end-user information systems: theory and results (Doctoral dissertation. Retrieved June 4, 2016 from <http://hdl.handle.net/1721.1/15192>
- Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science*, 35(8), 982-1003. Retrieved from <http://www.jstor.org.proxy.lib.sfu.ca/stable/2632151>
- Desire2Learn. (2016). D2L | Learning Management System (LMS). Retrieved from <http://www.d2l.com/>
- Douglas College. (2016). About Douglas – Douglas College. Retrieved from <http://www.douglascollege.ca/about-douglas>
- Downes, L. (2009). The laws of disruption: harnessing the new forces that govern life and business in the digital age. Retrieved from Books24x7
- Ellucian. (2012). Ellucian: New Company Name Announced for Datatel and SunGard Higher Education Combination | Newsroom | Ellucian. Retrieved from <http://www.ellucian.com/News/Ellucian-New-Company-Name-Announced-for-Datatel-and-SunGard-Higher-Education-Combination/>

- Ellucian. (2016). CRM for Higher Education | Ellucian CRM. Retrieved from <http://www.ellucian.com/crm-for-higher-education/>
- FileMaker. (2016). Create custom apps with the FileMaker platform | FileMaker. Retrieved from <http://www.filemaker.com/products/>
- Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention, and behavior: an introduction to theory and research*. Reading, MA: Addison-Wesley Pub. Co.
- Gartner. (2016). Gartner Says Customer Relationship Management Software Market Grew 12.3 Percent. Retrieved from <http://www.gartner.com/newsroom/id/3329317>
- Ghazizadeh, Y., (2009). Total Cost of Ownership: Factors to Consider | Intel® Software. Retrieved from <https://software.intel.com/en-us/articles/total-cost-of-ownership-factors-to-consider>
- Henderson, J. C., & Venkatraman, N. (1993). Strategic alignment: leveraging information systems for transforming organizations. *IBM Systems Journal*, 38(2.3), 472-484. doi:10.1147/SJ.1999.5387096
- Inside Higher Ed. (2005). Blackboard, WebCT to Merge. Retrieved from <https://www.insidehighered.com/news/2005/10/13/merger>
- Instructure. (2011). Canvas Goes Open Source. Retrieved from <https://www.canvaslms.com/news/press-releases/canvas-goes-open-source>
- Instructure. (2016a). Canvas wins ERA Secondary Resource Award. Retrieved from <https://www.canvaslms.com/news/pr/canvas-wins-era-secondary-resource-award&122591>
- Instructure. (2016b). Our Story | Canvas Learning Management System. Retrieved from <https://www.canvaslms.com/about-us/>
- Instructure. (2016c). 10-Q Report. Retrieved from <http://d1lge852tjjqow.cloudfront.net/CIK-0001355754/c7aa269a-8dd7-4106-ac9f-a6b3bf2d9b68.pdf>
- Kwantlen Polytechnic University. (2015). KPU Facts | KPU. Retrieved from <http://www.kpu.ca/about/facts>
- Langara. (2016). Langara. About Langara: Langara at a Glance. Retrieved from <http://langara.ca/about-langara/langara-at-a-glance/index.html>
- LON-CAPA. (2013a). The LearningOnline Network with CAPA. Retrieved from <http://www.lon-capa.org/institutions.html>

