MODELLING GIRLS' ACTIVITIES, MAKING IT RELEVANT: AN EXPLORATORY APPROACH TO PROMOTING TECHNOLOGY FLUENCY THROUGH NON-FORMAL LEARNING DESIGN

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ABSTRACT

Women remain under-represented in technology-creation fields. While studies have shown that the middle-school years are particularly important for motivating positive interest in science and technology fields, one issue that arises is *how* to engage girls, at the critical middle-school age, in IT related practice. In this thesis, I describe a mixed methods approach to the development of flexible heuristics, derived from the implementation of an interactive storytelling and game design workshop, to engage middle-school girls in technology-creation activities. Girls' technology-creation needs and preferences are explored from a study of the everyday activities of a purposive sample of 30 middle-school children, along with analysis of story and game projects developed by workshop participants. Such design heuristics, derived from insights gained during the course of the workshop and from activity study data, contribute to technology fluency objectives and ongoing, practice-based research in the fields of non-formal learning and IT education.

Keywords: activity modelling, computer science education, game design, gender, non-formal learning, technology fluency

DEDICATION

For VML.

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GLOSSARY

Content Analysis	A research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use (Krippendorff 2004).
Creativity	The ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints) (Sternberg & Lubart 1999).
DBR	Design-based research (DBR) is a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researchers and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories (Wang & Hannafin 2005).
Digital Natives	“Native speakers” of the digital language of computers, video games and the Internet. Digital Natives are used to receiving information really fast. They like to parallel process and multi-task. They prefer their graphics before their text rather than the opposite. They prefer random access (like hypertext). They function best when networked. They thrive on instant gratification and frequent rewards. They prefer games to “serious” work (Prensky 2001).
Engagement	Students are cognitively engaged when they give sustained, engaged attention to a task requiring mental effort. The highest form of cognitive engagement is self-regulated learning (Corno & Mandinach 1983).
Heuristic	A rule of thumb that often helps in solving a certain class of problems, but makes no guarantees (Perkins 1981).

1: INTRODUCTION AND BACKGROUND

1.1 Problem Domain

Increasingly, the teaching and learning of 21st century skills, such as critical thinking, problem solving, and IT literacy are emerging as central concerns for educators (International ICT Literacy Panel 2002, Partnership for 21st Century Skills 2010). National educational policy initiatives (National Research Council 1999a, National Research Council 2003, National Research Council 2006b), for example, have promoted several “innovation through design” efforts to address barriers to access and participation in IT practices, as well as to motivate the acquisition of IT competencies (Koch 2007, Koch 2009). Technology, as a primary driver for innovation, requires individual proficiencies including the abilities to learn, communicate, critically evaluate, and manage the types and forms of information (International ICT Literacy Panel 2002) essential to IT design and development (Baker & O’Neil 2003).

Despite advocacy for integrating technology competency initiatives into formal education, research shows that girls and women are still underrepresented in both interest level towards, and participation in, technology-related curricular and career domains (AAUW 2001, Margolis et al. 2000b, NCWIT 2008). Diversity in undergraduate computing disciplines is poor, with declining rates of women and ethnic minority enrolment (Zweben 2009). Labour statistics, in turn, reveal that women hold only 25% of professional IT-related occupations in the North American workforce, and contribute as named authors on only 9% of U.S. tech patents (National Center for Women and Information Technology 2010).

The limitations in multiple perspectives that result from field diversity deficits hold serious implications for the future of technology research and development (R&D) work (Trauth et al. 2008). Innovation requires the inclusion of “diverse experience, skills and knowledge perspectives” (Trauth et al. 2008) to support problem solving and facilitate the development of products that can speak to the different needs of different populations. Diversity of viewpoint in R&D practice is central to advancing technological innovation (Terrenghi et al. 2006), and reaches beyond issues of access to the culture of computing itself.

Technology Fluency

As the gender divide in IT disciplines and applied work continues to be of concern to education and industry analysts, national population studies have shown marked increases in the number of women *using* technology in their day-to-day lives (Burst Media 2007, Fallows 2005, Statistics Canada 2009). For example, the Canadian Internet Use Survey (2009) reveals that a similar proportion of men (81%) and women (80%) used the internet in 2009. Previously, in a 2005 study, the Pew Internet Project outlined shifting internet demographics with women having caught up to men in online engagement, and younger women and black women surpassing their male peers in internet use (Fallows 2005).

While the popularity of the Internet as a communication media has helped narrow the gap in technology *use* between the genders (Miller et al. 2001, National Science Foundation 2006), "girls and women are still less likely to participate in the *creation* of technology" (National Science Foundation 2006). The increased parity in technology use suggests that skills-based competencies have come to underline the socio-cultural realities and modes of engagement definitive of the 21st century. However, there is a growing concern that technology literacy, or the ability to "use" technology, is limited if not accompanied by conceptual understanding. The capacities to manage complexity, understand computer fundamentals such as information system organization, and algorithmic thinking, alongside technology use skills, form a foundation of IT fluency, which is crucial to contemporary knowledge economies (Lorenzo & Dziuban 2006, McEuen 2001, National Research Council 1999a).

The National Science Foundation (NSF) has maintained that literacy, alone, "is no longer sufficient," and that a move toward "fluency" should be the priority of IT education (National Science Foundation 2006). Fluency, in this context, "includes literacy skills, but it also includes a conceptual knowledge about when and how to use information technology, and the capability to apply that knowledge to new situations and to manage the inevitable problems that occur when new approaches are introduced" (National Science Foundation 2006). The National Research Council (NRC) (1999) similarly positions "fluency" as a "deeper understanding" of technology than is suggested by a literacy centrally defined by the ability to use an application. For the NRC (1999), fluency is more responsive to the high rate of technological change than literacy. Fluency has "staying power" and is linked to lifelong learning, while literacy is less adaptable to new skill acquisition needs and provides no clearly defined "migration path" to new or enhanced technology skill sets (1999). Individuals with acquired fluencies are better able to adapt to the rapid rate of technological transformation, having developed competencies important to self-directed learning outside of formal training and education contexts.

The fluency triad of "concepts, capabilities, and skills," comprise a developmental continuum of "FITness," or, "Fluency in Information Technology" (National Research Council 1999a), which evolves over time and meaningfully connects to the personal, workforce, educational, and societal spaces engaged by individuals (National Research Council 1999a). Prioritizing fluency objectives for the teaching and learning of technological knowledge may by-pass the skills-based constraints of specific application literacy, which is volatile and discontinuously changeable (National Research Council 2006a). As William Wulf, former president of the National Academy of Engineering, notes: the conceptual fundamentals underlying technology both drive change, as well as remain relevant with change (National Research Council 2006a) – a flexibility that does not exist with particularized technology use knowledge.

Broadening the Pipeline, Building Diversity

As a critical component of the 21st century knowledge economy, technology fluency is also recognized as a priority factor for broadening the IT pipeline. Coupling technology fluency and diversity objectives provide for multi-faceted approaches to address declining enrollments and representational equity issues in technology domains (Stephenson 2009). One strategy proposed to address unresolved diversity issues within the IT pipeline and promote early stage technology fluency objectives is targeted outreach to K-12 education. Cross-institutional partnerships are seen as key to the creation of a national culture of computing. Such initiatives are intended to advance technology fluency objectives and promote positive images of computing to youth. Focusing on equity issues and the lack of standardized curriculum in early education, outreach from national computing associations such as the National Center for Women & Computing (NCWIT), the Canadian Information Processing Society, and the Computing Research Association (CRA) has been strongly directed to the middle-school population with an eye to changing perceptions of the IT field and motivating early interest in STEM (Science, Technology, Engineering and Mathematics) domains.

Supporting studies have indicated that the middle-school years are of particular importance for fostering engagement with, and social acceptance of, computers (Doerschuk et al. 2007), as well as for responding to the disconnect that exists both conceptually and in praxis between girls and computing science. Loss of interest by girls toward computing science manifests in the high school years (Moorman & Johnson 2003), making middle-school a particularly important target for early stage intervention. Vermillion (2006) cites trend analyses that show girls' diminishing attitudes toward technology from first grade to eighth. Positive perceptions of computing peak in grades 4 and 5, with grade 6 identified as the turning point for the decline in girls' enjoyment and engagement with technology (Vermillion 2006). Denner (2007) indicates, as well, that middle-school is key for intervention as girls make critical choices regarding identity and perceived ability during these developmental years.

Bussey and Bandura's (1999) social cognitive theory of gender offers a salient perspective for framing such technology-engagement initiatives, emphasizing the dimension of self-efficacy. As Bussey and Bandura (1999) note, "[a]mong the mechanisms of agency, none is more central or pervasive than people's beliefs in their capabilities to produce given levels of attainments." Gender-typed modelling, which conventionally masculinises IT fluency, results in "perceived inefficacy in the use of computer tools" for girls, which, in turn, influences disciplinary choice at the college level and occupational selection (Bussey & Bandura 1999). Margolis (2000), further, finds the absence of female perspectives in the teaching and learning of computing sciences a contributing factor to women and girls' senses of disenfranchisement with IT as a space of engagement. Early outreach can help strengthen girls' self-efficacy in technology engagement and foster girls' positive identification with technology practices before the high school disconnection occurs.

To bridge disconnections between girls and IT, issues of access, image, learning content and educational policy remain areas requiring further investigation and advocacy (Cohoon 2007). Prior work has focused on increasing opportunities for girls to engage with technology (Campe et al. 2005, Liston et al. 2008b) and describing the nature of women and girls' experiences with computing domains (Margolis et al. 2000a). Campe et al. (2005), for example, hold that while computer literacy tasks have been integrated into middle-school curricula, skills-based knowledge is not sufficient to promote technology production roles and computing efficacies for girls. Increasing technology fluency opportunities for girls requires affording deep encounters with technology-creation tasks, which empower girls to “discover and pursue their own role[s] . . . and interests” (Campe et al. 2005).

The literature suggests that providing strengthened, learner-centered models *designed* to encourage and cultivate girls’ interest in, and motivation towards, technology creation activities during the middle school years is an essential strategy for addressing continued gender differences in IT-related educational and career choices. Previous research into girls and technology has provided guidance indicating *when* and for *whom* interventions for motivating positive interest in science and technology fields can be effective (Denner 2007, Vermillion 2006). One issue that remains is *how* to engage girls and under-represented populations, at the critical middle-school age, in technology centred practice. While the *need* for interventions to address barriers to participation in technology-creation fields by girls and women has been persuasively detailed (Denner et al. 2005, Miller et al. 2001, Vermillion 2006), there remains much work to be done with regard to cultivating practice-based knowledge for the design of such interventions.

Where practice-based knowledge does exist, the perspectives of external evaluators or designers generally dominate the formulation of operational principles. Rarely is guidance directly or robustly cultivated from the participant population. For example, the *Guide to Promising Practices in Informal Information Technology Education for Girls*, a large-scale study of informal, technology-centred initiatives aimed at girls, derives the majority of its findings from instructor and program director self-reports of success. Feedback elicited from small sample focus groups of girls appears distilled into a single sidebar quote in the final document (Liston et al. 2008b). Similarly, Doerschuk et al. (2007) detail a pilot summer camp in computing for middle school girls, providing valuable implementation and evaluation process descriptions to assist in the development of similar programs. They; however, fold post-intervention participant feedback into general future work directives without a meaningful discussion.

Notable exceptions to expert perspective taking in formulating guidance are the "Values at Play" design paradigm (Flanagan et al. 2005), and Denner's (2007) work with the Girls Creating Games program. Flanagan et al. (2005) outline a values-sensitive methodological framework for project implementation. Offering a systematic approach for values discovery, reflection, and integration into processural design practices, Values at Play emphasizes formative evaluation and the benefits of situated, demographic analysis for design practice. Such "participant as design partner" approaches, however, are still relatively uncommon in the literature. Educators and designers, both in formal and non-formal settings, would benefit from the production and validation of principled heuristics grounded in rigorous theory and participant-centred practice to support the development and evaluation of targeted, field-based interventions for girls and under-represented populations in IT.

In order to respond to the current gaps in the field, which include the need for enhanced, situated design guidance, this thesis explores the utility of adaptive, interest-based intervention design for promoting technology fluency objectives to middle-school girls in inner-city environments. Leveraging design experiences and findings from an after-school Interactive Storytelling and Game Design workshop, I propose case-based design heuristics that focus on contributing to the *how* in addressing engagement and motivation issues related to increasing girls' interest in IT domains.

The Proficiency Gap

Foundation design decisions for the intervention outlined in this thesis draw from prior work in technology-mediated program design targeted to girls. Such related work has tended to incorporate gender research that suggests ways in which girls may learn best (Carmichael 2008, Flanagan et al. 2005, Kelleher & Pausch 2007), or, gather attitudinal and preference data (Brunner & Bennett 1997, Miller et al. 1996, Turkle 1986) to shape curriculum and environment development, and ground theory. Brunner and Bennett (1997), for example, find that the "feminine" technology voice speaks to the social function of the machine; thus, introducing technology as a "means to an end" is more appealing to women and girls. Miller et al.'s (1996) investigation of girls' technology preferences found aligned results, including girls' preferences for collaboration over competition, and interest in technologies that afford communication; while

Carmichael (2008) shows that introducing girls to computer science through focus on what it can “do” as opposed to what it “is” speaks to girls’ general learning preferences.

As a corollary to gender-based initiatives, interventions that have targeted inner-city youth populations have focused, primarily, on equity issues and related barriers to the development of technology competencies for economically disadvantaged youth. Exemplar research has explored the relationship between interest and access in building technology fluencies (Barron & Kafai 2006); as well as investigating FITness (Fluency in Information Technology) outcomes derived from increasing access to technology resources in out-of-school environments (Maloney et al. 2008). Further work has documented the impact of technology-mediated interventions for enhancing engaged learning for underserved populations (Squire & Barab 2004).

Barron and Kafai (2006) have explored how after school computer clubs can broaden access to technology tools and promote equitable technology fluency learning opportunities. Limitations to technology access at home and in school, in addition to the variability of resources for learning affecting economically disadvantaged youth, endanger domain interest and require situational nurturance. Similarly, Maloney et al. (2008) discuss affordances offered by the community centre based computer clubhouse for promoting technology competencies to underserved youth. Technology access in non-traditional environments is, here, a context in which alternative learning can occur through self-direction.

Emphasis in research work focused on gender and socio-economic variables take up similar strands of the access and participation thread (or digital divide) that is critical to addressing diversity deficits within technology-creation fields. There is a perceived double threat to girls from lower economic contexts, a dual axis disadvantage, which development policies have sought to mediate by synthesizing gender and socio-economic factors in analyses of increased barriers to technology access and competency building. The integration of gender-based technology initiatives into inner-city contexts has been a strategy intended to unsettle this digital divide.

Outside of take-up of the keystone of access; however, few initiatives have directly explored and presented guidance for implementing interest-based interventions to address what the National Higher Education Information and Communication Technology (ICT) Initiative (2003) has termed the "proficiency divide." In many instances, the affordance of technological opportunity is viewed as sufficient for addressing institutionalized issues of access and participation. However, as noted in Sipior et al. (2002), concentrated focus on access alone is "short-sighted." Approaches that are more robust would investigate *how* to introduce computing skills to disadvantaged populations, as well as increase technology presence and use in communities (Sipior et al. 2002). Such approaches would attend to the gap that exists between those who "have the blend of cognitive and technical capabilities required to negotiate information [technology] demands in the academy, or the workplace, or society, and those who lack them" (Educational Testing Service 2003).

This project's approach contributes to the ongoing proficiency conversation in the field as well as fills guidance gaps by directly and indirectly collecting reported activity data, eliciting girls' revealed interests and activity preferences for adaptive, learner-centred intervention design. Adaptive design, stemming from design-based research methods (DBR), promotes the organizational processes of frequent inspection and adaptation with development aligned to include both learner needs and intervention goals. Adoption of this approach motivates a flexible and dynamic heuristics-based curriculum design model for promoting technology fluency in non-formal learning contexts. Knowledge of what girls do in their everyday lives, including the contexts, and affective dimensions of engaged activities, offers a responsive design method that affords authentic alignment between design practices and participants' real-world interests. The big-picture goal of the research is to instantiate meaningful connections between girls' learning experiences and technology-creation work. This thesis research holds that curriculum design for non-formal technology-creation aligned to girls' day-to-day activities and interests, and supported by persistent evaluations of girls' needs and preferences, will increase engagement and motivation, leading to enhanced learning outcomes and technology fluency achievements.

Designing for connected experience through activity modelling, prioritizes the cultural position of the girls themselves (Laurel 1998), and seeks to mitigate essentialist gender assumptions that emerge from forced choice preference surveying alone (Green 2001). As Green (2001) notes, typically, preference research lacks any contextualization of activity, which conceals significant qualitative differences in experience and meaning for respondents. The adaptive nature of the model proposed in this thesis ensures that formative evaluation takes place both in process through observations of participant engagement and disaffection with learning content, as well as through targeted, context-sensitive everyday activity surveying. The combination of in-process feedback with a robust elicitation of activity preferences through time diaries allows for dynamic adjustment of curriculum and context patterns to participant needs during the course of the intervention as well as providing insight for future iterations.

Conceptual Background

Grounding discussions of the impact of non-formal, interest-based approaches on connecting girls, more meaningfully, to technology-creation domains is conceptual terrain important to:

1. understanding the technological identities of contemporary youth;
2. the special nature of non-formal learning design and evaluation; and
3. the historical goals of after-school programming, more generally.

The construct of the “digital native” (Prensky 2001) has emerged to popularly define the technological realities of 21st century youth. Prensky (2001) asserts that technological ubiquity has instituted radical changes in how students receive and internalize information. For Prensky (2001), these “new students” are “digital natives” who are “native speakers of the digital language of computers, video games and the Internet.” Traditional education systems, consequently, are unequipped to respond to the dynamic needs and unique cognitive capacities of the digital native (Prensky 2001).

While research reveals that contemporary youth generally "perceive" themselves to be highly technologically "literate" (McEuen 2001, Oblinger & Oblinger 2005, Salaway & Caruso 2008), findings also indicate that "digital natives" lack "actual" conceptual knowledge of technology. Conceptual deficits include critical problem-solving capacities, and understandings of the underlying structures and systems of commonly used technologies (Bennett et al. 2008, Eagleton et al. 2003, Kvavik et al. 2004, Lorenzo & Dziuban 2006, McEuen 2001). Kaminski's (2003) survey of 2,102 undergraduate students, for example, shows mid- to low- proficiency self-ratings for creation-based use of web and multimedia development software respectively and low proficiency self-ratings (between 2 and 3 out of a maximum score of 9) for programming, with no significant difference between males and females in skills. McEuen's (2001) findings support Kaminski's (2003) analysis, clarifying that while digital natives are "comfortable" and "confident" with technology, they lack "conceptual knowledge of computers and technology . . . hinder[ing] the reasoning and thinking activities embodied in the elements of intellectual capabilities." Such results point to the need to develop targeted strategies to engage youth in critical and computational thinking, which would support the development of technology competencies separate from use-based skills.

Formal technology-based education at the K-12 level, particularly at the early middle-school level; however, is rare. Opportunities for students to engage in technology-creation tasks typically consist of activities embedded in larger modules such as creative writing and social studies. In British Columbia, for example, no dedicated information technology curriculum is available until the high school years. Media literacy in B.C. middle schools is cross-curricular and folded into general outcomes for English Language Arts and Social Studies in the use of multiple media to communicate ideas, general support for critical and creative thinking, and modules introducing students to media message analysis. Due to systemic resource and instructional skills limitations, these opportunities often employ outdated technologies and approaches, which are insufficient to prepare students for the reality of contemporary technology domain work (Kuenzi 2008).

Learning interventions occurring outside of formalized education spaces, have thus been central to addressing this deficiency in early IT knowledge acquisition. While existing frameworks for the promotion of technology competencies have, for the most part, been directed towards providing formal learning scenarios with content direction for technology education (International Technology Education Association 2007), non-formal learning environments show exceptional promise for filling the gap between formalized (at-school) and ad-hoc (at-home) technology learning opportunities.

The European Centre for the Development of Vocational Training, in outlining the "character of learning," emphasize the contextual differences that ground formal, non-formal, and informal learning (Bjornavold 2000, Eshach 2007). Formal learning is understood as learning that a) takes place within organized, structured contexts, which are explicitly designed "as learning," b) usually leads to the gain of a recognition (such as a diploma), and c) is engaged “intentionally” from the learner’s perspective (Bjornavold 2000, Colardyn & Bjornavold 2004, Coombs et al. 1973). Non-formal activities may not be explicitly presented as learning activities, but, nonetheless contain learning elements. It is also typically engaged intentionally by the learner (Bjornavold 2000, Colardyn & Bjornavold 2004), but operates outside of established formal systems (Coombs et al. 1973). Learning, which takes place in non-formal contexts tends to be more intrinsically motivating than formal learning while retaining similar structural features such as intentional engagement (prearrangement) and instructional support (Eshach 2007). Lastly, informal learning is learning that emerges from daily life; often categorized as experiential or accidental learning. Informal learning contains no structured learning objectives or support and while it may be engaged intentionally, it is usually incidental or random (Colardyn & Bjornavold 2004), and is regarded as a lifelong process (Coombs et al. 1973). Table 1 summarizes the characteristics of formal, non-formal, and informal learning based on setting, motivation, interest, social context, and assessment, as found in the literature (Eshach 2007). The comparative review found in Table 1 shows areas of overlap, as well as distinctions, between the three learning situations.

Table 1. Differences between Formal, Non-formal and Informal Learning (Eshach 2007)

Formal	Non-formal	Informal
Usually at school	At institution out of school	Everywhere
May be repressive	Usually supportive	Supportive
Structured	Structured	Unstructured
Usually prearranged	Usually prearranged	Spontaneous
Motivation is typically more extrinsic	Motivation may be extrinsic but it is typically more intrinsic	Motivation is mainly intrinsic
Compulsory	Usually voluntary	Voluntary
Teacher-led	May be guide or teacher-led	Usually learner-led
Learning is evaluated	Learning is usually not evaluated	Learning is not evaluated
Sequential	Typically non-sequential	Non-sequential

The National Research Council's report, *Taking Science to School* (National Research Council 2007), outlines two strands of focus for the development of non-formal, out-of-school learning interventions: 1) build on learners' interests and motivations through affording choice and agency in determining individual learning strategies; and 2) emphasize construction of the learner's identity vis-à-vis the targeted knowledge domain so that individuals become "capable of engaging" in the targeted domain (Bell et al. 2009). In "Bridging In-school and Out-of-school Learning: Formal, Non-Formal, and Informal Education," Eshach (2007) highlights the importance of integrating learner perspectives on their non-formal learning experiences into program evaluation and development research. Interest in mapping attitudinal changes toward target domains, as a result of the non-formal learning experience, has tended to outweigh considerations of participants' own evaluations of, and motivations for engagement in out-of-school learning contexts and opportunities. Building participant voice into environment design and gaining deeper understandings of participant motivations for engaging in non-formal learning would enrich the theory base (Rogers 2005) and facilitate the “reinforcing of events and experiences” (Falk & Dierking 2000) in alternative contexts.

The development features of non-formal learning are closely connected to histories of after-school programming, more generally. “After-school,” or, “out of school” educational programs are leveraged toward a broad based student population and “typically” include activity blocks for “(1) homework help and tutoring, (2) enriched learning experiences, and (3) nonacademic activities, such as sports, arts, or play” (Bell et al. 2009, Noam et al. 2002). “Designed” settings for non-formal learning differ from “ad hoc” informal learning engagements, which are often “opportunistically encountered and identified, without any particular prior intention to learn” (Bell et al. 2009).

The majority of research pertaining to after-school programming has focused on the potentials of such initiatives to address obstacles to learning and access to resources posed, particularly, by low-income or vulnerable student populations in urban centers (Halpern 2003, Hamovitch 1997, Lippman et al. 1996). School-based after-school programs provide opportunities to more closely link after-school activities to classroom needs (Halpern 2003), despite a high degree of ambivalence towards such ventures by principals and host school faculty (Bell et al. 2009, Halpern 2003). Tensions over program priority setting and philosophy often hinder after-school initiatives directed by community-based agents working within the school site (Halpern 2003). Community-based agents often struggle to meet school expectations that after-school programming become a partner in improving learning and literacy standards (Noam et al. 2002), adding to existing implementation challenges. Requirements for such program matching between in-school and after-school activities can elide children's needs for non-school-like approaches to learning after a full day at school (Halpern 2003).

After-school programming, viewed as part of a larger, and perhaps more pragmatic and participant-centered, "developmental" project, would, thus, concentrate "less on the acquisition of specific academic skills and knowledge and much more on providing a physically and psychologically safe environment with supportive relationships and a sense of belonging" (Bell et al. 2009). The incorporation of a specialized focus, such as technology fluency, is not seen as conflicting with the more global "nonacademic outcomes" indicative of non-formal, out-of-school activities (Bell et al. 2009). From this perspective, non-formal learning should best orient itself towards "promoting interest" and changing attitudes towards engagement areas (such as STEM subjects), as well as building knowledge capacities for traditionally underserved populations (Project Exploration 2006). "Interest," here, is viewed as contributing to longitudinal conceptual knowledge of an engaged domain, as well as supporting the growth of self-efficacy and positive views of self in relation to the promoted domain (Hilton 2010, National Research Council 1999b, National Research Council 2007).

Findings from the study outlined in this thesis support the broader implementation objectives of non-formal and after-school programming, and suggest that learning design, which is targeted to, and inclusive of, girls' enacted interests and values makes the conceptual learning content more salient and engaging. Game design and interactive storytelling activities function within the workshop as structural metaphors to facilitate the acquisition of foundational programming knowledge and connect learning content more directly to girls' real-world interests. Storytelling practices motivate reflection, problem solving, and reasoned thinking, which serve as analogues to the algorithmic logic process central to computer programming practice (Barker & Cohoon 2007, Kelleher 2006). Storytelling, moreover, connects the learning content to personal significance, can help make learning more meaningful (Cassell & Ryokai 2001, Kelleher & Pausch 2007, Werner et al. 2009), and build information technology fluency (Campe et al. 2005, Werner et al. 2009, Werner et al. 2005). Research indicates, as well, that computer game playing is a significant early influence on developing the skills and attitudes that are best predictors of future technology-related choices (Denner 2007, Levine & Donitsa-Schmidt 1998, National Science Foundation 2006, Subrahmanyam & Greenfield 1998). Positive effects associated with game play include the development of complex thinking and problem solving skills (Keller 1992); logical thinking (Inkpen 1997); strategic planning (Keller 1992); self-regulated learning (Rieber 1996); and motivation toward learning (Betz 1995). Linking storytelling and game design frameworks supports girls' interests and efficacies, as well as reinforces positive technology engagement behaviours.

Orienting non-formal learning practices to match participant interests and experiences may facilitate the kinds of knowledge transfer that policy-makers envision by fostering deeper and more engaged understandings of learning content. Such strategies support forms of concept mastery essential for the process of transferring knowledge to “new problems” (National Research Council 1999b) more effectively than conventional in-school learning practices, which focus on the shallow “acquisition of factual knowledge” (National Research Council 1999b). The heuristics developed in this thesis attend to these concerns and provide guidance for targeted intervention design and implementation. Focus on learners, tools and resources, contexts for learning, expectations and objectives, and learning tasks/activities provide a holistic model for situated technology fluency enactments.

1.2 Research Questions

Specifically, this thesis explores how non-formal, interest-based learning design can support the development of technology fluency objectives for inner-city girls in an after-school Interactive Storytelling and Game Design workshop. In order to examine what contexts and activities can best motivate and support girls in technology-creation work, I adopted a mixed methods approach drawn from the design-based research paradigm to guide the research and data collection. In particular, I examine the following research questions:

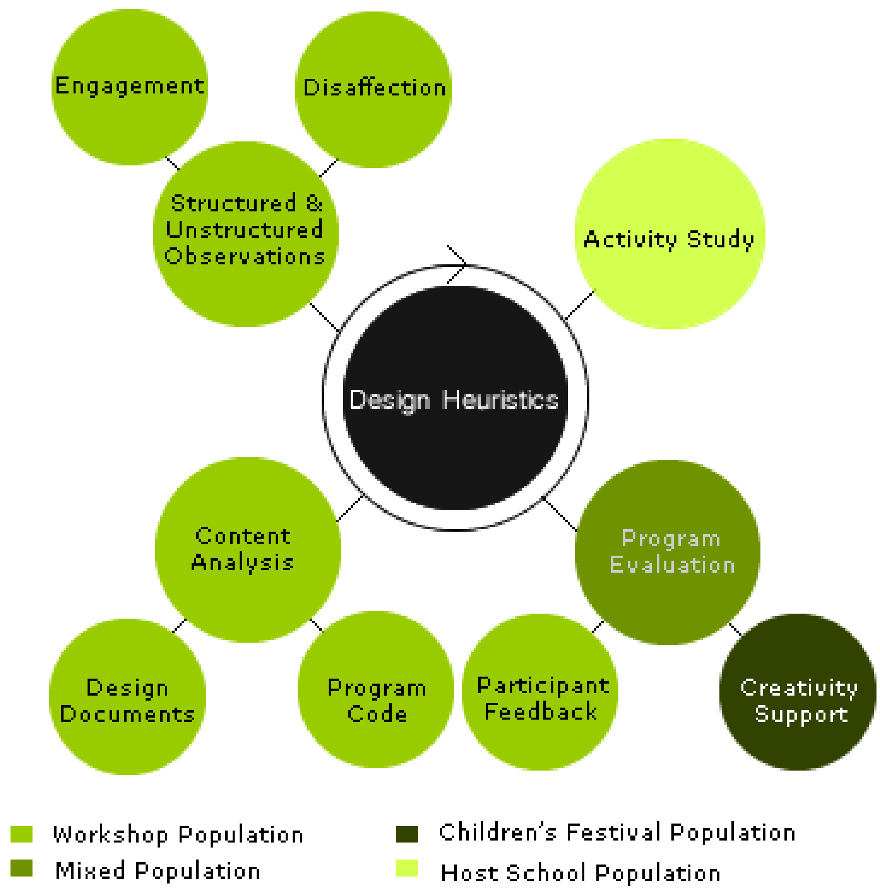
1. How can adaptive, interest-based learning design support the development of technology fluency objectives for girls?

2. What is the quality of girls' experiences within the Interactive Storytelling and Game Design workshop?
3. What characteristics of the workshop intervention are motivating to girls?
4. What characteristics of the workshop intervention are challenging to girls?

I explore these questions by looking at early adolescents' activities and their subjective experiences of engaged activities through the administration of a time use survey to capture activity episodes, activity context, and the affective dimensions of the episode. Participants' experiences with technology-creation activities are elicited from content analysis of digital story and game artefacts, and field observations (both structured and unstructured) recorded during the workshop sessions. Questions associated with girls' engagement in the workshop include observational assessments of technological challenge, motivation, and general quality of experience during workshop technology-creation activities. Such analyses add to the discussion and development of case-based heuristics for guiding intervention design in similar contexts.

Figure 1 shows the data collection process. Data from three populations sharing the same demographic characteristics are mixed in interpretation to support the proposed heuristics. The heuristic model is emergent, based on findings elicited from the implementation of the detailed intervention, activity study data, and evaluation of the Scratch tool for creativity support. A heuristic-based design process is reflective and iterative, indicating that heuristics should be provisionally implemented then adapted based on the situational needs and discoveries unique to each program instantiation.

Figure 1. Evaluation Factors Merged in Design Heuristics



Thirty-three inner-city middle school children (22 boys and 11 girls) participated in the formative evaluation of the Interactive Storytelling and Game Design workshop using Scratch, an entry-level visual programming and media creation application, over the course of a 6-month period. Twenty-one workshop sessions (1.5 hours/week) were delivered, with a twenty-second session dedicated to demonstrations of the participants' games to the community and project closeout. A separate exploratory study was conducted with 108 middle-school children between the ages of 8 and 13 recruited from the same regional district to assess the level of creative support offered by the Scratch tool to novice programmers. In the secondary study, a one hour workshop in Digital

Storytelling using Scratch introduced middle-school groups attending a local Children's Festival to programming for interactive media creation. Sixty-four participants completed self-reports of creativity support for the workshop activities using Scratch. The results of this secondary study are included for supplementing the evaluation dimension of the heuristic model. The research questions specified here are linked to the broader research objectives outlined in Chapter 3.

Preliminary results generated from the study's evaluation factors are connected and cross-validated in the interpretation phase of the study. A time-use diary study, using the Day Reconstruction Method (Kahneman et al. 2004b), conducted with 30 inner-city middle-school children recruited from the workshop participant and larger host school populations, along with data captured from observations and informal information gathering during the intervention adds to the analysis of the target population needs and preferences. Findings contribute to the development and validation of 15 design heuristics, or rules of thumb, for the promotion of technology fluency in non-formal learning environments. Such heuristics include situational focus on tools, tasks, learners, expectations / objectives, and the non-formal learning context, and are grounded in the mixed methods approach of design-based research (Barab & Squire 2004, Brown 1992, Cobb et al. 2003, Collins et al. 2004, Design-Based Research Collective 2003).

Intended to support the design and evaluation of targeted, technology-fluency program interventions, the heuristics derive from inquiry into the needs and preferences of inner city youth for technology-creation activities, and direct observation of the challenges and successes experienced by the target population involved in the after-school Interactive Storytelling and Game Design workshop. The selected methods of analysis are concurrently leveraged toward a deeper understanding of girls' interests. Understanding learners' revealed interests through activity surveying, in-situ observation, and analysis of the types of media participants *choose* to create assists in the production of program design that is continuously adaptive to learner needs.

Adaptive design accommodates diversity, and affords customization for differential implementation. Such analysis provides example focus for discussion, and facilitates the operationalization of insights. Further, situational design factors outlined in the proposed heuristics support the production of testable differences in outcomes through comparative manipulation. Heuristic guidance is easily translated into variables, which investigators could exploit for enhanced empirical study, and causal comparative research design.

Over the course of the detailed intervention, in-session observations and participant feedback derived from informal information gathering and intervention closeout surveys are used to validate the choice of storytelling and game metaphors for framing foundation computer programming learning. The alignment of workshop design with girls' revealed preferences and enacted interests supports the production of a sustainable learning space for the creation and experience for girls of "new identities as technology 'experts' within their school" (Jenson et al. 2003), enhancing girls' self-efficacy and motivation to become "producers, rather than just users, of technology" (Denner 2007).

Contributions

The high-level contributions of this thesis are:

1. a set of adaptive heuristics for including technology-creation activities in non-formal learning programs for girls;

2. contextualized knowledge of girls' day-to-day activities;

3. identification of the challenges and successes experienced by girls when engaging in technology-creation activities; and

4. knowledge of girls' gaming preferences emerging from the types of games girls design during game creation activities.

Research work concerned with exploring mixed methods for evaluating interest-based learning environments will benefit from the study's analysis of how a non-formal implementation of storytelling and game design metaphors can support and enhance conceptual, problem-based learning. Improved understandings of the affordances of non-formal learning environments for supporting technology fluency objectives, and how such objectives might be enhanced through educational and instructional design practices are the practical contributive outcomes of this thesis research.

This research is intended as a small first step in exploring ecologically valid methods for everyday activity capture, and the application of real-world activities to targeted non-formal learning design. Further projects, a possible few, which are described here in Chapter 8, must add to the data and theoretical analysis surrounding this question.

2: PRIOR WORK

From a literature review of relevant scholarship in the fields of computer science education, and girls and technology, several general support themes for intervention design emerged including:

1. Design for connected learning;
2. Afford creative problem-solving and risk-taking;
3. Prioritize learning by doing; and
4. Promote active relationships to technology.

This chapter provides a condensed overview of these interconnected themes and situates the research outlined in this thesis within the spectra of prior work in the field. A fuller field-based review of related prior work in the domains of computer science education, and girls and technology follows the summary presentation found in Table 2.

Table 2. Condensed Overview of Prior Work

Theme	Implementation Example or Practice from the Literature	Incorporated Design Feature or Practice (Interactive Storytelling and Game Design Workshop)
Design for Connected Learning	"Building to Teach" shows the learner that programming has effects outside of the lab, and can have socially positive effects" (Barnes et al. 2007)	Prioritized user-centered principles for design learning. Participants were exposed to concepts such as experience design and were encouraged to reflect on "who" they were designing their game for.
	Storytelling creates personal significance (Cassell & Ryokai 2001, Kelleher & Pausch 2007, Werner et al. 2009).	Deployed storytelling as one of the central structural metaphors of the interaction to facilitate connected learning.

	Technology fluency for girls is political, requiring long-term investment and community engagement (Denner 2007)	Created a freely accessible, online knowledge and resource repository for community access to the intervention’s learning materials.
	Game modding affords personally relevant meaning-making opportunities (Gee & Hayes 2010)	Structurally activated opportunities for participants to customize learning material through technology-creation activities.
	It is important to create real-world connections to conceptual learning content (Norton 2006)	Introduced offline activities to support the learning of conceptual content such as Algorithms in Everyday Life.
	Phase-based approaches to learning through game development increase self-efficacy and motivate learning (Rajaravivarama 2009)	Incorporation of progressive vignettes to developmentally structure learning process and increase learner investment in technology-creation processes.
	Heuristics are important for philosophically grounding environment design (Resnick et al. 1998).	Provisioned heuristic design guidance based on intervention outcomes.
Afford creative problem-solving and risk-taking	Exploit the benefits of cognitive apprenticeship approaches for supporting creative algorithm design and problem-solving (Ginat 2008).	Allowed participants to explore their own solution-spaces while making just-in-time guidance available to work through individual challenges.
	Program to play paradigm (Plass et al. 2007)	Incorporated critical game play sessions into free time spaces to encourage creative and reflective thinking around game mechanics and interaction design.
	Support divergent thinking to afford exploratory learning and increase motivation (Romeike 2007)	The non-formal learning model adopted for the intervention created a safe, no-stakes environment for learners to explore new knowledge on their own terms.
	Introduce programming concepts “as needed” to advance game design. Determine the timeline for introducing CS concepts	**Modified.** Adapted foundation concept learning “order” to logically match game development activities to initiate learning. After basic

	based on need, not by difficulty level, or how they might appear in a traditional CS textbook (Wang et al. 2006)	concepts have been grasped, new concepts are demonstrated by need. Strategy is designed to facilitate transfer to formal learning contexts as well as to support unique learner needs.
Prioritize Learning by Doing	Coordinated Residential Game Camp and Teacher Game Institute – show teachers how to implement the curriculum into their classrooms (Al-Bow et al. 2009)	Created strong relationships with host school administrators and teachers and advised on how to incorporate Scratch into standardized curriculum for literacy and numeracy objectives.
	Girls dislike direct instruction in non-formal environments (Denner 2007)	Supported self-directed learning through facilitation and just-in-time guidance for programming activities.
	Intervention design should adopt a reflective and iterative development model (Denner 2007).	Adopted a design-based research model for situated and dynamic content and context iteration.
	Promote between-peer mentorships, which position learners with experience in facilitator positions (Maloney et al. 2008).	Afforded in-session opportunities and spatial contexts (grouping layout for workstations) for cooperative and collaborative learning.
	Promote a teamwork approach to activities for authentic hands-on learning (Falkner & Palmer 2009, Rankin et al. 2007).	Encouraged team-based design projects and group free play, although participants were free to choose to work either independently or collaboratively.
	Scaffold self-directed learning by moving progressively from instructionist support to constructionist (Wang et al. 2006).	Combined facilitator-led demonstrations, independent tutorial guided work, and self-directed learning to scaffold learning development.
Promote active relationships to technology	Create learning contexts where girls are producers rather than users of technology (Denner 2007)	Production of the Interactive Storytelling and Game Design workshop stream for girls.
	Media and game creation platforms for teaching CS concepts provide immediate visual feedback to learners	Review and selection of a visual media creation tool (Scratch) to support foundation CS learning and

	(Leutenegger & Edgington 2007).	game design activities.
	Game creation affords problem visualization (Leutenegger & Edgington 2007).	Iterative testing processes built into activity structures to demonstrate visual debugging practices.
	The metaphor of the Brazilian Samba School can guide community-based learning interventions (Papert 1980).	Built-in opportunities and affordances for shared-meaning making through group review of work and participant-led activities.
	Games-based approaches centralize active learning processes (Rajaravivarama 2005)	Selection of interactive storytelling and game design metaphors to frame the learning intervention.
	Employ top-down, application-focused strategies for CS learning (Rankin et al. 2007).	Presented foundation CS concepts through the principles of game design.

2.1.1.1 Creative Approaches to Teaching and Learning Foundation Programming

Learner disenfranchisements from traditional instructional strategies in Computer Science (CS) have catalyzed discussion in the field as to how CS education can better align itself to students' interests and needs. Attention to supporting "creativity" factors in programming activities has emerged as an especially effective strategy for engaging new learners in computing domains (Ginat 2008, Romeike 2007).

Game Design Approaches

Recently, significant attention in the CS education community has been directed toward using game development as a motivating theme for the teaching and learning of the foundations of programming. Research shows that video game play has an early positive influence on the types of skills and attitudes that are best predictors of future technology-related behaviors (Denner 2007, Levine & Donitsa-Schmidt 1998, Subrahmanyam & Greenfield 1998). Adopting a game development approach to introductory CS curriculum is presented in the literature as a two-pronged solution: 1) to address decreasing enrollments in computer science; and 2) to connect more authentically to the real-world interests of new students (Leutenegger & Edgington 2007, Rajaravivarma 2005).

Several CS researchers have promoted the use of games as the curriculum driver for introductory programming (Al-Bow et al. 2009, Leutenegger & Edgington 2007, Rajaravivarma 2005, Romeike 2007, Schuster 2010). Noting the priority of motivation and involvement in increasing CS program retention, Rajaravivarma (2005) outlines a games-based approach for introducing CS1 concepts that centralizes student experimentation and active learning. Learning tasks become progressively complex as students' programming efficacies are developed. Simple games, here, are iterated throughout the course with additional features. Incremental implementation stages are based on learners' competencies. Rajaravivarama (2005) holds that the phased, game-based approach increases engagement with foundation programming tasks and motivates students to learn advanced programming skills for enriching their game development processes.

Using games (formally and informally) to structure the learning process facilitates problem identification, solution design, implementation, and testing, while encouraging creative, critical thinking (Rajaravivarma 2005). Rajaravivarma (2005) notes, further, that game play and problem solving for game programming has the benefit of providing visual representations to the “abstract nature of the problem;” this visual component clarifies the description of the abstraction – one of the most difficult tasks in teaching programming (Rajaravivarma 2005).

Leutenegger and Edgington (2007) have found, similarly, that a “Game First” strategy for teaching programming fundamentals allows students to “see” code errors, as instantiated by the graphical component, and makes object-oriented concepts more meaningful to learners. Using a media creation platform, such as Flash/ActionScript, for the game development base provides learners with on-demand graphical feedback of programming instructions. For novice programmers, error detection is simplified when it can be visually observed through “playing” the programmed animation or game behavior (Leutenegger & Edgington 2007).   Piloted over the course of 3 semesters, Leutenegger and Edgington’s (2007) CS1 Game First curriculum showed evidence of effective learning, supported by student survey results reporting increased self-perceptions of learning; improved introductory course retention (85%); and increase in enrollment (from 36 to 60 from Year 1 to Year 2).

The success of game-based approaches for introducing foundation computer science concepts to novice learners provides evidence-founded support for the decision to use a game design framework for the intervention detailed in this thesis. However, interest-based approaches require grounding in activity preference and developmental research for validation. In the majority of the literature, games are assumed to have connective value based on anecdotal or popular beliefs as to the ubiquity of game playing in youth populations.

Verification of the metaphors used to structure strategies based on population interests is necessary for ensuring authentic links between the learners' realities and the curriculum. The dynamic nature of interests demands regular demographic auditing to ensure that intervention groundings hold contemporary meaning for their audiences.