- LON-CAPA. (2013b). The LearningOnline Network with CAPA. Retrieved from <http://www.lon-capa.org/whois.html>
- LON-CAPA. (2013c). The LearningOnline Network with CAPA. Retrieved from <http://www.lon-capa.org/history.html>
- McFarlan, F. W., McKenney, J. L., & Pyburn, P. (1983). The information archipelago – plotting a course. *Harvard Business Review*, 61(1), 145-156. Retrieved May 19, 2016 from Business Source Complete database.
- Microsoft. (2016a). Customer Relationship Management (CRM) Systems | Microsoft Dynamics. Retrieved from <https://www.microsoft.com/en-us/dynamics/crm.aspx>
- Microsoft. (2016b). ERP Business Systems and Solutions | Microsoft Dynamics. Retrieved from <https://www.microsoft.com/en-us/dynamics/erp.aspx>
- Microsoft. (2016c). CRM Public Sector Solutions | Microsoft Dynamics. Retrieved from <https://www.microsoft.com/en-us/dynamics/public-sector.aspx#Education>
- Moodle. (2016). Moodle – Open-source learning platform | Moodle.org. Retrieved from <https://moodle.org/>
- Norman, D. A. (2013). *The design of everyday things*. Retrieved from Safari Books Online (Original work published 1988)
- Oracle. (n.d.a) Oracle Contacts. Retrieved from <https://www.oracle.com/corporate/contact/index.html>
- Oracle. (n.d.b) PeopleSoft Campus Solutions | Applications | Oracle. Retrieved from <http://www.oracle.com/us/products/applications/peoplesoft-enterprise/campus-solutions/overview/index.html>
- Pearson. (2016a). Mastering Physics | Pearson. Retrieved from <http://www.pearsonmylabandmastering.com/northamerica/masteringphysics/>
- Pearson. (2016b). Integrating Modified Mastering with Canvas for easy access. Retrieved from <http://www.pearsonmylabandmastering.com/northamerica/educators/mm-support/integrate-with-canvas/index.html>
- Prahalad, C. K., & Hamel, G. (1990). The core competence of the corporation. *Harvard Business Review*, 68(3), 79-91. Retrieved June 5, 2016 from Business Source Complete database.
- Salesforce.org. (2016). Product Stories – Salesforce.org. Retrieved from [http://www.salesforce.org/product-stories/?story\\_type=higher-ed](http://www.salesforce.org/product-stories/?story_type=higher-ed)

- Samuelson, W., & Zeckhauser, R. (1988). Status quo bias in decision making. *Journal of Risk and Uncertainty*, 1(1), 7-59. doi:10.1007/BF00055564
- SAP. (2014). SAP for Higher Education and Research [PDF file]. Retrieved from <http://go.sap.com/documents/2014/12/eca9d15d-3b7c-0010-82c7-eda71af511fa.html>
- Scantron. (2016). Our Story – Scantron. Retrieved from <http://www.scantron.com/about-us/company/our-story>
- Schein, E. H., (1996). Kurt Lewin’s change theory in the field and in the classroom: notes toward a model of managed learning. *Systems Practice*, 9(1), 27-47. doi:10.1007/BF02173417
- Schein, E. H., (2002). Models and tools for stability and change in human systems. *Reflections, The SoL Journal*, 4(2), 34-46. doi:10.1162/152417302762251327
- Simon Fraser University. (2013). Salary Scale Lab Instructors, Lecturers & Senior Lecturers A20.02 [PDF file]. Retrieved from [http://www.sfu.ca/content/dam/sfu/policies/files/academic\\_policies/20\\_series/SEPT\\_2013\\_Laboratory%20Instructors%2C%20Lecturers%20and%20Senior%20Lecturers.pdf](http://www.sfu.ca/content/dam/sfu/policies/files/academic_policies/20_series/SEPT_2013_Laboratory%20Instructors%2C%20Lecturers%20and%20Senior%20Lecturers.pdf)
- Simon Fraser University. (2016). 2015/16 Annualized Undergraduate Enrolment Report [PDF file]. Retrieved from <https://www.sfu.ca/content/dam/sfu/irp/enrolment/EnrolmentDashboard/documents/ug.enrol.report.2015.2016.pdf>
- Simon Fraser University. (n.d.a). Implementation Plan – Canvas Support – Simon Fraser University. Retrieved from <http://www.sfu.ca/canvas/implementation.html>
- Simon Fraser University. (n.d.b). Cloud Computing FAQ. Retrieved from [https://www.sfu.ca/itservices/info\\_security/cloud-computing-faq.html](https://www.sfu.ca/itservices/info_security/cloud-computing-faq.html)
- Stewart, J. (2008). CALCULUS. Retrieved from [http://www.stewartcalculus.com/media/16\\_inside\\_supplements.php](http://www.stewartcalculus.com/media/16_inside_supplements.php)
- Tableau. (2016). Tableau Server | Tableau Software. Retrieved from <http://www.tableau.com/products/server>
- Torkkeli, M., & Tuominen, M. (2002). The contribution of technology selection to core competencies. *International Journal of Production Economics*, 77(3), 271-284. doi:10.1016/S0925-5273(01)00227-4
- TSSU. (2016). Wages and Paystubs | TSSU. Retrieved from <http://www.tssu.ca/wages/>