Game Modding Approaches

A corollary focus to the use of game design in formal Computer Science education (CSE) has been investigation into how the practice of "game modding" might contribute to foundation conceptual knowledge in CS. In general, "game modding" is the "customization, tailoring, or remixing of game embodiments" (Scacchi 2010), usually of game content, utilizing non-supported toolsets and editors often distributed as part of commercial game releases. Gee and Hayes indicate, in *Women and Gaming: The Sims and 21st Century Learning* (2010), that game modding provides support for complex thinking and problem-solving – often within collaborative, or, modding community contexts, which are particularly rich arenas for plough-sharing into CS education reform.

Game modding, importantly, affords learners the opportunity for active participation in technology-creation in ways that are divergent and personally meaningful – the levels that are created and programmed tell learners' own stories and instantiate individually connected modes of game play (Gee & Hayes 2010). Affordances such as storytelling are key for connecting technology-creation work in authentic ways to learners on the boundaries of participation. Storytelling practices motivate reflection, problem solving, and reasoned thinking, which serve as analogues to the algorithmic logic process central to computer programming practice. Storytelling, moreover, connects the learning content to personal significance, can help make learning more meaningful (Cassell & Ryokai 2001, Kelleher & Pausch 2007, Werner et al. 2009), and build information technology fluency (Campe et al. 2005, Werner et al. 2009, Werner et al. 2005).

While studies of game modding as a teaching and learning strategy for acquiring programming competencies have not been widely undertaken, a notable few (Barnes et al. 2007, El-Nasr & Smith 2006, Rankin et al. 2007, Yucel et al. 2006) have provided interesting preliminary findings.   Barnes et al.'s (2007) *Game2Learn* CS undergraduate capstone initiative, for example, used GameMaker, Unreal Tournament 2004, NeverWinter Nights, 3D GameStudio, and RPGMaker as prototyping tools for student game creations designed to teach foundation programming concepts derived from the ACM-IEEE computing curriculum. This matched approach to CS education (game design *for* game-based learning) shows, based on post-program participant surveys, that learners felt the game modding approach "enhanced their interest in [CS] research and in [CS] graduate studies" (Barnes et al. 2007). "Building to teach," additionally, may have particular significance for interventions interested in connecting technology-creation learning to girls. Research shows that girls prefer learning conceptual content when linked to real-world concerns (Norton 2006).

Rankin et al. (2007) have used Microsoft's Flight Simulator X game platform for team programming assignments designed to facilitate object-oriented programming learning for CS 102 students. Adopting modding activities motivates engagement with CS curriculum by taking advantage of students' familiarity with computer games to leverage foundation programming learning. Here, team-based modding activities support positive student outcomes, and prioritize learning-by-doing strategies (Rankin et al. 2007). Suggesting that game modding tools are particularly adapted to collaborative learning approaches, Rankin et al. (2007) find that such "top-down design" and application focused strategies provide motivating contexts for CS learning. Rankin et al.'s (2007) team-based approach; however requires comparative evaluation to determine if individual objectives are met in collaborative learning contexts. Additionally, analysis of transfer effects to core curriculum in subsequent CS courses would add support for the approach.

Sturtevant et al. (2008) also find advantage to team-based modding activities for promoting engaged learning in CS and technology knowledge domains. The CMPUT 250 course at the University of Alberta uses the NeverWinter Nights Aurora toolset for collaborative game programming and foundation CS learning (Sturtevant et al. 2008). Sturtevant et al. (2008) acknowledge; however, that project evaluation is difficult due to the team-based nature of the assignments. Post-course student feedback shows that while participants had high self-perceptions of content learning for CS knowledge such as artificial intelligence, actual material comprehension scores were low. Overall; however, students ranked course content highly, indicating that the novel learning structure was conducive to engagement and motivation (Sturtevant et al. 2008).

Of remaining concern is that the novelty of interest-based approaches overshadows the learning objectives. While game-based pedagogical strategies appear well coordinated with learners' interests, it is important, particularly for formal instantiations, that domain knowledge is not elided in the gaming of the conceptual content. If one of the goals of affording creative and divergent thinking within formal CS teaching and learning practices is opening the field up to non-traditional students, and changing perceptions of computing practices, it is essential that students *know* that what they are *doing* is programming, regardless of the metaphor leveraged to frame the material. The challenge in implementing new approaches to CS education is to demonstrate the benefits of creativity-within-constraints that technical subjects demand. Such demonstrations are, in fact, cornerstones of game development practices. As opposed to divorcing the learner from the objective, creating curriculum, which balances hard (concepts) and soft (design) knowledge should be the goal of creative programming initiatives. This was the central development challenge, as well, of the intervention discussed in this thesis.

2.1.1.2 Game Design to Promote Technology Fluency in Non-Formal Contexts

Outside of formal CS education, game design has been used as a motivator for non-formal technology learning contexts, most popularly, as a means to engage children and teens in IT and promote interest in technology-centered fields among under-represented populations, such as girls. Non-formal contexts for technology-creation encompass a wide-range of formats from structured, intensive game development workshops (Yucel et al. 2006) and technology camps (Microsoft n.d., Stanford University n.d.) to informal computer clubs (Maloney et al. 2008, Resnick et al. 1998). Encouraging technology fluency through game and media design has found resonance with its target youth populations.

The computer clubhouse model developed by MIT Media Laboratory in collaboration with The Computer Museum (Resnick et al. 1998) is rooted in Papert's radical re-formulation of the Brazilian samba school, which positions both novice and expert in collaborative learning relationships as a model for community-based computational learning (Papert 1980). The "computer clubhouse" has become an important site for connecting young peoples' real-world experiences to IT culture. Emphasizing that access to new technology is meaningless without supported contexts, the computer clubhouse facilitates project-based, exploratory technology learning and creation for inner-city youth and currently has an international presence and over 15 years of community-based technology activism.

The computer clubhouse, notably, was developed according to 4 heuristic principles intended to promote a new, replicable non-formal learning environment for supporting youth technological fluency. The computer clubhouse's guiding principles include: 1) Support Learning through Design Experiences; 2) Help Youth Build on their Own Interests; 3) Cultivate "Emergent Community"; and 4) Create an Environment of Respect and Trust (Resnick et al. 1998). Connected clubhouse learning outcomes include: the ability the express oneself with technology; the ability to collaborate, communicate, and work in teams; the ability to solve complex problems; the ability to develop, plan, and execute complex projects; and self-esteem and self-confidence (Michalchik et al. 2008). The heuristic-based design principles that guide clubhouse development were central to the program design approach adopted for the intervention outlined in this thesis.

Such non-formal interventions have important implications for supporting formal IT learning, as well as for provisioning learning opportunities for new knowledge that has not yet been incorporated into traditional, school-based curricula (Sefton-Green 2004). Formal learning might be supported by the extension of learning environments outside the school context, which can be more closely connected to learner interests, and more motivational for learning as non-formal learning is typically engaged voluntarily. Non-formal technology-creation environments, such as the computer clubhouse, have also provided “learning community” models, which have been incorporated into formal CS education to promote collaboration, and idea and code sharing towards the facilitation of interactive, open classroom pedagogical approaches to computer programming (Repenning et al. 2009).

The Scratch visual programming environment for rich media and game creation occupies a central position within clubhouse learning culture. The forms of games and media arts that the Scratch environment affords, supports the development of programming skills as a *means* to building progressive understanding and self-efficacy in the creation of “familiar media” (Peppler & Kafai 2005). Within the clubhouse framework, Scratch is used to promote a community-based technology fluency, which includes group “Scratch-a-thons” (Maloney et al. 2008) and mentorships between experienced “Scratchers” and novice programmers that promote youth empowerment and ownership of their own expertise.

Interestingly, investigators found that Scratch users most commonly associated Scratch with the arts. When asked what school subject Scratch was most like, respondents most frequently cited fine arts (such as drawing), with the least frequent response being “computer class” (Maloney et al. 2008). The lack of a connection between users’ mental models of computer programming (“What is that?”) and their use of Scratch is problematic for assessing the efficacy of the clubhouse model for promoting and supporting recognized technology fluency outcomes. If participants do not perceive that they are engaged in technology-creation activities, the value of the intervention for changing under-represented youths’ perceptions of IT domains and participating in an activist dialogue toward challenging the structural inequities that control membership and participation in technology-creation knowledge is severely undermined.

This problem of “definition” that Scratch illustrates, points to one longstanding concern that non-formal learning interventions have faced, which is outcome assessment and evaluation both at the program and learner levels. There are, currently, no generalizable means of evaluating cross-program implementations to generate a useful knowledge base of replicable strategies for long term design guidance (Acker & Oatley 1993). Measurable learning outcomes for non-formal engagements with technology-creation activities require longitudinal, comparative study analyzing performance of learners with prior exposure to creative programming tools to those without (Cooper et al. 2000). Such research has yet to be performed and validated, although the use of Alice and its variant Storytelling Alice bridge formal and non-formal learning contexts offering a particularly salient opportunity for outcomes and transfer study.

Quantitative evaluations of participant projects and qualitative assessments of engagement with creative coding tools in non-formal settings; however, have been widely collected and show increased confidence levels with programmatic tasks and knowledge (Al-Bow et al. 2008, Al-Bow et al. 2009, Cooper et al. 2000, Javidi & Sheybani 2009), and the use of fundamental programming concepts to implement design ideas (Maloney et al. 2008, Wang et al. 2006, Werner et al. 2009). Al-Bow et al. (2009), for example, show that game creation embedded within a project-based learning model for delivery to high-school students can produce significant improvements in computer programming knowledge (based on pre- and post-intervention foundation programming knowledge tests); and increase self-confidence in technology-creation tasks. The outcomes derived from a pilot 2-week residential summer camp in game design for high school students, included matched findings from a 4-week professional development component in programming for teachers using the same curriculum delivered to camp participants. Teacher reports show similarly strong increases in knowledge acquisition, confidence in using technology, and, most importantly, buy-in to the intervention's approach (Al-Bow et al. 2008, Al-Bow et al. 2009).

Wang et al. (2006), similarly, targeted high school learners in a non-formal, after-school pilot using StarLogo TNG to teach computer programming through 3D game design. Anecdotal results suggest that StarLogo TNG's block programming metaphor facilitated easy entry for learning the programming language. The media creation platform base afforded immediate visual feedback, which increased participants' enjoyment in programming activities (Wang et al. 2006). The positive outcomes detailed by Wang et al. (2006); however, are not supported by an evidence-based evaluation of proficiencies or self-confidence gains developed over the course of the intervention.

The sustained problematic of generating intervention outcomes continues to reside in the positioning of such programs as "solutions" to fluency acquisition, particularly for under-represented populations. Such a focus on producing "positive outcomes" elides the reality that such outcomes often "do not outlast the presence of the researcher" (Jenson et al. 2003) and are not embedded in a priority of either sustainability or formative and reflective design iteration. Attention in the discussion dimension of the workshop described in this thesis addresses the lack of holistic evaluation of both the successes and limitations of such challenging interventions. Providing details of negative outcomes assists future iterations and other designers in developing improved responses to the challenges faced by prior program implementations.

2.1.1.3 Girls and Technology Education

Sex-based and gender differences with regard to technology fluency levels have been investigated, variously, with regard to access, participation, and knowledge use (AAUW Commission on Technology Gender 2000, Barron 2004, New London Group 1996). Much work produced prioritizes increasing the relevancy of STEM (Science, Technology, Engineering, and Mathematics) curriculum to girls by focusing on how learning materials, instructional approaches, and pre-existing belief systems with regard to STEM domains can be changed (Acker & Oatley 1993) to afford higher levels of participation and engagement.

Non-formal learning design to increase the accessibility of IT skill-building to girls has shown particular promise (Liston et al. 2008a, Liston et al. 2008b, Peters 2007, Yucel et al. 2006) as an alternative, or supplemental, strategy to institutionalized, structured learning opportunities (Lave & Wenger 1991, Papert 1980, Rieber 1996). Non-formal technology engagement is suggested to lead to higher baseline skills within the classroom, and provide a “wider ‘ecology’ of learning” (Sefton-Green 2004) that may serve to enhance links between learning, technology-creation practices, and everyday lives (Munk 2007, Peppler & Kafai 2007b, Resnick et al. 1998, Vermillion 2006). Non-formal learning resources are, as well, important facilitators for modelling participation in civic life, for, particularly, marginalized youth communities (Lyman et al. 2004). As Lyman et al. (2004) note further: “kids’ participation in ... new digital spaces may predict their future participation in adult forms of public life, for digital media must be centrally concerned with developing kids’ sense of agency, identity, and collaborative production of knowledge.”

Researchers have developed several programs, methodologies, specialized tools, applications, and learning content to engage girls in technology-creation and foundation programming practice. Flanagan's participant-centred work with RAPUNSEL (Flanagan 2007, Flanagan & Nissenbaum 2007), for example, supports both a working methodology for the teaching of computer programming to girls, as well as a targeted approach to application design for activist interventions. RAPUNSEL is a game-based programming environment in which players/coders are required to restore objects to an emptied world to achieve the game's objective. World restoration is progressively instantiated through the completion of character dance challenges. Players must program "moves" into clothing pieces that can be organized into outfits, and which are called into effect using hot keys during competitive play (Flanagan 2007). A one-month, 4 session study of girls' using RAPUNSEL in a non-formal, semi-guided setting shows significant increases in general self-efficacy between pre- and post-test results, but no significant difference in computer self-efficacy (Plass et al. 2007). The study also shows no gains in programming knowledge; however, a significant positive difference in girls' senses of confidence in engaging programming tasks was found (Plass et al. 2007).

Here, as seen previously, a gap between self-perceived and actual knowledge compromises outcomes. This gap is relevant if one of the articulated objectives is to instantiate programming knowledge in the learner, and quantitative methods to assess learning impact are in place. Such endemic results indicate that sustained, longitudinal interventions are required to influence learning. Reviewed short-term interventions; however, show to be useful and effective in increasing self-efficacy with regard to programming tasks (Campe et al. 2005, Denner 2007, Kelleher et al. 2007, Plass et al. 2007, Vermillion 2006, Werner et al. 2005), which can positively affect future choices with regard to technology learning and careers (National Science Foundation 2006, Subrahmanyam & Greenfield 1998).

The Girls Creating Games Program (Denner 2007) is an exemplar initiative that has had much success in promoting technology fluency objectives to middle-school girls through programming for game design. Focusing on improving aspects of girls' self-efficacy in relation to technology-creation activities, Denner's (2007) program took place over 23 sessions with 126 participants and was designed to make technology work "fun" and linked to real-world concerns for the girls. Significant results from pre- and post-tests measuring subjective task value and expectations for success include increased computer skill level for participants ($p<.001$) and heightened self-perceptions of computer knowledge ($p<.001$). Findings of concern included girls' self-reports that participation in the intervention did not increase their interest in taking another technology-creation course, and ambivalent responses to the perception that boys are better suited to computer work than girls (Denner 2007).

Denner (2007) adopts a multi-faceted advocacy approach to the promotion of technology fluency for girls. The Girls Creating Games program provides a rich repository of online resources supporting the intervention and associated work in the area. Teacher oriented program guides and lesson plans, additionally, are publicly available to facilitate the integration of game creation activities into standardized curriculum (Denner 2007). The civic characteristics of Denner's (2007) intervention motivated the creation of web-based, participant-centred community spaces for the workshops I detail in this thesis.

Further work on promoting technology fluency to girls includes Kelleher et al.'s (2007) Storytelling Alice system. Storytelling Alice (Kelleher et al. 2007) is a tool and learning platform designed to support pre-adolescent girls in computer programming for animated 3-D story production. An offshoot of the Alice project (Pierce et al. 1998), Storytelling Alice draws upon children's' interest in "Dreamworks-style" 3-D movies to introduce sequential programming and foundation programming concepts for the creation of animated stories.

Exploratory results from a controlled study with 88 girls suggest that participants enjoyed using the tool and were motivated to experiment with programmatic constructs to realize their story ideas (Kelleher et al. 2007). Although participants completed a forced-choice quiz on programming knowledge post-intervention, results discussed are relational – noted anecdotally as strong correlations shown between quiz score, enjoyment of the tool and activities, and increased interest in IT fields (Kelleher et al. 2007). Researchers provide no score data to clarify the outcomes and their relationships to individual learners. A subsequent uncontrolled study (Werner et al. 2009) of Storytelling Alice for engaging middle-school students in computer programming found that computational thinking was supported by the system with evidence of parallelism

(52% of reviewed projects), and two or more foundation concepts including algorithmic thinking, programming, modelling, and abstraction (74% of projects).

Qualitative outcomes, particularly with regard to enhancement of girls' perceived competence in technology creation activities, are essential to strengthening the links between IT and girls' interests and lived experiences. As discussed prior; however, in addition to improving girls' senses of self-efficacy with regard to technology-creation activities closer analysis must be given to the gaps that such research suggests for conceptual knowledge acquisition. In the studies reviewed above, while significant gains in *perceptions* of competency are noted, discussion of the weaknesses of *actual* technical competencies is avoided or marginalized.

Linking creative problem solving to programming practice is essential for supporting the development of authentic technology fluency for learners and appears as the critical aporia in the literature to date. While strategies for remedying this recurrent problem are unclear, in the implementation of the Interactive Storytelling and Game Design workshop described in this thesis, I took care to use the language of programming when working with participants through design problems. Naming concepts such as variables, loops, and conditionals helped reinforce foundation knowledge when applied to participants' specific programming challenges. For example, when asked by a participant how to implement a health meter for her game, I explained how creating a "variable" is useful for holding changeable values such as a character's health. We reviewed a prior activity where we had created a "score" variable to implement a points system, which clarified the idea and function of a variable and allowed the participant to transfer conceptual knowledge from one context to a different but related context.

2.1.1.4 Take-Aways from Prior Work

Increasing focus on promoting technology fluency from educational development interests has taken place against the backdrop of concerns emerging from the computing sciences, which shows declining participation in post-secondary CS (Computer Science) and CE (Computer Engineering) degree programs by women (Computing Research Association 2008). Research-based and pedagogical explorations of the role of games in learning processes, and the use of game design and development as curriculum frameworks have emerged as dominant paradigms for motivating interest and engagement with IT fields.

Research has shown a particular interest in developing early-stage interventions for promoting IT fluency for the middle- and high-school years, as well as in the targeting of traditionally under-represented populations in IT fields, through non-formal "computer clubhouses" and technology-creation camps or workshops. Such interventions reveal considerable promise; however, few evidence-based studies have been produced, which show the benefits of such approaches for the acquisition of foundation programming and IT knowledge – this is particularly so for non-formal cases, which tend to emphasize participant gains in areas such as self-efficacy and motivation for technology-creation over domain-specific or conceptual learning objectives.

Making both “hard” and “soft” IT competencies relevant and motivating girls’ interest in IT domains requires connecting technology-creation, in meaningful, “safe” forms, to girls’ day-to-day lives. Making connections to girls’ lives, additionally, requires that educators, researchers, and designers understand what girls do, the contexts of their activities, and their feelings and motivations with regard to the activities that comprise their everyday. While not every programming concept has a real world analogue that can facilitate direct relationships between experiences and the conceptual domain, creative extrapolations using known objects and phenomena to make programming practice more familiar to girls may operate as a useful bridge for learning.

3: RESEARCH OBJECTIVES

In order to gain an understanding of which activities and contexts are most motivating to girls in their day-to-day lives, four main objectives were established. These objectives permitted me to investigate the dynamic parameters of participants' day-to-day lives, and construct a provisional understanding of how non-formal learning contexts, connected to young people's lived experiences, can enhance interest and participation in technology-creation and IT knowledge domains. The design of technology learning environments for girls received specific critical attention.

The four objectives underlying this study are:

Objective 1: Develop a differential understanding of the activity composition of boys' and girls' everyday lives.

Objective 2: Understand the situated nature of boys' and girls' activities (duration of activities, location of activities, and social nature of activities)

Objective 3: Understand the affective dimensions of boys' and girls' experiences (how they feel about an enacted activity)

Objective 4: Determine design heuristics and best practices for connecting non-formal, technology-mediated learning opportunities to youth, with specific focus on design for girls.

The associated research questions underlying this thesis are:

1. How can an adaptive interest-based learning design support the development of technology fluency objectives for girls?

2. What is the quality of girls' experiences within the Interactive Storytelling and Game Design workshop?
3. What characteristics of the workshop intervention are motivating to girls?
4. What characteristics of the workshop intervention are challenging to girls?

In order to investigate the research questions posed, I conducted several workshops to engage middle-school girls in technology-creation activities. Using these workshops as a vehicle, independent, concurrent data, with different units of analysis were collected (see Figure 2). The mixed methods research approach supports the generation of concurrent data intended to address different types of questions (Creswell 2003). Mixed methods research is both a methodological, or, philosophical approach to the collection and analysis of data, as well as a method for the collection, analysis, and mixing of both quantitative and qualitative data in a study (Creswell & Plano Clark 2007). The purpose of mixed methods research design is to facilitate convergence or corroboration of results derived from different methods (triangulation); elaborate the results from one method with the results from another (complementarity); use the results from one method to inform another method (development); discovery of new perspectives (initiation); and to extend inquiry by using different methods for different inquiry components (expansion) (Greene et al. 1989).

Figure 2. Data Collection Model

The result of this research approach is a contextual audience model, composed of girls' revealed activity and situational preferences. This model forms the basis for the design heuristics proposed within this thesis for non-formal learning environments, generally, and focused curriculum development for promoting technology fluency objectives for girls, specifically.

4: WORKSHOP DESCRIPTION

A technologically fluent person should be able to go from the germ of an intuitive idea to the implementation of a technological project (Papert & Resnick 1995).

The primary intervention was implemented as a sponsored after-school activity in an inner-city middle school in British Columbia, Canada. The goals of the workshop were to provide a supported introduction to concepts forming the foundation of computer programming through interactive storytelling and game design. Workshops ran once a week, for an hour and a half each session, from December 15, 2009 until June 30, 2010. The workshop sessions until June were run by one facilitator (the primary research investigator). The final project close-out phase (June 1 – June 30) included a second facilitator to provide extra support to participants for project completion.

Two workshops, one for girls and the other for boys, were held on two separate days of the week until mid-May, 2010 at which time the two groups were combined for full group collaboration on final interactive story and game projects. Workshop sessions were gender disaggregated for core activities to critically account for systemic constraints on IT competency building for girls relating to the material practices of teaching and learning (Bryson & de Castell 1995), which include evidence-based reporting of male domination of technology use in integrated contexts (Bryson et al. 2003, Burke & Murphy 2006, Denner et al. 2005, Jenson et al. 2003, Kay 2007, Van Eck 2006). Prior work finds that girls prefer technology learning in single-gender settings (Burke & Murphy 2006), leading to more positive attitudes toward technology and increasing girls' interest in technology-related activities (Lichtman 1998).

The workshops targeted boys and girls in grades 6 and 7. Two participants, one girl (grade 4) and one boy (grade 3), joined the groups after expressing interest and aptitude in design and programming. Primary recruitment strategies elicited 33 total participants (22 boys and 11 girls). Participant retention fluctuated throughout the duration of the program, maintaining a stable core of returning participants – 14 boys (64% retention rate) and 9 girls (82% retention rate) – by the start of the final project phase in May 2010.

The Interactive Storytelling and Game Design workshop provided a focused introduction to programming concepts through the creation of event-driven stories and games in digital media. Participants were supported in the creation of an animated story or interactive game using the Scratch visual programming environment. In the process, participants worked with integral programming concepts such as variables, loops, conditionals, parallelism, and debugging. The storytelling and game design activities were specifically designed to promote self-efficacy in technology-creation activities and motivate participation in IT-related domains based on a review of current literature in the field (Kelleher 2006, Werner et al. 2009). The storytelling and game design frameworks provide accessible entry-points for learning foundation programming knowledge that is targeted to participants' interests, and which makes programming concepts easier to grasp through a positive connection with prior experiences and familiar media (Cassell & Ryokai 2001).

The goal of the workshop was to enhance the accessibility of programming to middle-school children (ages 8-13), with specific attention given to the needs of girls in programming activities. The workshop aimed to fulfill technology fluency objectives through technology-creation activities. The impact of using technology-mediated game and interactive storytelling frameworks for the acquisition of foundation programming skills by middle-school girls, as the target population for the intervention, was also investigated.

Guidance for embedding foundation computer programming concepts into the workshop's media creation activities was taken from the ACM's *A Model Curriculum for K-12 Computer Science* (Tucker et al. 2003), which outlines opportunities to engage youth and underrepresented groups in developing computer programming competencies and technology fluencies through digital media creation, collaboration, and computational thinking. The Level 1 recommendation for grades K-8 focuses on providing learners with basic ideas about algorithmic thinking, and incorporating programmatic concepts such as sequencing, conditionals, and loops into step-by-step problem solving processes. While the use of variables, data types, procedures and parameters, managed complexity, and tools for design expression (in addition to sequencing, conditions, and loops) are part of the Level 3 (high school) recommendations, interactive storytelling and game design facilitate the introduction of more advanced programming constructs at earlier levels (Ladd 2006). Advanced concepts such as object-oriented programming are naturally accessed in interactive storytelling and game design as participants develop and implement strategies for managing the properties and behaviours of game elements (Overmars 2005). Table 3 summarizes the ACM level recommendations for standardizing K-12 computer science curriculum (ACM K-12 Task Force Curriculum Committee 2003). Highlighted cells indicate the programming concepts engaged in the Interactive Storytelling and Game Design workshop outlined in this thesis.

Table 3. ACM Level Recommendations for Standardized Computer Science Curriculum (K-12)

Level I (K-8)	Level II (9-10)	Level III (10-11)	Level IV (11-12)
Algorithms / Algorithmic Thinking	Variables, data types, and the representation of data in computers	Methods (functions) and parameters	Data structures
Conditionals	Managing complexity through top-down and object-oriented design	Objects and classes (arrays, vectors, stacks, queues, and their uses in problem-solving)	Recursive algorithms
Loops	Procedures and Parameters	Graphics programming	Object-oriented design and coding
	Sequences, conditionals, and loops (iteration)	Event-driven and interactive programming	Programming simulations
	Tools for expressing design (flowcharts, pseudocode, UML, N-S charts)		

Observable Technology Fluency Objectives Statement

Several technology fluency objectives for the primary intervention were developed. It was seen as important that by the end of the primary intervention, participants would have had the opportunity to

1. develop a design document to structure and facilitate their story and game design process;
2. program and run a story sequence or game level using the Scratch visual programming environment; and
3. be able to recognize and work with foundation programming concepts such as sequencing, variables, loops, conditionals, and debugging in the creation of their own interactive digital artefacts.

The FITness content triad of “concepts, capabilities, and skills” as outlined by the National Research Council (1999) are supported by the workshop curriculum, which provides participants with an introduction to game design theory and practice (intellectual capability), critical game play (abstract thinking), digital media production tools (contemporary skills), and programming concepts (foundational principles of computing) essential for creating interactive experiences using digital media.

Interactive Storytelling and Game Design Tools

During the course of the workshop, participants were introduced to the fundamentals of game design and computer programming for game design and animated storytelling. The MIT Media Lab’s (Lifelong Kindergarten Group) open source Scratch programming environment was the primary learning and game development tool used throughout the duration of the workshop.

Several game creation, modding, and creative programming tools were considered for the workshop based on the literature and prior work including: Alice and Storytelling Alice (Kelleher & Pausch 2007, Pierce et al. 1998), Game Maker (Overmars 2005), Greenfoot (Henriksen & Kolling 2004), Neverwinter Nights Aurora toolset (Atari 2006), Scratch (Maloney et al. 2004), StarLogo TNG (Klopfer & Begel 2005), and the Warcraft III World Editor (Blizzard Entertainment 2002). Primary criteria for review were: 1) compatibility with host school computer systems (Mac OS 10.3.9 iBooks); 2) ability to support the production of interactive stories and games; 3) conceptual accessibility (low floor for entry to programming tasks); 4) economic accessibility (open-source or low cost); and 5) portability (cross-platform to support at-home tool access). Alice, Greenfoot, and Scratch matched all of the evaluation criteria and affordances with respect to participant needs further explored.

Table 4. Review of Design Tools

	School System Compatibility	**Content Support**	**Low Floor**	**Open-source or Free**	**Cross-Platform**
Alice	Y	Y	Y	Y	Y
Game Maker	N	Y	Y	N	N
Greenfoot	Y	Y	Y	Y	Y
NWN Aurora Toolset	N	Y	Y	N	N
Scratch	Y	Y	Y	Y	Y
StarLogo TNG	N	Y	Y	Y	Y
Storytelling Alice	N	Y	Y	Y	N

Warcraft III World Editor	Y	Y	Y	N	Y

The Alice environment supports 3D game creation, while Greenfoot, built on top of the BlueJ Java development environment, and Scratch are 2D media programming tools. Both Alice (Cooper et al. 2000, Sattar & Lorenzen 2009) and Greenfoot (Al-Bow et al. 2008, Henriksen & Kolling 2004) have been used with reported success with high school and first year university (CS1 and 0) novice programming populations, while Scratch's (Maloney et al. 2008, Resnick et al. 2009, Resnick et al. 1998) intended learner audience is focused, more directly, towards the middle-school years. All three environments facilitate media creation activities for novice programmers.

While Alice connects well to the age group's 3-D game playing experiences and expectations, it can be a difficult and complex first encounter with graphics programming for, particularly, younger participants. The first two workshop sessions were held just prior to Winter break (December 20 – January 3) for the participants, and were dedicated to introducing core game design history and theory, which participants translated into board game prototypes. Free time, at the end of these two introductory sessions, engaged open play and experimentation with the three systems under consideration for the digital media creation work to begin following the two week break.

It was informally observed that all participants skipped the Alice tutorials built-in to the tool, leaving them unprepared for the programming components of media creation. Participants spent the majority of their time in Alice exploring world building, which was a frustrating experience for some who were not able to master world rotation and panning for effective asset placement. When it was suggested that working through the tutorials could assist in creating richer stories, participants complained that there were “too many pages” in the tutorials and they wanted to be able to start creating animations and interaction “right away.” Participants who did work through the tutorials thought they were inflexible and “babied” them through over-guiding instructions such as “click on the x to close the box.” Moreover, the tutorial stories were considered “boring,” and “annoying.” More girls than boys indicated being bored by the tutorial content even though the art assets used to support the programming tutorials were, ostensibly, more “girl-focused,” including a female figure skater. One female participant learned how to decompose the figure skater model object by creating separate action methods for the body parts causing the legs to walk away from the body to demonstrate her dislike of the object and environment following the tutorial.

Both boys and girls were de-motivated by the rigidity of Alice’s tutorial system, which does not afford experimentation with concepts, but, rather “forces” the learner to mechanically replicate the tutorial steps with no latitude for creative re-working of the methods being demonstrated. For example, one girl complained that she wanted her character to move 10 increments instead of the 5 requested by the guide stencil; however, when she would enter the different value the tutorial would not allow her to proceed to the next page, indicating, instead, that she had made an “error,” which in fact she had not. It was further determined that collision detection in Alice is quite difficult to instantiate, requiring many lines of code, imposing complexity for young novice programmers to develop very simple games.

Participants using Scratch easily discovered the sprite editor and spent the majority of their time creating art pieces. While the interface was easy for the participants to explore, and they recognized that the code blocks “looked” like puzzle pieces that should fit together, dragging and dropping the blocks, and organizing them from toolbox to script pane, was not intuitive. Once introduced to the difference between background editing and sprite creation, and shown that code blocks could be placed in the script area to effect created elements, participants took pleasure in experimenting with code block combinations; producing simple, animated comic book style screens using the <say> and <think> blocks and recording their own sounds for incorporation into their proto-programs.

While participants did not create any specific “event triggers” for instantiating animations, they were able to figure out that clicking on a code block, once placed in an object’s script pane, would “play” the code. Most participants discovered this affordance without it being demonstrated, and quickly showed others in the group how to “play Scratch.” Sensing blocks available in Scratch make the development of simple colour or object-based detection easy and intuitive to novices, and allows for rapid prototyping of interactions common to game development for the types of action-adventure and platform genres that the participants showed greatest enthusiasm for when discussing personal game play choices.

Greenfoot, overall, presented a mystifying and non-engaging experience for participants. There was no “out-of-the-box” appeal of Greenfoot to any of the participants, although its scenario-based development environment is promising for structured introductions to programming through game design. Greenfoot’s Java syntax fidelity would be helpful for providing novice learners a more conventional (and potentially transferrable) introduction to programming, as well. Object placement in Greenfoot is facilitated by right-clicking on the desired actor class in the object tree, which gives a visual instance of the actor connected to the user’s cursor-pointer, which can then be positioned on the scenario map prior to compiling and running built scenarios. Unfortunately, technology resources at the host school did not include mice for the laptops used in the workshop and thus participants were unable to figure out the hotkey keyboard and trackpad combinations on the Mac laptop systems to access the right-click commands in Greenfoot. The absence of pull-down menu options for creating new instances of actor classes for scenario building, particularly given the limitations of the technology resources at hand, was a significant factor for rejecting Greenfoot as a suitable development environment for the workshop’s interactive storytelling and game creation activities.

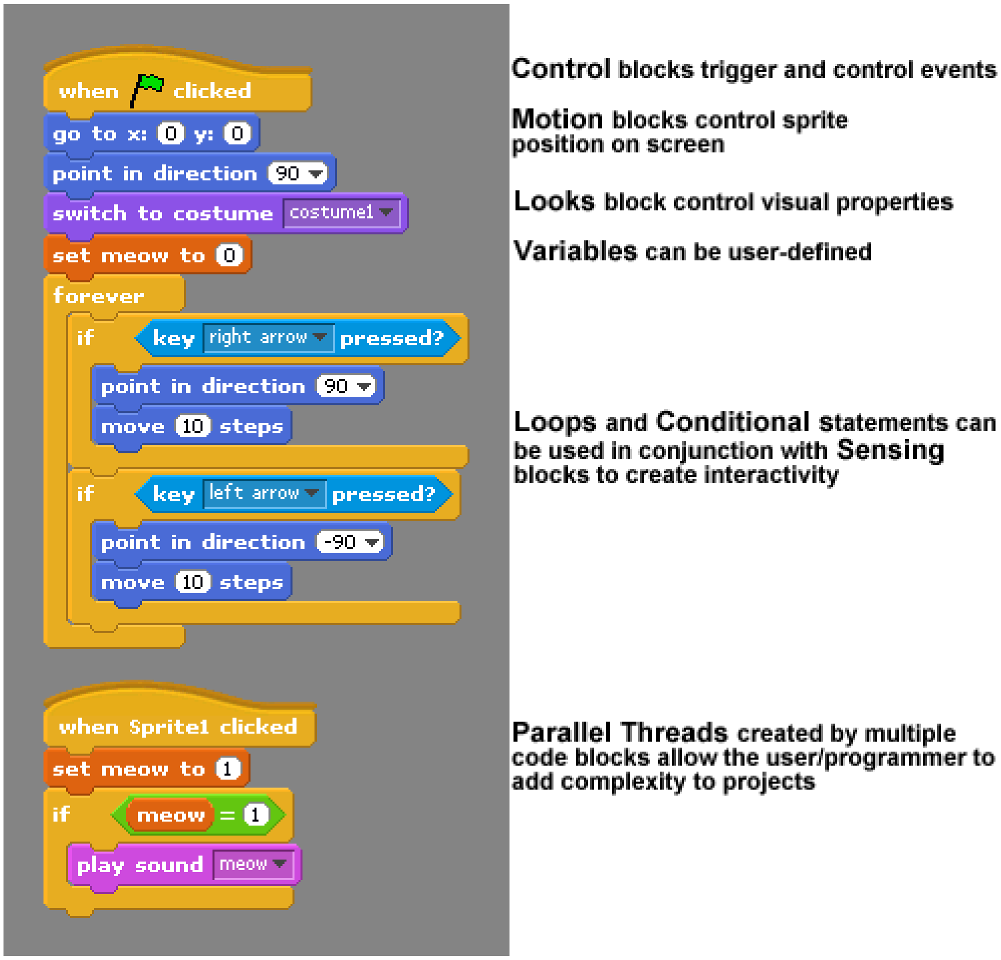
Scratch was selected for the workshop based on its accessibility to novice programmers (drag-and-drop coding paradigm), efficacy in supporting informal, self-directed learning (Peppler & Kafai 2007b), sustainability (web-based learning community), portability (variety of versions supporting multiple operating systems – including legacy systems), and open-source philosophy. Informal participant engagement with the application suggested, additionally, that Scratch would be a best fit for introducing foundation programming concepts in a “fun” way, and for meeting the “quick start” expectations of the workshop participants. Additionally, it was particularly important to use a development environment that economically disadvantaged participants could freely download and access on older computer systems at home and school, or, run from a CD or USB drive on publically accessible computers in libraries and community centers. All participants were provided with Windows and Mac versions of the Scratch software on CD to work with outside of the workshop context at the end of the first programming session with Scratch (designated Week 3 on the curriculum outline).

Scratch

Scratch is a “low barrier” visual programming environment, which uses a Lego-like “building block command structure” (Peppler & Kafai 2007b) to support novices in media creation activities by eliminating programming syntax errors and debugging related to syntax errors (Maloney et al. 2008, Peppler & Kafai 2007b, Resnick et al. 2009). Scratch; however, does not prevent the user from making logic errors, so debugging practices and paper programming strategies for code organization and game design documentation can be leveraged in this area. Code blocks are grouped into eight colour-coded categories (Motion, Looks, Sound, Pen, Control, Sensing, Operators, and Variables). Command blocks in Scratch are designed to “snap” together in syntactically sensible ways (Resnick et al. 2009) and facilitate the creation of parallel programming threads (Figure 3). By affording the creation of multiple code stacks for simultaneous command execution and event triggering, essential to interactive gaming experiences, rich complexity can be easily and intuitively added to user productions, which would, otherwise, be more difficult for the novice coder to instantiate both conceptually as well as programmatically in more conventional, text-based scripting environments.

The Scratch paradigm allows novice coders to “naturally” write parallel processes into their programs through the simplification of object-relation (sprite) links. The formulation of simultaneous event occurrences evolves intuitively from user/creator real-world experiences and expectations with game play and digital media interaction more generally. This familiarity is supported in translation by Scratch’s multiple block stack capability, which makes “parallel execution as intuitive as sequential execution” (Resnick et al. 2009).

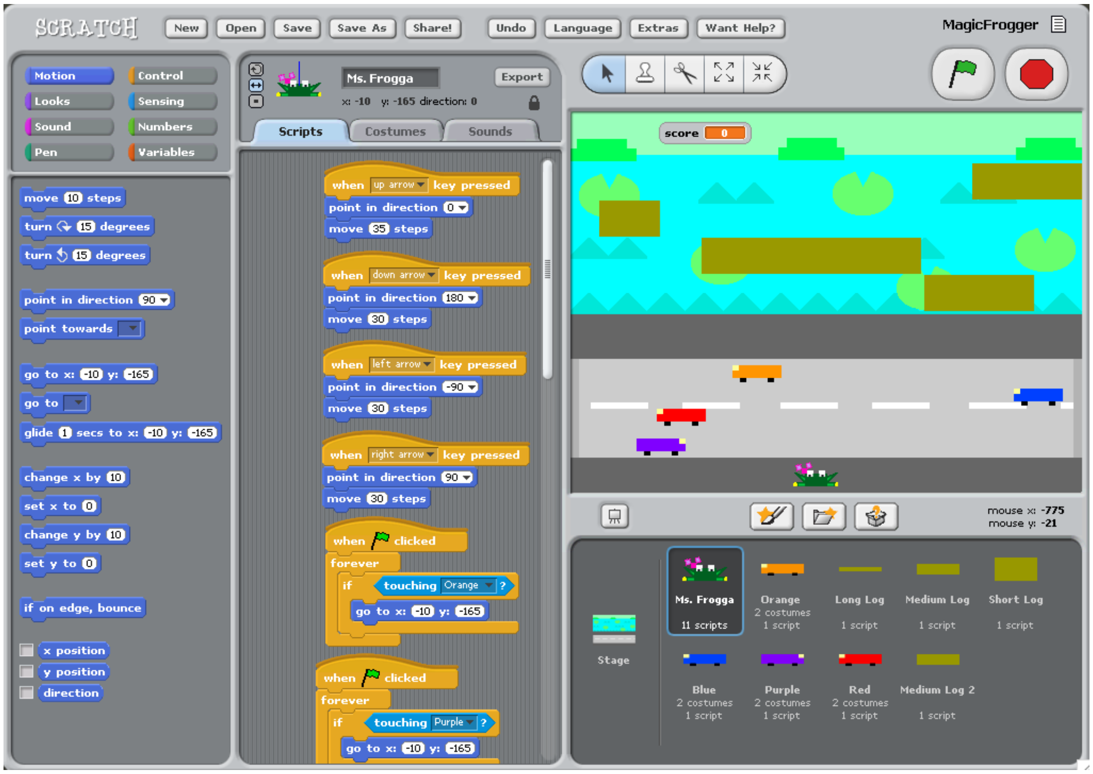
Figure 3. Scratch Code Blocks



The Scratch interface is divided into four primary panels: 1) the code block toolbox; 2) the code editing panel; 3) the output, or "preview" pane; and 4) a visual overview of the user-created sprites and background stage (Figure 4). Further, opportunities to "share" Scratch creations are supported in-program through direct project export and upload to the Scratch community website, although site membership is required to utilize this program feature. The Scratch community promotes project collaboration and iterative development through the advocacy of code "remixes" in which community members modify existing Scratch projects for their own creative works.

The “low floor, wide walls” approach of Scratch to introducing programming as a creative activity, as well as its prior successful use in non-formal “Computer Clubhouse” settings (Maloney et al. 2008, Peppler & Kafai 2007a, Peppler & Kafai 2007b, Resnick et al. 2009, Resnick et al. 1998), recommended the tool as an ideal beginning design and development environment for the Interactive Storytelling and Game Design workshop. The “wide walls” approach taken by Scratch developers emphasizes support for a wide variety of project “types” (Resnick et al. 2009), which privileges creative code “tinkering” techniques towards the development of computational thinking over more professionalized “high ceiling” environments such as Flash (Resnick et al. 2009). As computer programming represented a “new language” for the majority of participants, Scratch provided a useful, scaffolded approach to the teaching and learning of programming fundamentals. The building block metaphor used by Scratch can encourage user experimentation with the effects of code linkages in relation to graphical objects, and ease the learning curve with regard to object-related, modular programming practices.

Figure 4. Scratch Interface



4.1 Workshop Details and Curriculum

Workshop sessions ran in two primary phases, with a final “tail-end” phase reserved for game testing and refinement:

Phase One involved introducing participants to the Scratch visual programming environment and incorporated self-directed learning using activity handouts with just-in-time facilitator guidance for activity completion.

Phase Two consisted of facilitator-led live coding sessions demonstrating an example solution to a particular design or coding problem raised by participants' design documents. For both phases of the workshop, the facilitator allocated 10 minutes at the start of each session for introducing the session activity and explaining the general programming concept(s) that the activity was centered around.

From December 15, 2009 until mid-May, 2010 workshops were conducted on two separate days for boys and girls. From mid-May, 2010 until June 30, 2010 the two workshops were combined and met on the same day to address scheduling conflicts with participants' extracurricular activities, and to increase peer support and collaboration opportunities for final interactive story and game development. Intervention design had initially planned on integrating the two working groups in June to support project completion and game testing. However, scheduling conflicts for both boys and girls due to school sponsored sporting activities mandated an earlier merge.

The workshops consisted of 22 sessions in total (21 working sessions and 1 demo day), 2 icebreaker activities (board game design sessions), 10 focused activities using visually-rich activity walkthroughs (handout format) and just-in-time guidance to support self-directed learning, 2 in-session design document brainstorming sessions, 5 live coding activities generated from participants' design documents, and 2 sessions focused on assisting individual participants with problems specific to their own projects, testing, and debugging in preparation for demo day. Spatial design of the workshop setting exploited the existing pod desk formations in the classroom used for sessions, which afforded small group formation (approximately 4 students per pod), collaborative and cooperative working opportunities between participants, as well as facilitating access both to individuals and groups for just-in-time assistance during self-directed programming activities. Curriculum details, by week, are outlined in Table 5.