- University of British Columbia. (2004). UBC News Digest Oct. 15, 2004 – UBC Public Affairs. Retrieved from <http://news.ubc.ca/ubcnewsdigest/2004/04oct15.html#4>
- University of British Columbia. (2016a). UBC Overview and Facts 2015/16 [PDF file]. Retrieved from [https://www.ubc.ca/\\_assets/pdf/UBC\\_Overview\\_Facts\\_2015-16.pdf](https://www.ubc.ca/_assets/pdf/UBC_Overview_Facts_2015-16.pdf)
- University of British Columbia. (2016b). Enrolment Statistics 2015/16 – Vancouver Academic Calendar 2016/17 – UBC Student Services. Retrieved from <http://www.calendar.ubc.ca/Vancouver/index.cfm?page=appendix1>
- Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science*, 46(2), 186-204. Retrieved from <http://www.jstor.org.proxy.lib.sfu.ca/stable/2634758>
- Ward, J. M. (1990). A portfolio approach to evaluating information systems investments and setting priorities. *Journal of Information Technology*, 5(4), 222-231. Retrieved June 4, 2014 from Business Source Complete database.
- Yahoo! Answers. (2011). Please Help Me With LonCapa (Chemistry). One Question Left..? | Yahoo Answers. Retrieved from [https://answers.yahoo.com/question/index;\\_ylt=AwrXgCNdQU5XghMAjw1PmolQ;\\_ylu=X3oDMTByZDNzZTI1BGNvbG8DZ3ExBHBvcwMyBHZ0aWQDBHNIYwNzYw--?qid=20110306153036AA7iRgh](https://answers.yahoo.com/question/index;_ylt=AwrXgCNdQU5XghMAjw1PmolQ;_ylu=X3oDMTByZDNzZTI1BGNvbG8DZ3ExBHBvcwMyBHZ0aWQDBHNIYwNzYw--?qid=20110306153036AA7iRgh)

## **Appendices**

## **Appendix A**

In Appendix A is presented a background on the chosen subset of local higher education institutions for comparison to SFU. In addition, a brief statement is provided on the SIS and CMS in use at each school.

### **University of British Columbia**

First opened in 1915, UBC reported an undergraduate enrolment at Vancouver campuses of 42,986 for the 2015/16 academic year (University of British Columbia, 2016a). Of this total, 7,803 undergraduate students were enrolled in the Faculty of Science (University of British Columbia, 2016b). The satellite campus in the interior of British Columbia, UBC Okanagan, had a 2015/16 total enrolment of 8,392 (University of British Columbia, 2016a).

The UBC SIS is a twenty year old in-house developed database, accessible through either “student service centre” or “faculty service centre” portals. In 1995, an internal development project at UBC led to the implementation of WebCT as the officially supported CMS of the university. In 1999, WebCT merged with Massachusetts-based Universal Learning Technology, thereby gaining access to broader markets (University of British Columbia, 2004). In 2005, Washington, DC-based educational software provider Blackboard acquired WebCT for \$180 million (Inside Higher Ed, 2005). The end result of this series of mergers and acquisitions is that the officially supported CMS, UBC Connect, is built on the Blackboard technology platform.

Student registration information from SIS is imported into UBC Connect through a subsystem called the Learning Tools Provisioning Service. While the central CMS is UBC Connect, instructors have the academic freedom to use any technology of their liking. When an instructor chooses to use any other CMS, student registration info is pulled from UBC Connect.