The workshop ran in weekly 90 minute after-school sessions, which took place in the host school according to the current academic calendar. Workshop sessions were not held during winter holiday break, spring break, designated professional development days, or, on other statutory holidays.   Each session was delivered according to the following rough breakdown, noting that flexibility in workshop activity management was a priority according to participant needs: 1) for Phase One activities, approximately 10 minutes were reserved for the facilitator to introduce the activity and related concepts, and distribute hand-outs. Forty-five minutes of each focused activity were allotted to participant self-directed completion of the session activity with just-in-time guidance provided by the workshop facilitator. Ten minutes at the completion of the activity were reserved for participants to circulate and view each other's projects, followed by 15 minutes of free play and socialization. Ten minutes for clean-up and shutting down computer equipment generally closed out each workshop session; 2) Phase Two sessions involved a thirty minute introduction and live coding demonstration of a programmatic technique or design issue drawn from a randomly selected participant design document. Participants would code along with the demonstration, which was followed by a brief discussion of how the technique may or may not be usefully integrated into individual projects. Approximately 35 minutes following the live demonstration were allocated to individual work on game projects with 15 minutes of free play and 10 minutes for clean-up closing out the Phase Two sessions; 3) One-on-one consultation sessions were concentrated sessions with 60 minutes of workshop time devoted to participant self-directed work on individual game design and development with the facilitator meeting with individuals and working groups during the session to discuss process and outstanding problems. Twenty minutes of free play and 10 minutes clean-up concluded these final workshop sessions. To assist in the concluding workshop phase, a second volunteer facilitator from the graduate student population of the Simon Fraser University, School of Interactive Arts and Technology was recruited and participated in the final 5 sessions, including close-out, of the workshop.

Table 5. Workshop Curriculum Outline, by Week

Week	Objective	Activity	Learning Objectives
1	Introduction to Game Design	In groups of 3-4 design and prototype your own board game. Free Play Activity: Participant testing of Game and Media creation environments.	Understand how to create and implement rule-based systems into games, be able to define game objectives, exercise creativity in the design process, and learn how to work collaboratively in design processes.
2	Introduction to Game Design	Finalize and play test each other's board games. Free Play Activity: Participant testing of Game and Media creation environments.	Develop an understanding of the importance of user testing for refining games and increasing playability and enjoyment, develop skills in delivering useful critical feedback, and exercise and develop collaboration skills.
3	Introduction to Scratch	In a guided exploration activity, familiarize participants with the Scratch interface and visual programming capabilities.	Learn how to create and save new files in the Scratch environment. Become familiar with and explore the Scratch

Week	Objective	Activity	Learning Objectives
			interface and how to interact with the Code Block Toolbox, Scripting Pane, Preview Window, and Sprite Library. Experiment with programming a simple action in Scratch using the default Sprite.
4	Creating Your First Sprite in Scratch	Introduce and experiment with the paint editor tools in Scratch's Sprite Creation editor. Guide participants through the Sprite creation process ensuring that all of the paint editor tools are explained and demonstrated.	Learn how to use the paint tools in Scratch's Sprite Creation editor to create your own programmable Sprite.
5	Animating Your First Sprite in Scratch	Introduce the concepts of variables, conditionals, loops, program structure, and I/O by programming a simple movement animation in Scratch. Offline Activity: Flip book for guiding and practicing animation processes.	Learn how to initialize a program in Scratch, manipulate and connect code pieces in the Scratch environment, set Sprite orientation, modify variables, and create program blocks that respond to user input.
6	Code Block Challenge	Challenge: using at least 8 different code blocks from the Motion, Looks, Sound, and Control categories, create unique programs to tell a short animated story.	Learn how to combine code blocks to create an animated or interactive experience for an end-user. Explore and experiment with code block elements to create a working program that responds to user input.
7	Maze Game	Create a simple maze game in Scratch. Part One: define the rules and objectives of a simple maze game, design your Maze and player character.	Learn how to define game rules and objectives, and how to use pseudo-code and flow charts/concept maps to sketch out game play. Use creativity to design challenging mazes for increasing player enjoyment.
8	Creating Simple Movement	Create a simple maze game in Scratch. Part Two: Program your player character so that it	Learn the difference between programming movement using the "change x(y) position by _"

Week	Objective	Activity	Learning Objectives
		is able to move up, down, left, and right in response to user keyboard or mouse input. Practice programming concepts: variables, conditions, loops.	code blocks and “move _ steps” code block. Learn how to program a Sprite to face in the direction they are moving. Learn how to change and test movement variables for best gameplay. Experiment with the effects on gameplay using different input devices to control player movement.
9	Sensing and Collision Detection	Create a simple maze game in Scratch. Part Three: Program your player character so that it is able to detect maze walls. Practice programming concepts: variables, conditions, loops.	Learn the different ways to “sense” other objects/sprites and qualities (such as colour) in Scratch to create simple collision detection systems. Learn how to create custom conditions for object detection in Scratch.
10	Adding Items and Enemies	Create a simple maze game in Scratch. Part Four: Create Item and Enemy Sprites to add into your game for increased play enjoyment and challenge. Think of the role you want items and enemies to play in your game, ex.: will they move or be static? How will they affect your Player character? Practice programming concepts: variables, conditions, event triggers.	Learn how to add complexity into a simple game template to increase play value. Determine effects of complexity on game play and develop solutions for implementing effects into the game template.
11	Scoring Systems	Create a simple maze game in Scratch. Part Five: Implement a scoring system into your maze game to keep track of the effects of Player encounters with Items and Enemies. Practice programming concepts: creation of variables, manipulation of variables, conditions.	Learn how to create custom variables to keep track of changing conditions like a game score. Learn how to programmatically modify variables by attaching changes in a variable to a game event.
12	Adding Levels	Create a simple maze game in Scratch. Part Six: Create	Learn how to trigger game levels using the broadcast method in

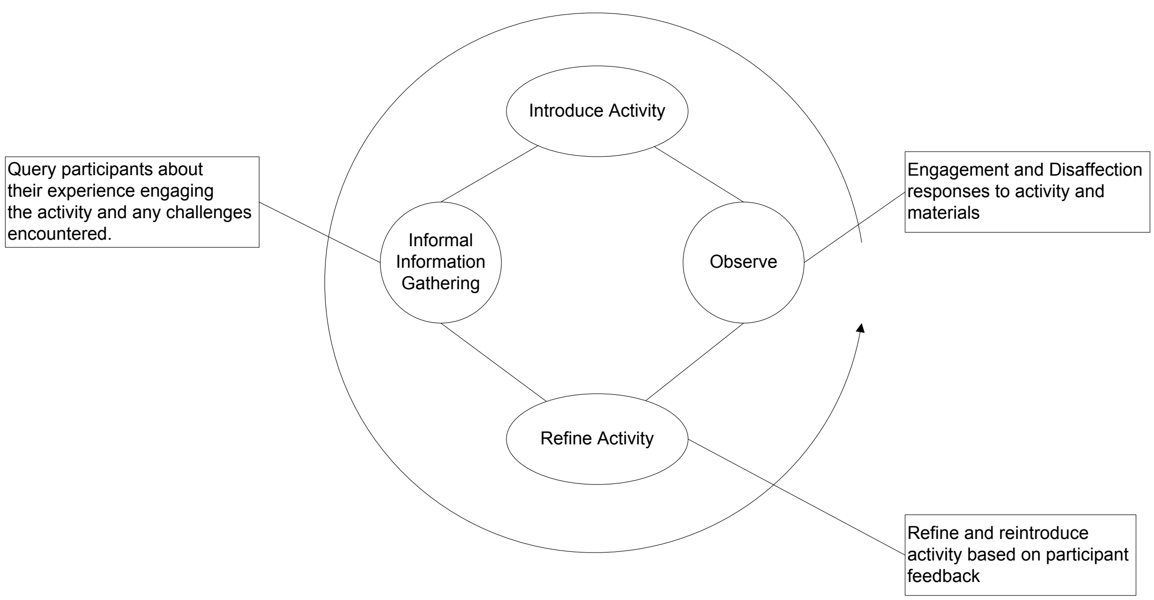
Week	Objective	Activity	Learning Objectives
		multiple game levels in Scratch using conditions and event triggers. Practice programming concepts: variables, conditions, event programming.	Scratch when a Player meets a certain goal. Learn how to use the "show," "hide," and "go to x _ and y _" to reset player positions in new levels using conditions.
13	The Design Document	Use the distributed design document handout to create a working outline for your individual story and game design projects. The design document is a "living" document and participants are expected to revise throughout their design process.	Learn how to create and use a design document to structure the game design process, including detailing basic game information (title, rules, and objectives), Sprite Information (names, looks, sounds, and movements), Object Interaction Information, Score and Level Management.
14	The Design Document	Continue work on individual design documents in preparation for prototyping and implementing final project story and game projects.	Practice brainstorming techniques, understand the structural elements of interactive games and apply these principles to own projects.
15	Creating a Title Screen and Game Start Button	Activity from Participant Design Document. Getting your game started. Create a title screen for you game that will attract players. Create a button on the title screen that will initialize game play. Practice programming concepts: conditions, events, user interface design. Offline Activity: Paper prototyping of Level 1.	Introduction to user interface elements. Learn how to create a screen that can be used to introduce your game to a potential player. Learn how to create buttons for user interaction. Learn how to create level maps on paper to guide game programming and implementation processes.
16	Creating Realistic Movement	Activity from Participant Design Document. How to use an x_velocity variable to create realistic character movement. Practice programming concepts: variables, conditions.	Learn how to use simple physics to make your character movements look more realistic. Create and modify variables and use conditions to control variables.
17	Creating Simple Gravity	Activity from Participant Design Document. How to use a y_velocity variable to create	Learn how to use simple physics to make your character movements look more realistic.

Week	Objective	Activity	Learning Objectives
		realistic Character jumps. Practice programming concepts: variables, conditions, collision detection and sensing.	Create and modify variables and use conditions to control variables.
18	Adding Character Customization Features to Your Game	Activity from Participant Design Document. How to create a character customization screen to give your user more control over a character or object's appearance. Practice programming concepts: conditions, event triggers (broadcasting).	Learn how to use conditions and the costumes features of Scratch sprites to let your user customize aspects of their character before beginning game play.
19	Advanced Collision Detection: Creating Invisible Sensors and Using Custom Variables	Activity from Participant Design Document. How to create invisible sensors and custom variables for better collision and object detection. Practice programming concepts: variables, conditions, event programming, loops.	Learn how to use the "ghost" effect and "go to Sprite" code blocks in Scratch to create invisible sensors that can be used for advanced collision detection in your games. Learn how to create custom variables that can be used for boundary detection in maze games.
20	One-on-one Consultations and Play Testing		
21	One-on-one Consultations and Play Testing		
22	Demo Day and Workshop Closeout		

Supporting Learning

Several participant learning support methods were integrated into and procedurally revised during the course of the workshop (see Figure 5 for a visual model of the iterative design process). To facilitate the introduction of programming concepts and Scratch’s affordances for media-creation, activity cards were designed and distributed as hard-copy hand-outs at the beginning of each workshop session. Digital copies of the activity cards were uploaded to a community-based learning resource repository, which was maintained on a weekly basis for the duration of the workshop. Workshop participants were given user accounts, which allowed them to access workshop resources, create their own profiles and blogs, participate in online forums created to discuss game design and development processes, build polls, and comment on posted workshop-related content.

Figure 5. Process Flow Diagram for Learner-Centered Design



Based, initially, on the popular “Scratch cards” support materials made available by the Scratch project team through the Scratch website, the activity card format evolved over multiple working sessions based on participant feedback with regard to content presentation and format. The activity cards functioned as “take-away” tutorials and demonstrations, which participants used in-session to scaffold their Scratch learning and programming practices. The original activity cards used in the workshop were relatively text-heavy and challenging for some of the participants with low reading comprehension skills to follow (see Figure 6). While the boys’ group did not suggest any changes, which might make the cards more accessible and useful for learning, the girls’ group was active in the cards’ redesign. The girls requested that the cards be made more colourful, use less text, and substitute visual images, where possible, for textual explanations. The final iteration of the activity card design saw the card format reduced in size from full 8.5 by 11handouts to 8.5 by 5 printed cards that were corner hole-punched and distributed at the beginning of each session on key rings, which added a “collectible” dimension that was particularly appealing to the girls (see Figure 7).

Digital versions of the activity cards were made available on the shared workshop website as a redundancy measure enabling the distribution of learning resources in a variety of formats to support learner access to materials outside of the workshop context and afford individual learner material choice preferences. It was observed that girls preferred the hard-copy format of the cards and took pleasure in creating their own resource booklets from the weekly handouts. Boys preferred the digital activity card format, making extensive use of the online resources throughout the workshop while often leaving their hard-copies behind at the end of workshop sessions or misplacing hard-copies in the intervals between workshop sessions.

Figure 6. Original format for Workshop Activity hand-out.

Getting Started with Scratch

1. Scratch

When you first start the Scratch program you will see three main screens.

The **Button Screen**, the **Code Screen**, and the **Stage Screen**.

The **Button Screen**: This is where all of the buttons, or "blocks" that you can use to piece together on the code screen. At the top of the screen, there are eight different categories of buttons to select from. Clicking on any of these will show all the buttons in that category on the Button Screen.

The **Code Screen**: This is the area where you piece blocks together to "write" code. The code is basically an instruction recipe, which tells your Sprites what to do. You "write" code by dragging blocks from the button screen onto the code screen. On the code screen you can test out a code block by double clicking it. Watch your Sprite on the Stage to see your code run!

The **Stage**: This is where you can see your game, or progress on your game played out. It shows your background, as well as all your Sprites. Sprites are any characters or objects which you want to be able to program.

Exercise A

1. On the diagram below, label the screens on the Scratch interface. Which screen is the **Button** Screen? Which screen is the **Code** Screen? Which screen is the **Stage** Screen?

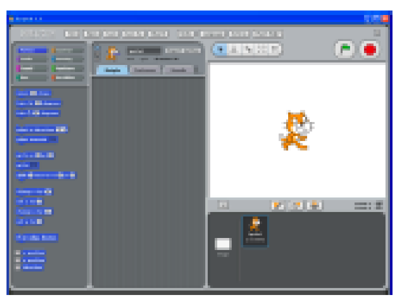
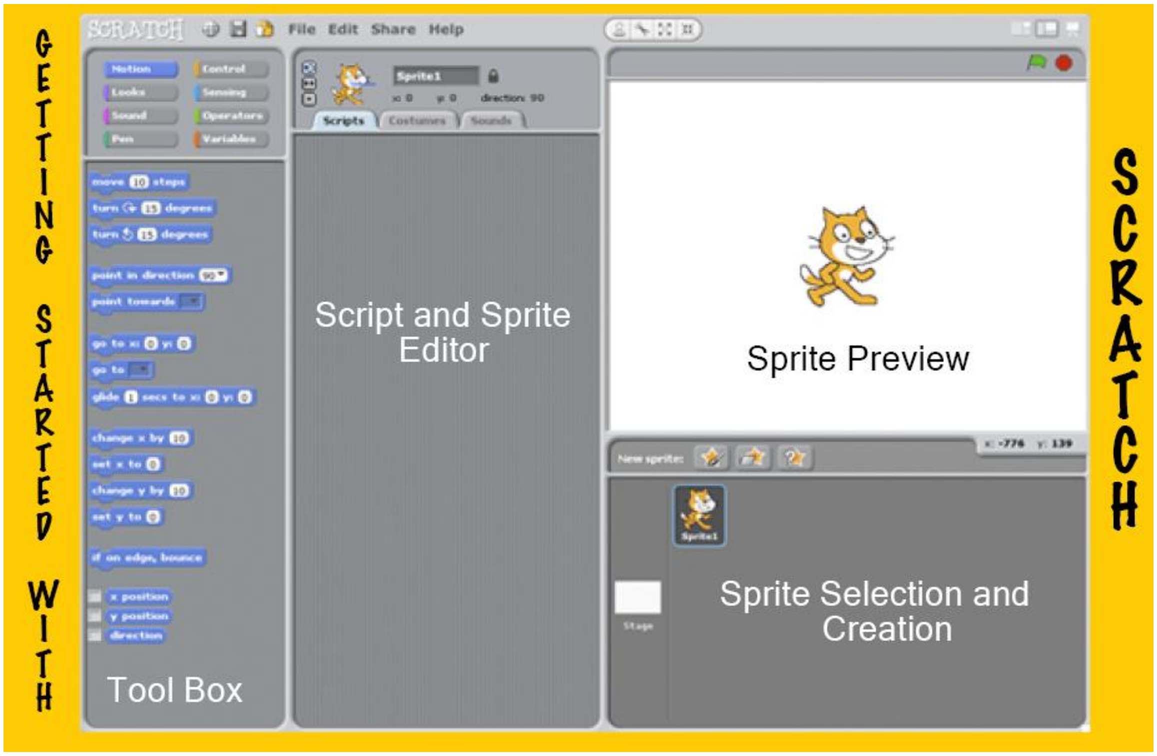


Figure 7. Final Activity Card presentation format based on participant feedback.



A website (see Figure 8) was developed to support learner community formation outside of the sessions and provide a sustainable resource for participants following close-out of the intervention. Web-based material included a “Modules” section, which contained digital versions of the workshop activities; a “Drafts” repository where participant work was uploaded on a weekly basis for outside-session access to on-going projects; an “On Your Own” component, which housed non-technology mediated activities intended to support the development of algorithmic thinking including guidance for decomposing everyday processes such as making a sandwich to encourage participants to practice the construction of logical sequencing processes prior to story and game programming; and a “Tutorials and Resources” section that linked to alternative open source programming software such as Processing, Arduino, DrawBot, and

Unity 3D, as well as providing links to free online programming resources such as “CS Unplugged” and “Java for Kids” to support learners’ growth out of Scratch into more advanced creative programming environments.

The workshop website additionally afforded opportunities for social engagement and communication through user created blogs, topical forums, and poll creation. Workshop forums were structured according to session modules and were intended to organize participant discussions related specifically to workshop content. Blogs and polls could be created and posted according to individual user choices and were not constrained to workshop-specific content, however, participants who engaged these forms stayed, interestingly, “on task” with blog posts used to capture session reflections and report on out of session programming and design practices (see Figure 9), and polls used to query other users about gaming choices (see Figure 10).

In contradistinction to revealed resource preferences for hard copy handouts, more girls than boys actively engaged the communicative affordances of the workshop website. All girls registered on the website as users, creating profiles and maintaining reflective weblogs on workshop sessions. Girls made frequent comment postings on announcements and activity modules, using the website space to pose questions to the facilitator and each other concerning progress and project ideas, as well as creating polls centering primarily around game play and console preferences. In contrast, only one male participant registered as a user on the workshop website. The single male user restricted comments and questions to the structured online forum portion of the website, which none of the girls accessed. In this way, the male participant did not involve himself in a community of practice, but, rather, used the forum space as an opportunity for directed, one on one communication with the workshop facilitator outside of session meetings.

Design journals, which were distributed to participants at the initial workshop session, were not used by girls until the final project stage for level mapping activities – which was requested work. Boys; however, made greater free use of the journals to document progressions in game ideas and collect character sketching over the course of the workshop. Boys regarded the journals as portfolios to display their game art and game content snippets toward the final project from the early stages of the intervention, while girls were less interested in conceptualizing game ideas throughout. Girls showed more focus on tasks “at hand,” which were supported by the activity cards, while boys showed more interest in large-scale goals such as the final game projects, which the design journal format supported.

Figure 8. Workshop support website

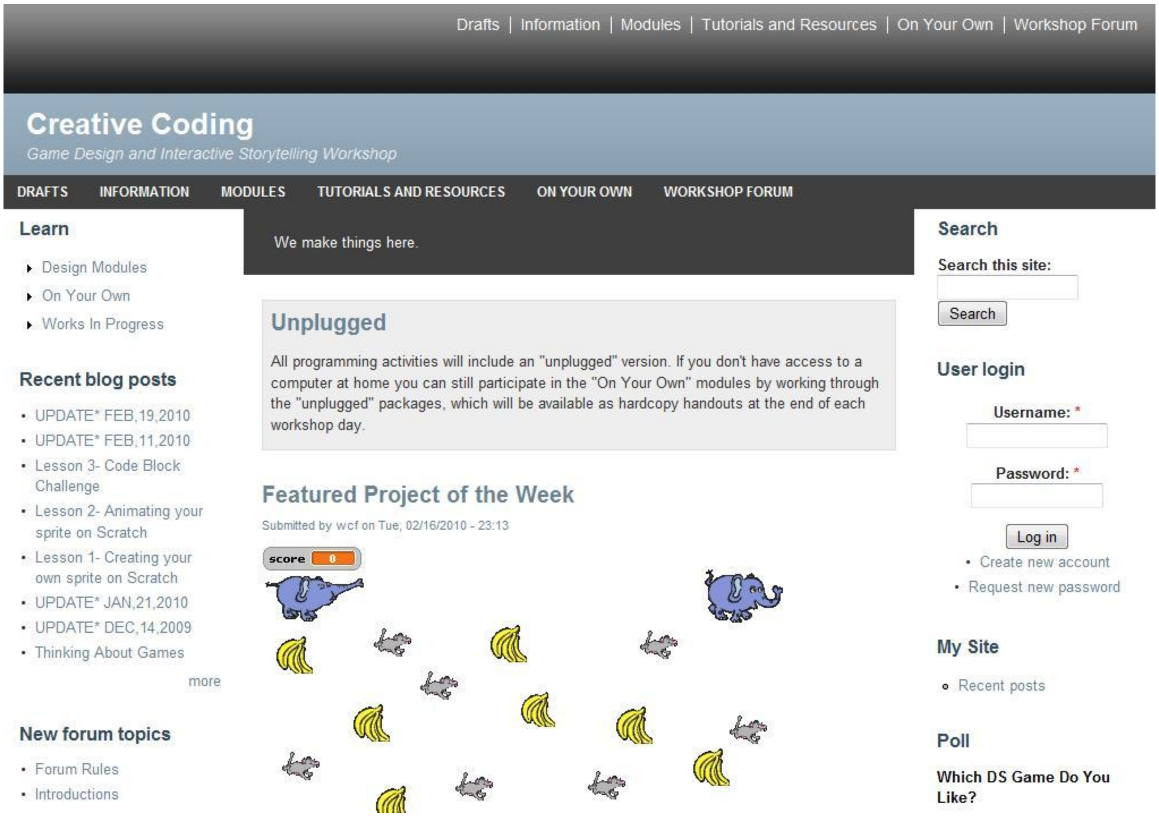


Figure 9. Example blog posts from female workshop participants.

Home » Blogs » STREETFIGHTER101's blog

UPDATE* FEB,11,2010

Submitted by STREETFIGHTER101 on Thu, 02/11/2010 - 19:38

I am very happy to announce that i have made my first maze using scratch i made an early one wich was very simple but i also made one at my own home wich is a tad more complicated and is way more fun too.Im working on it almost every day now, to fix any glitches and to play it when im bored ^_^.I am definatly going to make more levels and posabally put them all together to make one full flash game! I am also -as you know- going to make a board game wich i will make into a computer game so i am very excited for that!

STREETFIGHTER101's blog   Login or register to post comments

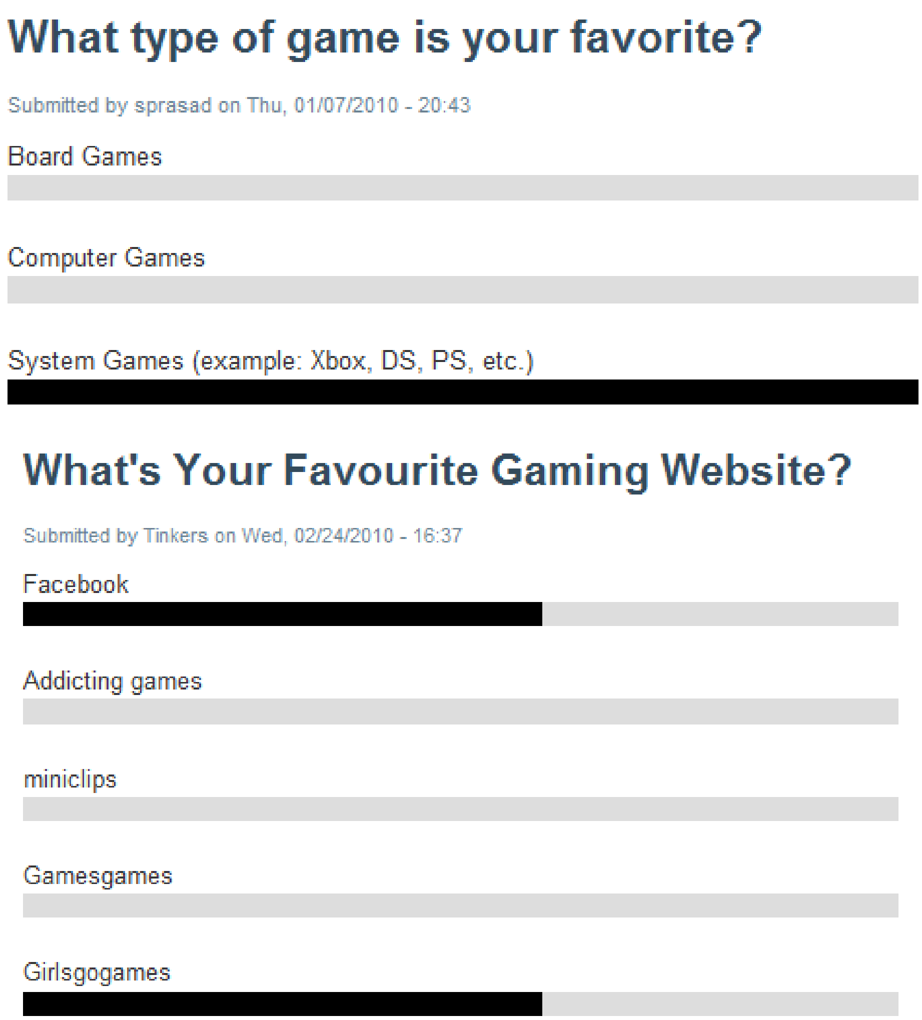
Lesson 2- Animating your sprite on Scratch

Submitted by ChocolateGirl on Sat, 01/30/2010 - 11:02

In our second lesson we learned how to animate our own sprite on Scratch. Before we started to animate our sprite on Scratch we made a flip book. Making the flip book was easy if you did a simple action like walking. After we made our flip books we tried it on Scratch. It was easy if you did a simple action. This lesson is fun because after you make your sprite do a simple action you can make it say things like, I like the computer workshop. You can also put music on while your sprite does a simple action. A thing to always remember is when your making your sprite on Scratch start by doing a simple action. This lesson was fun and I'm so excited to start using Scratch at my on house. And I cant wait for Lesson 3.

ChocolateGirl's blog Login or register to post comments

Figure 10. Examples of user created polls.



4.2 Organizational Lessons Learned

This section is provided to assist designers in the development of future iterations and alternative versions of the intervention. A detailed accounting of the challenges encountered in implementation may be of use for planning processes associated with similar design activities. Challenges related to participant engagement, disaffection, and managing expectations are discussed in Chapter 7.2.2.

Attrition

Retention and consistent participation throughout the duration of the workshops was a fundamental challenge. Although the workshops were strongly supported by the host school administration, there was little assistance in integrating the program into the existing school-sponsored extra-curricular activities schedule. Consequently, the design workshops ran as a floating activity on top of, as opposed to alongside, the strong after-school sports programs that construct much of the school's identity. Workshop attendance was affected by student involvement in after-school, organized sports activities, which resulted in participants missing large blocks of workshop sessions or arriving late to accommodate sports practices. Efforts were made on the part of the researcher to provide flexibility in session scheduling to afford participants the opportunity to attend the workshop and meet their sports commitments, but this was difficult and proved unsustainable in the long term, particularly in the last two months of the workshop when the difficult work of producing individual game projects began.

Retention rates for the workshop, particularly the boys' workshop, were highly variable throughout the duration of the program. The core group of 23 fluctuated between 12 and 8 core participants throughout as sports participation and other activities conflicted with the regularly scheduled workshop days. Approximately 8 boys removed themselves from the workshop after the first session stating that the work was too difficult, and that they wanted to make games easily. One boy left because the workshop was not challenging enough, he participated sporadically; however, throughout the year. The boy who didn't find the work challenging has taught himself basic programming and 3D modeling skills (using Blender) at home. I provided both him and his parents with further resources for at-home study. He often dropped into the workshop to play with Scratch, talk about his interests, and assist other boys with their game design and development work in Scratch.

Attempts to accommodate other activities to afford workshop participation were only partially successful. Workshop meeting days were moved monthly to accommodate the school's sports program rotation, but, didn't prove effective in the end as the schedule disruption could not absorb conflicts with sports that had a more intensive, multi-day practice schedule. The girls' workshop was more consistent, from an initial 11, 9 core girls were retained, 2 were lost to attrition due to an increase in after-school academic responsibilities (for grade 7 girls preparing to enter high school the next year). The majority of grade 6 girls (6 out of 9 participants); however, missed one month of workshop sessions in mid-May due to participation in track and field events and practices, which didn't allow them time upon return to complete their story and game individual projects.

Initial recruitment strategies for the after-school workshop were successful. Consistent attendance was the challenge as competing after-school activities and responsibilities contributed to a fluctuating participation rate. Running the workshop over the course of multiple school terms was problematic as other after-school activities required the workshop to change dates to accommodate, resulting in lack of predictability for scheduled session days. Irregular participation due to these factors diminished participants' ability to achieve the program's overall learning objectives, irregular program attendance, as well, placed obstacles in the path of participants' achievement of a rich learning experience, and fully engage the workshop structure, which required participants to build upon prior knowledge (gained through weekly activities) in order to successfully produce a final product, and receive the benefit of gaining self-efficacy with the programming environment introduced during the workshop. It is worthwhile to note; however, that even when participants missed significant blocks of workshop sessions for sports, they always checked in for 10 or 15 minutes at the end of practice to see what activity was delivered within the session. In addition, participants always returned to regular session attendance at the conclusion of their chosen sport "season," which ranged on the average, between 3 and 4 weeks.

Environmental and Resource Limitations

Throughout the duration of the program, struggles with limited and outdated resources impacted activity delivery and, at times, levels of participant engagement. The intervention took place after-school at the host school as parental concern with regard to the safety of the participants walking to the researcher's university for workshop sessions was a factor. Workshop sessions made use of the school's technology resources for activity delivery. The school had two school board selected laptop carts consisting of approximately 15 -20 Mac iBooks per cart running OS 10.3.9. The age of the laptops and operating system made it difficult to find a compatible tool to use for game design and development. In addition, approximately half of the computers on each cart had difficulty with start-up and shut-down processes due to wear and tear and improper maintenance. Approximately 10 minutes of each workshop session was taken up with participants attempting to find a working computer to begin the activity.

Selected software for the workshop was required to be approved by the school board and installed by the school board's district IT services. Scratch was selected as best fit for introducing digital media programming to the participants and was a pre-approved software for the school district, which expedited installation. Unfortunately, due to the age of the school's computers and operating systems the newest version of Scratch (1.4) could not be installed. Participants worked with an older Scratch version (1.2) during the workshop, which had limited functionality and several interface issues that the newest version of the program had resolved. Additionally, participants who had access to computers off-site installed Scratch 1.4 to work with to take advantage of the improvements, but, were unable to open their projects on the 1.2 version being used with the workshops due to lack of file compatibility.

Wireless access in the classrooms was poor, which affected participants' ability to do online research for their game projects, upload their project files to the Scratch community website for easy access, and make use of the workshop website's help resources. As the majority of participants had restricted or no at-home computer access, technical difficulties with the school's computers and network impacted the ability of participants to engage more deeply with the workshop content through exploring Scratch projects and additional tutorials online. Java plug-ins required to play online Scratch programs were not available on all school laptops, which was frustrating for the participants.

In the planning phase of the workshop, host school administration provided a list of resources that would be made available to assist in program production including, laptop computers, LCD projector, and classroom whiteboards. At workshop commencement; however, it was discovered that computer carts were kept in a locked storage closet, which required a master key to open. As the workshop was being run as an after-school program, it was necessary to be present at the school half an hour before the last bell to borrow the key from the school secretary to unlock the closet where the computers were stored. Often; however, the computers would be in classroom use and not returned at the end of the day, which resulted in many "scavenger hunts" for the carts with workshop participants before activities could begin. At the end of each workshop session, the computers were required to be re-locked in the closet. Normally, the only person still on school property who had key access was the janitor who was difficult to locate. The logistics of computer access during the workshop tenure was a complication that often resulted in delays to session commencement.

The school's LCD projector was kept locked in the vice principal's office, which prevented access and use for workshop content delivery. The vice principal was in sole possession of the key to this office, which prevented return of the equipment at the end of workshop sessions. An LCD projector was borrowed, when possible, from the researcher's university library to assist in workshop activities and demonstrations; however, consistent access was an ongoing obstacle.

For future work, it is suggested that program facilitators provide their own technology resources to ensure the best experience for participants. Ideally, computers should be PC running the most current Windows operating system as the range of inexpensive, free, or open-source game development tools for Windows is greater than that available for the Mac platform, currently. While participants enjoyed working with Scratch they would have appreciated the opportunity to explore other tools, particularly as competencies and interests grew. However, due to the limitations of the systems we had access to, we were unable to install and run many other current game development options, including Game Maker, which participants showed a keen interest in and which would have presented a natural knowledge step for their design and programming work.

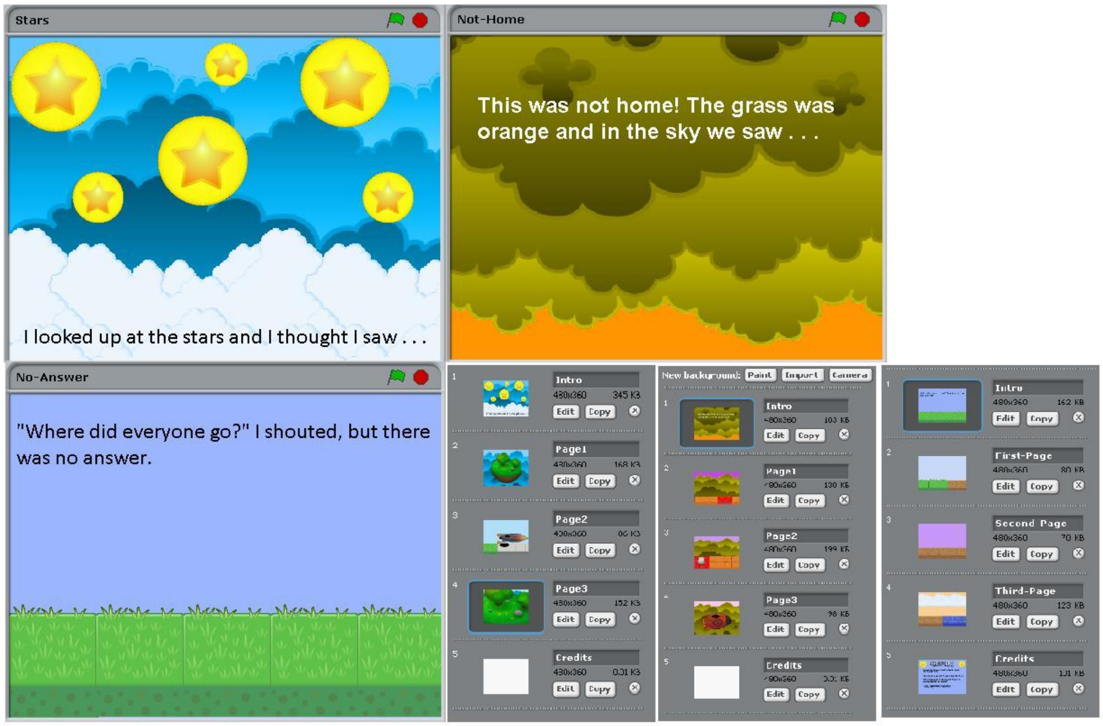
4.3 Festival Digital Storytelling Workshop

A condensed version of the primary intervention was offered over the course of a 3-day children's festival in seven 50 minute sessions. The Festival Digital Storytelling workshop was delivered to 108 pre-registered students (56 boys and 52 girls) from 3 participating local middle schools. An estimated 30 additional children participated in open drop-in sessions held on the final day of the Festival. Ages of pre-registered students ranged from 8 to 13 years, while drop-in participants tended to be younger, representing the Festival's conventional target demographic, and ranged from 6 years to 9 years old. Participants of the Festival workshop were invited to complete a short Creativity Support Index (CSI) survey at the conclusion of each session, which was used to evaluate the efficacy of the Scratch tool to support creative programming activities for novice users and media producers in non-formal learning environments. An overview of the CSI instrument, survey analysis, and discussion of survey results can be found in the appropriate sections.

Sessions were organized in 50 minute blocks with a maximum of 30 participants per session. Fifteen PCs with Windows 7 operating systems and Scratch 1.4 installations were provided for use in festival activities by the School of Interactive Arts and Technology at Simon Fraser University. Participants in the workshops were paired at a laptop computer for a collaborative story programming and design activity. Pair programming is the practice of two programmers working together at one computer to collaborate on the same design and coding processes. Pairs consist of a “driver” and a “navigator” working together to solve a programming problem (ACM K-12 Task Force Curriculum Committee 2003). Each festival session began with a projected demonstration of an example interactive digital story intended to provide participants with an idea of the kind of creative storytelling media that they would be working with and modifying in the workshop. Following the demonstration, participants were introduced to the Scratch application’s interface through a directed, facilitator-led tutorial, which showed children how to import a story-starter template and art assets including backgrounds, props, and characters into the Scratch environment for programming.

Participants were given access to a pre-compiled library of art assets to incorporate into their choice of one of three interactive story starter templates created in Scratch. Story starter templates and art assets were provided to accommodate the shortened duration of workshop time and facilitate the production of an artefact that participants could “play” with by the end of each session (see Figure 11). Once participants had composed their “scenes” they were guided through a basic programming exercise, which taught them how to initialize a story, show and hide objects on screen, position their characters and props on the screen using Scratch’s x and y coordinate system, create interactive dialogue and actions between characters on screen, and send event-triggers (broadcast messages in Scratch) to control and organize character actions and to move between story scenes. Following the tutorial, participants were given open-time to experiment with the concepts they had been shown to expand their stories. Three “just-in-time” facilitators were available on the workshop floor to provide programming assistance and design support to the participants as they were in engaged in self-directed work.

Figure 11. Story starter templates for Children's Festival Digital Storytelling workshop.



Participants’ projects were uploaded to a special website created for the festival at the conclusion of each workshop day (see Figure 12). Participants were provided with a unique bookmark, which they filled out with their project title, session number and day, and programming partner’s name. Session bookmarks functioned as an analog “key” to accessing individual projects (organized by session and day) on the festival workshop website, and included the festival workshop url link and participant specific project information as completed by the students (see Figure 14). Class teachers from the participating schools were provided separate information documents describing how students could access their projects, as well as resource links to the Scratch software and Scratch learning materials. For example screenshots of participants' interactive stories, see Figure 13.

Figure 12. Website home page for the Digital Storytelling Festival workshop.

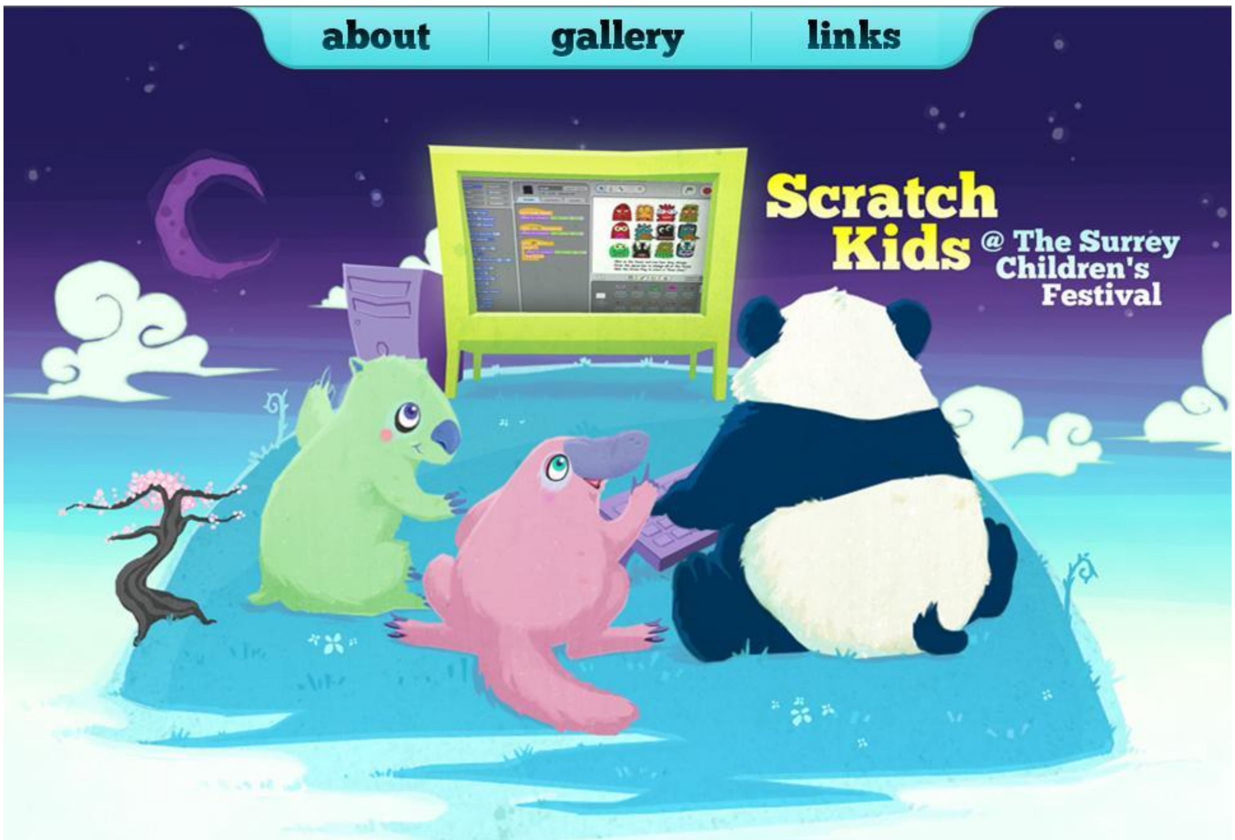


Figure 13. Festival projects made available for participant download on a special website.

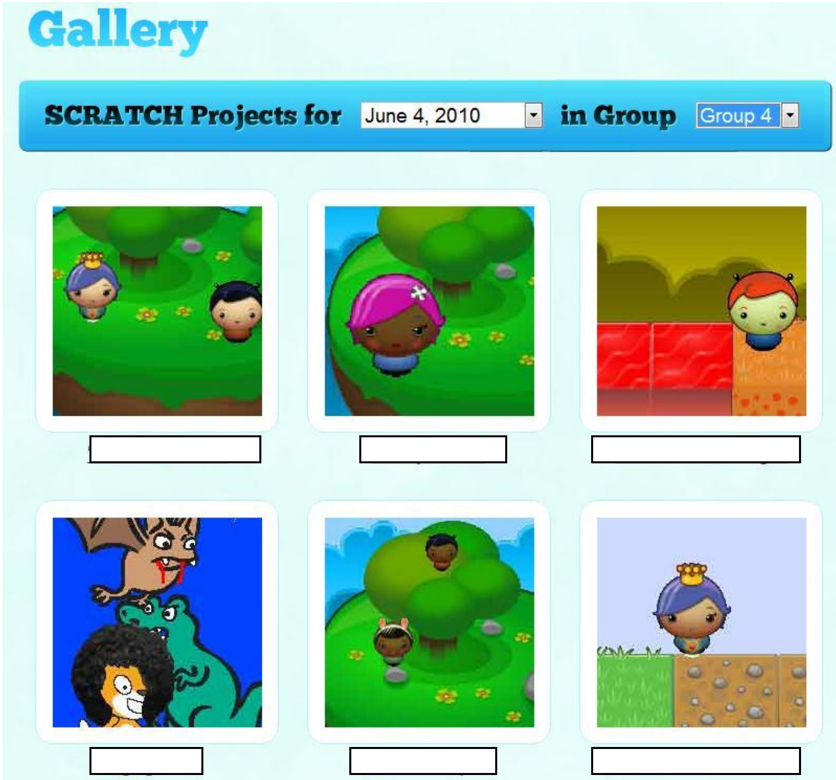


Figure 14. Front and back of the Festival workshop bookmarks provided to participants to facilitate project recovery and continued work on their digital stories.