## **Kwantlen Polytechnic University**

Kwantlen Polytechnic University (KPU), founded in 1981, boasts annual enrolment of 19,000 students across four campuses in Surrey, Richmond, Cloverdale, and Langley (Kwantlen Polytechnic University, 2015). KPU offers a wide variety of certificate, diploma, and undergraduate degree programs.

The KPU SIS is a SunGard Higher Education installation called myKwantlen. In 2012, SunGard Higher Education merged with Datatel to form Ellucian (Ellucian, 2012). As the myKwantlen back-end is still branded as a SunGard installation, it is assumed that this deployment went live before the merger. The officially-supported CMS, KPU Courses, is powered by Moodle, an open-source CMS platform (Moodle, 2016).

## **Capilano University**

Founded in 1968, Capilano University has an annual enrolment of approximately 7,000 students across two campuses in North Vancouver and Sechelt (Capilano University, n.d.a). Capilano University offers a variety of certificate, diploma, and undergraduate degree programs with a greater focus on academics than trades or technical streams (Capilano University, n.d.b).

The Capilano University SIS is a modern Ellucian installation, while the CMS is powered by Moodle.

## **Douglas College**

Founded in 1970, Douglas College offers a number of certificate, diploma, and undergraduate degree programs. Approximate annual enrolment across campuses in New Westminster and Coquitlam numbers 14,000 (Douglas College, 2016).

Similar to KPU, the Douglas College SIS is powered by a SunGard Higher Education installation. The Douglas College central CMS is powered by Blackboard.

## **Langara College**

Founded in 1965, Langara College has an annual enrolment of 20,615. Langara College offers a number of programs across the traditional academic fields of study. Although there is a Baccalaureate degree program, approximately half of the students enrolled at Langara College are in programs geared towards transfer to a university (Langara, 2016).

As with Capilano University, the Langara College SIS is an Ellucian installation. The CMS is powered by Brightspace, a product from Ontario firm Desire2Learn (Desire2Learn, 2016).

## **Appendix B**

This appendix provides an overview of the department size by undergraduate enrolment, maximum class size, and IS use for the other seven departments in the Faculty of Science. The maximum class size is of particular importance to the Chair in the Department of Chemistry as they worry that an approach in a smaller class in a different department may not be appropriate for a larger class in Chemistry. This discussion shows that there are comparable class sizes for which different grades submission processes are followed across the faculty.

### **Biological Sciences**

The Department of Biological Sciences was the third largest department in the faculty in the 2015/16 academic year with an undergraduate academic full-time equivalent (AFTE) enrolment of 586.0 (Simon Fraser University, 2016). Introductory first-year biology courses have enrolment in the range of 400 - 500 students. For these courses, students attend and receive marks for the lecture and laboratory components, suggesting a common need for robust information systems to deliver content and record component grades for eventual submission to Student Services.

Biological Sciences does not make use of a departmental grades database. Instructors have the academic freedom to choose how they deliver course content and record grades, so it is possible that there are limited uses of non-Canvas CMS, online quiz systems, and grade processing spreadsheets or programs. However, Biological Sciences does not explicitly direct instructors to follow a prescribed procedure for grade calculation and submission. This department does not use FacSIMS for administrative tasks, instead relying upon the previously discussed collection of FileMaker databases maintained in-house.

### **Physics**

The Department of Physics was the sixth largest department in the faculty in the 2015/16 academic year with an undergraduate AFTE enrolment of 350.2 (Simon Fraser

University, 2016). As a core science, introductory physics courses have enrolment in the range of 300 - 400 undergraduate students.

Similar to Biological Sciences, the Department of Physics has no tailored departmental systems for student assessment or grade tracking. Instructors use Canvas to set up and manage courses and marks from exams and in-class iClicker participation questions are entered manually into the Canvas Gradebook. The Department of Physics does have an online tool that allows for guided learning and assessment. This system is called MasteringPhysics, offered by Pearson Education as a complement to their textbook products (Pearson, 2016a). Students either receive an access code with their purchased textbook, or can purchase an access code separately should they choose. MasteringPhysics presents a modern graphical interface with videos, extended readings on difficult concepts, quiz problems with hints that guide the student through the problem, and full data analytics for the instructor on which problems prove challenging for the class as a whole. MasteringPhysics can be fully integrated into major CMS platforms, including Canvas, allowing for seamless student access and automated grade transfers from MasteringPhysics quizzes into the Canvas Gradebook (Pearson, 2016b). It is unclear if any instructors are making use of this integration service at this time.