The Digital Storytelling workshop constituted the first technology-mediated activity to be included in Festival programming and provided a compelling opportunity to introduce the Scratch tool and creative media production technologies to a large sample of novice users in a playful, participant-centered environment. Festival workshop objectives and participant demographics were linked to the primary intervention in design to support triangulation of CSI survey data captured from the Festival workshop with data generated from the Game Design and Interactive Storytelling after-school program.

5: DATA COLLECTION

5.1.1 Participants

The target demographic was middle-school children between the ages of 8 and 13. Thirty-three children participated in the Interactive Storytelling and Game Design Workshop, 30 children took part in the activity study, and 138 children participated in the Children's Festival Digital Storytelling Workshop. All the participants were recruited without discrimination other than satisfying the age constraint (8-13). Age was constrained to ensure relative group homogeneity and understanding of the conceptual content of the workshop learning material and activity study questions.

In the Interactive Storytelling and Game Design Workshop and activity study, all participants were recruited from the research partner host school. Participants in the Children's Festival Digital Storytelling Workshop were recruited from local middle schools and the community at-large.

5.1.1.1 Purposive Homogenous Sampling

This research study employs purposive sampling, as the research's primary concern is the exploration of activity patterns in the context under study as opposed to generalizing findings to a broader population (Erlandson et al. 1993). Purposive sampling selects subjects based on a target characteristic. Purposive, homogenous sampling strategies are relevant for exploration of a particular universe and for audience understanding. Homogenous sampling allows for the selection of a small sample with similar characteristics to describe a particular sub-group in depth. Purposive sampling is acceptable for both quantitative and qualitative research studies, is useful for qualitative components of audience research, and is, as well, sufficient for generating understandings of human perceptions, problems, needs, behaviours, and contexts. Purposive, homogenous sampling is fit for the purposes of this study, while acknowledging selection bias and inability to generalize to the wider population (Cohen et al. 2007). Findings from the proposed research study are generalized to a theory as opposed to a population. Small sample research, additionally, is shown to have smaller or less bias using purposive sampling than using probability-based sampling (Royeen & Fortune 1987).

5.1.1.2 Recruitment Strategies

Interactive Storytelling and Game Design Workshop and Activity Study

Workshop and activity study participants were recruited from an inner-city host middle-school in a growing urban center (population 466, 195) that is in close commuter proximity to a large metropolitan area (population approximately 2 million). The city center area from which participants were drawn is ethnically diverse, with strong Aboriginal and South-East Asian (primarily Sikh) immigrant populations. The area is historically low-income and working-class although city growth and inner-city gentrification initiatives have contributed to the economic diversity of the area. Two grades 6 and 7 classes from the host school were invited to a tour and interactive demonstration of new media technologies at the researcher's academic institution, which is located in walking distance from the host school. Workshop and study information were distributed to the participating students at this event. Recruitment follow up was held subsequent to the university tour with a visit by the researcher to the host school to informally describe the workshop and study to interested students. Flyers for the workshops with participant and parent informed consent forms for combined study and workshop components were distributed to all grades 6 and 7 students in the host school through their homeroom teachers.

Initial recruitment elicited 22 boys and 11 girls (*mean* age 12.06, *range*=8-13, *mode*=12). Thirty-nine percent of participants were in grade 7 (*n*=13), and 55% in grade 6 (*n*=18). One boy (grade 3), and one girl (grade 4) registered in the workshop after showing interest and aptitude in the activity content. Ethnic backgrounds of the workshop participants were diverse with Caucasian (*n*=8), Southeast Asian (*n*=8), Filipino (*n*=6), and Aboriginal (*n*=5) representing the largest proportions. See Figures 15 and 16 for details.

Figure 15. Age Ranges of Registered Workshop Participants

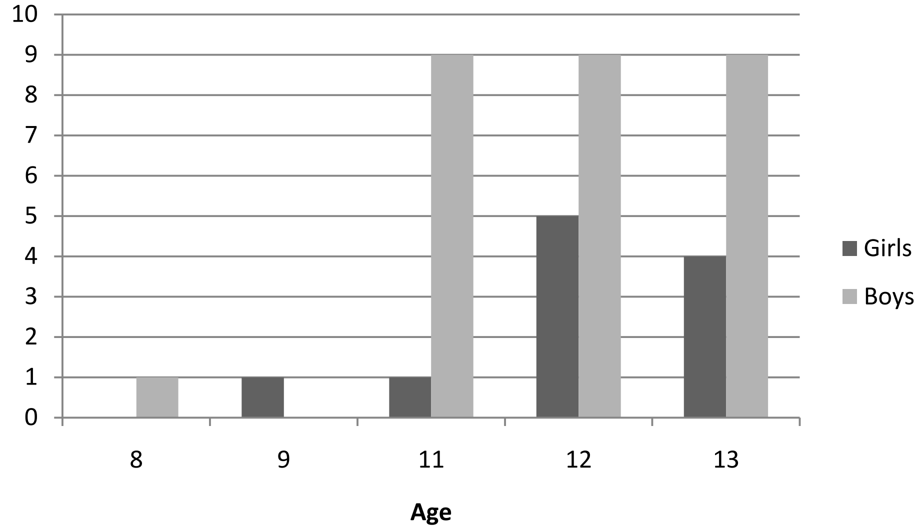
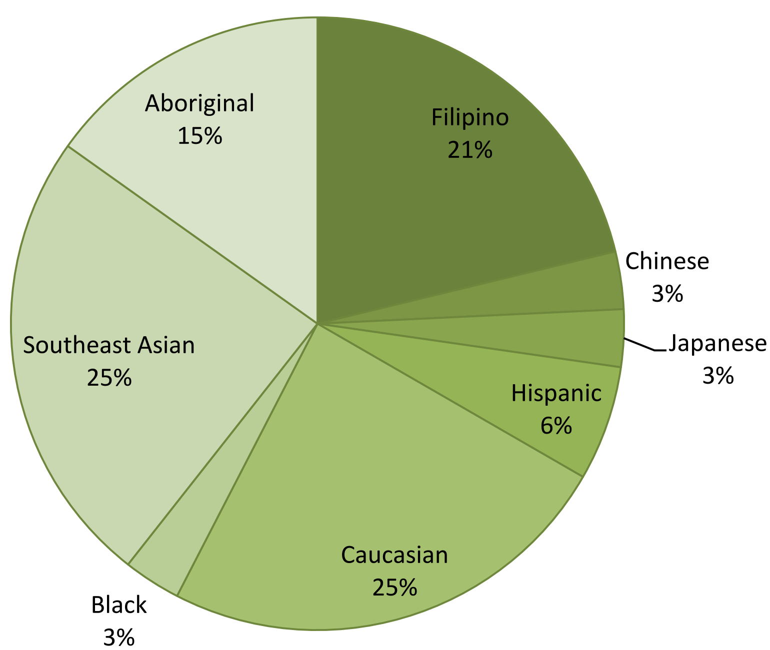


Figure 16. Ethnic Characteristics of Registered Workshop Participants



The program began with 33 student participants. Of the 33 starting participants, 23 core registrants regularly attended sessions and engaged the workshop activities and challenges, which ran from December 15, 2009 – April

30, 2010. Attendance was considered “regular” if participants attended at least 2 out of every 4 workshop sessions. Individual game projects were designed and developed from April 15, 2010 – June 30, 2010 with 23 students participating in the individual game design phase and 9 students (39% of core participants), at workshop closure, having completed substantial programming work on their game or story projects, resulting in playable demos.

Twenty students registered in the Interactive Storytelling and Game Design Workshop participated in the activity study (9 girls and 11 boys). An additional 10 study participants (6 girls and 4 boys) were recruited from the general student population at the host school to make the activity survey more robust. The 10 non-workshop participants who completed the activity survey were students who had attended one or more workshop sessions on a drop-in basis for open time game play held at the end of each workshop meeting. Participation in the after school workshops and activity study was voluntary and free.

Children’s Festival Digital Storytelling Workshop

Participants for the Children’s Festival Digital Storytelling workshop were purposively recruited with the assistance of Festival coordinators from local, partner middle schools. Targeted outreach to the principals of Festival partner schools elicited connections with interested teachers of the target demographic (grades 5-7). Participating teachers pre-registered their classes for workshop time slots, and distributed informed consent forms for the research component of the workshop to their students. Signed informed consent forms were collected from supervising teachers at the beginning of each workshop session. Five classes in total (108 students) registered for Festival workshop sessions. Approximately 30 additional children participated in drop-in workshop sessions held the final day of the Festival. Drop-in participants were recruited by Festival volunteers providing “walk-by” information on the digital storytelling activities to children and their parents throughout the Festival grounds. Workshop participation and Creativity Support (CSI) survey completion were voluntary and independent, with survey completion not a mandatory condition for workshop participation.

5.1.2 Types of Data

Study data collected included contextualized activity self-reports; demographic data; structured and unstructured observational data; programming code; textual data; and survey data (open- and close-ended data). Activity data, including event, context, and affect dimensions were collected using the Day Reconstruction Method (DRM) instrument detailed in section 5.2.1.1. Both structured and unstructured observational data were captured in-situ, during the course of the intervention. Structured observational data were organized according to the Engagement and Disaffection with Learning checklist (Skinner et al. 2009), described in section 5.2.2.1. Quantitative and qualitative content analysis was conducted on participants’ programming code and game design documents collected during the intervention. The Creativity Support Index (Carroll et al. 2009) collected Scratch tool evaluation data from Children’s Festival participants, and is documented in section 5.2.4.1.

Because of the types of data produced, both descriptive statistics and inferential tests (parametric and non-parametric) were performed. Means tests, frequency counts, Wilcoxon Signed Rank, Spearman ρ, Cohen's *d*', and *t* tests were conducted. Data from this research were analyzed and results were obtained using SPSS 18 and JMP 7. Inferential tests were based on matched pairs of sample data described in Chapter 6.

Table 6. Uses of Data Types for Analysis

Data Type and Instrument	Use of Data
Activity Report data (self-report DRM)	Activity Model, Design Heuristic
Activity Context data (self-report DRM)	Activity Model, Design Heuristic
Subjective Report of Experience (self-report DRM)	Activity Model, Program Evaluation, Design Heuristic
Observations of Engagement and Disaffection with Learning (structured observational checklist)	Activity Model, Technology Fluency, Engagement and Disaffection with Learning, Program Evaluation, Design Heuristic
Unstructured Observations and Informal Information Gathering (field notes)	Activity Model, Technology Fluency, Program Evaluation, Design Heuristic
Programming Code (content analysis)	Technology Fluency, Program Evaluation, Design Heuristic
Design Document (content analysis)	Activity Model, Preferences, Design Heuristic
Creativity Support Index (self-report survey)	Program Evaluation, Design Heuristic
Participant Feedback Survey (self-report)	Program Evaluation, Design Heuristic

5.2 Methods and Instruments

5.2.1 Capturing Activity

Activity modelling has a long history, wide field of application, and a range of associated methods and methodologies. While the Experience Sampling

Method (Csikszentmihalyi et al. 1977), Ecological Momentary Assessment (Stone et al. 2003), and the Day Reconstruction Method (Kahneman et al. 2004a) stand as example exceptions, conventional techniques for measuring activity, such as time-budget studies (Bureau of Labor Statistics 2009, Ver Ploeg 2000), often exclude consideration of the subjective experience of particular activities and contexts. When affect measures have been included in time-budget methods they are often global, as opposed to event-specific, reports measuring domain satisfaction or happiness (Harvey 1990).

In design domains, cultural probes (Gaver et al. 1999) and probe variants (Hulkko et al. 2004, Iversen & Nielson 2003, Riddle & Arnold 2007) based on emerging ethno- and techno-methods have been employed to capture empirical and phenomenological activity and activity context data for design inspiration and more structured user studies depending on variant and study objectives. As an experimental design strategy, probes are an uncontrolled, purposefully imprecise methodology for provoking *designerly* reflection on users (Gaver et al. 2004, Gaver et al. 1999). Formulated as packages of “evocative tasks,” probes catalyze playful contexts for capturing “fragments” of user’s lives and experiences toward an understanding of users’ dynamic contexts. Typically, probe packages consist of engagement items such as disposable cameras, journals, postcards and maps; and are accompanied by open-ended requests such as “take a picture of something you’d like to get rid of” (Gaver et al. 2004). Cultural probes constitute an exploratory design tool, which can be useful in gaining rich, qualitative understandings of unfamiliar populations (Benford &

Capra 2005). Probes are not considered comprehensive strategies for eliciting activity models (Gaver et al. 2004), although several researchers have "methodized" probe techniques for user preference research (Jung & Anttila 2007) and perspective-based audience modelling (Berkovich 2009).

Other activity capture methods considered for use in this study included: Direct Observation (Hutt & Hutt 1970), Experience Sampling Method (Csikszentmihalyi et al. 1977), and Time-Diary Method (Robinson 1999, Szalai 1965). The gold standard with respect to accuracy for activity capture is Direct Observation. However, labour and time intensity associated with the method (including videotaping variants of the method), along with cost, data coding burdens, and concerns with how surveillance (either direct or videotaped) can influence participant behaviour render this method incompatible for the purposes and resource constraints of this study.

Experience Sampling methods (ESM) randomly sample activities and the experience of activities throughout the day, and are commonly referred to as "beeper studies." ESM requires respondents to record their activities and experience electronically or by pen-and-paper when paged. ESM is capable of assessing both internal (experience) and external (location, social context) dimensions of activities. The benefits of ESM include the collection of activity and activity experience data in real-time, but, requires respondents to both maintain the beeper and respond in the moment when paged (participant burden), is costly, and is unable to assess total duration of the activity, and issues of time-tradeoffs.

Time Diary methods are excellent techniques for capturing everyday activities, asking respondents to record the day as it unfolds, closely approximating the chronology of their day and allowing for full-day accounting useful for examinations of time trade-offs. The use of time-diaries to measure activity and collect both objective and subjective activity dimensions are favoured by researchers in leisure studies, and are considered to capture the full and differential character of “leisure reality” (Harvey 1990). Multidimensional time-use diaries are included in large-scale national activity surveys such as the 1981 Canadian Time Use Pilot Study (Kinsley & O’Donnell 1983), which collected primary, secondary, and tertiary activity data, and the 2004 American Time Use Survey (Bureau of Labor Statistics 2009), which collected data on primary activities. Analyses of Time Diary methods have shown close correspondences with Direct Observation measures. Time Diary methods, additionally, are extensible to studies of large populations; however, this method is costly, produces large sets of data for coding, and is not traditionally effective for capturing multi-tasking.

Ideal methods for activity modelling typically require the capture of time-use data approximating the flow or chronology of a real day, as well as activity context and subjective experience data for the fullest snapshot of everyday life. Based on fit with the research questions, method criteria for activity measurement as defined in the literature, and project resources, the Day Reconstruction Method (Kahneman et al. 2004a) was selected for this study. The Day Reconstruction Method (DRM) assesses “how people spend their time and how they experience the various activities and settings of their lives, combining features of time-budget measurement and experience sampling" (Kahneman et al. 2004a).

Limitations of the DRM

Limitations of the DRM include potential retrospection biases; however instrument design (Kahneman et al. 2004a) and preliminary evidence (Kahneman et al. 2004a, Schwarz et al. 2009, Srivastava et al. 2008) suggests that the DRM is successful in minimizing such biases. Additionally, single day assessment per participant contains significant within-subject variability in social participation and positive affect (Srivastava et al. 2008), which diminishes generalizability of results. While traditional experience sampling designs can collect more events per person and cover multiple days to enhance generalizability, the lack of facilitation for time-tradeoffs analysis, and activity contexting within the frame of a complete day recommends the DRM over ESM despite outstanding issues with obtaining generalizable results. The use of multilevel modelling for analysis of data derived from DRM administrations may minimize the problem of generalizability; however, simple descriptive statistics are often the best fit for exploring DRM data despite the complexity that nested observations suggest. Power limitations due to the small sample size of this research will be overcome in future work by utilising larger samples to construct a more dynamic model of activity, and expanding the current scope of variables assessed for model formation to allow for more complex inferences to be made regarding the role of measured variables in determining activity preferences.

In summary, the DRM was selected as best fit for the study based on its capability to provide "a joint assessment of activities and subjective experiences, including information about the duration of each experience that can be used for duration-weighted analyses" (Schwarz et al. 2009), mitigation of retrospective reporting biases, full-day activity coverage, ecological validity, and low respondent burden. While this study is exploratory, one of the research aims is future extension of the activity modelling objective to a wider population (such as a school district). The DRM is an effective tool for activity capture and well-being measures for large populations, and it is hoped that the methods and results from this project may be used to inform further work with larger and more heterogeneous participant samples.

5.2.1.1 Day Reconstruction Method

A modified version of the Day Reconstruction Method (Kahneman et al. 2004b) instrument captured day-to-day activities, activity context, and activity affect dimensions for modelling. I modified language in the DRM to increase comprehension for the target study population; additionally, instrument questions focused on "work" contexts were modified to investigate "school" realities better suited to an investigation of youth daily experience. To answer a wide range of research questions, the DRM supports adaptation of the content of the instrument to the needs of the specific study (Kahneman et al. 2004b).

According to the DRM protocol, an activity is composed of the event episode, its context, and the affective experience of the respondent in relation to the event episode. Sequentially diarized episodes, with respondents noting the beginning and end of each episode, and named by respondents in general terms such as “walked to school,” “ate lunch with friends,” etc., assist in activity recall for the structured questioning component of the protocol. The end of an episode is defined as “going to a different location, ending one activity and starting another, or a change in the people you are interacting with” (Kahneman et al. 2004b). Structured episode questions include: when the activity occurred (start and end times); what they were doing (by checking one or more of listed activities); where they were; with whom they were interacting; and how they felt, using 12 affect descriptors. Affect scales range from 0 (not at all) to 6 (very much) (Kahneman et al. 2004a, Kahneman et al. 2004b).

Features of the DRM

The DRM Instrument consists of 4 packets to be completed by the respondent: Packets 1 and 4 document the variables to be assessed in the study (and include demographic and personality measures). Packet 2 contains a short diary instrument, which facilitates the reinstantiation of the previous day into working memory by asking respondents to diarize their prior day as a sequence of episodes (Packet 2 is confidential and is not returned to the researcher). Packet 3 asks questions descriptive of key features of recorded episodes including 1) when the episode began and ended, 2) what they were doing, 3) where they were, 4) whom they were interacting with, and 5) how they felt on multiple affect dimensions (this response form is returned to the researcher for analysis). Participants responded to global episode satisfaction questions, in addition to the general protocol described by the DRM (Kahneman et al. 2004b).

The Day Reconstruction Method (DRM) (Kahneman et al. 2004a), uses imaginative reconstruction and quantitative evaluation to provision a summary of daily activities and their subjective valences. The DRM combines time-use study methods with the measurement of affective experiences. DRM respondents produce a diary of all activities engaged in for the preceding day, commencing with the first activity after waking and concluding with the last activity before sleeping. Based on the structuration of the preceding day in the diary, respondents describe each activity by answering questions with regard to what occurred during the episode, and with whom they interacted. As found in experience sampling methods, respondents are provided a list of positive and negative feelings and are requested to evaluate how strongly they felt each of these emotions during the particular activity (Kahneman et al. 2004a, Kahneman et al. 2004b, Kahneman et al. 2006, Schwarz et al. 2009).

Grounded in cognitive science, the Day Reconstruction Method (Kahneman et al. 2004a) reinstates the previous day into working memory "by producing a short diary consisting of a sequence of episodes" (Schwarz et al. 2009) covering the waking day. The DRM diary format is based on cognitive research conducted with Event History Calendars (Belli 1998) and "facilitates retrieval from autobiographical memory through multiple pathways" (Schwarz et al. 2009). The episodic reinstantiation format of the respondents' diaries attenuates biases in retrospective reporting methods previously observed (Robinson & Clore 2002, Schwarz 1999). Respondents' diaries are private and not shared with the researcher, allowing respondents the opportunity to include notes and details that they may not wish to share.

Participants use diary notes to respond to a series of questions requiring descriptions of the central features of each activity episode, including:

1. when the episode began and ended (providing time use data);
2. what they were doing;
3. where they were;
4. whom they were interacting with; and
5. how they felt during the activity (according to multiple affect dimensions) (Schwarz et al. 2009).

Response forms can be easily customized to specific research questions, administered to either individuals or groups, and can be completed in 45 to 75 minutes (Kahneman et al. 2004b, Schwarz et al. 2009). The DRM is not recommended for use with individuals under the age of 10 years, as responses require a level of introspection and ability to verbalize introspections. The DRM has been successfully used in diverse contexts such as personality and affect relations (Srivastava et al. 2008), pain research (Krueger & Stone 2008), user experience modelling (Kray et al. 2008, van Schaik & Ling 2008), and public policy (Mentzakis & Moro 2009, Stone et al. 2006).

The DRM's combination of ESM and Time Diary techniques allows for a systematic analysis of girls' everyday activities, and facilitates the estimation of how much of girls' time is spent on the complete range of human behaviour, in addition to the affective dimensions associated with individual activities and thematic behaviour clusters. As with the Time Diary Method, the DRM captures total time spent on, for example, leisure or work, as well as the granular components of those categories, which is not available to ESM without dense sampling and resultant over-burden of respondents. The DRM, moreover, provides insight into how activities are situated within the overall lifestyle of the respondent, which cannot be provided by ESM.

Validation of the DRM

The DRM has been validated against Experience Sampling (ESM) data (Kahneman et al. 2004a, Stone et al. 2006). Analysis of DRM reports against ESM data from other samples shows that the DRM closely corresponds to ESM captured changes in affect over the course of the reported day, providing concurrent validity for the DRM. Additionally, the analyzed diurnal patterns "are not obvious to respondents and often contradict respondents' own beliefs, indicating that these episodic reports of affect are not derived from general semantic knowledge" (Schwarz et al. 2009). Graphed comparisons of diurnal patterns of tiredness and negative affect for DRM and Experience Sampling studies can be reviewed in the article "A survey method for characterizing daily life experience: The Day Reconstruction Method (DRM)" (Kahneman et al. 2004a). As previously described, the DRM possesses high ecological validity, as its measures are made in the real-world. The test-retest reliability of the DRM, as a measure of subjective well-being, was analyzed (Krueger & Schkade 2007) to assess the reliability of the measurements for the same set of individuals over time. Krueger and Schkade (2007) found that "overall life satisfaction measures and affective experience measures derived from the DRM exhibited test-retest correlations in the range of .50-.70." The test-retest correlations were determined by Krueger and Schkade (2007) to be "sufficiently high to support much of the research that is currently being undertaken on subjective well-being."

The DRM is more effective at capturing infrequent activities than ESM given the full-day coverage provided by the DRM; however, Schwarz (2009) cautions that "the usefulness of the DRM is limited when only a few respondents engage in an activity on a given day." As a holistic method, the implications of the DRM for activity modelling are promising given the DRM's combination of time use data and hedonic experience indicators. The DRM's facilitation of data capturing for activity time-allocation and the affective experience associated with a given activity make the method particularly suited to the research questions grounding this study.

For the specific purposes of this study, the DRM was administered to a purposive sample of middle-school girls and boys (n = 30) to elicit contextualized activity data and affect dimension for the formulation of a contextual model of children's day-to-day activities disaggregated by gender. The activity models inform design heuristics for the development of non-formal and extra-curricular programming specifically targeted towards increasing technological fluency for middle-school girls. The activity model generated from the DRM results may have additional utility for educational policy and curriculum evaluation outside of the case specific context of this study.

Activity data captured by the DRM is combined in analysis with observational and content evaluation data derived from the implementation of the workshop for activity model construction and design recommendations in the form of 15 heuristics for workshop iteration and related non-formal learning program interventions. Additional data captured from creativity support self-reports, and participant program evaluations have been used to inform and validate suggested design heuristics. While the construction of an activity model alone is sufficient for producing interest-based design guidance, the addition of information gathered during an actual program implementation is held to enrich the research's discussion and provide enhanced validity for the conceptual approach underlying the study.

5.2.2 Participant Observation

Participant observation has been generally defined as observation that is performed when the researcher is also a participant in the scene or context that is being studied (Atkinson & Hammersley 1994). Direct, observation-based research is an important component of ethnographic fieldwork and qualitative evaluation of phenomena and is most commonly captured by the recording of detailed field notes (Patton 1987), which may be organized according to pre-determined structural categories or allow for open, unstructured observational recordings. Structured observations are systematic and facilitate the collection of quantitative data for contextual comparison, frequency counts, and pattern elicitation (Cohen et al. 2000).

Participant observation is best suited for exploratory and descriptive research focused on generating interpretive theory (Jorgensen 1989). In direct observation methods for behaviour assessment, more generally, there are no to low levels of inference in interpreting assessment data (frequency counts, durations, and interresponse times of behaviours, for example, are used to interpret data) (Bernard 2000, Gresham et al. 2007). Clear operational definitions and specificity of behaviour class of interest are crucial for direct observation methods (Skinner et al. 2000). Validity is not seen as a critical aspect for determining the quality of direct observational data, as the method "does not involve the measurement and interpretation of hypothetical constructs (Gresham et al. 2007). With direct observation methods, the data captured is assumed to be axiomatically valid, and researchers prefer emphasizing "accuracy" (the degree to which a measure represents the objective, topographic features of behaviour) over validity for observational methods (Gresham et al. 2007). Validity; however, can be determined for direct observation procedures by triangulating methods. Observational data may be correlated with self-report data, for example, to provide evidence of convergent validity (Furr & Funder 2007).

Interobserver agreement assesses the reliability of direct observation methods, reflecting the degree to which at least two independent observers behave as "equivalent measuring instruments" (Gresham et al. 2007). Observers, viewing the same behaviour are reliable if agreement is met on a behaviour's occurrence and non-occurrence (Furr & Funder 2007, Gresham et al. 2007, Skinner et al. 2000).

While structured observations afford quantitative analysis of captured behaviors and situations, it has been noted that the method is "behaviorist" in that it excludes consideration of the subjects' intentions and motivations, risks the loss of individual subjectivity in aggregated scoring procedures, and assumes that observed behavior is evidentiary of underlying feelings, which may undermine the validity of the findings (Cohen et al. 2000). The event sampling approach to the collection of structured observations is limited by the absence of a chronological order to captured behaviors, which may compromise the reliability of the "story" that the data can tell (Cohen et al. 2000). The absence of event sequencing in behavior frequency recording constrains interpretation to incidence reporting without the benefit of contextualizing factors and increases the probability that significant unintended outcomes will be overlooked (Cohen et al. 2000).

The limitations of structured observations and event sampling approaches to structured observation can be mitigated by the triangulation of data derived from alternative sources and contexts, which would allow for a fuller accounting of factors of interest, contributing to a "thick description" (Geertz 1973) of the social process and interactions underlying observed behaviors. For the purposes of this thesis, both structured and unstructured observations were collected for analysis. Structured observations of engagement and disaffected behaviors and emotions were captured using the Engagement and Disaffection with Learning checklist (Skinner et al. 2008) and are supplemented in discussion with field notes generated from unstructured observations and informal information gathering that took place during the course of the workshop. Observational data is used to provide insight into the challenges and motivations girls experienced with technology creation activities throughout the tenure of the primary intervention.

5.2.2.1 Engagement and Disaffection with Learning

Engagement as a measure for participant learning has been found to be a valid assessment indicator of learning and pedagogical efficacy (Hunley & Schaller 2006, National Survey of Student Engagement 2007). Using both direct and indirect methods, such as observation in conjunction with interviews and surveys, changes in engagement over time can be captured for impact on learning evaluations and contribute to the participant dimension in overall program assessment. Engagement, as captured through participant observation during workshop sessions, is defined according to cognitive, behavioural, and affective indicators associated with specific story and game programming tasks. Engaged children show sustained behavioural involvement in learning activities accompanied by a positive emotional tone. They select tasks at the border of their competencies, initiate action when given the opportunity, and exert intense effort and concentration in the implementation of learning tasks; they show generally positive emotions during ongoing action, including enthusiasm, optimism, curiosity, and interest (Skinner & Belmont 1993).

Workshop participant engagement and motivation was drawn from observations collected during the course of the workshop. Initial observations were organized according to a modified version of the “Engagement Versus Disaffection with Learning: Teacher Report” instrument (Skinner et al. 2009), which collects behavioural engagement, emotional engagement, behavioural disaffection, and emotional disaffection factors for individual participant learners. Minor modifications were made to observation checklist wording, only, to account for learning re-contextualization from the formalized spaces of the “classroom” and “lessons” to the more non-formal “workshop” and “activity” paradigm of the intervention.

The “Engagement Versus Disaffection with Learning: Teacher Report” is an adaptation of evaluative scales and subscales documented in *Engaged and disaffected action: The conceptualization and measurement of motivation in the academic domain* (Wellborn 1991). The adapted checklist (Skinner et al. 2009), captures individual levels of behavioural and emotional engagement versus disaffection with the learning context and activities. Markers of engagement include behaviours such as effort, persistence, attention and concentration. Engaged emotions add to conceptualizations of engagement and include enthusiasm, interest, and enjoyment (Skinner et al. 2009, Skinner et al. 2008). Disaffection is operationalized in behaviours such as passivity, lack of initiation, lack of effort, and giving up; and in emotions such as tired, sad, boredom, frustration, anger, and anxiety (Skinner et al. 2009, Skinner et al. 2008). Table 7 outlines the motivational matrix of engagement and disaffection conceptualized by Skinner et al (2008, 2009) and as described above.

Table 7. Motivational conceptualization of engagement and disaffection in structured learning environments (Skinner et al. 2008).

	ENGAGEMENT	DISAFFECTION
BEHAVIOR	**Behavioral Engagement**	**Behavioral Disaffection**
	Action initiation	Passivity
	Effort, Exertion	Giving Up
	Attempts, Persistence	Withdrawal
	Intensity	Inattentive
	Attention, Concentration	Distracted
	Absorption	Mentally disengaged
	Involvement	Unprepared
EMOTION	**Emotional Engagement**	**Emotional Disaffection**
	Enthusiasm	Boredom
	Interest	Disinterest
	Enjoyment	Frustration/anger
	Satisfaction	Sadness
	Pride	Worry/anxiety
	Vitality	Shame
	Zest	Self-blame

Using data from 1,018 third through sixth graders, psychometric properties of scores captured from teacher reports of behavioural engagement, emotional engagement, behavioural disaffection, and emotional disaffection were examined (Skinner et al. 2009). Findings that teacher reports correlate with student reports support score validity, with *in vivo* observations in the classroom, and with markers of self-system and social contextual processes (Skinner et al. 2009).

Psychometrics may be supplemented with coded observation scoring for on-task behaviour (on-task active initiative, on-task working, and on-task passive) and off-task behaviour (off-task initiative, off-task working, and off-task passive behaviour). On- and off-task observational coding procedures are sequential, and consist of registering the respective behaviour code as well as time (or running time if video captured) when a specific event occurs. Reliability checks display an average kappa of .71, with the lowest agreement of 57% (for off-task initiative) and the highest agreement of 87% (for on-task working), with a range of agreement between 69% and 91% for the remainder of the coded categories (Skinner et al. 2009).

The primary instrument makes use of event sampling or sign system procedures to capture observations of behaviors of interest. In event sampling, “tally marks” are entered for each observed statement, yielding data pertinent to the research questions. Event sampling approaches to observational data collection facilitates frequency measures of observed behaviors for comparative analysis (Cohen et al. 2000); but obscure the chronology of behavior occurrences.

5.2.3 Content Analysis

Content analysis, as it is contemporarily understood within the social sciences, is an empirically based, exploratory method prioritizing context of use, and can be employed for either predictive or inferential inquiry into texts, images, or other symbolic material to form a systematic reading, which is fundamentally distinct from that of an author or user (Krippendorff 2004). Qualitative or interpretive approaches to content analysis are grounded in literary theory, ethno-methods, and critical theory and are more popularly engaged as “close readings” or hermeneutic encounters (Krippendorff 2004, Mayring 2000). Qualitative data derived from content analyses may be triangulated with quantitative approaches to strengthen conclusion validity (Altheide 1987, Neuendorf 2002).

Empirically-driven content analysis often makes use of structured coding or categorization procedures to assist in organizing complex or “unwieldy” data or text (Krippendorff 2004, Neuendorf 2002). Coding processes transform text into analyzable forms, reducing large volumes of data into types or tokens for frequency analysis (Krippendorff 2004). Both qualitative and quantitative approaches to content analysis make determinations of relevance (select the unit of analysis), unitize text, contextualize the analysis, and engage the analysis with specific research questions that shape the approach and selection of units (Krippendorff 2004).

The reduction of text to tokens can lead to the loss of information when statistical techniques for aggregating units of analysis are performed, such as calculating correlation coefficients, parameters of distributions, and indices (Krippendorff 2004). Additionally, the imposition of structure on a text to be analyzed may be inappropriate and can lead to conceptual weaknesses in the analysis, undermining the validity of findings. The transformation of text into analyzable units of analysis through the coding process abstracts the variable of interest from its original form producing nonlinear relationships with other measures, which impact analysis (Neuendorf 2002).

The validity of coding schemes must be established through reliability checks with a second coder (inter-rater reliability). When only one coder is used it is not possible to demonstrate that the obtained ratings and resulting analysis are not derived idiosyncratically from one rater's subjective judgment (Neuendorf 2002). As a result of resource limitations, only one coder, the primary investigator, conducted analysis for "gameness", which methodologically resituates the derived findings from a "true content analysis" to that of an "expert analysis" (Krippendorff 2004, Neuendorf 2002) and, hence, the reliability of the content analysis cannot be assessed.

Participant game design documents and digital artefacts produced during the intervention are analysed, using content analysis methods, to elicit technology fluency indicators as well as revealed preferences and motivations for technology-creation activities. Content analysis of participant work is connected in discussion to engagement and disaffection factors emerging from structured and unstructured observations captured over the course of the intervention and activity data derived from the DRM to inform environment design heuristics.

5.2.3.1 Technology Fluency

Technology fluency indicators, consisting of the triad of intellectual capabilities, conceptual knowledge, and an appropriate skill set (National Research Council 1999a), were evaluated based on content analysis of participants' digital media projects developed over the course of the intervention.

Analysis of participants' game design documents and use of programming constructs comprise the raw core materials for content-based evaluation of technology fluency objectives. Participant feedback surveys provide additional resources for determining intervention impact and for eliciting data on participants' self-reported perceptions of technology competencies gained during the workshop.

Design documents were evaluated for "gameness" (Juul 2003) to determine participant understanding and transfer of game design theory advanced throughout the workshop to participants' own personal projects. Documents were also analysed for their utility in revealing preferences for game play informative of the interest-based design framework underlying the intervention's research program, more generally. Digital media creations for two significant project challenges – the Maze Game project and final individual projects – were analyzed for take-up of foundation programming knowledge, with particular attention paid in analysis to the implementation and extension of taught programming examples to novel conditions. Attention to such conditions for technology fluency, or FITness, facilitates assessment of participant understanding of essential concepts through demonstrated application of theory and practical programming knowledge, as well as affording learner-centered focus on the achievement of a level of FITness that is "personal, graduated, and dynamic" (National Research Council 1999a).

5.2.4 Survey Methods

Social surveys are generally used to produce statistics with regard to aspects of interest of the study population. Information is collected by asking questions of a sample of the population of interest whose answers form the data to be analyzed (Fowler 2009), and are generally interested in exploring the attributes, attitudes or actions of a population (Buckingham & Saunders 2004). Survey methods were employed to measure the level of creativity support (Carroll et al. 2009) afforded by the media creation tool used in the primary and festival workshops as well as to collect participant feedback on the quality of their experiences during the workshop.

Self-administered questionnaires and interviews are the dominant modes of survey data collection. Self-administered procedures are effective for capturing sensitive data, while interviews are useful for probing more deeply into participant responses or for querying complicated research questions (Babbie 2008, Fowler 2009). Question forms may be either structured (close-ended) or unstructured (open-ended). Close-ended questions provide greater uniformity in responses, while open-ended questions require coding, which can introduce mis-interpretation and researcher bias into analysis. Survey methods are considered “weak on validity and strong on reliability” (Babbie 2008) due to the artificiality of the format.

5.2.4.1 Creativity Support

To assess how well the Scratch tool used in the workshops supports user creativity, a modified version of the Creativity Support Index (CSI) (Carroll et al.

2009) survey metric was deployed in a separate tool evaluation study (Festival context). The CSI assists in the quantitative evaluation of tools in supporting creative tasks. Grounded in general theories and concepts of creativity as expressed in flow, play, and creativity support research, the CSI measures six orthogonal factors including: 1) Results Worth Effort; 2) Expressiveness; 3) Exploration; 4) Immersion; 5) Enjoyment; and 6) Collaboration (Carroll et al. 2009). Creativity support factors are rated on a sliding scale from 0 (Highly Disagree) to 10 (Highly Agree). The CSI allows for a tool support rating out of 100 to be derived by summing values from the scale and dividing by 1.5: CSI = (Exploration*ExplorationCount + Expressiveness*ExpressivenessCount + Immersion*ImmersionCount + EffortResults*EffortResultsCount + Enjoyment*EnjoymentCount + Collaboration*CollaborationCount)/1.5.

The Creativity Support Index (Carroll et al. 2009) was refined through three user studies to gain increased construct validity for the final factor ratings. A 300-participant word rating study and principal components analysis, which extracted six components of correlated factors from 19 creativity words, accounting for 58.20% of the data's variance (Carroll et al. 2009) validated CSI factors. Reliability testing through test-retest studies remains to be completed.

5.2.4.2 Participant Program Evaluations

To elicit participant feedback on the quality of their experience in the Interactive Story and Game Design workshop, a short assessment survey was developed to query and gain insight into learners' individual gains and challenges during the course of the intervention. Survey components included: 1) overall level of satisfaction in the workshop on a scale of 1-5 where 1=Poor and 5=Excellent; 2) multiple-choice self-report of perception of competencies gained including self-perception of programming knowledge acquired, knowledge of game design, understanding of game and media-creation technology, ability to teach others the Scratch media creation tool, and confidence using computers and computer software; 3) two open-ended questions requesting participants to reflect on what they liked best about the workshop and what they would change about the workshop if they could; and 4) investigation of workshop context with regard to learner preference for same-sex or mixed-sex workshop sessions.

5.2.5 Human Research Ethics Approval

Approval to conduct the outlined workshop and activity study was received from the Office of Research Ethics, Simon Fraser University, in October, 2009. The research study was categorized as “Minimal Risk.” Minimal Risk is defined by the U.S. Department of Health and Human Services as “the probability and magnitude of harm or discomfort anticipated in the research are not greater in and of themselves than those ordinarily encountered in daily life or during the performance of routine physical or psychological examinations or tests.” This definition is commonly accepted, and has been adopted by the Government of Canada for CIHR, NSERC and SSHRC ethics review guidelines.

Approval for conducting research in schools was obtained from the Surrey District School Board (District 36), host school principal and vice principal. Informed consent and participant assent were obtained from participant parents/guardians and participants prior to commencing workshop activities and data collection. A criminal record check, per school board policy for working with minors, was obtained and distributed to school board and host school administration with the request for permission to conduct research in schools.

A separate ethics approval process was completed for the Scratch creativity support evaluations as the intervention and user study was conducted with a different participant pool and in a different situational context than the primary intervention. Approval to conduct this secondary research was received in June, 2010 and was categorized as “Minimal Risk” by the ORE.

6: RESULTS AND ANALYSIS

This study draws on

- contemporary research in everyday activity capture for gender disaggregated participant analysis (Kahneman et al. 2004a);
- direct observation of workshop participants for deepened understanding of engagement and disaffection with technology-creation activities (Skinner et al. 2008);
- survey methods to measure the level of creativity support (Carroll et al. 2009) afforded by the media creation tool used in the primary and festival workshops as well as to collect participant feedback on the quality of their experiences during the workshop; and
- content analysis of participant artefacts generated over the course of the workshop for evidence of technology fluency objectives and content creation preferences.

A gender disaggregated model of the rich contexts and affective dimensions of early adolescents' day-to-day activity provides a stronger understanding of girls' differential needs and experiences than can be derived from preference surveys alone for informing design-based, participant-centred research. Studies have shown that predictive, stated preference reports "are usually more extreme than their experiences" (Schwarz et al. 2009), and are inadequate indicators of future or actual behaviour in a real environment (Ben-Akiva et al. 1994). "Revealed" preference data (data describing actual behaviour), as can be elicited by in-situ experience capture methods, provides a more authentic model of activity, choices and behaviours than preference surveys.

I analyzed activity, artefact, and observational data collected from the parallel streams and combined workshop sessions for informing convergences and divergences to assist in sensitizing learning environment design with regard to target population needs and opportunities. Additionally, I explored this data to assess the dynamics of gendered take-up, processing, and transformation of the workshop learning content into individual digital story and game design projects. Data derived from the activity model, field observations, and digital artefact evaluation assisted in the creation of design heuristics for guiding future iterations of the workshop and for providing best response to targeting girls' learning needs and engaged interests in-situ.

6.1 Activity Study

Activity using data was captured by the Day Reconstruction Method (Kahneman et al. 2004a) modified for sensitivity to the age range of the participant pool and specified research questions underlining this study. Data captured from the DRM was analyzed using descriptive statistics of central tendency to discuss activity means and frequency tables. Analysis of emotional state during specific activities includes details of episode satisfaction, and net affect for activity clusters of interest. Comparisons of states to location, activity, and social context are also included for construction of situated time-use matrices. Where appropriate, I performed inferential statistical tests (both parametric and non-parametric) to compare paired data and add to analysis.

The following sub-sections provide key activity study analyses conducted to provide a snapshot of “a day in the life” of the population of interest. Analysis of participant well-being in life, home, and school, in addition to activity choices and affect levels for activity engagement provide informing data to support the design and development of connected, meaningful, and situated learning interventions.

6.1.1 General Characteristics of the Host School

The host school at which the intervention took place is a provincially designated inner-city elementary through middle school with a population of 385 students[1]. Aboriginal students constitute 19.2% of the student population, with ESL students comprising 48.1 percent. Approximately 2.6% of students have diagnosed learning disabilities and 7.0% with diagnosed behaviour disabilities. English and Punjabi represent the top two languages spoken at home (60% and 11.4% respectively). The host school houses a dedicated local division of the Boys and Girls Club, which provides after-school activities for students from 2:30 p.m. until 5:00 p.m. Mondays to Fridays.

Foundation skills assessments show that 34% of all grade 7 students (*n*=65) are not yet meeting expectations, with only 3% exceeding expectations in reading. Numeracy skills show similar outcomes with 34% not meeting, and 3% exceeding expectations. School outcomes are significantly poorer for female and ESL students in comparison to district averages. In reading and numeracy,

[1] All school and district statistics are derived from the B.C. Government, Ministry of Education District and School Reports (2010).

female students are poorer performers than male students, with 41% of all female grade 7 students not meeting expectations in reading and 48% not meeting expectations in numeracy. No female students exceed expectations in numeracy, while only 1 does so in reading. Girls' challenges in numeracy are higher than those of ESL students (48% compared to 42% of ESL reported as not meeting expectations) and are comparable to ESL students in reading (41% compared to 42% of ESL reported as not meeting expectations). To afford deeper comparative analysis, Figures 17 and 18 chart disaggregated statistics for students not meeting expectations in reading and numeracy in foundation skills assessment for the host school, host school district, and two comparator regional school districts (Vancouver and West Vancouver). Vancouver represents the largest municipal neighbor to the host school district (Surrey), while the West Vancouver district is an affluent "waterfront community" in proximal location to the Vancouver core.

Figure 17. Students not meeting expectations in Reading (percentages for Female, Male, and ESL)

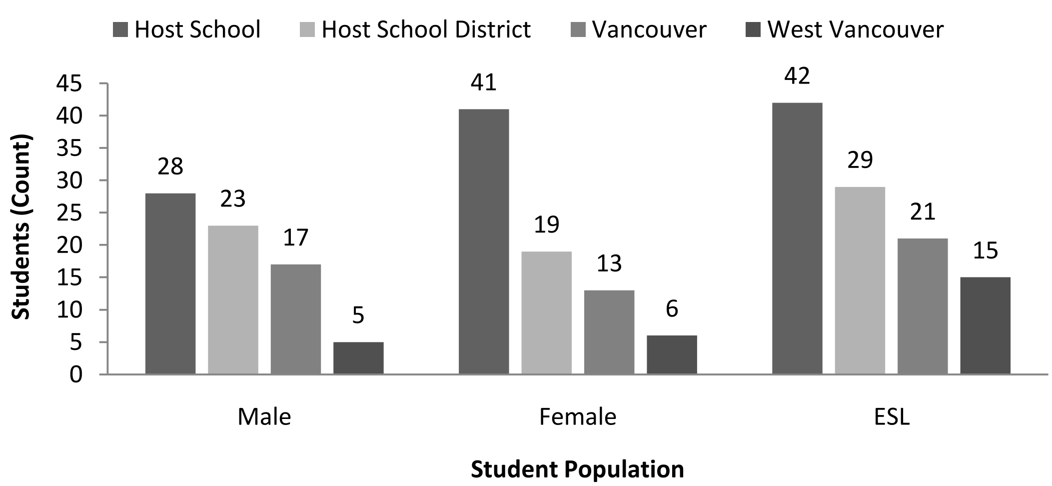
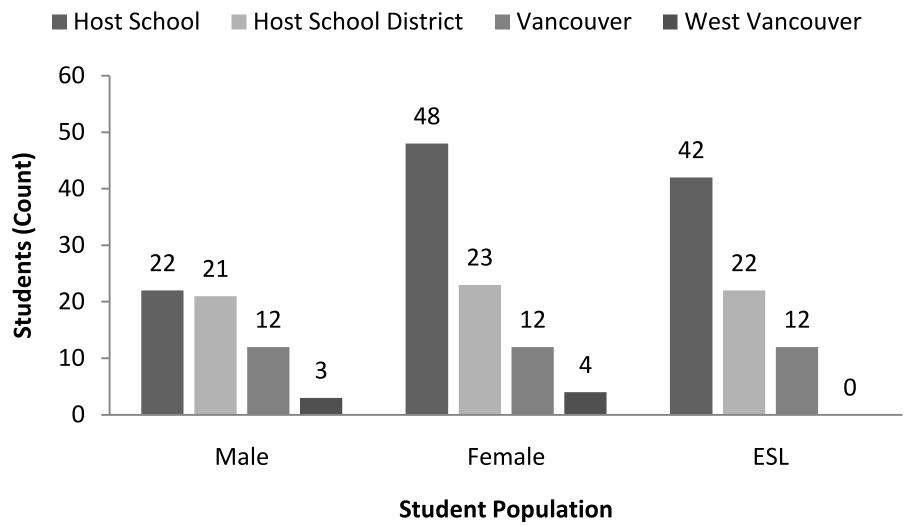


Figure 18. Students not meeting expectations in Numeracy (percentages for Female, Male, and ESL)



6.1.2 Demographic Characteristics of Study Population

Demographic variables including participant gender, age, household composition and socio-economic complexion (see Figures 19, 20, and 21) were captured for respondent profile construction and correlation with reported activities and their affective dimensions. Demographic characteristics captured in the activity study are compared to municipal and district-level statistical indicators to assess the representativeness of the study sample; however, given the small sample size obtained for the activity survey, no strong generalizations can be drawn to the wider population. Representational comparisons are made for descriptive value and to assist in study contextualization alone.

Figure 19. Demographic Characteristics of Activity Study Participants (Count and Age)

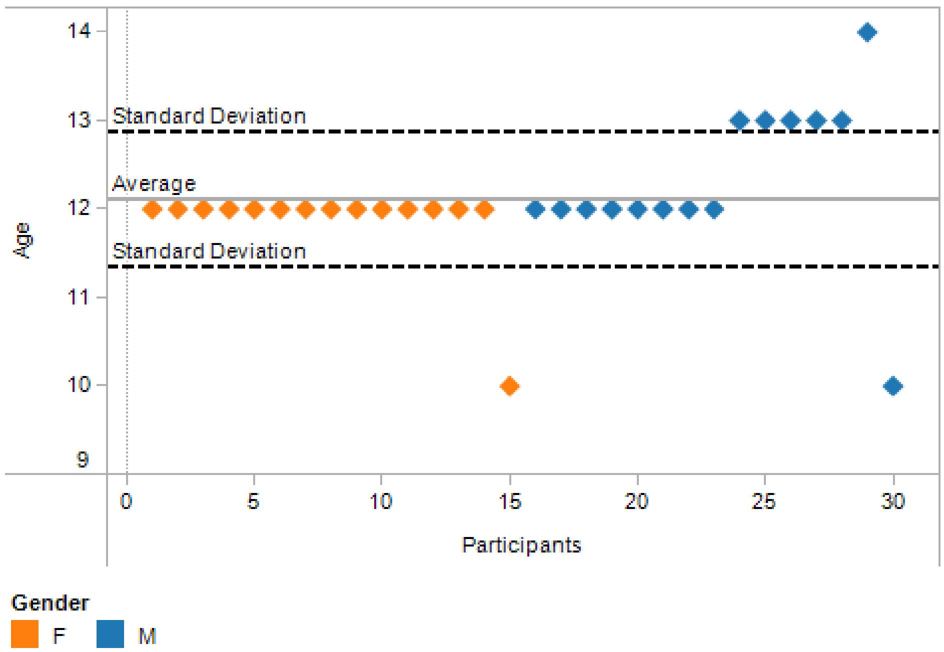
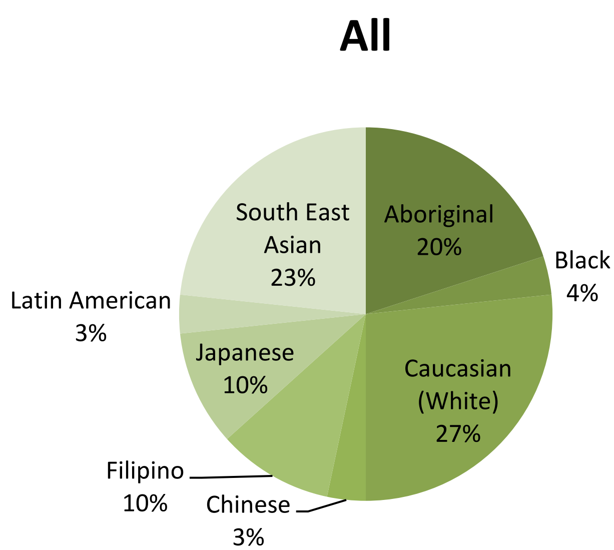
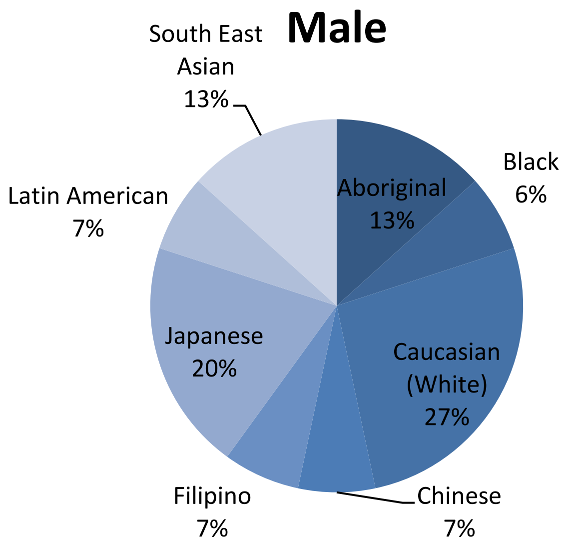


Figure 20. Demographic Characteristics of Activity Study Participants (Ethnicity)




Male
South East Asian 13%
Aboriginal 13%
Black 6%
Latin American 7%
Japanese 20%
Caucasian (White) 27%
Filipino 7%
Chinese 7%

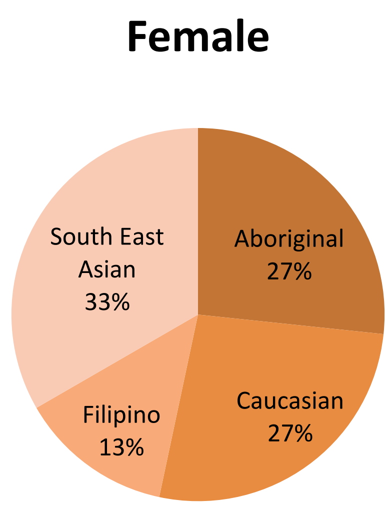
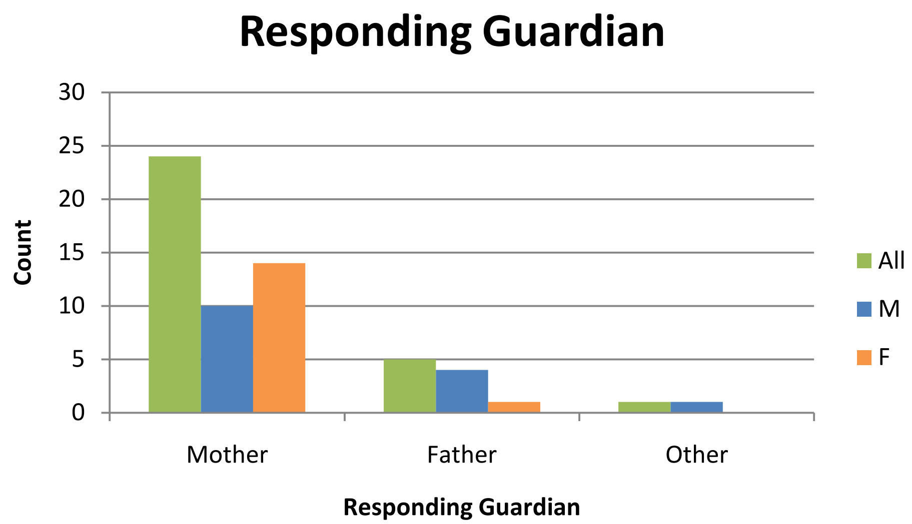
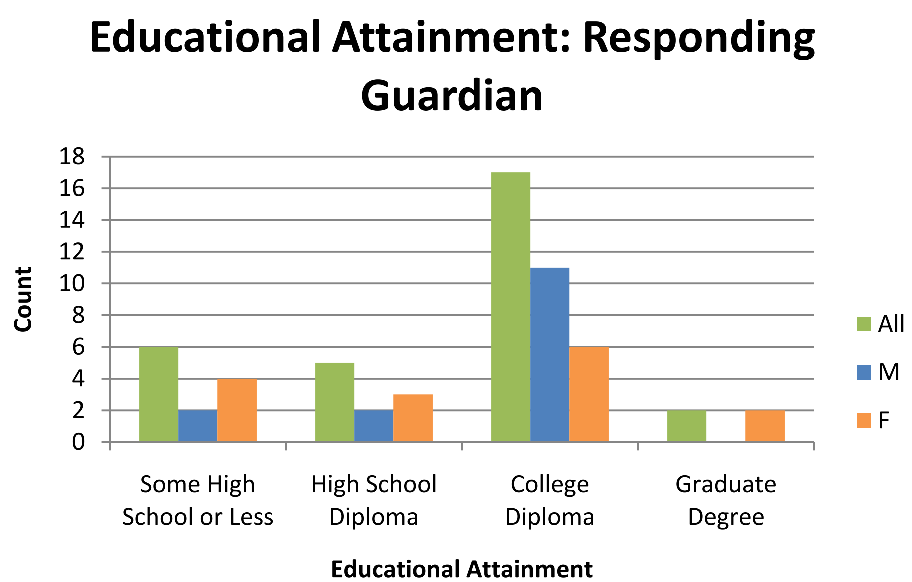
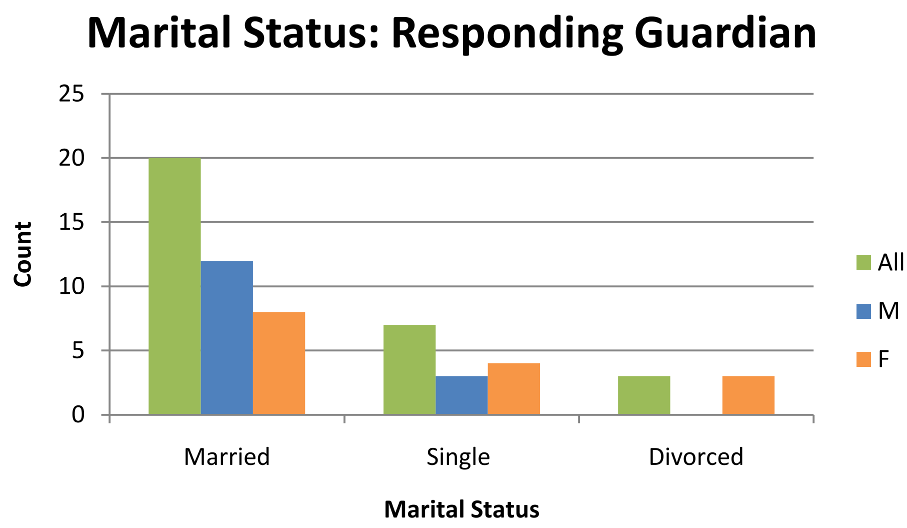
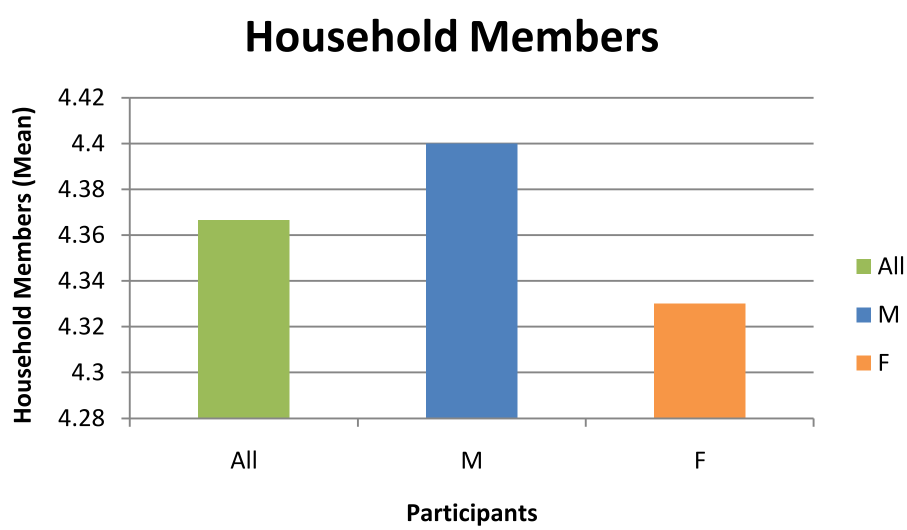

Female
South East Asian 33%
Aboriginal 27%
Filipino 13%
Caucasian 27%

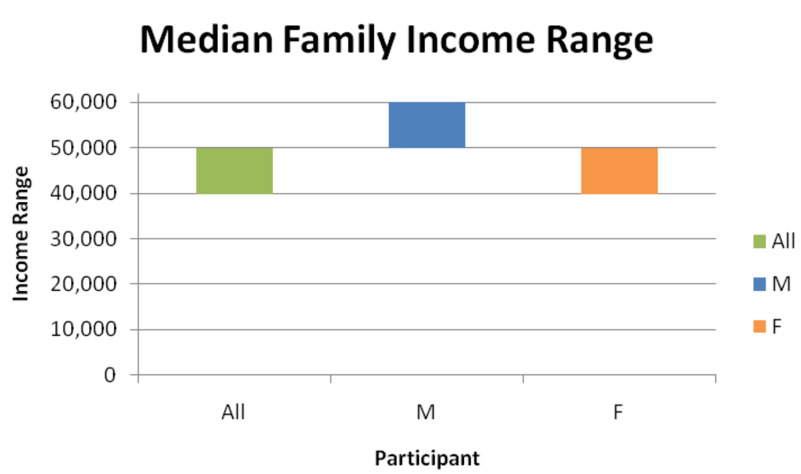
Figure 21. Demographic Characteristics of Activity Study Participants (Household Data)






Marital Status: Responding Guardian
Count
25
20
15
10
5
0
Married
Single
Divorced
Marital Status
All
M
F


Household Members
Household Members (Mean)
4.42
4.4
4.38
4.36
4.34
4.32
4.3
4.28
All
M
F
Participants
All
M
F


Median Family Income Range
Income Range
60,000
50,000
40,000
30,000
20,000
10,000
0
All
M
F
Participant
All
M
F

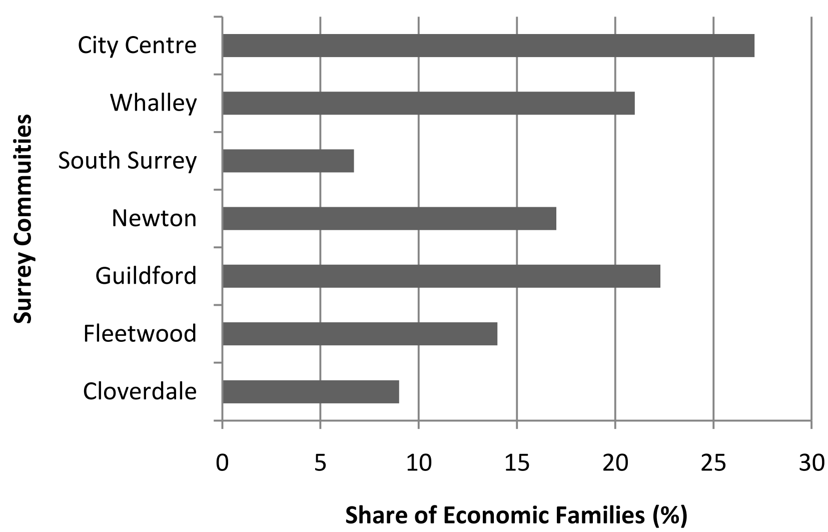
Collected respondent socio-economic variables are consistent with the latest Census (2006) survey of the area and school reporting of students' family income for 2008-2009, which suggest that the activity study participants are representative of the general character of both the region and localized context within which the study took place. Comparator socio-economic and educational outcome statistics were gathered from Statistics Canada, B.C. Stats, BC Ministry of Education, and the City of Surrey. Median annual family income for married-couple families in the Surrey district at-large is reported as $69,119 (Statistics Canada 2006), with single-parent annual median income reported as $37,160 (Statistics Canada 2006). Median annual family income for the Whalley-City Centre region in Surrey in which the intervention took place is reported as $53,343 (see Table 8 and Figure 22 for comparative summaries). The ethnic make-up of the district is diverse with South Asian ethnicities comprising 26.3% of the population distribution (BC Stats 2009), represented in the study population at 23%. The most current educational attainment statistics for the region (2006) report 31.5% of the district population having completed post-secondary education diploma or degree qualifications and 30.8% having completed a high school certificate or equivalent (City of Surrey 2009). Study participant family demographics show that 57% of respondents' primary caregivers have completed post-secondary education and 17% have completed high school qualifications alone, skewing the sample from general population representativeness. However, reported educational attainment levels are consistent with area growth and development projections due to focused city planning initiatives in the urban inner-city core (General Manager 2008), which included the opening of the Simon Fraser University, Surrey satellite campus in the inner-city centre in 2006.

Table 8. Income Characteristics for Vancouver, Surrey, and Whalley-City Center

	Population	Median Annual Family Income
Vancouver	628,621	$64,007
Surrey	446,561	$69,119
Whalley-City Center (Surrey)	81,035	$53,343

Sources: Statistics Canada (2006 Census of Population) data, and City of Surrey (Total Income Fact Sheet).

Figure 22. Low Income in Surrey's Communities (Economic Families)



Source: City of Surrey (Low Income Fact Sheet, 2009)

6.1.3 A Day in the Life

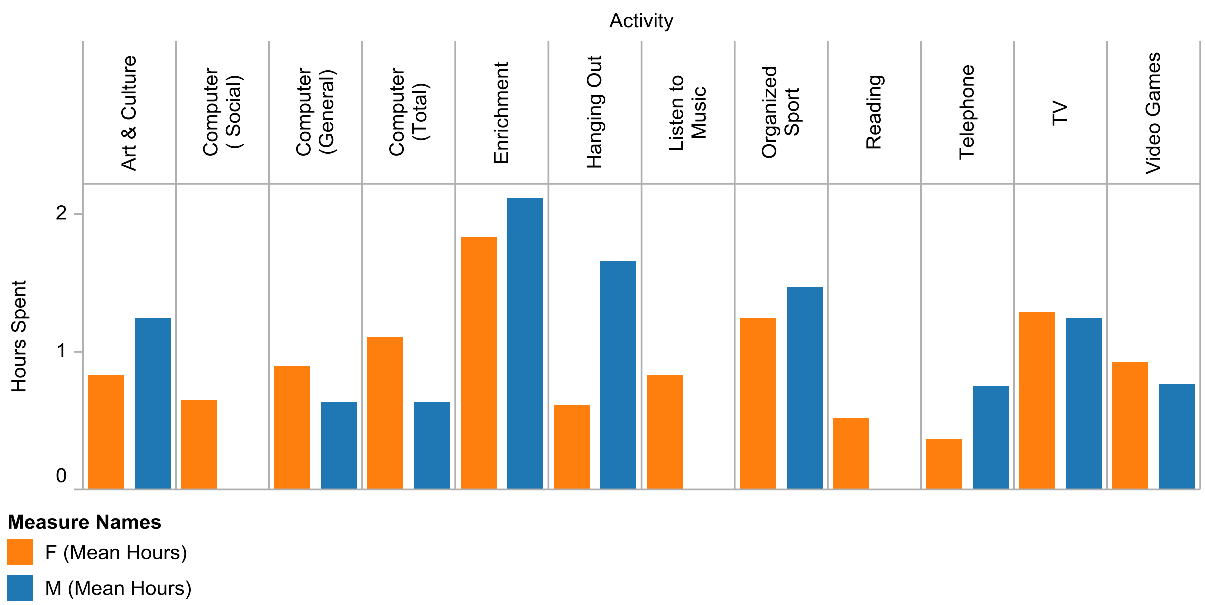
On average, study participants reported 14.5 hours of time spent awake. Time spent "in school" accounted for 6.5 hours of their waking time on a typical weekday, or, 45% of their waking weekday, with an additional 1 hour and 38 minutes dedicated to personal care (washing and eating), and chores accounting for an average of 36 minutes per day. Twenty-five minutes, on average, were spent in total commuting time to and from school, and 1.75 hours, on average, were reported being devoted to homework in school during recess and lunch hours and/or after school. Free or leisure time accounted for 2 hours and 53 minutes of an average waking day, with 17% of 75 total free time events reported (13 of 75) spent in structured activities such as clubs and organized sports, and 83% of total reported leisure events (62 of 75) occupied in unstructured activities such as watching TV, hanging out, using the computer, playing video games, and reading.

Of the 75 reported leisure events, watching TV was the most frequent, accounting for 20 of 75 events (approximately 27%, proportion of sample reporting 0.63). Computer use and playing video games comprised 23 events (13 and 10, proportion of sample reporting 0.33 and 0.2, respectively), followed by hanging out (11 events, proportion of sample reporting 0.4), organized sports (8 reported events, proportion of sample reporting 0.37), enrichment events (learning outside of school) (5, proportion of sample reporting 0.2), reading (3, proportion of sample reporting 0.1) and talking on the telephone (cellphone) (3 events, proportion of sample reporting 0.1), listening to music (1, proportion of sample reporting 0.03), and art and culture (drawing, playing music) with 1 event. Average TV viewing time for reported events was 1 hour and 19 minutes, while average computer time use and video game play were 56 minutes and 52 minutes respectively. See Figure 23 for a visual overview of average time spent engaging categories of interest. Event occurrence counts include all reported instances of discrete (time-separated) engagements within and between subjects. For example, a subject might report an episode of watching TV when arriving home from school, in addition to reporting a second episode of the same activity category later in the day. Activity count totals compared to proportion of sample reporting provides a fuller snapshot of activity engagement, preference and time-use across the sample population.

With regard to proportion of sample reporting, watching TV (0.63), hanging out (0.4), and organized sports (0.37) are the most common activity engagements, followed by computer use (0.33), video game playing (0.2), enrichment events (0.2), reading (0.1), talking on the phone (0.1), listening to music (0.03), and art and culture (0.03). Watching TV, computer use, and video game playing; however, tend to be repeated events for subjects choosing to engage in these activity categories, as opposed to single-event engagements within the subjects' day. Typically, structured leisure time events constitute single daily instances, while unstructured events are characterized by multiple instances of engagement throughout the subjects' day.

When disaggregated by gender, activity clusters by engagement emerge. The amount of time spent watching TV is approximately equal between genders, with girls reporting an average of 1.28 hours of TV on a given day, and boys reporting 1.24 hours spent watching TV. Girls spend more time engaging technology than boys, in general. Girls report 0.92 hours on average spent playing video games compared to boys reporting of 0.77 average hours for the documented day. Boys tend to play video games on the computer or on larger consoles such as the Xbox or PlayStation, while girls favour handheld consoles such as the Nintendo DS for video game play, which may account for the time differential. Girls, as well, show “pick up and play” gaming patterns, using game play to fill gaps in spare time or to help them fall asleep, while video game play time for boys appears to occur in dedicated blocks or play sessions.

Figure 23. Average time spent when engaging category of interest for subjects’ reported events.



Computer use between boys and girls reveals salient differences (see Figure 22). Girls spend 1.1 hours average total for the reported day on the computer, while boys spend, on average, 0.63 hours using a computer. Approximately 59% of girls’ time on the computer is spent engaging in social and communication activities such as IM, or on social networks such as Facebook and Good Reads. Boys report spending no time using the computer for social activities; preferring, instead, to surf the internet or play online games, which accounts for an average of 0.63 hours of use for the day reported. By comparison, boys spend a significantly larger percentage of their free time "hanging out" (an average of 1.67 hours for the given day), while girls report significantly less time (average 0.61 hours) devoted to hanging out alone or with friends. On weekdays, outside of school, the majority of girls' socialization time is leveraged through the computer in online chat, while boys prefer face-to-face socialization, reporting spending time at friends' houses after school to play sports or video games.

6.1.3.1 Time Use Matrix

To gain a more complete understanding of the inter-relationships between activity, context, and affect, participants' experiences at school, at home, and outside of home and school were examined. Primary activities engaged for the three selected contexts may have duration and context overlap (for example, socializing reported as taking place during class time, or, participation in free time activities both at home and outside the home) and as such, depart from summary descriptives reported above. Event classes were chosen to represent the broadest activity spectra participated in, as reported by respondents. A more granular activity analysis, including multi-tasking and accounting of secondary activities, is proposed for future work, which would build on insights generated by the study detailed herein.

The context probes, described in Figure 24, show an event matrix for a general "activity class," which comprises a cluster of coded activities determined to be related for the purposes of analysis (See Table 18, 19, and 20 in Appendix F for data tables). Figures show both aggregate and disaggregated values for the variables of interest. Event class "duration" represents the calculated *mean* duration of each reported activity included in the event class. "Duration" is thus the *mean* value of the included event duration means. Motivation to participate and interaction with others are calculated as the decimal percentages of respondents reporting the category for individual events. Satisfaction is given as the *mean* level of global satisfaction reported on a scale ranging from 1 (Not at all satisfied) to 10 (Completely satisfied) for each event included in the activity class. Additionally, affect (mood measures) for each reported event was rated on a scale from 0 to 6, with 0 indicating that the feeling wasn't experienced at all. A rating of 6 indicates that the feeling was a very important part of the experience. Twelve affect dimensions were rated for each reported episode, including 6 negative affect categories, 3 positive affect categories, and 3 neutral categories. Table 9 details the 12 positive, negative, and neutral affect categories used to capture and summarize the affective complexion of respondents' day.

Table 9. Affect categories rated by respondents for each reported event.

Positive	Negative	Neutral
Happy	Frustrated/annoyed	Competent/capable
Warm/friendly	Depressed/blue	Tired
Enjoying Myself	Hassled/pushed around	Impatient

Angry/hostile
Worried/anxious
Criticized/put down

Net affect is a measure, which facilitates comparisons of the experienced utility for all participants for investigated activity classes, as well as for affect comparisons between respondents as disaggregated by gender. Mood measures are aggregated in the net affect score, which is defined as the difference between the average score given by the respondents to all positive attributes and the average score of all negative attributes (Knabe et al. 2009). Tiredness and competency (or self-reported perceptions of capability) *mean* aggregate values are provided separately, alongside net affect, for each activity class. Research has shown that positive affect reinforces self-control and can support future-directed behavior (Daly et al. 2008). Such potential outcomes for learning in non-formal environments can be approached by investigating the subjective meaning of participants' activities in addition to the traditional descriptive patterns of daily activity that can be elicited from time use data. New directions in time use research have focused on considering captured activity within wider frameworks including situational factors and affect dimensions attached to engaged activities (Michelson 2002), providing a broadened analysis crucial to policy formation.

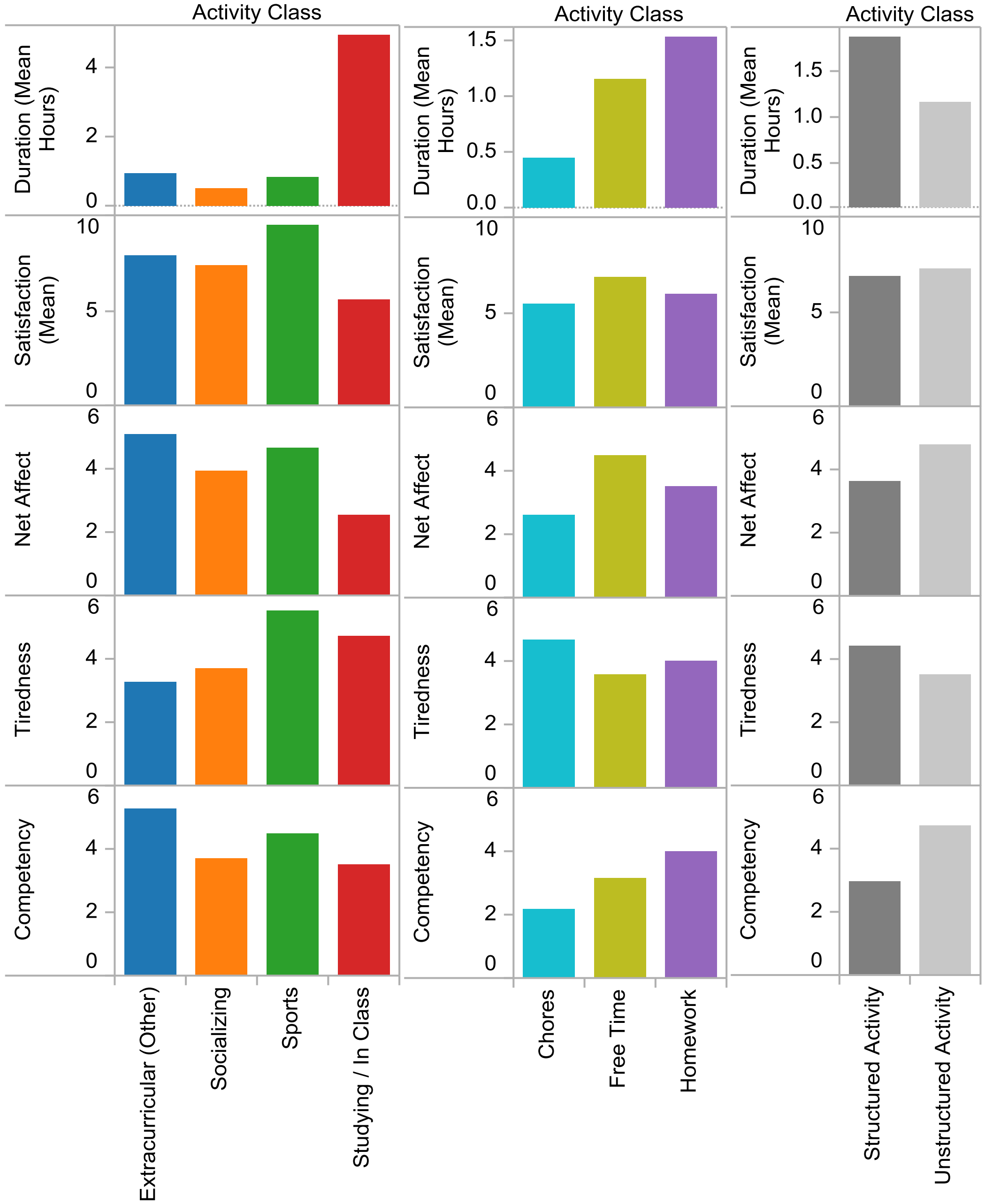
Findings of interest from the context probes, including activities and contexts eliciting highest and lowest satisfaction and net affect ratings; and highest and lowest self-perceptions of competency are summarized in Table 10.

While boys rate sports highest in terms of general satisfaction, girls are most satisfied when engaging in non-sports related extracurricular activities. Both boys and girls report their lowest self-perceptions of competency and general satisfaction when doing chores at home. There is general consistency between activities rated highest for satisfaction, net affect, and competency; as well as between activities given lowest satisfaction, net affect, and competency ratings for both boys and girls. Overall, chores, homework, and in-class schoolwork receive the lowest ratings for satisfaction, net affect, and competency for both boys and girls (see Figure 24). One outlier finding is girls' low net affect rating for participation in school sponsored sports activities. While the net affect rating is low, girls report a high general satisfaction level for engagement with sports activities, 7.0 out of 10.

Table 10. Context Probe Summary

		Highest Satisfaction	Lowest Satisfaction	Highest Net Affect	Lowest Net Affect	Highest Competency	Lowest Competency
Boys	Activity	Sports	Chores	Sports	Chores	Sports	Chores / Unstructured Free Time Activities
	Context	At School	At Home	At School	At Home	At School	At Home / Outside of Home and School
	Rating	9.5	4.8	4.67	2.47	4.0	2.17
Girls	Activity	Extracurricular (Other)	Chores	Extracurricular (Other)	Sports	Extracurricular (Other)	Chores
	Context	At School	At Home	At School	At School	At School	At Home
	Rating	7.86	5.47	5.08	2.14	5.25	2.18

Figure 24. Probes for Understanding Context of Experience at School, Home, and Outside of Home and School (from left to right)



6.1.3.2 Well-Being and Diurnal Mood Variation

Response measures for global well-being were captured for three dimensions: 1) life as a whole (Q1); 2) life at home (Q2); and 3) life at school (Q3). Participants were asked to select a response measure ranging from "Very

Satisfied" to "Not At All Satisfied," which best described their opinion. Response measures were coded as follows: Very Satisfied= 4; Satisfied=3; Not very Satisfied=2; and Not at all satisfied=1. Median score for both male and female groups for well-being across all three domains (life, home, and school) was 3 (satisfied).

Additionally, participants were asked to provide a percentage breakdown for their mood when at home and when at school across five measures ranging from "In a bad mood" (Q4 and Q5 A) to "In a very good mood" (Q4 and Q5 D). Questions 4 (Q4) and Questions 5 (Q5) queried what percentage of time the respondent was in: a) a bad mood; b) a little low or irritable; c) In a mildly pleasant mood; and d) In a very good mood when at home (Q4) and school (Q5). Participants were asked to ensure that the percentages of time spent in each affect state would sum to 100% for each home and school mood queries (see **Error! Reference source not found.**). No significant differences in global satisfaction ratings for the domains of interest were shown between boys and girls (see Figure 25).

Mood decomposition was highly variable; with no significant differences in mean percentages of mood for a given negative or positive state found between boys and girls at home and in school. Boys; however, reported slightly higher extreme positive mood percentages for time spent at home and in school than girls and higher extreme negative mood percentages for at home. Standard deviations for mean mood response categories reveal the high degree of variability in responses from the mean and are found in Figure 26.

Figure 25. Global Well-being Response Frequencies for All, Female, and Male Respondents (from top to bottom)

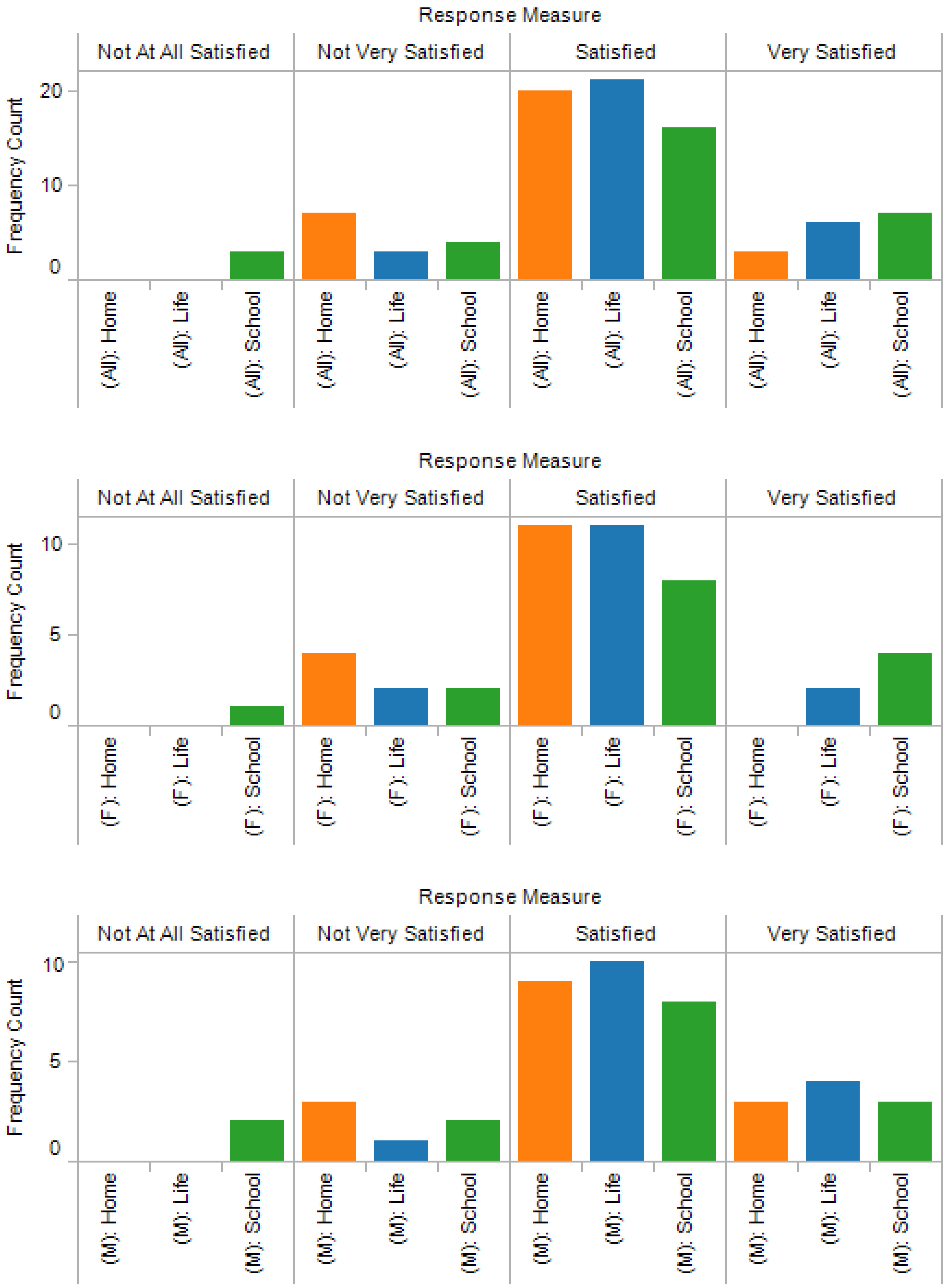
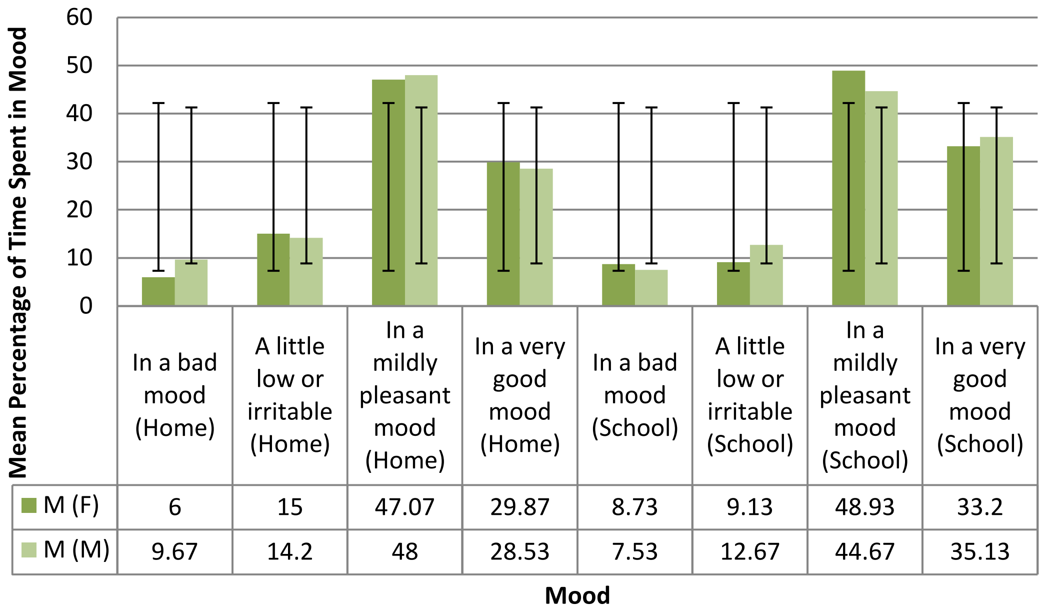


Figure 26. Mood Decomposition (in percentage) for Home and School



Tables 11, 12, and 13 chart respondents' reports for global satisfaction measures for life as a whole, life at home, and life at school; and mood ratings for home and school compared to satisfaction ratings for comparative analysis. Within and between subject comparisons show moderate to high levels of general satisfaction with life and reveal correlations of interest between holistic satisfaction and micro-reports for life dimensions, here, home and school (see Figure 27). Pairwise correlations between satisfaction ratings reported for "life as a whole," "life at home," and "life at school" show moderate correlation (average r=.57) with significance at $p<.05$. A matched pairs t-test on overall satisfaction ratings shows significance for comparisons between Life at Home and Life as a Whole (p=.008). The results suggest that life at home has an effect on whole life satisfaction for the participants, generally. Positive experiences of life at home have typical correspondences to positive perceptions of life as a whole.

When disaggregated by gender, moderately high to strong significant correlations are shown for life at home and life as a whole for both boys and girls. All pairwise satisfaction dimension correlations show significance for boys, as opposed to girls, indicating that effects between life domains, for boys, are more highly interdependent than for girls. In particular, effects between life at home and life at school show weak correlations for girls, but strong correlations for boys (see Table 13).