Instructors in the Department of Physics export the populated Canvas Gradebook and determine percentage cut-offs for final letter grade assignment in Excel. These letter grades are entered into SIMS either manually or through the previously described import process. It has been described as a tedious process, taking upwards of a day to complete. However, instructors in this department suggest that this pales in comparison to registration issues that arise at the beginning of the semester. When registration is relatively fluid, as students add or drop daily, Canvas lags behind and so cannot provide the instructor the full set of tools for all students who are currently registered.

The Department of Physics does use FacSIMS to a limited degree for TA and RA application and assessment, research grants tracking, and personnel information. All historical student grades data that is required is retrieved directly from SIMS.

## **Mathematics**

The Department of Mathematics was the largest department in the faculty in the 2015/16 academic year with an undergraduate AFTE enrolment of 831.8 (Simon Fraser University, 2016). First year courses are large, with enrolments of approximately 500 undergraduate students.

The Department of Mathematics uses a combination of content delivery and assessment tools, including LON-CAPA, Canvas, and textbook publisher web systems.

Similar to the Department of Physics, an online teaching and assessment tool provided by the textbook publisher is used to complement students' learning. For example, selection of the Stewart Calculus textbook can allow the instructor to make use of the following online systems: Tools for Enriching Calculus; Cengage Learning Testing; WebAssign (Stewart, 2008). Instructors have the academic freedom to decide on which tools to use while considering added costs for students.

As with others, this department uses the content delivery and Gradebook features of Canvas extensively for courses. Grades from LON-CAPA, publisher web tools, and marked exams are entered into Gradebook and exported for eventual submission to SIMS through the previously described process. As with other departments, processing grades for a class of 500 students can take most of a day yet allows for the instructor to apply judgement in assigning final grades. Even if it appears that a student should pass a course, their performance may suggest that they have not actually mastered the content and will abjectly fail the next level course. In those cases, it is preferable to assign a failing grade rather than set them up for later failure.

As with most other departments, Mathematics uses the basic FacSIMS functionalities of TA and RA assignment, teaching load tracking, and personnel information.

## **Biomedical Physiology and Kinesiology**

The Department of Biomedical Physiology and Kinesiology (BPK) was the second largest department in the faculty in the 2015/16 academic year with an



undergraduate AFTE enrolment of 827.1 (Simon Fraser University, 2016). Course enrolments are in the range of 100 – 200 students.

Instructors use Canvas for course management and marks tracking, following the described process of transferring marks from the Canvas Gradebook to SIMS.

FacSIMS is used for the administrative functions of TA and RA applications, personnel information, and grants tracking. BPK does have a GPA maintenance requirement for students to remain in the program. As FacSIMS is synchronized with grades data from SIMS, it can almost be used to generate a GPA report for students in a particular program, but there are persistent bugs that prevent this feature being used with confidence. This leads to the time-consuming requirement to double-check the FacSIMS report against advising reports and other sources.

## **Earth Sciences**

The Department of Earth Sciences was the smallest department in the faculty in the 2015/16 academic year with an undergraduate AFTE enrolment of 105.2 (Simon Fraser University, 2016). The largest first-year courses can have enrolment of up to 150 undergraduate students.

This department uses Canvas for course management, marks entry, and eventual export-import of final grades to SIMS. Some classes are small enough that grades can be entered into SIMS one at a time instead of going through the import process as described elsewhere.

In the Department of Earth Sciences, FacSIMS is used for the typical administrative tasks of TA and RA appointments, personnel information, and report generation for the Institutional Research and Planning (IRP) department at the university.

## **Molecular Biology and Biochemistry**

The Department of Molecular Biology and Biochemistry (MBB) was the fifth largest department in the faculty in the 2015/16 academic year with an undergraduate

AFTE enrolment of 364.9 (Simon Fraser University, 2016). The largest course in MBB has an enrolment of approximately 250 undergraduate students.