Table 11. Pairwise Correlations for Satisfaction (Life as a Whole, Life at Home, and Life at School)

Variable	By Variable	Correlation	Count	Signif Prob
Life at Home	Life as a Whole	0.60	30	0.0005*
Life at School	Life as a Whole	0.59	30	0.0006*
Life at School	Life at Home	0.52	30	0.0033*

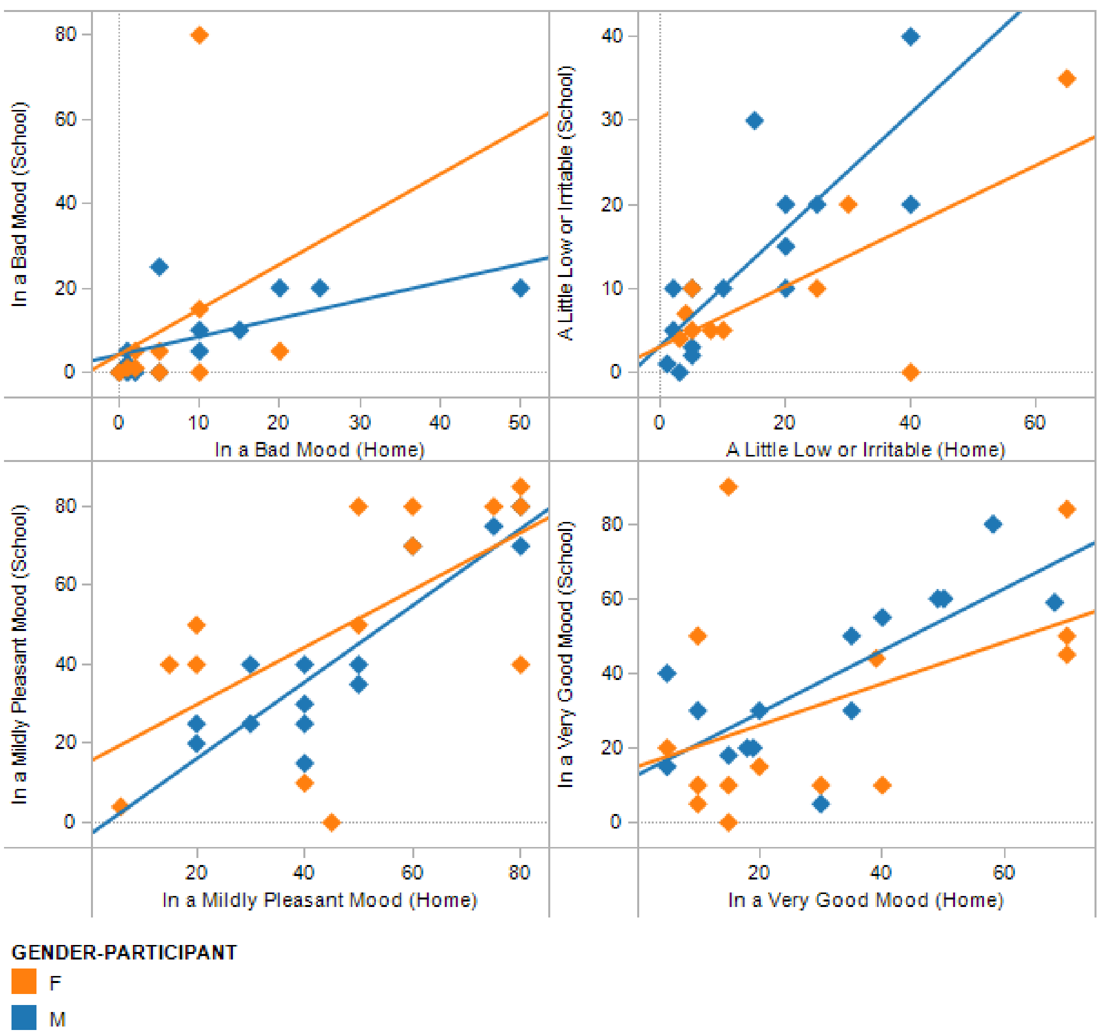
Table 12. Matched Pairs Difference for Satisfaction (Life as a Whole, Life at Home, and Life at School)

Variable	By Variable	Mean Difference	Std. Error	CI (95%)	Count	t-Ratio	DF	Prob>t
Life at Home	Life as a Whole	0.23	0.09	0.42, 0.05	30	2.54	29	0.008*
Life at School	Life as a Whole	0.2	0.13	0.47. -0.07	30	1.53	29	0.07
Life at School	Life at Home	-0.03	0.14	0.25, -0.32	20	-0.24	29	0.59

Table 13. Pairwise Correlations Disaggregated by Gender for Satisfaction (Life as a Whole, Life at Home, and Life at School)

Gender	Variable	By Variable	Correlation	Count	Signif Prob
F	Life at Home	Life as a Whole	0.58	15	0.02*
M	Life at Home	Life as a Whole	0.58	15	0.02*
F	Life at School	Life as a Whole	0.47	15	0.07
M	Life at School	Life as a Whole	0.76	15	0.001*
F	Life at School	Life at Home	0.37	15	0.18
M	Life at School	Life at Home	0.70	15	0.004*

Figure 27. Strength of Correlations between Mood at Home and in School (Linear Model)



Diurnal variance in respondent affect levels was not significant for affect given average time of captured events. For analysis, the average of event start and end time was calculated and used to indicate time of event occurrence. A matched pairs t-test showed no significant difference in mood variation over the course of the day for boys or girls.

Diurnal mood variance between genders was not significant; a matched pairs t-test of mood variation over the course of the day (using 15 minute intervals from waking to sleeping) between male and female respondents showed only a slight positive correlation (0.2), with a difference in affect means between the genders to be 0.08, with a standard error of 0.08. Diurnal mood patterns can be mapped to captured activities for ranges of interest and generally hold for both male and female respondents (see Figure 28 and Figure 29). Valleys (negative affect) typically correspond to waking up (approximately 7:00 a.m.), start of regular classes (approximately 9:00 a.m.), time spent in class (distributed between 9:00 a.m. and 2:30 p.m.), time spent doing chores and homework (distributed non-regularly between 3:00 p.m. and sleep). Peaks (positive affect) correspond to meeting friends before school (approximately 8:00 a.m.), recess (approximately 10:30 a.m.), lunchtime (approximately 12:00 p.m.), last bell at school (approximately 2:30 p.m.), dinner (approximately between 5:00 and 6:00 p.m.), and free time activities (approximately distributed between 3:00 and 5:00 p.m. and again between 6:30 p.m. and sleep).

Figure 28. Diurnal changes in mood for male respondents (from waking to sleep). Positive affect = 1, Negative affect = 0

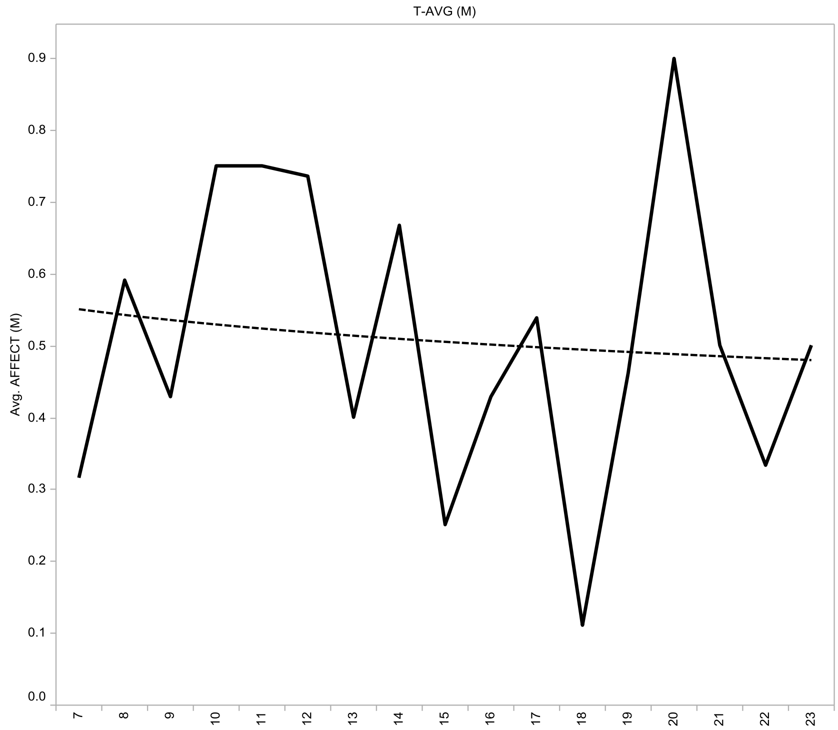
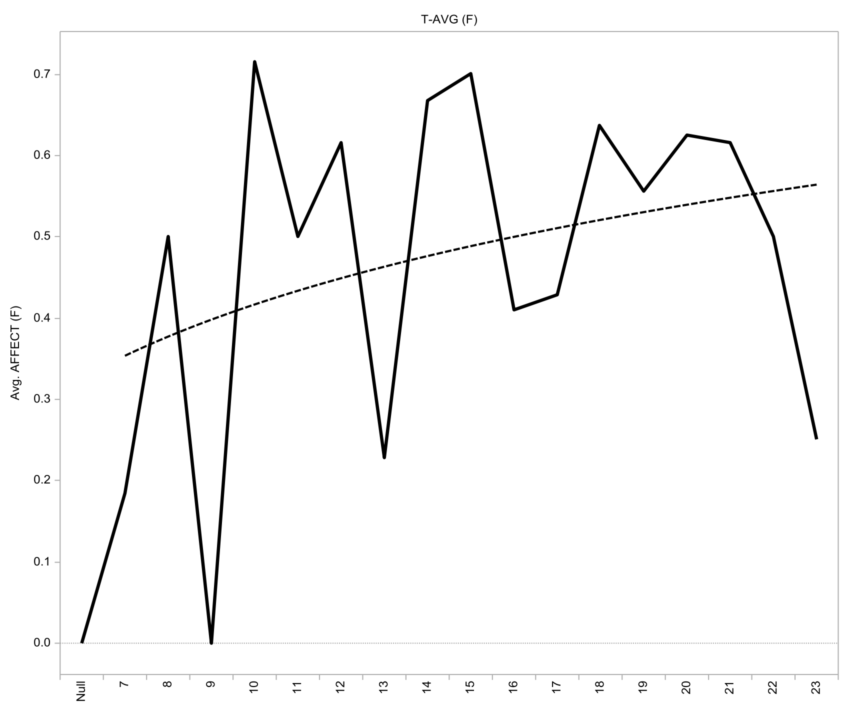


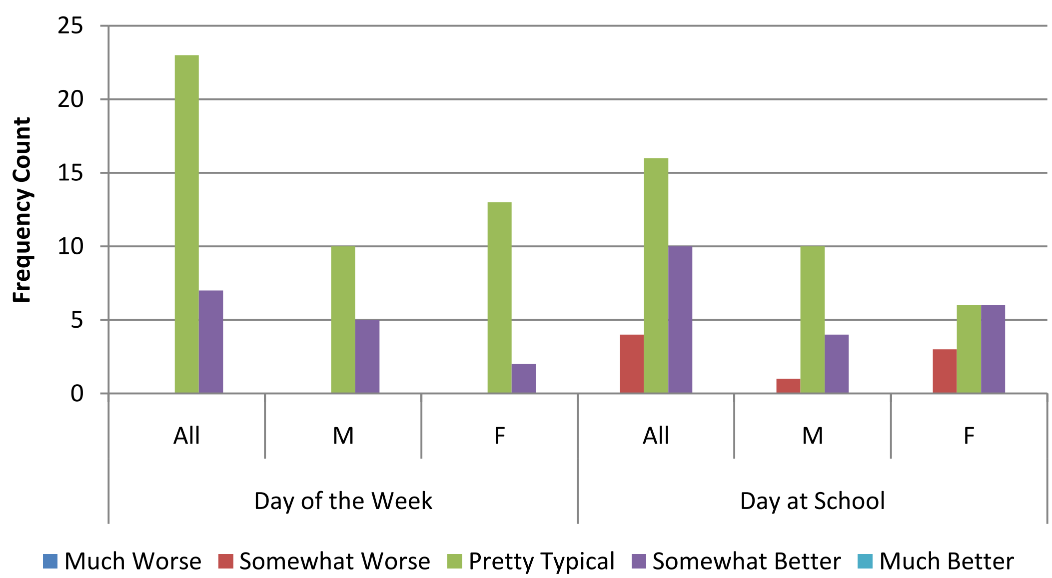
Figure 29. Diurnal changes in mood for female respondents (from waking to sleeping). Positive affect = 1, Negative affect = 0.



6.1.3.3 **Typicality of Reporting Day**

To situate the day being reported within the larger context of the respondents' day-to-day life experiences, participants were asked to rate the typicality of the day being reported, by comparison, with what that day of the week is usually like for them. Respondents were also asked to compare the day being reported on to a typical day at school to increase the generalizability of the reports to their experienced life as a whole. Day comparison ratings were provided for a 5-point scale with all points labeled, including: 1=Much Worse, 2=Somewhat Worse, 3=Pretty Typical, 4=Somewhat Better, and 5=Much Better. Participant ratings of typicality for day global was *M*=3.23, *SD*=0.43 and day at school was *M*=3.2, *SD*=0.66 indicating that the day being reported was fairly typical (neither significantly better nor worse) on average for the respondents, with little variation around the mean (see Figure 30).

Figure 30. Typicality of Day Reported Ratings (Response Frequency Count)



6.2 Learner Engagement and Disaffection

Structured observations of participant engagement and disaffection were collected in two phases. During the first four weeks of workshop sessions and over the last five weeks of sessions, a modified version of the "Engagement Versus Disaffection with Learning: Teacher Report" instrument (Skinner et al. 2009), was used to capture structured observational data on the connected dynamics of participant behavioural and emotional engagement and disaffection with workshop content and context. I report results captured by the "Engagement Versus Disaffection with Learning" instrument below.

Factor medians and range for each observation phase, phase difference and correlation statistics are calculated for primary constructs. All aggregate correlations (cross-phase stability) are statistically significant at the $p <= .05$ level. All aggregate phase differences are statistically significant at the $p <= .05$ level, excepting phase differences for emotional engagement.

Nonparametric general tests appropriate to small, non-random sample sizes (n=23) with all data in hand and non-normal distribution (Leech & Onwuegbuzie 2002) were conducted to investigate differences between related variables and relationships between variables, including tests for phase correlation (Spearman ρ), phase difference comparison (Wilcoxon Signed-Ranks), and simple descriptive statistics. The Wilcoxon test has about 95% of the power of the t-test, and does not require a normal distribution. Standardized skewness and kurtosis coefficients for examined constructs were assessed to determine degree of departure from normality based on accepted effect sizes

(Leech & Onwuegbuzie 2002) prior to selecting the nonparametric tests for data analysis.

Effect sizes, calculated using Cohen's *d'*, a parametric statistic independent of sample size (capable of representing practical significance), are determined for constructs that lie within the +-3 boundary suggested for assessing deviations from normalcy as small (Leech & Onwuegbuzie 2002), and are represented with a double asterisk (**). Small departures from normality can generally be accommodated by the parametric measure for effect, but, should be regarded with caution, nevertheless. Effect sizes measured by Cohen's *d'* can be reasonably interpreted as a d' of 0.20 indicating a small effect, a *d'* of 0.50 as a medium effect, and a *d'* of 0.80 to infinity as a large effect. For constructs whose skewness and/or kurtosis coefficients lie outside the +-3 boundary, indicating important deviation from normalcy, effect size is calculated by dividing the *Z* score obtained through the Wilcoxon test by the square root of *n*.

A summary of statistical test results can be found in Table 14 for constructs between the two structured observation phases for all participants and for participants disaggregated by gender. P-values for F in gender disaggregation of correlation tests is suspect due to small sample size (*n*=9) and are provided only as a sample comparison to the aggregate reference group. Related Samples Wilcoxon Signed-Ranks standardized test statistic is reported in the Difference column as an absolute value. While sample size is small, which brackets derived p-values, effect sizes for Behavioral Engagement, Behavioral Disaffection, Behavioral and Emotional Engagement, Behavior Engagement v.

Disaffection, and Engagement v. Disaffection are shown to be moderate indicating the probability of practical significance for difference between the two observation phases without confound by sample size.

Table 14 presents the medians, ranges, effect sizes, phase differences and cross-phase correlations for engagement and disaffection scores derived from the Engagement and Disaffection with Learning checklist between the two structured observation phases. Cross-time correlations show a moderately high level of stability across the two phases (average ρ=.67) for the four primary constructs: behavioral engagement; behavioral disaffection; emotional engagement; and emotional disaffection. A comparison of median levels from phase one to phase two reveals losses in disaffected behaviors and gains in engaged behaviors, while emotional engagement and disaffection factors remained constant.

Analysis of component-level differences in engagement as a function of gender reveals higher levels of engagement and greater decrease in disaffected behaviors for girls (compared to boys) by phase two, suggesting that girls tended to be more behaviorally motivated than boys at the second phase point of the intervention. Comparisons of the cross-phase stability correlations show these differences as a function of gender. Boys, as well, made cross-phase gains in behavioral engagement, although gains were smaller than those shown for the girls. Boys' entry-level enthusiasm for the content of the intervention may be a contributing factor to higher phase one engagement scores than girls.

Table 14. Summary of constructs derived from structured observations of participant engagement and disaffection across intervention phases

Engagement vs. Disaffection with Learning						
	Phase One	Phase Two				Cross-phase stability
Construct	*Median*	*Median*	*Range*	Effect Size	Difference |P2-P1|	Correlation ρ
Behavioral Engagement	3	5	P1=5 P2=5	|0.48|**	t=3.020 p=.003	0.81 (p<.0001)
M	3.5	4.5	P1=5 P2=5		t=2.3 p=.02	0.93 (p<.0001)
F	2	5	P1=5 P2=3		t=2.04 p=.041	0.79 (p=.035)
Behavioral Disaffection	2	0	P1=5 P2=5	|0.64|**	t=2.83 p=.005	0.56 (p=.006)
M	1.5	0	P1=5 P2=5		t=1.98 p=.048	0.54 (p=.048)
F	2	0	P1=4 P2=3		t=2.04 p=.041	0.61 (p=.079)
Emotional Engagement	5	5	P1-5 P2=5	|0.28|	t=1.9 p=.059	0.81 (p=.05)
M	5	5	P1=5 P2=5		Z=1 p=.32	0.99 (p<.0001)
F	5	5	P1=5 P2=1		t=1.63 p=.102	0.65 (p=.056)
Emotional Disaffection	0	0	P1=4 P2=3	|0.31|	t=-2.1 p=.038	0.49 (p=.02)
M	0	0	P1=4 P2=3		t=1.41 p=.16	0.73 (p=.003)
F	0	0	P1=2 P2=0		t=1.63 p=.102	--
Behavioral & Emotional Engagement	7	9	P1=10 P2=10	|0.49|	t=3.3 p=.001	0.82 (p<.0001)

M	7.5	8.5	P1=10 P2=10		t=2.53 p=.011	0.95 (p<.0001)
F	7	10	P1=10 P2=3		t=2.23 p=.03	0.65 (p=.057)
Behavioral & Emotional Disaffection	2	0	P1=8 P2=8	|0.43|	t=2.95 p=.003	0.59 (p=.003)
M	2	0	P1=8 P2=8		t=2.21 p=.027	0.55 (p=.0395)
F	2	0	P1=6 P2=3		t=2.03 p=.042	0.61 (p=.0785)
Behavioral Engagement v. Disaffection	2	5	P1=9 P2=10	|0.58|**	t=3.15 p=.002	0.76 (p<.0001)
M	2.5	4.5	P1=9 P2=10		t=2.395 p=.017	0.82 (p=.0003)
F	0	5	P1=9 P2=5		t=2.02 p=.043	0.71 (p=.034)
Emotional Engagement v. Disaffection	5	5	P1=9 P2=8	|0.36|	t=2.46 p=.014	0.76 (p<.0001)
M	5	5	P1=9 P2=8		t=1.73 p=.083	0.91 (p<.0001)
F	5	5	P1=7 P2=1		t=1.84 p=.066	0.60 (p=.086)
Engagement v. Disaffection	6	9	P1=18 P2=18	|0.49|	t=3.31 p=.001	0.76 (p<.0001)
M	6.5	8.5	P1=18 P2=18		t=2.54 p=.011	0.84 (p=.0002)
F	5	10	P1=16 P2=6		t=2.20 p=.028	0.69 (p=.041)

6.3 Technology Fluency

Technology fluency indicators were evaluated from content analysis of participants' digital artefacts at the mid- and end- phases of the intervention and design documents produced prior to the final project development stage. Content analysis of participants' game design documents assessed evidence of conceptual and critical engagement with the characteristics, and core ideas of digital game design as a disciplined practice, through a review of project incorporation of "gameness" factors (Juul 2003), held to be demonstrative of participants' ability to synthesize and transfer their growing knowledge of critical game play and game design into new and personal contexts. Analysis of digital artefacts yielded determiners of participants' knowledge of programming constructs, and capability in translating design concepts into working implementations using technology-creation tools. Such analyses access both the content areas and cognitive dimensions proposed for assessment of technology fluency by the National Research Council (2006b).

6.3.1.1 Content Analysis

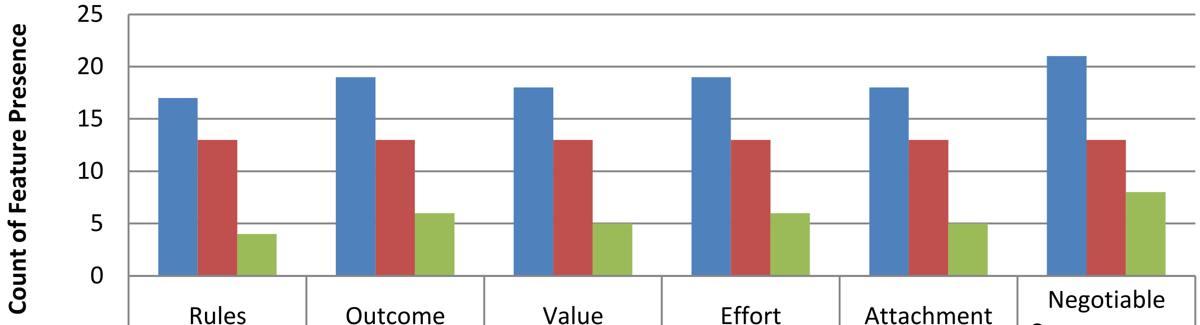
As the Scratch visual programming environment affords the creation of a wide range of digital media productions, not solely game creation, participants were encouraged during the design phase to develop projects that would be personally meaningful to them, and which didn't necessarily "have" to be animated stories or games. Examples were explored on the Scratch website, which indicated how Scratch could be used to create music players, interactive tests and quizzes, and tools such as simple paint programs and calculators. The majority of participants; however, expressed their interest in creating "games," which raised the possibility of including analysis of the "gameness" of participants' digital artefacts in content evaluation. In "The Game, the Player, the World: Looking for a Heart of Gameness" (Juul 2003), Juul describes six features, which can be considered "necessary and sufficient" for something to be a game, or, belong to a formal game system: 1) Rules; 2) Variable, quantifiable outcome; 3) Value assigned to possible outcomes; 4) Player effort (challenge); 5) Player attached to outcome; and 6) Negotiable consequences. Juul (2003) holistically defines a game, based on the six classic game features, as follows:

> A game is a rule-based formal system with a variable and quantifiable outcome, where different outcomes are assigned different values, the player exerts effort in order to influence the outcome, the player feels attached to the outcome, and the consequences of the activity are optional and negotiable.

Using Juul's (2003) classification, it is possible to analyze the participants' designs according to their adherence to or subversion of the "classic" game structure. Juul (2003) points out that "computer" games often rework and have "changed" the classic game model. This is particularly true with respect to allowing rules to emerge from game play; suspending outcomes (such as in MMORPG's); removing goals (as exemplified in open-ended simulation games like the Sims); and affording "cheats," which gives the player opportunities to modify the game rules, and transforms the game into a "playground or a sandbox." Juul's (2003) qualifications assist in orienting analysis and discussion of workshop participants' game designs both in terms of their engagement with classical game structure and new game forms particular to computer or video game constructs.

Twenty-one design projects were developed between 23 participants, with one collaborative (pair) project in each the girls' and boys' workshops (see Table 15 and Table 16). Of the 21 design documents produced, 17 can be categorized as "games" according to Juul's (2003) formal system, with the remaining 4 projects developed as an interactive story with micro-game elements, 2 virtual worlds, and a doll dress-up application respectively (see Figure 31). All thirteen of the projects from the boys' workshop were specifically designated as "games" by the participants, while only 4 of the 8 projects designed in the girls' workshops were explicitly defined as "games" by the participants. Of the 8 projects detailed in the girls' design documents, 4 were articulated as games, 2 as "playable" virtual worlds, 1 as an interactive story, and 1 as a doll-maker, which the designer variously referred to as a "game" or as "something to play with that's fun." The two virtual world projects, like the interactive story project and doll-maker, contain micro-game and *game-like* elements, which, for the purposes of analysis, can be classified as subversive, non-classical, or, "toyplay" (Bateman & Boon 2006) games.

Figure 31. Participant designs demonstrating "Classic" game features.



	Rules	Outcome	Value	Effort	Attachment	Negotiable Consequences
All	17	19	18	19	18	21
Male	13	13	13	13	13	13
Female	4	6	5	6	5	8

Girls' designs, while not contained within a "classical" game design framework are, importantly, *intended* to provide a "game-like" experience for their user-player. Throughout the design process, female workshop participants consistently stressed their desire to make a "game" or a "game play" space for their individual projects, and discussed what types of games they enjoyed most. Most girls, anecdotally, were more interested in open-ended exploration and social gaming – demonstrated during free time when they would connect wirelessly for multiplayer gaming using their Nintendo DS's. It is both interesting, and revealing, that girls' preferred gaming and design methods fall outside of conventional game design paradigms. The exclusion of girls' preferences, in Juul's (2003) outline of the formal scheme of game design, has a profound resonance for understanding and helping to explain the gaps and conflicts that discursively and *real-ly* circulate around female participation in hegemonic spaces, generally, and which find extension with domain-specific concerns in regard to gender imbalance in masculine-defined fields such as IT, specifically.

Do female choices and preferences evade or lie outside of formal systems, or, do they just engage formal systems in divergent ways?

Table 15. Game Design Concepts (Girls)

Participant ID (P_number_gender)	Game Design Concept
P_001_F	**Banana Skateboarding** – *Objective*: Earn points for performing tricks on a half-pipe while riding a banana peel. Player will use combinations of the ASDF keys to create complex moves. The space bar will let the player jump and earn extra points for "air" on tricks. You're on a banana peel so the tricks will be harder to do and you'll often slip around if you're not careful. There will be a time limit for each round and the player should try and improve their score. Scores should be saved to a leaderboard or there should be a way to save "personal bests."
P_002_F **P_003_F**	**Game-based Interactive Music Video** – (Collaborative Project) *Overview:* A narrative music video with self-created digital music and vocals. The player will be able to interact with the video by clicking on hotspots in the scene to activate micro-games like the ones in Wario World.
P_004_F	**Fashion Plate** – *Objective*: Generate your own dolls, and create custom avatars using the model customization tool. For girls. You will be able to change your model's hair, eyes, skin colour, clothes and accessories. You will be able to save your model at the end to use in projects and on the web. You can save outfits in a closet to collect a wardrobe, too.
P_005_F	**Find Your Way Home Adventure** – *Objective*: Navigate through levels to guide your character safely home. Avoid obstacles and collect clues and treasure along the way. The changes in scene by level will help tell the story: Level 1 (Forest), Level 2 (Cave with sinking platforms and underground lake), Level 3 (City), Level 4 (Home neighborhood, locate your house to finish the game). The player will move the character using the keyboard.
P_006_F	**Explore and Find Adventure** – *Objective*: Try to locate all of the missing treasure in the game world. Talk to Non-player characters to get clues and find all the items to win the game. No enemies or fighting, just puzzle-solving – most of the clues will be riddles or math problems that you have to solve to figure out the location of the item.

P_007_F	**Adventures of Stickman** – *Objective:* Explore all nine planets in the solar system to reach your final destination … the Sun! You can explore levels in any order and can access them from a main "Universe" screen. Level design and obstacles will be based on the unique features of each planet, ex. Venus is hot and has sulphuric acid clouds so that level will have gas and lava obstacles. On levels you also can collect candy bullets for Stickman's health gun. If Stickman is injured he must shoot himself in the face with the candy to restore his health. *Trick Ending*: After all the planets have been explored a movie shows you being transported to the Sun, unfortunately, once you reach the Sun, you burn up and die.
P_008_F	**My Neighborhood Virtual World** – *Objective*: Exploration and mini-games with no defined end-goal, just for fun. The player gets to explore different activities in the neighborhood and can move from spot to spot through a main map. The mini-games will be "life games" like if you go into the McDonald's in the neighborhood, the game will be to serve as many customers their orders as fast as you can. If you visit the Community Garden you will have to take care of the plants, give them water and trims or they will die. Points collected during mini-games can be exchanged for money to buy stuff at shops or turned into good citizen points to increase your community reputation like buying carbon credits!
P_009_F	**My School Virtual World** – *Objective*: Exploration and Encounter-based 3D world with social games and conversations (inspired by Habbo Hotel and Farmville). Sandbox game, no end goal – the objective is having players explore and interact with the things they come across in the school world. The characters will be based on friends and classmates and players will also get to customize their characters (clothes and physical appearance). The world should be a space that reflects mine and my friends' own experience so the spaces will be the class room and in school for the environment.

Table 16. Game Design Concepts (Boys)

Participant ID (P_number_gender)	Game Design Concept
P_010_M	**Street Bounty Hunter** – *Objective*: Guide The Rock to finding 50 Cent to deliver him to prison and collect the bounty money. Exploration/Adventure game with hand-to-hand combat and cool evasive actions for The Rock like somersault jumps to avoid enemies

	like junkyard dogs. No blood. Soundtrack. Movements controlled by keyboard.
P_011_M	**Revenge** – Action adventure game with serious, emotional, dramatic story. Objective: Solve puzzles to unlock the main character's story and resolve his mysterious conflict. Inspired by Silent Hill. This game will be an exploration of mood and all of the puzzles will be to help the main character resolve his feelings of revenge. Each puzzle solved will go to a cut scene which will explain more of the main character's back story. Point and click adventure.
P_012_M	**Mountain Bike Obstacle Course** – *Objective*: Use your mountain bike skills to jump and avoid obstacles on an urban mountain bike course. Many courses with a race element option. Player will use the keyboard to move the bike and perform jumps.
P_013_M	**Street Bond: Out for Blood** – *Objective:* Lead the main character Street Bond (hip hop James Bond) through encounters with enemies in this shooter style action / revenge game. There's no goal, just revenge and a lot of enemies to defeat as you move through the city. Option to toggle blood on and off.
P_014_M	**Pokemon Escape** – *Objective:* You are a Trainer who has to navigate your chosen Pokemon over treacherous terrain while you are being chased by evil species. Temporarily capture and use wild Pokemon to reach special platforms or get over hard obstacles. Use deep sea Pokemon to move through a secondary underwater course if you don't want to go by land! Reach the end of the course to win. Inspirations: Pokemon and Extreme Pamplona. Keyboard is used for movement.
P_015_M **P_016_M**	**Star Wars Droid Ship** – (Collaborative Project) *Objective*: Find your way out of the maze-like Engine Room of the Droid Ship while defeating enemies, avoiding obstacles, and collecting items. Use steam jets in the engine room to catapult to higher regions. The Engine Room is divided into four parts and the player can choose to get to other screens (parts of the room) by moving to the top, bottom, left, or right boundaries of the starting screen. The player will start out in the middle of the first screen. You will use a lot of the keyboard. Arrow keys to move and space to jump, but there will be special actions that you can perform with secret keys.
P_017_M	**Street Legal Racing** – *Objective:* Time trials. Beat your best time or race against computer-controlled ghost car to win. Multiple courses, city streets location. Would like to use a game pad to play this game but Scratch can't? So if you can't use a game controller the player will use the keyboard to move the car.

P_018_M	**Forest Labyrinth** – *Objective:* Find your way out of a forest maze filled with traps. Avoid enemies and collect treasure on the way. There will be an inventory system that will keep track of the different items you collect. Treasure will earn you gold and there will be a health meter – if you are injured in a trap or by an enemy you will lose a certain amount of health points depending on the type of trap or enemy. You will also be able to find and use a variety of weapons. You will be able to choose your weapon by pressing a hot key or by selecting it from your inventory. There will be a HUD at the top of the screen where you can see your health, inventory (items and weapons), and gold.
P_019_M	**Robot Battle Gods** – *Objective*: Fight your robot against computer controlled robots in a ring battle to the death. You can choose from many robots, each have their own special weapons and abilities that give you advantages or disadvantages against certain opponents. You have to defeat your opponent before your life meter runs out and you earn points based on how hard your enemy was to defeat. You have offensive and defensive poses so you don't always attack, you have to know when to defend too.
P_020_M	**Mario in SonicLand** – *Objective*: Move through a multi-universe as Mario to defeat Dr. Robotnik with Sonic's help. There will be two difficulty levels with save points and options to continue that are different based on the difficulty level chosen at the beginning of the game. On the Easy level there is no score, but you get infinite continues. On the Hard Level you have to earn continues and have limited lives but you get points. This is to encourage people to try the Hard Level. Each level will have mini-bosses and coins to collect.
P_021_M	**Pac-Man –** *Objective:* Clone Pac-Man maze game. Avoid ghosts, collect fruit and power-ups to defeat the ghosts. Clear all the pellets in each level to get to the next level. You will use the mouse or keyboard to control the Pac-Man.
P_022_M	**Battle Cards** – *Objective:* Card based battle system based on YU-GI-OH. Play against a computer opponent. Randomly generated cards used to Duel against each other. You start out with 8000 life points and 40 randomly generated cards. The duel is turn based and you use your Monsters, Spells, and Traps cards to fight your opponent and damage his life points. Fight until your opponent's life points are zero OR the opponent can't draw a card because their deck is empty OR you automatically win because you got all 5 pieces of Exodia the Forbidden One. There should be an option for playing against a real player or choosing a computer player. If the opponent is a real player they also can choose to surrender, meaning the other player wins.

P_023_M	**Go-Kart Racing** – *Objective*: Race your custom go kart against computer karts. Get the best time to win the round. There will be a lot of courses to choose from. If you are in the top three of a round there is a ceremony and you get a trophy. Try and get gold trophies on all the rounds to be the best.

Girls' game design strategies are, in fact, highly complex, so we can look at the results of "fit" with formal game features as being somewhat misleading. Aspects of the girls' game designs take up, albeit partially, each of the structural qualities of classic game design, but, there is no full buy-in to the features, excepting the marginal and ill-defined category of Negotiable Consequences. Girls' games are fundamentally borderline cases. It is worthwhile to examine Juul's (2003) six primary features in turn, with respect to the girls' game designs, to explore how each category is interpreted and modified to match the girls' design preferences. Analysis is derived from review of design documents, as well as from unstructured, one-on-one interviews conducted with the participants during the design phase.

Rules

Juul (2003) notes that game rules are "well defined," "unambiguous." Conversely, "folk" or "non-commercial" games have rules that have ambiguous tendencies – "ingenuity" is required to "play," but not to "uphold the rules." Only 4 out of 8 game designs in the girls' workshop have "unambiguous" rules; however, 7 out of the 8 total projects have clearly defined rules of engagement for subsets of their designs. "Rules," here, minimally guide user experience, when the experience can be enhanced by a focused structure, or, are integrated into micro- or “twitch” games, which mimic the kinds of 5-10 second games that Wario Ware Inc. has popularized.

Variable and Quantifiable Outcome

A game “must provide different possible outcomes” and match the skills of the player (Juul 2003), and provides an unambiguous outcome (or goal). As Juul (2003) notes, Massively Multiplayer Online Role-Playing Games such as World of Warcraft and Everquest prioritize an open-ended gaming experience that is always already in progress and thus, suspends the outcome of the game – perhaps indefinitely. As such, the outcome of the game is not the quality that makes the game meaningful to the player and, while outside formal game classification systems, does provide micro-outcome possibilities for players in the form of sub-quests, campaigns, or mini-games that the player can engage. The idea of embedded micro-outcomes is a feature of 6 of the 8 games designed by the girls’ during the workshop and is foregrounded in the exploratory and virtual world designs, particularly. As well, six of the games designed by the girls include more formal instantiations of the variable and quantifiable outcome feature. The two sets of games, here, are nested.

Outcomes, in the majority of girls’ games are fluid because game goals are less oriented towards competitive play and more directed towards open-ended exploration and player experience. It is worthwhile to note that complex outcomes can be linked back to the lack of rule rigidity within girls’ game designs, proper.

Valorization of Outcomes

The game must provide outcomes of different value – that is, some outcomes will be better than others (Juul 2003). Five of 8 games elaborated in the girls' design documents express variable play experiences, which usefully result in correlatively variable outcomes. More uniquely, virtual world designs offer mini-game experiences, for example, which translate into global game gains to enhance play including spendable money or "good citizen points" as rewards for completing micro challenges. In this sense, outcomes of different value can be more highly personalized and, in fact, internalized by players – transforming extrinsic motivations for game play (higher score, for example) into intrinsic motivations (becoming a better virtual citizen, for example). In girls' games, game goals, challenges, and outcomes are largely determined by the player who is afforded choice among a diverse range of game play experience afforded by the open-ended designs.

Player Effort

Player effort can be understood as the level of challenge offered by the game, or, may indicate that the game contains a conflict or is interactive (Juul 2003). All outlined games (8 out of 8) are interactive, 6 of 8 games incorporate conflict or challenge into the game play experience. Challenge or conflict in the girls' games include level time limits, obstacles, and puzzle solving.

Player Attached to Outcome

Attachment to outcome is a psychological feature of game play, which operates by convention. For example, a player is "actually" happy if he or she wins, and "actually" unhappy if he or she loses (Juul 2003). As the girls' game designs are more closely connected to experience generation than traditional game play, many of the designs do not specify "winning" or "losing" outcomes. Only 4 of the 8 designs incorporate traditional scoring and outcome systems, which lead the player towards a game end condition. Many of the designs; however, are geared towards the production of enhancing player mood and competency levels by encouraging creative exploration of the game spaces and the self-construction of game play goals. Outcomes, here, are self-generated and dynamic, and are thus, arguably, more available to attachment than offered through conventional gaming experiences. Global satisfaction, as a continuous goal of a number of the girls' game designs, has a psychological complexity and difficulty in instantiation and maintenance throughout the game play duration than reductionist motivations towards a "winning" or "losing" end goal controlling player affect. Choice, here again, is prioritized – and attachment to outcome (the weight an individual player provides to a given consequence) is player determined.

Negotiable Consequences

Negotiable consequences refer to the fact that a game can be "optionally" assigned real-life consequences (Juul 2003). All 8 of the girls' games support consequences that are bounded within the game play experience and are not necessarily transferrable to the real world.

6.3.1.2 Analysis of Programmatic Constructs used in Creative Programming Activities

The Scratch programming environment affords evaluation of a number of key foundation programming concepts.

Programming Constructs Reviewed

1. Sequence: Logical ordering of program
2. Looping: Use of <forever> or <repeat>
3. Conditions: Use of <if>, <forever-if>, <if-else>, <repeat-until>, <wait until>
4. Variables: Creation of either a global or object-specific variable and used in program
5. Threads (Parallel Execution): Launching two program stacks at the same time to create two independent threads that execute in parallel
6. Synchronization: Use of <broadcast> to coordinate the actions of multiple sprites
7. Boolean Logic: Use of <and>, <or>, <not>
8. Event Handling: Use of <when key pressed>, <when sprite clicked>: event handling to respond to events triggered by the user or another part of the program
9. Object-oriented Programming: Each sprite has its own scripts and data (NOTE: Scratch does not support classes or inheritance)
10. User Interface Design: Creation of buttons for user interaction/interface design
11. Data Types: Use of data types such as numbers to control, for example, x and y position of a Sprite on the screen

In addition to evaluation of the programming constructs specifically afforded by the Scratch environment, participants' digital artefacts were assessed according to the ACM's curriculum model for K-8 computer science education. The ACM's Level I curriculum suitable for K-8 CS education prioritizes algorithmic thinking and problem solving. Broadly, students should become comfortable with using computational tools for problem solving and communication, gain competency in self-directed learning, and develop collaborative and cooperative skills for team problem solving. Algorithmic thinking, here, includes the capability to engage step-by-step problem solving using conditionals (“if” statements) and repetitions (loops or “while” statements).

Case Study: Maze Game Creation

Workshop participants designed and programmed a basic maze game using programming concepts practiced in prior session activities, which included variables, loops, and conditions. The activity also required participants to build new knowledge, specifically, how to make use of Scratch’s sensing and control blocks to program simple collision detection and event-handling procedures.

The activity outline provided participants with a general structure to guide their game design and development. Design guidelines indicated that each game should have

1. an end goal for the player to attain (such as a clearly represented maze exit);
2. a player sprite that could move by responding to user input (keyboard or mouse);
3. challenging obstacles (such as enemies or barriers/traps); rewards (items to collect, such as treasure);
4. a scoring system to track player encounters with obstacles and/or rewards; and
5. a bounded environment (maze walls should not be penetrable).

Workshop participants took 6 sessions to complete their maze games, with each session focused on implementing one of the core game elements as outlined in the activity directions.

Participants' maze game projects demonstrated a good grasp of the core programming concepts required to implement an interactive experience for their user (see Figures 32, 33, and 34). All projects showed understanding of sequential logic and program ordering. ACM Level 1 priorities (algorithmic thinking, variables, loops, and conditionals) are well represented with 100% of all participant projects evidencing algorithmic thinking (sequential logic), 57% making use of repetitions (loops), and 91% implementing conditionals ("if" statements) into their game projects.

Figure 32. Maze Game Project (Programming Features Used by Project: All Participants)

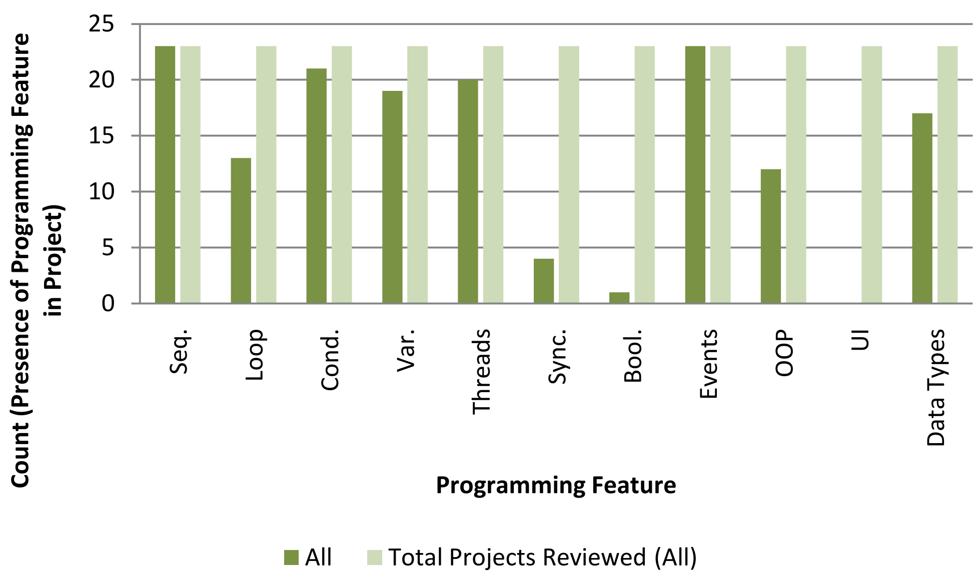


Figure 33. Maze Game Project (Programming Features Used by Project: Boys)

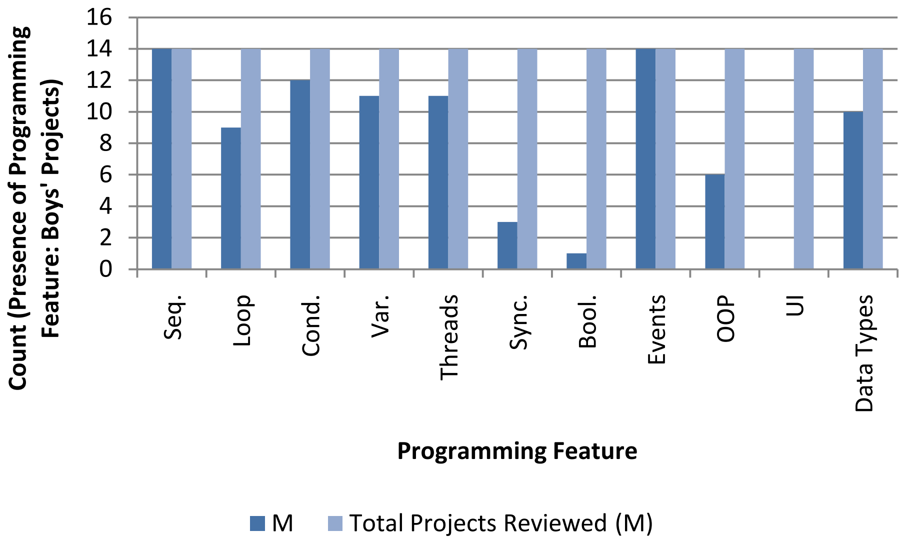


Figure 34. Maze Game Project (Programming Features Used by Project: Girls)

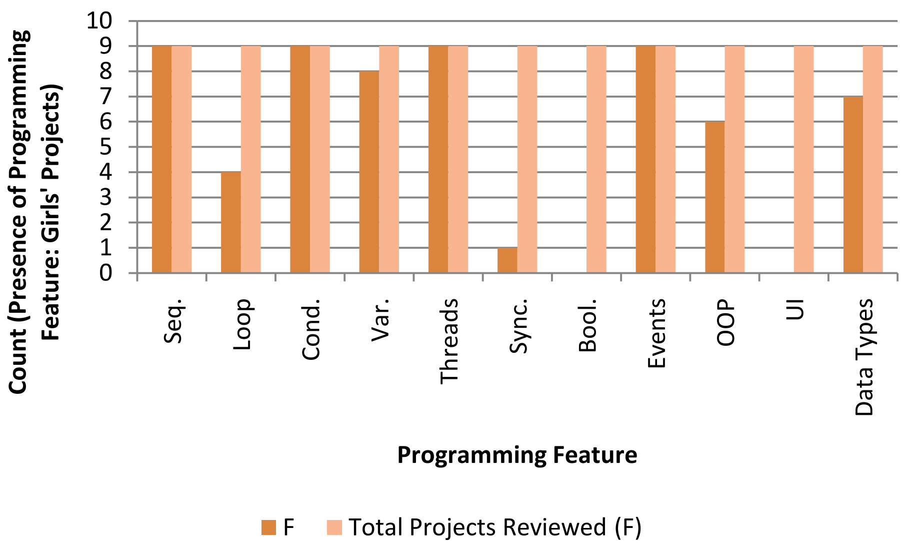


Figure 35. Participant (F) Maze Game Example

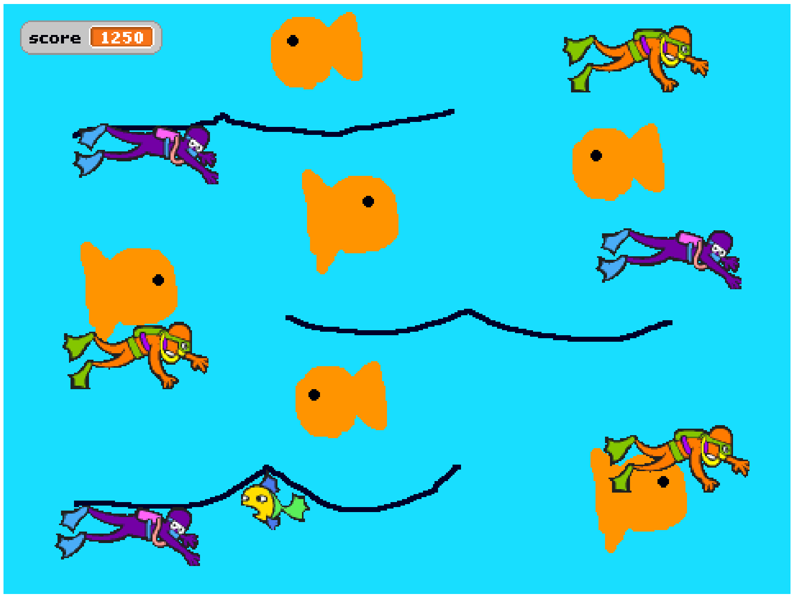
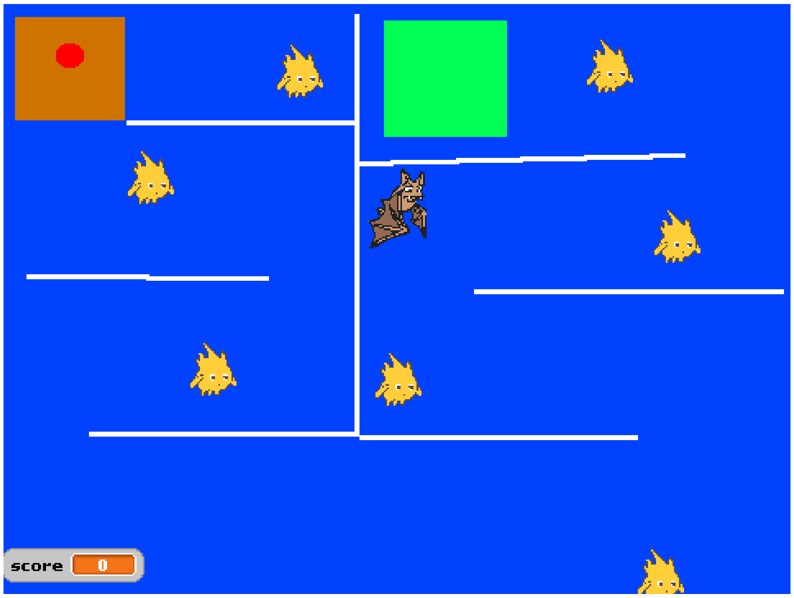


Figure 36. Participant (M) Maze Game Example



Two experts, including the researcher, evaluated the participants' Maze Game code for presence or absence of the 11 core programmatic features supported by Scratch. An inter-rater reliability analysis using the Kappa statistic and Krippendorff's alpha was performed to determine consistency among raters with a starting sample of 6 games. The inter-rater reliability for the raters was found to be Kappa = 0.747 ($p<0.001$), Krippendorff's alpha = 0.747, with average pairwise percent agreement of 88%. Differences in scoring stemmed from one rater's interpretation of the <forever if> construct as counting both as use of loop and conditional, as opposed to being understood as a conditional statement solely. One further point of difference was the interpretation of the presence of the scoring variable on screen as constituting a user interface element. Raters conferred with regard to the definitions of problematic programmatic constructs and UI features until consensus was reached prior to coding the full sample. Inter-rater percentage agreement for the full sample was 100%, with kappa coefficient of 1.0.

Case Study: Final Projects

No formal external constraints for guiding game structure or making use of specific programming constructs governed participant final project design and development. I expected participants to draw upon their existing knowledge to design and program an interactive experience for a user. While the facilitator provided just-in-time guidance and targeted tutorials to scaffold participants' programming activities, participants took initiative in defining their own problem spaces. For example, many participants sketched out their programming problems in pseudo-code or used diagrams to organize the flow of interactions they were interested in programming. While much of the programming required for instantiating their game designs was more advanced than their current knowledge base, all participants achieved significant results in the design phase of their project. Evaluations of participant final projects looked for evidence of considered use of foundation programming constructs introduced over the course of the workshop; and were divided into two assessment groups: projects in-progress and finalized projects. Only one participant (male) did not advance from the design document phase.

In-progress projects included projects where programmatic implementation of design and interaction features had begun; but had not reached a sufficiently "playable" phase by workshop close-out (see Figures 37, 38, and 39). Participant focus on the creation of art assets, and immersion in exploring complex programming problems related to game mechanics development typified in-progress projects. For example, one male participant spent 4 sessions programming a complicated "fog of war" effect for his game. The elegance of the final solution, which took many hours of testing and debugging, was a significant achievement.

Figure 37. Final Project (Programming Feature Used by Project – In-Progress Games) – All Participants

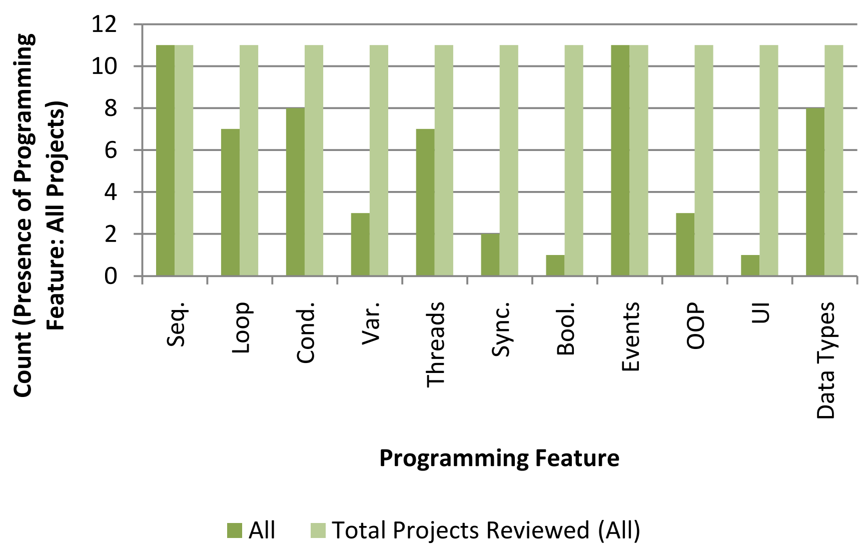


Figure 38. Final Project (Programming Feature Used by Project -- In-Progress Games) – Boys

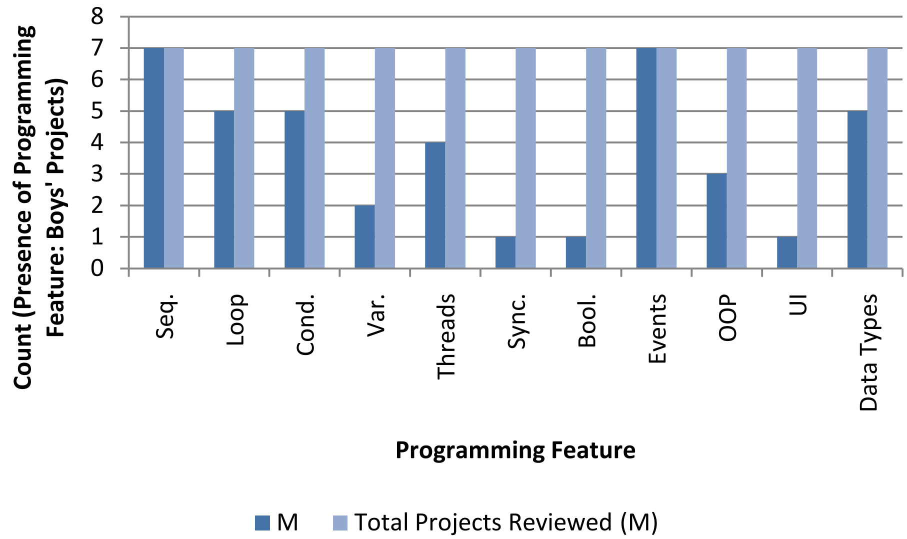
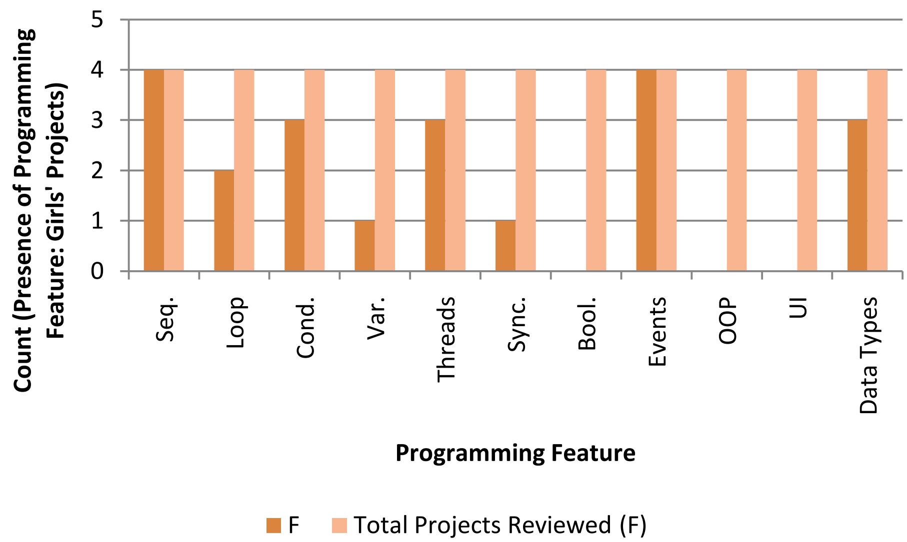


Figure 39. Final Project (Programming Feature Used by Project -- In Progress Games) – Girls



Projects were assessed as “finalized” for the purposes of project evaluation if a game level, or activity sequence for a virtual world, (a) demonstrated evidence of a playable goal; (b) afforded interaction such as user control of a character or customization option; and (c) attempted experience structuring through the implementation of user interface elements (see Figures 40, 41, and 42). User interface elements could include start screens, or HUDs (Heads-Up Displays) with score or health accounting. Participants' final projects showed 100% evidence of assimilation of algorithmic thinking (sequential ordering) and conditionals ("if" statements). Sixty-seven percent of all final projects made use of repetitions (loops). Male participants made extensive use of loop constructs to create user controlled object movement, while female participants made wider use of event triggers to accomplish the same effect (see Figure 43 for example).

Figure 40. Final Project (Programming Feature Used by Project -- Finalized Games) – All

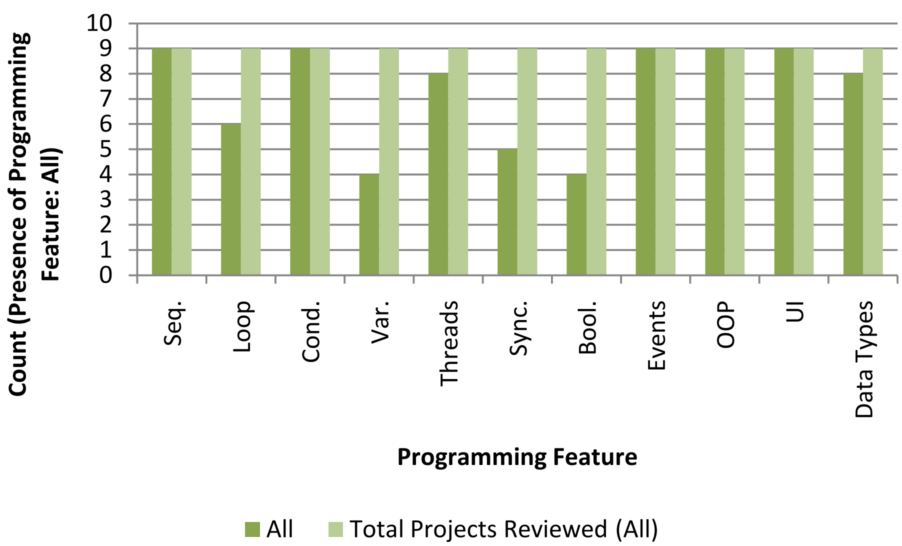


Figure 41. Final Project (Programming Feature Used by Project – Finalized Games) -- Boys

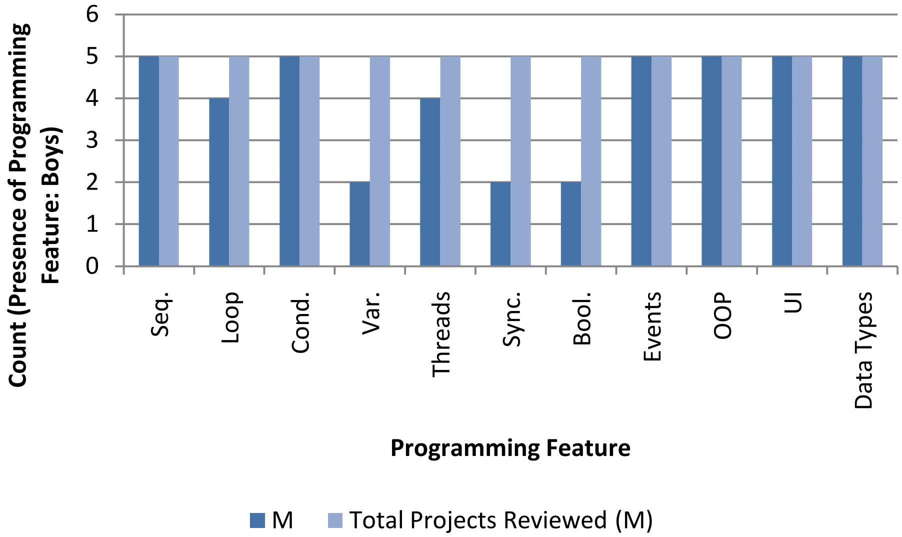


Figure 42. Final Project (Programming Feature Used by Project – Finalized Games) – Girls

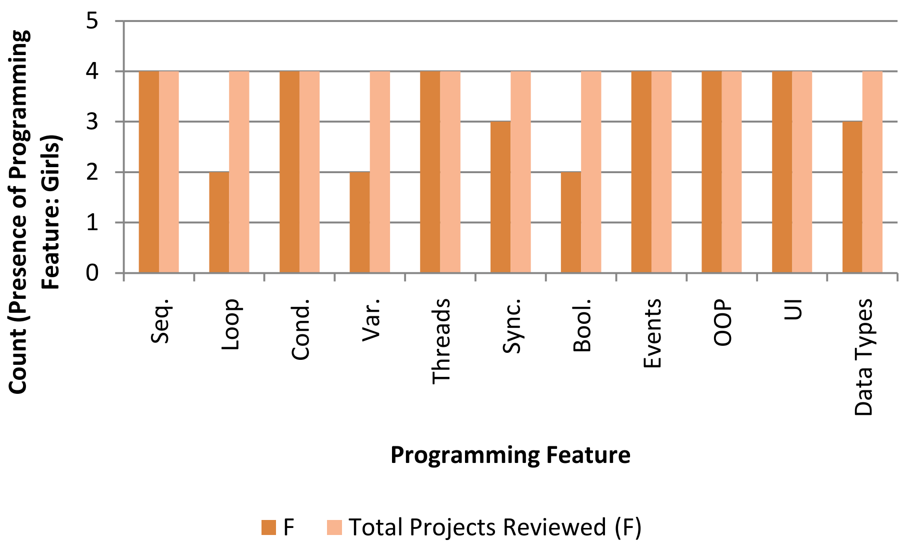
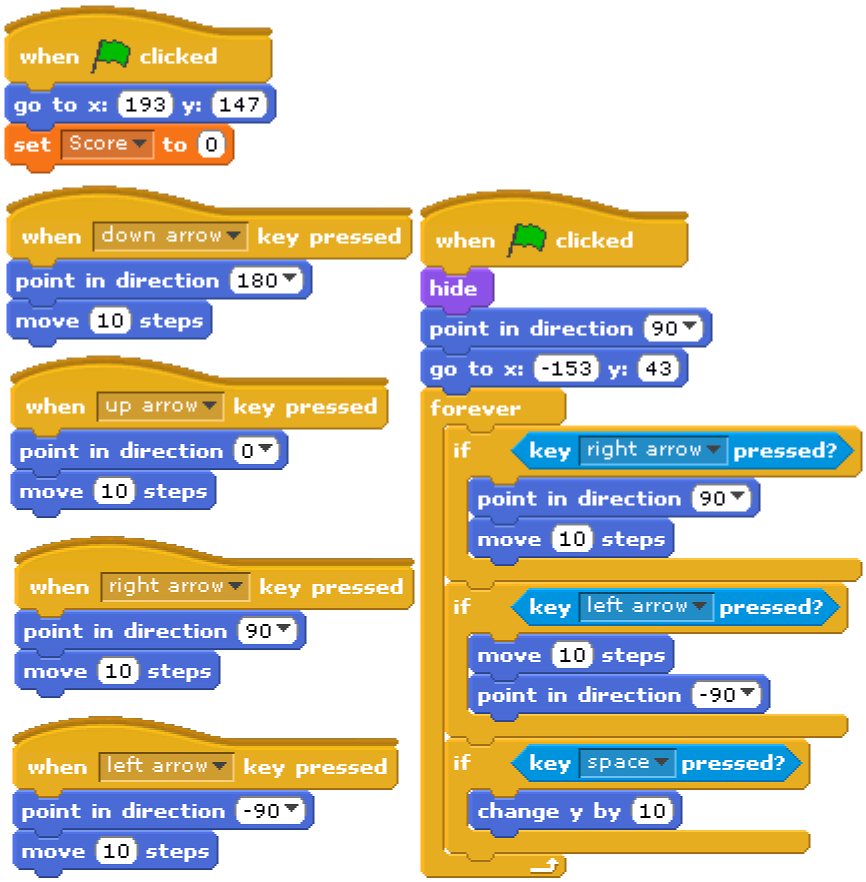
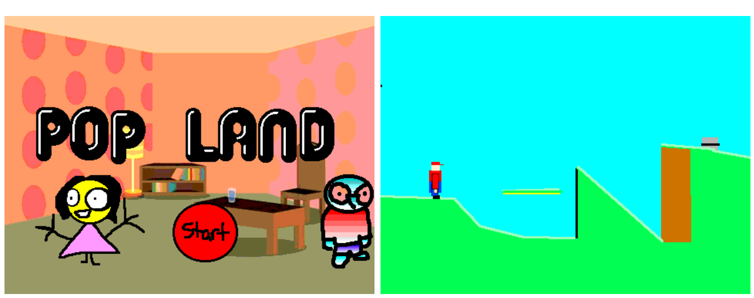


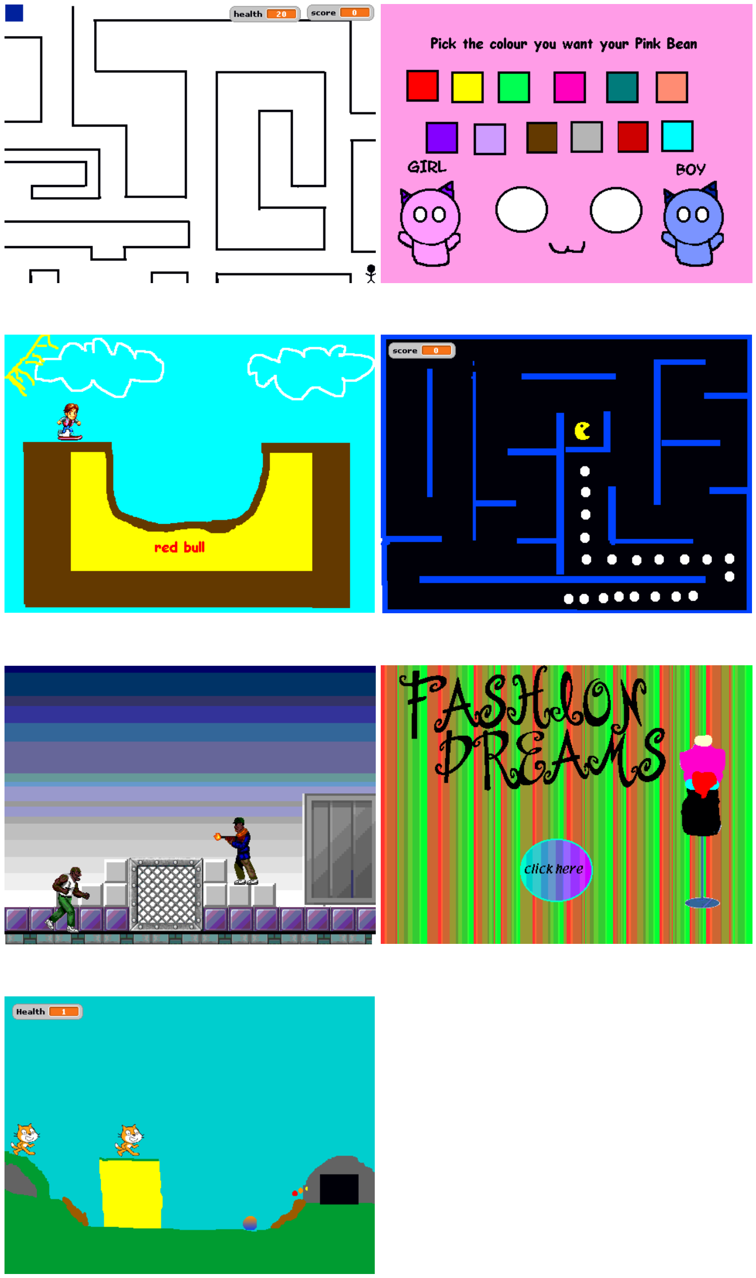
Figure 43. User controlled object movement in Scratch created using Event Triggers (left) and Looping Constructs (right)



Two raters, including the researcher, coded finalized and in-progress final projects for programmatic construct evaluation. Inter-rater percentage agreement was 100%, with kappa coefficient of 1.0.

Figure 44. Sample screenshots from participants' final game projects (finalized games).





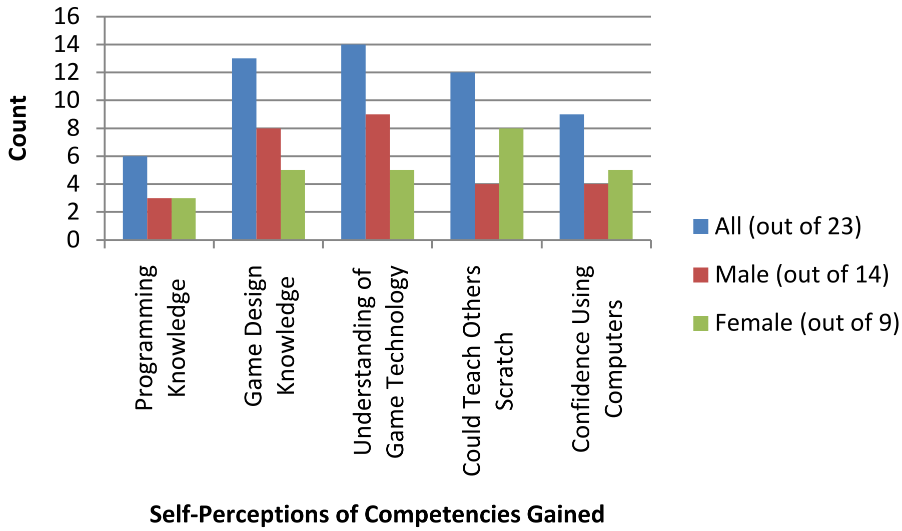
6.3.1.3 Program Evaluation

At the conclusion of the intervention, participants were asked to complete a short, 5-item feedback survey designed to explore components of the learners' quality of experience over the course of the intervention. Twenty-three participants (9 girls and 14 boys) received the evaluation, with 3 participants answering every question, 2 participants responding to 4 of the 5 questions, and 18 participants answering 3 of the 5 questions. All respondents rated the quality of the experience in the workshop (Q1) and indicated their preference for workshop context with regard to same-sex or mixed-sex workshop sessions (Q5).

The mean rating of quality of overall experience in the workshop was 4.3, where 1 indicates a “poor” experience and 5 indicates an “excellent” experience. Mean experience rating for girls was 4.2 and boys’ mean rating of experience in the workshop was 4.4. Forty-eight percent of all respondents (11 out of 23) indicated that they preferred separately held workshops for boys and girls, while 52% (12 of 23) of respondents preferred boys and girls together in workshop sessions. Eight out of 9 girls (89%) preferred gender-separated workshop sessions, while only 3 out of 14 boys (21%) preferred workshop sessions to be held separately for boys and girls.

Participants were also asked to reflect on what kinds of competencies they felt they had gained over the course of the workshop (Q2). Respondents could select “all that apply” and were given five options to choose from including: a) have programming knowledge I wouldn’t have had otherwise; b) have knowledge about game design I wouldn’t have had otherwise; c) understand the technology used to create games; d) could help others use game creation software like Scratch; and e) have confidence using the computer and computer software.

Figure 45. Participant self-reports of perceived competencies gained during the intervention.



Five out of 23 (3 boys and 2 girls) participants responded to the open-ended question: "What were the 3 things you liked best about the workshop?" (Q3). All 5 indicated that "making games" was the best part of the experience, with 3 respondents listing learning Scratch as one of the most positive aspects experienced, and 2 respondents listing "learning new things," "working with others," and "the instructor" as some of the most positive aspects of the intervention. Only 3 respondents (2 boys and 1 girl) completed the section, which asked "What are 3 things you would change about the workshop if you could?" (Q4). All 3 respondents indicated that having more time to work and more overall sessions would have improved the experience. Two of the 3 respondents stated that having more instructors participating in the sessions would be a change they would make for a future iteration of the workshop.

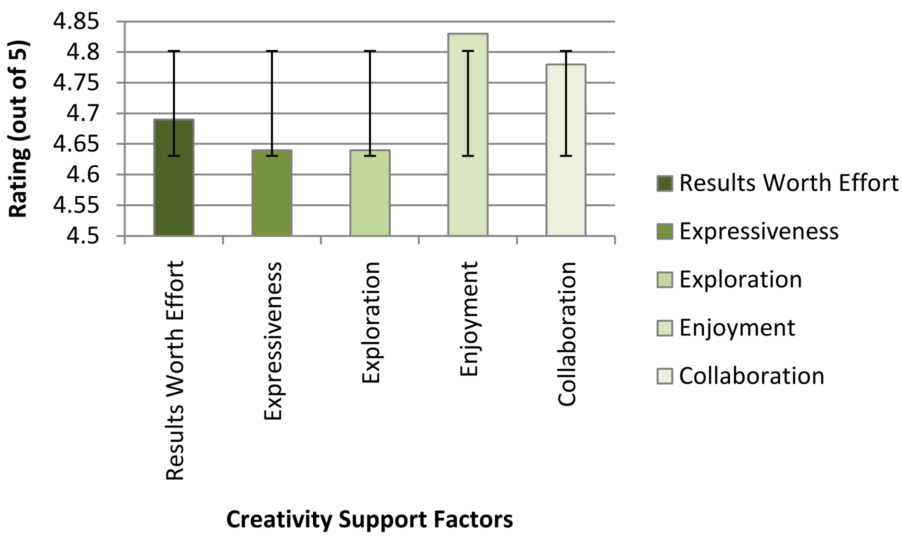
6.4 Creativity Support

A modified version of the Creativity Support Index (CSI) (Carroll et al. 2009) to measure the Scratch application's affordances for creativity in digital media creation with novice users was piloted with participants attending the Digital Storytelling workshop at a local children's festival over a 3 day period. The Digital Storytelling festival workshop was run as a condensed, hour long paired-programming version of the primary intervention, and was designed to provide participants with an introduction to the Scratch tool through a structured session in collaborative interactive storytelling design and development. The festival workshop was attended by 108 children between the ages of 8 and 13 (56 boys and 52 girls). Of the 108 participants, 64 completed the CSI survey distributed at the end of each session.

The CSI metric's language was modified to be more accessible to the participant age group, as well, one question concerning "transparency" of the tool to the user (measuring immersion, or, "flow" experience) was removed as the construct would not be understandable to the demographic self-reporting. The sliding scale metric used in the original CSI to generate ratings from 0 to 10 was replaced by a "smiley-o-meter" (Read 2008, Read & MacFarlane 2006) 5-point scale to facilitate younger participants' selection of a rating appropriate to their experience. The delivered survey consisted of 5 questions rated on the symbolic 5-point scale from "Highly Disagree" to "Highly Agree" (see Figure 46). Participants were asked to rate the following statements: 1) What I was able to make using Scratch was worth the effort I had to give to make it (Results Worth

Effort creativity factor); 2) I was able to be very creative while doing this activity (Expressiveness creativity factor); 3) It was easy for me to try out different ideas using Scratch without becoming bored (Exploration creativity factor); 4) I was very absorbed in the activity – I enjoyed it and would do it again (Enjoyment creativity factor); and 5) It was easy to work with other people using Scratch (Collaboration creativity factor).

Figure 46. Mean ratings for Scratch's creativity support affordances.



The CSI allows for calculation of the tested tool's creativity support index between 0 and 100 by summing factor values (23.58) and multiplying factor sum by 4 to achieve a global index score (94.32) out of 100. While all of the creativity support factors evaluated for Scratch received high positive ratings, tool support factors connected to enjoyment (Item 4) and collaboration (Item 5) were scored highest (*M*= 4.83 and *M*=4.78).

7: DISCUSSION

The aim of this research project was to gain an understanding of girls' lived realities and activity preferences towards the formulation of a heuristic model supporting the connection of girls, more authentically, to non-formal, technology-mediated learning opportunities. Preferences revealed through activity modelling, observations of engagement during the course of technology-creation activities, content analysis of digital artefacts produced during the workshop, and participant program evaluation contribute to the analysis and discussion of this primary aim.

7.1 Limitations

The exploratory study detailed in this thesis has several limitations. The small sample sizes and purposeful selection of a sub-group focus for the research prohibits generalizability of results to a larger population. The participant composition of the intervention study group, additionally, was variable throughout the duration of the intervention. During the intervention, participation was irregular due to boys' and girls' conflicting extra-curricular and academic commitments. As well, a number of participants had diagnosed learning and social cognitive disorders or behavioral conditions, which impacted their ability to fully engage with the study activities. All of these limitations impact external validity and make the results difficult to generalize to a wider population of learners in other learning settings.

Additionally the lack of a control group or condition for studying environment affordance factors for technology-fluency promotion reduces the study's ability to generalize its findings outside of the specific context of the intervention's design and implementation. A comparison of outcomes between non-formal and formal learning environments and / or between intervention iterations would assist in the validation of the proposed heuristics derived from the analysis and interpretation of findings in the current study.

Issues with subjective interpretations of observational data in the collection and analysis phases, resulting from the absence of multiple raters for engagement and disaffection factors, diminish the reliability of the findings. As well, the variability of children as study participants and sources of data limit the elicitation of reliable data for analysis, which may weaken study findings and compromise the reproducibility of results.

Further limitations are related more directly to the implementation of the intervention. Problems with scheduling and access to resources (technology and support resources) during the intervention affect the internal validity of the results. The ability to provide more workshop sessions on more days of the week, in addition to providing for more in-session facilitators to supervise and assist in learning activities would contribute to results more accurately reflecting the positive impact of the intervention for technology fluency objectives.

7.2 Explanation of Outcomes

Several salient findings were illuminated in the study described in this thesis. The results of the study show that processurally enacted, participant-centered activity and context adjustments derived from formative assessments lead to increases in learner engagement and decreases in learner disaffection. Preferences revealed through studies of girls' everyday activities, observations of engagement with technology creation tasks, and analysis of girls' game designs and workshop feedback contributed to the development of a flexible set of heuristics to guide intervention design for targeted technology fluency objectives.

7.2.1 Preferences and Learning

Time, Activity, and Context Preferences

Activity analysis found that the girls surveyed spend more time using the computer (1.1 hours on average per day) and playing video games (0.92 hours on average per day) than boys (0.63 and 0.77 hours respectively). These results point to emerging trends, supported by recent research (Fallows 2005, Gross 2004, Miller et al. 2001, Statistics Canada 2009), which suggest girls' use of technology is equalizing to boys.

Additionally, the introduction and rapid assimilation of portable gaming devices such as the Nintendo DS and Gameboy into girl culture may help to explain the positive differential in time spent in video game play between girls and boys revealed in this study. Eight out of 9 of the female workshop participants (89%) informally reported owning a portable console, compared to only 3 out of 14 boys (21%), who primarily engage video games on the internet or on conventional console systems such as the Xbox or Playstation. The Pew Internet & American Life Project (Lenhart et al. 2008) reports that 99% of boys surveyed and 94% of girls play video games, with girls gaming experiences often social in nature, supporting the game play findings captured by the DRM and workshop observations.

Further analysis of time-use data suggests that girls have globally positive responses to time spent in school, 77.5% of time in school is spent in either a mildly pleasant or in very good mood. Girls' highest level of net affect and general satisfaction while in school are when socializing (3.64 out of a maximum rating of 6 and 7.29 out of a maximum rating of 10, respectively). While time spent in class is rated relatively low on net affect and general satisfaction scales (2.51 and 5.56), opportunities at school for engaging in socially oriented activities, including sports and extra-curriculars, contribute to girls' generally positive experiences within the school context. Such findings indicate that learning, which can be connected to girls' preferences for social situations and engagements may show a correlative increase in general satisfaction and net affect.

Girls enjoy both structured (sports and extra-curricular activities) and unstructured (free time socialization) social opportunities with highest levels of general satisfaction, net affect, and perceived competency reported when engaging in non-sports related extra-curricular activities (7.86, 5.08, 5.25) at school such as choir, computer club, and reading club. Research in the domain of non-formal learning supports these findings and conclusions (Barnett 2005, Fujita 2006, Salkind 2008), showing that positive individual level learning outcomes attached to students participating in extra-curricular activities may result from the links that are established to peers in the development of an “activity-based culture with shared norms and values” (Salkind 2008). It has also been suggested that extra-curricular activities provide adolescents with opportunities to explore identity, try out “new things” and explore learning limits (Barnett 2005) – factors, which were expressed in participants’ program evaluation self-reports that counted “learning new things” as one of the most positive aspects of their experience in the Interactive Storytelling and Game Design workshop.

Barnett (2005) has shown that girls active in extracurricular activities report gains in emotional competency, a finding supported by girls’ activity survey reports of high positive perceived level of competency (*mean* 5.25 out of a maximum of 6 rating) when engaging in non-sports related extracurriculars. Positive learning outcomes associated with participation in structured activities outside of the traditional school curriculum, additionally, have been revealed to be independent of differences in learners’ background and prior academic achievement (Fujita 2006), although direct cause and effect relationships between academic achievement and participation in extra-curricular activities cannot be shown due to the confluence of mediating variables that are difficult, if not impossible, to identify or separate out in analysis.

A primary difference that emerged out of gender disaggregated analysis of participants’ activities was in responses to chores and homework categories.

When engaging in homework activities, girls' ratings of satisfaction, net affect, and competency were significantly higher than those reported by boys. Girls' *mean* satisfaction rating for homework was 6.0 out of a possible 10, while boys' *mean* satisfaction rating was 5.2. Similarly, girls experienced higher levels of net positive affect and competency (3.52 and 4.0 out of a possible 6.0, respectively) than boys (2.82 and 2.2). When reporting chores, girls' net satisfaction was higher than boys' (5.47 compared to 4.8), while net affect and competency ratings were comparable. When engaging in class-based work at school, girls' self-perceptions of competency were rated much higher than boys' (mean rating of 3.5 versus 2.2), while mean levels of experienced satisfaction and net affect were almost identical. One explanation for these disparities might lie in the differential valuation of the personal reward that can be elicited from effort expended to successfully complete a task, even if the task does not hold intrinsic motivation for engagement, such as available through freely chosen or leisure activities. Research has suggested that higher levels of self-concept and apperception of both the intrinsic and external benefits of "work," are indicative of more highly motivated, competent, and achievement oriented individuals than those with low self-concept who require more external motivation for realizing competency and driving achievement (Jiang et al. 2005) and may, in turn, compose broader indicators of "goal-oriented" behaviours. Increased awareness of the gendered effects of motivation assists in targeting interventions more closely to a big picture model, which links learner processes of achievement to developmental self-efficacy outcomes. Here, emphasizing enhanced understandings of how self-perceptions of “ability” and associated affective dimensions may impact attainment of the objectives of the intervention can facilitate the design of learning and engagement contexts best suited to particularized populations.

Analysis of general well-being shows some interesting and relevant divergences between boys and girls, which can be significant for targeted intervention design. Results suggest that while there are strong correlations between satisfaction in life dimensions (life as a whole, home, and school) for boys, only moderate correlations exist for girls, with the strongest relationship found between life at home and life as a whole. Satisfaction at school did not appear to have deep correlations to either home or life as a whole for girls indicating that girls may tend to compartmentalize experiences more than boys. Finding ways to positively connect intervention activities with the domains of significance for both boys and girls could assist in bridging the domains of life and school that seem relatively disconnected for girls.

7.2.2 Observations

While the results of the initial structured observational assessments were useful in making critical early stage adjustments to activities, providing direction for creating environmental affordances for different learning needs, and for assessing changes in participant engagement and disaffection over time, the instrument does not provide a complete depiction of the complex negotiations with social and learning “work” that participants experienced.

A fuller narrative of engagement and disaffection emerged out of informal discussions with the participants both collectively and in one-on-one conversations about their needs and experiences within the workshop and in engagement with learning (both formal and non-formal) more generally. Specifically, learning challenges such as dyslexia and autism spectrum disorders were inappropriately observed as disaffected emotions and behaviours in Phase One. Phase Two observations benefitted from the identification of learning and engagement obstacles for individual learners and subsequent modification of learning activities and related contextual factors to more fully support the needs of the participants. For example, to increase the accessibility of learning material, I incorporated ordered screenshots into take-aways to assist participants with developmental reading disorders and low reading comprehension skills in recognizing Scratch interface elements and code blocks referred to in text within tutorials. Additionally, Scratch's colour coding of scripting categories facilitated user recognition when participants could not easily read textual labels. It was important, when delivering verbal instructions, to include script colour referencing to ensure all participants were able to progress uniformly with activities. Providing deepened contextual cues eased participants' frustration and anxiety with the programming process. Challenged learners quickly became familiar and comfortable with simple programming tasks by memorizing the colour category that often-used blocks were associated with as well as the order within the toolbox they were located. Live, projected demonstrations of coding were essential, as well, for providing visual modelling of processes for participants to imitate until competencies were developed. The second phase of structured observation collection for engagement and disaffection, additionally, was co-incident with initiation of individual participant design projects. Results reflect some increases in engagement and decrease in disaffected behaviours as session work became more closely connected with individual participant projects and individual learner needs requisite to project conceptualization and actualization.

Participant feedback throughout the workshop (formalized in the intervention close-out self-report) revealed that learners wanted more individualized assistance with activities and project tasks. In the final project phase, I recruited a second volunteer facilitator to provide enhanced one-on-one guidance for workshop participants. Increased support for student work, particularly in the individual project stage, could be a factor in increased engagement and decreased occurrences of disaffected behaviours in the second phase of structured observation. The implications of adding increased support for enhancing positive engagement factors; however, requires further analysis beyond prevalence.

In addition to engagement and disaffection factors, I collected unstructured observations using informal information gathering methods (anecdotal records) during the intervention to elicit insight into participants' activity preferences during structured and free-time periods, as well as to investigate individual challenges and successes encountered with technology-creation tasks. Use of free time at the end of workshop sessions revealed defined differences in activity preferences between the boys' and girls' groups. Boys tended to choose independently engaged activities such as single-player gaming on handheld consoles or laptops. Group play, for boys, was contained to battle card activities such as Yu-Gi-Oh! or Digimon. The girls' group, conversely, expressed interest in having end of session "social parties," and took turns organizing these mini-events throughout the duration of the intervention. The weekly organizer would designate group responsibilities for the following week's "party." Girls contributed shareable food and drink items on a weekly basis; activities performed included facilitator-led sessions in laughter yoga, cooperative game play using Nintendo DS handheld systems, participant demonstrations of favourite games played on the internet, and small group board game play.