As with most other departments, MBB uses Canvas for course management and marks tracking and while FacSIMS use is largely avoided.

### **Statistics and Actuarial Science**

The Department of Statistics and Actuarial Science was the seventh largest department in the faculty in the 2015/16 academic year with an undergraduate AFTE enrolment of 320.3 (Simon Fraser University, 2016).

Over the past few years, assignment and exam marks were entered into either Canvas or CourSys. At the end of the semester, the full marks data was exported to Excel and the weighting and shaping process carried out to determine final grades. Final grades were uploaded using SIMS class registration lists as templates, as previously described. Recently there has been a move to use only Canvas, in line with most other departments.

In the Department of Statistics, FacSIMS is an administrative tool for TA and RA appointments, personnel information, and other report generation. There has been a push from this department for the faculty to automate IRP report generation in FacSIMS, but it still is not a reality after a number of years of development efforts.

## Appendix C

In this appendix is presented an overview of enterprise products offered by the market leaders in the education CRM space.

The CRM market is led by two key players, Salesforce and SAP, with 2015 market shares of 19.7% and 10.2% respectively (Gartner, 2016). The next two largest firms, Microsoft and Oracle, accounted for a combined 12.1 % market share. The global CRM market grew from 2014 sales of \$23.4 billion to 2015 sales of \$26.3 billion.

The market leader, Salesforce, offers a Salesforce Higher Ed solution that has been implemented by dozens of leading universities globally (Salesforce.org, 2016). With their proprietary Higher Education Data Architecture, Salesforce Higher Ed allows for full student relationship management from initial recruitment through alumni interactions. A full SIS data analytics suite can be leveraged to support departmental teaching programs. The product is offered through a SaaS model with marginal monthly costs per student account. As a cloud-based SaaS offering from an American company based in San Francisco, California there are considerations around FIPPA that must be taken into account for product installations at universities in British Columbia.

SAP Higher Education and Research, used at a number of schools globally (SAP, 2014) is another product that promises full customer lifecycle management. Where Salesforce might be seen to be prioritizing university marketing, recruitment, and advancement, the SAP product seeks to serve the needs of both teaching and research programs. The drive behind the SAP product appears to be to derive efficiency gains through standardization, claiming that operating costs can be reduced by ~30 % when standard systems are deployed university-wide (SAP, 2014). SAP, based out of Germany but with global offices, provides Higher Education and Research product as either a cloud-based product or an on-site installation, the latter of which would allow a university in British Columbia to remain FIPPA-compliant.

Microsoft, based out of Washington state, offers CRM and enterprise resource planning (ERP) products under the banner of Microsoft Dynamics. As with other CRM providers, Microsoft Dynamics provides for full customer lifecycle management with

sales and marketing functionalities (Microsoft, 2016a). Microsoft Dynamics ERP allows for an integrated management and information platform for business operations, human capital management, and financial management (Microsoft, 2016b). Together, Microsoft Dynamics CRM and ERP are advertised as being an attractive information systems solution for the higher education sector (Microsoft, 2016c). However, Microsoft does not market a distinct version of Microsoft Dynamics tailored to the education sector. Similar to the SAP offering, this product is available as a cloud-based service or on-site installation. Other companies have built their offerings on the Microsoft Dynamics platform, most pertinent to this discussion being Ellucian (Ellucian, 2016). The Ellucian CRM product is marketed for the higher education sector, providing the customized version of Dynamics that Microsoft does not.

Oracle, based out of Redwood Shores, California, markets their popular PeopleSoft ERP database solution globally (Oracle, n.d.a). PeopleSoft Campus Solutions is their higher education product, adding to the core PeopleSoft database a set of education-specific functionalities such as SIS, student financials, and alumni information management (Oracle, n.d.b). This is the current backbone on which SFU SIMS, FINS, and HAP are built. The servers hosting these SFU enterprise systems are located on-campus, allowing for full FIPPA compliance.