Managing participant expectations was one of the most challenging aspects of the workshop. Participants wanted to create console games and highly complex gaming experiences, and were overwhelmed with the enormity of the task they faced. They were unprepared for how difficult it is to work with full spectrum game design and development, expecting their ideas to be easily transformed into games. These expectations resulted in frustration with the learning process at times. Participants would have preferred that the asset creation and programming be black boxed and would have liked to deal with a visual drag-and-drop level creation environment.

Structured and semi-structured activities provided participants with opportunities for active, hands-on learning, discussion, and the ability to make meaningful choices and assume roles of authority in decision-making.

Observations of activity engagement showed that a number of participants (generally boys and girls regarded as “high achievers” by their teachers) experienced initial struggles with the active learning paradigm – participants were not comfortable, at first, with making their own decisions, and guiding their own learning – they wanted facilitator control and assistance at every step, indicating self-efficacy issues that needed to be resolved. Some participants actively resisted exploring the visual programming environment and experimenting and discovering program affordances – they wanted to be told exactly what to do and were at a loss with how to negotiate ownership of their own learning process. By the second phase of the intervention; however, the majority of participants were comfortable modifying programming activities and initiating self-guided work using the Scratch tool. Facility with independent work was developed slowly, over-time as trust and relationships were built between participants and myself.

Unstructured and semi-structured activities required adequate supports of participant discipline, self-efficacy, motivation, and engagement. These qualities require significant investitures of time and resources, which, generally, are not available to non-formal after-school programs. Connection to formal school curricula and staff and faculty support would be crucial for future implementations in improving retention and providing best learning advantage to participants.

While during self-directed work time, girls exhibited more focused, “on-task” behaviours than did boys; both boys and girls, overall, gained increasing levels of comfort over the course of the intervention with customizing tutorial material to match their own interests. Participants considered the “academic leaders" of their grade cohorts exhibited significant exceptions to observations of participant pleasure taken in modifying example content. Honour role participants tended to mechanically reproduce tutorial material and were reluctant to institute changes to sample representations and programs. Prior training in "expectations for success" was an ongoing challenge over the course of the workshop for "high achieving" participants. Interestingly, participants who informally reported that they were regarded as mediocre students due to the "lack of effort" they put into their schoolwork were most inclined to experimentation and risk-taking in design and programming strategies, which resulted in qualitative gains in their projects, particularly with regard to enhancing game play experiences. A particularly salient example occurred during participant work on the Maze Game design challenge. One female participant who had earlier in the intervention claimed that she didn't "try very hard" in school was interested in creating a game play condition whereby the player character would be returned to its starting position if it collided with a maze wall. We briefly discussed the underlying coordinate system of Scratch to determine approximate x and y coordinate positions on the screen. After a few trials, the participant successfully implemented her "return to start" rule, and subsequently conducted her own in-session tutorial to teach the other girls how to create the same interaction.

When work on individual final game projects commenced, "high achiever" participants were, initially, unable to formulate design concepts in the absence of guiding constraints or themes. One-on-one brainstorming sessions with participants experiencing creative blocks to their design process assisted in overcoming creative obstacles. Word association play was employed to create lists of verbs from which participants could gain inspiration. Additionally, moving the design process away from participants' notions that the project constituted a consummating "outcome" of the workshop toward an understanding of the project as an expression of a story they wanted to tell, or experience they were interested in generating for a user, facilitated participants' design processes. It was emphasized that individual projects need not be "finalized" into completed games, but should, instead, focus on first elaborating a design concept; second on determining the project's engagement factors such as the kinds of interactions and rules that the game or story would require or exhibit; and third on developing the programmatic implementation of the design and interactions. In one case, this conceptual re-orientation strategy resulted in the design of the most creative and, in terms of conventional game play, subversive project out of both the boys' and girls' groups. The "Adventures of Stickman," designed by female participant P_007_F, evidenced a sophisticated and darkly humourous take-up of the traditional side-scroller adventure in which the end-game outcome would not result in a reward or typical "winning" scenario, but, rather, would culminate in the punishment of the player through the character's death in a cut-scene finale. Here, the participant used the metaphor of the game to express her deeply felt ambivalence toward how success is controlled, measured, and perceived in her own real-world experiences. The opportunity to deconstruct the parochial expectations attached to "accomplishment" afforded a particularly meaningful context for self-reflection and agency for this particular participant.

7.2.3 Content Analysis

7.2.3.1 Revealed Preferences Elicited from Girls' Game Design Documents

Girls' game designs reveal a concern with the ways in which the local embeds itself in the global. Personal connections to larger contexts (self in the world, and self in relation to one's local community) are instantiated in game worlds, which foreground open-ended exploration and social, problem-solving engagements. Interest in self-reflection and supporting player creativity are central components of girls' game experiences, as well. Player-centered game play dominates girls' game designs. Options for the customization of characters, goals, and challenges are central interaction elements built into girls' game concepts. Affordances for multiple opportunities, as well, to match the game play with players' own needs and interests, connecting the game play more closely with the personal self, and supporting player agency and autonomy characterize girls' designs. Girls' games, moreover, emphasize experience over competition. Intrinsic rewards, such as personal achievement and social or community contributions, carried heavier weight than conventional extrinsic reward systems, such as "high scoring."

7.2.3.2 Technology Fluency Indicators

Indicators of technology fluency were assessed through joint analysis of girls' produced game design documents, programming code, and workshop feedback responses. Technology fluency extends skill-based computer literacy objectives to include intellectual capabilities, or, the critical application of IT in complex and diverse situations; fundamental concepts; and contemporary skills including ability to use contemporary hardware resources and software applications (National Research Council 1999a). Technology fluency is considered dynamic as opposed to a "have/have not" capability. Emphasis; therefore, is placed on the growth of capability demonstrated by participants over the course of the intervention, and is formatively evaluated versus summatively evaluated.

Girls' game design documents exhibited reflective understandings of core game design concepts including player interaction, game mechanics, and aesthetics. Significantly, girls' designs offered innovation with regard to mechanics and attention to user experience demonstrating critical thinking and deepened, active engagement with game design processes.

The development of core computer programming competencies over the course of the intervention is shown in analysis of final projects, which evidence 100% assimilation of sequencing (logical ordering of programs), 50% assimilation of repetition structures (loops), and 100% assimilation of conditionals. Understanding of algorithmic process for general problem-solving, including use of loops and conditions, is designated Level 1 – Foundations of Computer Science for grades K-8 by the ACM Model Curriculum guide (ACM K-12 Task Force Curriculum Committee 2003). Girls, more than boys, tended to substitute event triggers for loops for programming specific behaviors such as user-controlled object movement. In this regard, 100% of girls' final projects made use of event constructs to control repeated actions such as moving a character on the screen through user input, and can be seen as an adopted programmatic "style" for producing the same output that could be achieved through the use of loops, which predominated in boys' coding practices (see Figure 43 for example).

ACM guidelines for grades 6-8, in line with technology fluency objectives, support building technology competency through use of tools and software, and the ability to apply tools to the design, development, and presentation of "products." Girls' technology-creation work with Scratch, and engagement with collaboration and presentation tools and opportunities made available through the workshop and Scratch community websites, demonstrated accrued confidence in the use of technology to critically evaluate and solve problems, participate in shared knowledge spaces, and appropriately use technology resources. Such evaluative findings are supported by participant feedback, which indicate increased understanding of game-related technologies (55% of girls responding), and confidence that they had become technology experts in their school – could teach others how to use Scratch to create games (89% of girls responding).

One point of concern found in participants' workshop evaluations was the lack of perceived competency in computer programming. Such a result may indicate that learners associate competency with mastery instead of assessing learning gains as developmental and built up overtime. Future iterations of the workshop would need to address this issue by focusing more positive attention on participant gains from programming efforts. Much of the programming work was quite difficult for participants given the complexity of their game designs and while the actual results were impressive to myself and external evaluators, close-out feedback suggests that participants did not self-value their programming work, perhaps focusing on the immensity of the challenge as opposed to the successes achieved.

Participants' difficulty in managing complexity, shown in only 41% of all projects (44% of girls and 38% of boys) reaching a playable state (considered a completed project for purposes of evaluation) was, perhaps, the primary challenge encountered by participants in the workshop. Given the non-formal nature of the enactment, participants had the freedom to choose which aspects of their game creation to focus attention. Much time, for both boys and girls, was spent on asset creation (art and sound effects) for their games, and was observed to be a particularly personal and deeply engaging activity for participants.

While programming was evidenced in 91% of commenced projects, participants struggled with aspects of complexity decomposition and setting realistic scope for their work. Future iterations might usefully incorporate project management strategies and tools into the activity structure to assist participants in achieving personal project outcomes. Team-based activity approaches, additionally, would facilitate division of labour, incorporate girls' preferences for social learning, and support individual task competencies toward project success.

7.3 EUREKA!: Fifteen Heuristics for Non-Formal Learning Design Supporting Technology Fluency Objectives

Heuristics for learning have commonly emphasized action-oriented approaches to instructional design, which prioritize authentic, experiential activities geared towards providing learners with supported "opportunities" to act, a "less to read but more to do" strategy (van der Meij & Carroll 1998). This approach can best be implemented for technology fluency objectives through "project-based" learning that affords skill acquisition in addition to meaningful application of conceptual knowledge, allowing learners to test, practice, and validate their perceived understanding of the material content being presented (Dougherty 2003). Project-based approaches can open the "black box" of technology products and processes (Jansen & Voogt 1998), but are often poorly integrated into curriculum, and are assumed to increase motivation to learn and facilitate knowledge transfer (Yilmaz & Seifert 2009) without adequate understanding of how these goals might be accomplished. Heuristic guidance for learning design can redress such theoretical gaps and provide flexible strategies for how to effectively design *for* active, interest-based learning goals.

It is important to note that the presented heuristics function as interdependent elements toward supporting broad-based learning interaction dynamics. This "ecological" approach to intervention design foregrounds open-ended processes and encourages adaptation based on emergence and alignment of design priorities to specified objectives and target populations.

7.3.1.1 Learners

Heuristic 1

"Visualize IT for Connected Thinking." Facilitate the creation of appropriate mental models of programming concepts by providing visual examples of abstractions that make sense to girls' lived experiences of the world.

Case-based Support

Strategies such as introducing concept modelling to help structure design processes and facilitate connected thinking assist in making algorithmic and logic-based procedures and critical reflection available to novice learners. Concept modelling appeals to girls' demonstrated interest in visual narratives and affords participants the opportunity to practice the fundamentals of dynamic and iterative development for managing and understanding system complexity.

Paper prototyping is, also, an effective strategy for supporting participants in visualizing abstract concepts and mechanics. Within the intervention, both boys and girls showed positive interest and task-oriented behaviours toward level mapping activities, which required participants to engage in detailed planning and critical thinking for developing game interactions and goals. Coordinated with concept mapping or flowcharting, paper prototyping affords learners "offline" design and programming opportunities, which can be used to work through specific coding challenges arising in game implementation.

Examples

- Concept Modelling
- Flowcharting
- Paper Prototyping
- Role Play / Improvisational Storytelling

Heuristic 2

"How Else Can We Show IT." Provide alternative representations to support individual learning styles.

Case-based Support

Deepen relationships between learner and content by developing robust or multiple representations to appeal to a diversity of learning approaches and needs. Screencast videos, for example, provide visual, interactive, and user-controlled alternatives to lecture-based or textual tutorials. Learners with reading comprehension challenges benefit from visual representations of materials, which afford autonomy to progression and active involvement in their own learning processes.

Lower fidelity resources for alternative representations may include tutorial materials that have high a graphical content to text ratio. Girls in the workshop, for example, helped design the look-and-feel of activity cards used in weekly sessions, which were colourful and substituted visual material for text, or used graphical elements, such as screen captures of user interface elements, to supplement walkthrough text. Having an accurate visual representation of tool and code elements at hand to guide independent work reduced learner frustration and eased the learning curve for the tool, as participants were able to quickly identify and engage areas of interest on the application using the screen captures as cues (see Figure 7 for a sample activity card).

Examples

- Screencast activity walkthroughs
- Comic-book style activity cards
- Physical models
- Simulations

Heuristic 3

"Build IT Step-by-Step." Use logically progressive vignettes to structure conceptual learning content and provide girls with immediate output for their efforts.

Case-based Support

Informal information gathering suggested that both boys and girls preferred the developmental structuration of activities, which allowed them to add increased complexity to a project over time as opposed to discrete, non-connected learning activities. Opportunities to "grow" projects increased learners' senses of accomplishment with regard to work produced, as well as providing regular visual feedback on progress through iterative design, development and testing of projects.

The detailed intervention, for example, afforded participants the opportunity to build on work completed from week to week to invest senses of ownership in their process. Introductory activities allowed participants to move from the design of a simple character to its animation and interactivity through the addition of sound and user control. The Maze Game Challenge and final projects elaborated upon this progressive technique by taking small concepts to increased complexity and playable games through each workshop session. Motivation was demonstrated by participant reports that work on projects were continued outside of workshop sessions and teacher reports that projects were accessed during free-time periods at school.

Examples

- Multi-session activities
- Project-based learning structure
- Iterative development

7.3.1.2 Tools

Heuristic 4

"Make IT Accessible." Select learning tools, which offer low floor and high ceiling to facilitate entry and support development of competencies throughout the lifecycle of the intervention.

Case-based Support

Tools should provide an easy pathway into technology-creation activities as well as grow with learners to match learner objectives, as well as the goals of the intervention. Evaluation of creative support for design-based tasks is critical to providing learners with tools appropriate to needs and interests. Understanding, from the participants' perspectives, how tools shape their experiences with technology-creation activities is a critical dimension that is often overlooked in intervention design.

I selected the Scratch application for the outlined intervention due to its affordances for game design and media creation work, fit with the resource constraints of the intervention context, as well as its documented success in engaging young users in non-formal and informal contexts (Resnick et al. 2009). Many of the tool's features supported low barriers to entry including a colour-based, building block metaphor for coding that encourages experimentation and helps learners avoid programming syntax errors. Learners were able to grow with Scratch as programming competencies developed. Scratch's familiar metaphor and simplified interface design scaffolded basic skill acquisition.

A simple survey (see Appendix C for details) evaluated the creativity support features of Scratch with novice programmers who used the tool to perform a creative, interactive storytelling task. Scratch received a total rating of 94.32 out of 100 by users. The rating validated tool selection and provided evidence that Scratch supports both foundation programming learning as well as factors determined to best facilitate creative work including expressiveness, exploration, enjoyment, and collaboration.

Examples

- Scratch (game and media creation)
- Storytelling Alice (3-D animations and game creation)
- GameMaker (game creation)
- StarLogo TNG (simulations and game creation)
- Processing (computational art)
- DrawBot (computational art)

Heuristic 5

"Take IT Away." Provide take-aways to support learning in multiple and alternative contexts. Opportunities for learning outside of the intervention context should be encouraged by supplying participants with off-site, off-line activities, as well as digital resources to enhance technology fluency objectives.

Case-based Support

Girls, particularly, benefitted from the provisioning of online space for community formation, question/response, and feedback supplementary to in-workshop support, showing high levels of engagement with site resources. Girls; however, preferred physical take-away learning material to digital files. Boys made greater use of online presentations of tutorials and distributed physical design journals than girls. Girls enjoyed the collectible dimension of physical activity materials more than boys, but preferred experimenting with design ideas in the Scratch environment over sketching plans and ideas out in a journal format. Building specified design journal oriented activities into the curriculum may address engagement issues and encourage all participants to make use of this valuable resource, which encourages ongoing reflection on design processes.

Examples

- physical tutorial materials
- design journals
- community-based website
- reflection blogs

Heuristic 6

"Make IT Shareable." Technology creation tools should afford artefact display, sharing, and modification to promote learning, community formation, and pride in created work.

Case-based Support

Scratch's built-in "Share" affordance, which uploads user files to a specified account on the Scratch website, made work accessible to learners outside of the workshop, and appealed to girls' interest in social network communications. Girls took pleasure in checking their files for comments from the Scratch community, and participated in knowledge sharing through Scratch community forums.

The workshop website operated as a vital resource for shared meaning making outside of sessions. Girls regularly posted questions and comments on postings and on each other's user blogs. The ability to interact with participants outside of workshop time assisted in trust and relationship building between the facilitator and participants in a forum that was familiar and comfortable to the girls. Activity surveying revealed that much of girls' computer use is for social purposes such as instant messaging and social networking on sites such as Facebook. Incorporating these online self-efficacies and preferences into intervention communication models can increase engagement and personal senses of investment into workshop activities.

Examples

- shared online forums
- dedicated community web portal for intervention
- web-based hosting of project files

7.3.1.3 Contexts for Learning

Heuristic 7

"Learn IT Together." Support meaningful collaborative and cooperative learning opportunities.

Case-based Support

Research suggests that girls prefer learning in socially enabled contexts (Liston et al. 2008a, Peters 2007, Snyder et al. 1996), a finding supported by this study's activity survey, which shows higher levels of net affect for activities performed with others than for those performed alone. Facilitating shared meaning-making contexts, additionally, allows girls to function as both knowledge experts and learners, increasing perceptions of self-efficacy and promoting a community-based model of learning.

Strategies for encouraging collaborative and cooperative learning in non-formal settings include arranging working spaces in small group (pod) formations to encourage productive discussion; pair programming; and team-building activities such as group design and programming challenges. Manipulating spatial arrangements is particularly effective in encouraging spontaneous collaboration and cooperation around otherwise independent work. Reserving time at the end of sessions, additionally, to share project developments and provide critical feedback on other participants' work was enjoyed by both boys and girls and extended regular opportunities for participants to discuss their design ideas with their peers and take pride in their work, enhanced by positive social feedback.

Examples

- Circular seating arrangements not rows
- Small group arrangements of workspace
- Centralized location for activity materials
- Team based learning

Heuristic 8

"Game IT." Approach the development of critical thinking and problem-solving skills through a game-based learning approach, which encourages girls to decompose familiar and meaningful game play experiences into the learning objectives.

Case-based Support

Game based examples, which provided meaningful elaborations of programmatic concepts included demonstrating how scoring and health systems were controlled by variables; the creation of character sprites facilitated understandings of object oriented programming practices; and deconstructions or critical game play assisted in exploring underlying game mechanics and basic algorithmic thinking.

Free time board game play with games such as Clue, for example, provided novel contexts to discuss problem-solving and algorithmic logic processes, and facilitated the development of cooperative relationships between peers. Approaching conceptual material from the play perspective made the learning content less intimidating to participants and assisted in connecting new ideas to familiar and fun experiences for the girls. Cooperative video game play, additionally, promoted critical thinking with regard to play choices and in-game decision making that supported girls' own game development processes. Research shows that computer gaming can support the development of positive attitudes toward technology and promote skills that are strong predictors of future technology-related behaviour (Levine & Donitsa-Schmidt 1998, Subrahmanyam & Greenfield 1998).

Examples

- Critical and reflective game play
- Cooperative game play
- Game-based demonstrations of conceptual material

Heuristic 9

"Take It Offline." Explore action-based methods for introducing and practicing technology fluency competencies offline.

Case-based Support

Barriers to technology access endemic to low-income populations, including limited at-home and in-school computer resources, presented significant problems for participants who wished to practice skills and continue project development outside of workshop sessions. While school administrators accommodated a number of participants through overnight laptop loans, access to technology was a significant challenge encountered throughout the duration of the intervention.

The CS Unplugged resource (Bell et al. 2002), developed at the University of Canterbury for supporting the teaching and learning of foundation computer science concepts without a computer, facilitated off-site technology learning. Activities for practicing algorithmic thinking (the use of Battleship to illustrate searching algorithms) and representing procedures (treasure hunts to demonstrate finite-state automata) provided participants with engaging and understandable alternatives to computer-based programming tasks for extending their knowledge base outside of the workshop context.

Examples

- CS Unplugged
- Algorithmic processes in everyday life
- Improvisational storytelling to illustrate event-based actions

7.3.1.4 Expectations/Objectives

Heuristic 10

“Make IT Formative.” Prioritize formative assessment over summative (both for program assessment as well as learner assessment) when conducting intervention evaluations.

Case-based Support

Adequately capturing the dynamic and continuous nature of learning is difficult due to the large range of unknown mediating variables affecting the learning process. Implementations, thus, should decentralize focus on what Freire has termed the “banking” approach to learning. Prioritize learner-centred outcomes, alternatively, with focus re-oriented towards perceived competencies and efficacies, which can motivate learners to re-access knowledge outside of the original context of the intervention.

A salient example of these kinds of transfer potentials from the intervention described in this thesis was evidence from teachers, brought back to the researcher, of girls requesting to use Scratch for assignments in the formal classroom outside of the workshop context. One male participant indicated that he had obtained teacher permission to use Scratch for a digital storytelling project instead of iMovie, stating that he preferred the Scratch software for creative work because it gave him more control over the look-and-feel of the project. A group of 4 girls indicated, similarly, that they had chosen Scratch as a storytelling platform as an alternative to producing paper storyboards for an in-class creative writing assignment. While such transfers are not possible to capture for summative accounts of learning objective realization, they are invaluable for formative assessments, which can use such anecdotal knowledge to adjust activities to include learner needs and interests that lie outside of the framing themes of the intervention.

Examples

- Regular informal information gathering
- Adaptive iteration and flexible design affordances
- Established communication protocols with all stakeholders

Heuristic 11

"Make IT Meaningful." Change perceptions by connecting content and environment to learners' real-world experiences, needs, and preferences.

Case-based Support

General activity studies on youth populations are regularly conducted as sub-sets of larger national time-use surveys and can be usefully merged with targeted explorations of the particular needs and realities of individual intervention participants for leveraging and evaluating interest-based design. Research has shown that girls prefer activities where conceptual material is meaningfully connected to the real world and familiar experiences and objects (Norton 2006).

Analysis of girls' game design documents produced during the intervention show a general grounding and interest in real-world contexts such as one's neighbourhood, or one's school. These inclinations toward civic engagement were ploughshared into opportunities to encourage the forms of critical and reflective thinking that are essential to the development of technology fluency. Example activities included: explicating algorithmic processes in everyday life (such as the steps engaged in making a sandwich or walking to school), or, identifying classes of objects in the world around us such as car models, and species of flowers, which connected to learners' previously established knowledge bases and understandings.

Examples

- informal or formal participant activity surveying
- Review related literature
- Research the popular culture of your target demographic

Heuristic 12

"Explore, Test, Discuss, and Reflect on IT." Encourage the *active processes* of critical thinking and problem-solving by affording girls low- or no-stakes opportunities to devise their own solution-paths, make errors, and reflect on their decisions without fear of consequences.

Case-based Support

The non-formal environment provided a rich and safe context for supportive exploration of ideas and solutions without the anxieties attached to evaluation, or the need to provide "correct" responses to problems encountered during the learning process. Girls, particularly, who had been identified by the school as "at-risk," and "under-performers" achieved significant gains when afforded the opportunity to progress at their own pace and explore divergent solution spaces that could be refined through iterative development and just-in-time facilitator guidance. "High achiever" girls, as well, benefited from the reorienting of the game design process away from outcome-based goals toward understanding projects and in-session work as opportunities to assert personal expressions of voice and for self-reflection.

Examples

- Use examples derived from participants' work to demonstrate alternative solutions to wicked problems
- Just-in-time guidance
- No-stakes exploratory activities

7.3.1.5 Tasks

Heuristic 13

"Make IT a Means not an End." Studies show that girls are more motivated to learn when learning content is introduced as a means to a larger end (Brunner & Bennett 1997).

Case-based Support

Connecting individual contributions to larger contexts is an important engagement strategy for making technology creation tasks relevant to girls' interests. For example, girls showed a greater motivation to make games for "others" to play (interest in enhancing the positive experiences of others) than boys who were primarily interested in making a game for "themselves" to play.

Girls, participating in the intervention, initiated supplemental work including developing their own survey tools to query their peers about gaming preferences to assist in their design work (see Appendix E for example). Girls showed a keen interest in survey design and in understanding how information gained through their tools could provide them with design insight and help them make games, which others would enjoy playing. Building links, for girls, between learning objectives and the socio-global effects of their game design enhanced intrinsic motivation for the process, supported by increased behavioural engagement factors shown in the second phase observation results.

Examples

- Social computing

- Human-computer Interaction (HCI) principles
- Participants as design-partners

Heuristic 14

"Relocate IT." Relocate the learning transaction from outside the learner to inside the learner by building learning activities around knowledge, competencies, and interests that girls already have.

Case-based Support

Give girls the opportunity to express their own perceived competencies and preferences, which should guide the activity design process throughout the intervention. Providing opportunities for girls to reflect on their own development throughout the learning process can assist in the creation of productive, self-directed spaces that are meaningful to individual girls.

Activity surveying revealed links between satisfaction levels for given events and competency ratings in girls' reports. Supporting individual self-efficacies by affording opportunities for girls to adopt positions as knowledge experts in guiding learning activities, and demonstrating solutions discovered to their peers are important practices to incorporate into intervention design. Non-formal contexts are particularly amenable to open knowledge sharing practices as there are fewer constraints on learners' behaviours within the environment.

Examples

- Customizable learning materials

- Presentations of work in progress
- Participant-led demonstrations of solutions

Heuristic 15

"Make IT Participatory." Afford self-direction and autonomy through learner customizable activities.

Case-based Support

Creating opportunities for the participatory design of learning activities and materials gave girls a sense of ownership over and voice in their own learning processes and increased engagement with content as indicated by structured observational recordings of engagement behaviours over the duration of the intervention. Girls demonstrated investment in the learning process and context by assisting in material design, and organizing a collective identity for the workshop group. Girls brainstormed and voted on a game "company name," *Chocolate Girls*, which they determined would promote the work they produced during the intervention. Importantly, the provisioning of space for girls to express their knowledge and expertise by leading demonstrations and informing upcoming tutorial focus in end-of-session de-briefings assisted in fostering inclusivity, and connecting workshop sessions more authentically and to the girls' needs.

Examples

- Game and activity modding

- Persistent collection of participant feedback
- Co-design

8: CONCLUSION

The purpose of the research was to explore the dynamic parameters of girls' day-to-day lives, towards the development of a provisional understanding of how non-formal learning contexts, connected to girls' lived experiences, can enhance interest and participation in technology-creation and IT knowledge domains. The conducted study illuminated some salient findings for the domain of participant-centered learning design as well as for the promotion of targeted technology fluency objectives within non-formal learning contexts.

The proposed heuristics are part of a broader design ecology (see Figure 47), which supports alternative formulations and objectives for situated, interest-based learning design, more generally. The SUMA (Scaling Up Mathematics Achievement) model (Kinzer et al. 2010), upon which the design ecology proposed herein is based, supports a collaborative, cross-domain method of research inquiry. To more closely connect research and practice, the design ecology mandates continuous communication between educational stakeholders and research and design interests. This feedback loop encourages the emergence of new theory and practices from the inclusion of multiple perspectives and divergent worldviews into the learning design process.

The heuristic model is sensitized to context-specific needs by providing both generalized guidance as well as localized examples drawn from the intervention outlined in the thesis (see Table 17 for a summary of the heuristic guidance). Such flexibility promotes the sustainable and adaptive use of the heuristics in multiple design applications to increase significance; promote linked conversations around diverse enactments; and contribute to the development of communities of practice interested in the exploration of design-based research practices for non-formal learning. I anticipate that the development of flexible, case-based heuristics can be leveraged toward aligned and alternative intervention implementation strategies. Heuristics may be used to elicit variables of interest for controlled studies or as guiding principles for exploratory learning design, and may be enacted in diverse contexts for a wide range of objectives.

Figure 47. Design Ecology for Contextually Sensitive Learning Interventions based on the SUMA model (Kinzer et al. 2010).

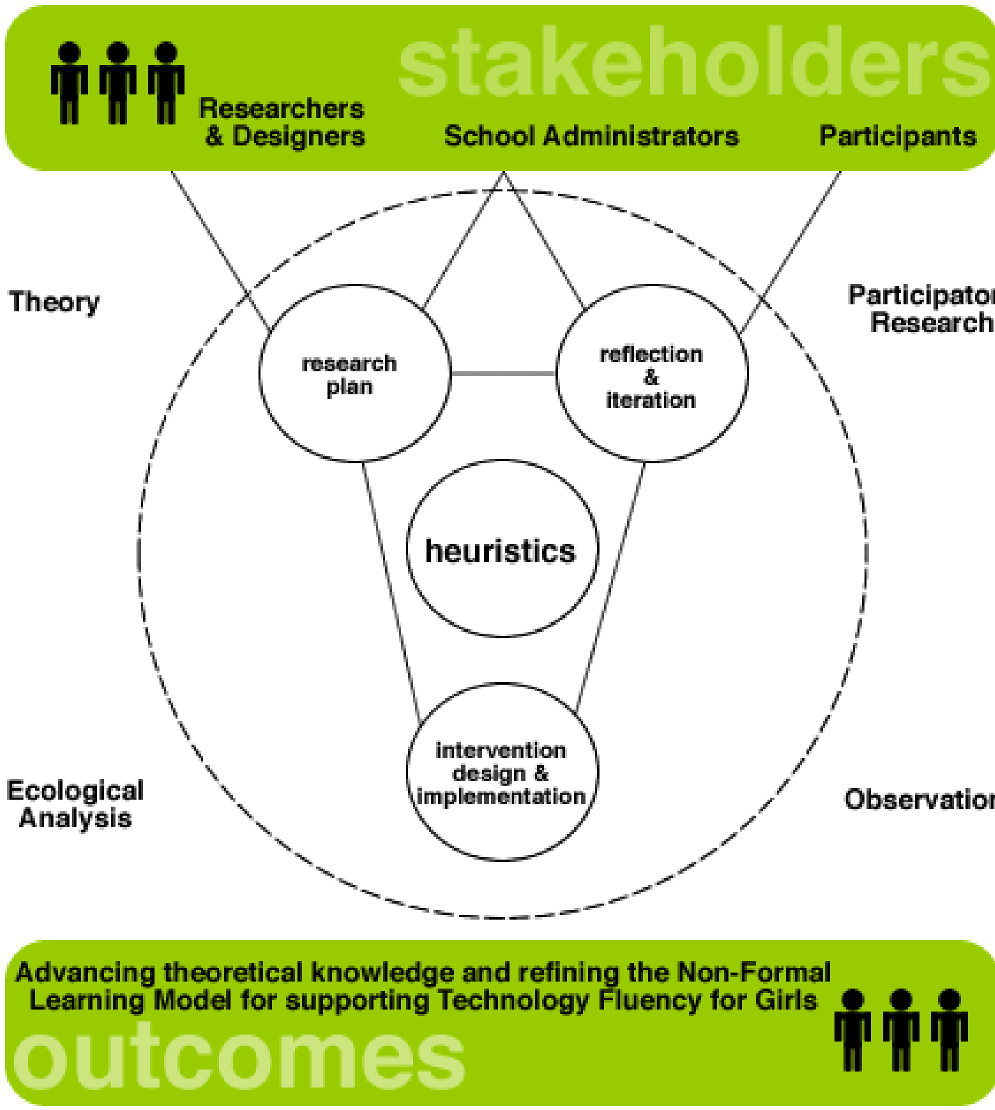


Table 17. Summary of Heuristic Model for Non-Formal Learning Design (for the promotion of Technology Fluency for Girls)

	Heuristic	Principle
Learners	Visualize IT for Connected Thinking	Facilitate the creation of appropriate mental models of programming concepts by providing visual and authentic examples of abstractions that make sense to girls' lived experiences of the world.
	How Else Can We Show IT	Provide alternative representations to support a diversity of learning styles.
	Build IT Step-By-Step	Use logically progressive vignettes to structure conceptual learning content and provide girls with immediate output for their efforts.
Tools	Make IT Accessible	Select technology learning tools that offer low floors and high ceilings to facilitate entry and support competency development.
	Take IT Away	Provide "take-aways" to support learning in multiple and alternative contexts.
	Make IT Shareable	Tools used should support sharing and collaborative modification to promote the formation of communities of practice around technology creation activities.
Contexts for Learning	Learn IT Together	Support meaningful collaborative and cooperative contexts, which allow girls opportunities to function in both expert and learner roles throughout the duration of the intervention.
	Game IT	Adopt game-based and socially oriented learning approaches, which encourage girls to decompose familiar experiences into the learning objectives through critical and reflective play.
	Take IT Offline	Explore action-based methods for introducing and practicing technology fluency competencies offline.
Expectations/Objectives	Make IT Formative	Prioritize formative program and learner assessment strategies to support dynamic, processural re-shaping of intervention contexts and activities.
	Make IT Meaningful	Change perceptions by connecting learning context and activities to girls' real world experiences, needs, and preferences.
	Explore, Test, Discuss, and Reflect on IT	Encourage active processes of critical thinking and problem-solving by providing girls with low- or no-stakes opportunities to devise their own solution spaces, make

		errors, and reflect on their decisions without fear of consequences.
Tasks	Make IT a Means, Not an End	Introduce technology-creation activities as means to a larger end, which connects more strongly to girls' learning preferences than activities that are perceived of as ends in themselves.
	Relocate IT	Relocate the learning transaction from outside the learner to inside the learner by building activities around knowledge, competencies, and interests that girls already have.
	Make IT Participatory	Afford the development of girls' self-direction and autonomy through learner customizable activities or participatory design of learning activities.

8.1 Future Work

Based on the results of the study, there are several recommendations for future research. First, some of the limitations outlined in this study may be minimized or eliminated in a revised implementation of the Interactive Storytelling and Game Design workshop. In order to improve or verify the accuracy of the observational data collection, inter-rater reliability could be used to cross check the number of engagement and disaffection behaviors exhibited and verify the chronology in which they occurred.

Second, future iterations of the intervention will benefit from integration of analysis derived from everyday activity surveys of the target population. Analysis of diurnal mood variations, for example, supports "after-school" contexting for matching non-formal learning opportunities to mood peaks evidenced for subjects between 2:30 and 3:30 p.m. In-situ observations corroborate this finding. In future work, I will seek to align intervention design, more closely, to activity patterns connected to positive affect and competency dimensions for girls including creating wider opportunities for social and collaborative learning through paired programming tasks and team-based projects.

Third, administration of the DRM to a school district for a designated demographic such as elementary, middle, or high school, will be explored in future work. District level activity modelling would facilitate needs-based program evaluations as the DRM can be adapted to query for specific curriculum-based activities, and leveraged to sample students' experiences within the classroom.

Activity data captured from the DRM could be usefully analyzed in correlation to a learning type indicator administered to students, such as the Murphy-Meisgeier Type Indicator for Children (Murphy & Meisgeier 2008). Understanding the relationships between everyday activity preferences and learning styles could provide a robust model for program evaluation and development, and assist in defining the connections between activity and learning as part of a shared information ecology (Takahashi & Komatsu 2007). Exploration of the relationships between everyday activity (including their mediations) and learning has been a focus, as well, of strategic planning for "neomillennial" educational initiatives (Dede 2005); such emerging frameworks would benefit from further work produced in this area of inquiry and engagement.

Last, intervention feedback collected from participants reveal that only 33% of female respondents feel they had gained competency in computer programming skills and knowledge (21% of boys report gains in programming competency). The game "design" component of the workshop was most appealing to both male and female participants. While programming competencies developed, evidenced in evaluations of projects over the course of the workshop activity sessions, different directions connecting programming tasks more closely to learner goals and preferences for creative, design-based work is required.

8.2 Summary of Contribution

This thesis makes several specific contributions:

1. **The observed high levels of engagement from girls when designing or developing games demonstrates that game design can be motivating for girls.** Girls participating in the Interactive Storytelling and Game Design workshop showed higher levels of observed engagement for game design and development activities than boys participating in the workshop. Girls indicated that they were more "serious" about making games than the boys. While boys showed much enthusiasm for game design theory and game play, the "work" of design and development showed lower levels of engagement than exhibited by girls for the same activities. Girls game design documents revealed highly narrative design concepts, which suggest, further, that storytelling activities are useful for grounding introductions to foundational programming concepts and for framing discussions of game mechanics and user interaction features.
2. **Scratch is an effective tool for introducing foundation programming concepts to novice programmers, and adequately supports users' creative tasks.** Participants' self-reports of creative support when using the Scratch visual programming environment for interactive storytelling and game design and development tasks shows that Scratch facilitates engagement with programming tasks by providing a scaffolded and easy to enter (low floor) paradigm for creative media production activities. Findings show Scratch to be particularly effective for supporting creative work, exploration, collaborative creative tasks, enjoyment, and reward from effort factors.
3. **Preferences for game play can be elicited from analysis of boys' and girls' game design documents and extrapolated to the design of learning contexts.**

Boys' and girls' game design documents reveal gender-specific convergences and divergences with regard to formal game play and design styles. Preferences emerging from participant choices in the design of their own games and interactive experiences can be usefully leveraged toward an understanding of what kinds of technology learning contexts might connect most closely with girls' interests and desired experiences. Content analysis of girls' game designs shows interest in the creation of experiences for others, play as problem-solving, as well as using play to explore identity (self in relation to others, self in relation to community).

4. **Analysis of girls' everyday activities can inform the learning environment design by revealing what contexts and forms of engagement are most motivating to the girls involved.** For example, activity analysis suggests that contexts with group interaction or social components elicit a higher average satisfaction and net positive affect rating for girls than for activities performed alone. Such contextual knowledge can be used to suggest the spatial organization of non-formal learning scenes, assist in the design of activities, and provide conceptual metaphors, grounded in participants' own interests, which may usefully guide the design and development of learning interventions. In-situ observations of girls' preferences in free time activities during the workshop and content analysis of girls' game design documents for revealed engagement preferences supports findings elicited from the everyday activity survey. Such results agree with prior work that suggests girls prefer learning in collaborative and social situations (AAUW Commission on Technology Gender 2000, Francis & Hutchings 2002, Lichtman 1998).

The findings of this exploratory study contribute to theory building in the fields of non-formal and game-based learning. Research work engaged in mixed and DBR methods for evaluating interest-based learning environments will benefit from the study's analysis of how the non-formal implementation of storytelling and game design metaphors can support and enhance conceptual, problem-based learning. This study contributes, additionally, to improved, case-based design practice in the formulation of situated heuristics for technology-mediated, non-formal learning environments. Improved understandings of the affordances of non-formal learning environments for supporting technology fluency objectives assist educators and instructional design practitioners in the pragmatic development of situated interventions concerned with enhancing such objectives.

APPENDICES

Appendix A: Day Reconstruction Method Instrument

Packet 1

First we have some general questions about your life. Please answer these questions by placing a check mark next to the answer that best describes your opinion.

1. Taking all things together, how satisfied are you with <u>your life as a whole</u> these days? Are you

__ very satisfied, __ satisfied, __ not very satisfied, __ not at all satisfied?

2. Next, let's turn to your life at home. Overall, how satisfied are you with <u>your life at home</u>? Are you

__ very satisfied, __ satisfied, __ not very satisfied, __ not at all satisfied?

3. And how about school? Overall, how satisfied are you with <u>school</u>? Are you

__ very satisfied, __ satisfied, __ not very satisfied, __ not at all satisfied?

4. Now we would like to know how you feel and what mood you are in when you are <u>at home</u>. When you are at home, what percentage of the time are you

In a bad mood ____%

A little low or irritable ____%

In a mildly pleasant mood ____%

In a very good mood ____%

Sum 100%

5. We would also like to know how you feel and what mood you are in when you are at school. When you are at school, what percentage of the time are you

In a bad mood ____%

A little low or irritable ____%

In a mildly pleasant mood ____%

In a very good mood ____%

Sum 100%

Next, we would like to ask for some background information about you and your family, for statistical purposes. Please have a parent or guardian fill this section out for you. Remember to include this section with Packet 1 before returning the entire package. [This section should appear on a separate page for parent or guardian completion]

1. What is the gender of the primary respondent? __ Male __ Female __ Other
2. What year was your son, daughter, or ward born? _____
3. What is your gender? __ Male __ Female __ Other
4. What is your relationship to the primary respondent? _____
5. What is the highest level of education you have completed?

   __ Some high school or less

   __ High school diploma or equivalent

__ Some college

__ College diploma

__ Some trade school or apprenticeship

__ Trade school certification or apprenticeship completion

__ Some graduate school

__ Graduate Degree

6. What is your marital status?

__ single (never married) __ married __ divorced/separated __ widowed

6. How many children do you have? _____

7. If you have children, how many of them are still living with you? _____

8. Including yourself, how many people live in your household? ______

9. Which of the following best describes your son, daughter or ward?

__ Aboriginal (Inuit, Métis, North American Indian)

__ Arab/West Asian (e.g., Armenian, Egyptian, Iranian, Lebanese, Moroccan)

__ Black (e.g., African, Haitian, Jamaican, Somali)

__ Chinese

__ Filipino

__ Japanese

__ Korean

__ Latin American

__ South Asian

__ South East Asian

__ White (Caucasian)

__ Other, please specify: ___________

10. What is your total annual household income?

__ $10,000 or less

__ $10,001 - $20,000

__ $20,001 - $30,000

__ $30,001 - $40,000

__ $40,001 - $50,000

__ $50,001 - $60,000

__ $60,001 - $70,000

__ $70,001 - $80,000

__ $80,001 - $90,000

__ $90,001 - $100,000

__ more than $100,000

Thank you!

Your daughter or son may now start on Packet 2

Please ensure that your daughter or son includes this background information sheet with the survey package.

Packet 2

Yesterday

We would like to learn what you did and how you felt yesterday. Not all days are the same – some are better, some are worse and others are pretty typical. Here we are only asking you about yesterday.

Because many people find it difficult to remember what exactly they did and experienced, we will do this in three steps:

1. On the next page, we will ask you when you woke up and when you went to sleep yesterday.
2. We would like you to reconstruct what your day was like, as if you were writing in your diary. Where were you? What did you do and experience? How did you feel? Answering the questions on the next page will help you to reconstruct your day.

   This diary packet is only for you, to help you remember and describe what happened during the first half of yesterday. It is yours to keep, so your notes are strictly personal and confidential. You do not need to turn it in. Nobody will read what you jot down about your day.
3. After you have finished reconstructing your day in your diary, we will ask you specific questions about this time (these questions are in Packet 3). In answering these questions, we'd like you to consult your diary page and the notes you made to remind you of what you did and how you felt.

To begin, please circle the day of the week that YESTERDAY was:

Monday Tuesday Wednesday Thursday Friday Saturday Sunday

Diary Pages

About what time did you wake up yesterday? _____

And when did you go to sleep? _____

On the next three pages, please describe your day. Think of your day as a continuous series of scenes or episodes in a film. Give each episode a brief name that will help you remember it (for example, “commuting to school”, or “at lunch with B”, where B is a person or a group of people). Write down the approximate times at which each episode began and ended. The episodes people identify usually last between 15 minutes and 2 hours. Indications of the end of an episode might be going to a different location, ending one activity and starting another, or a change in the people you are interacting with.

There is one page for each part of the day – Morning (from waking up until noon), Afternoon (from noon to 6:00 pm) and Evening (from 6:00 pm until you went to bed). There is room to list 10 episodes for each part of the day, although you may not need that many, depending on your day. It is not necessary to fill up all of the spaces – use the breakdown of your day that makes the most sense to you and best captures what you did and how you felt.

Try to remember each episode in detail, and write a few words that will remind you of exactly what was going on. Also, try to remember how you felt, and what your mood was like during each episode. What you write only has to make sense to you, and to help you remember what happened when you are answering the questions in Packet 3.

Remember, what you write in your diary will not be seen by anybody else.

Packet 2 is yours to keep if you wish – you don’t have to turn it in with the rest of your questionnaire.

Morning

(from waking up until just before lunch)

What happened? Episode Name	Time it Began	Time it Ended	Notes to yourself: What did you feel?
1M			
2M			
3M			
4M			
5M			
6M			
7M			
8M			
9M			
10M			

Afternoon

(from lunch until just before dinner)

What happened? Episode Name	Time it Began	Time it Ended	Notes to yourself: What did you feel?
1A Lunchtime			
2A			
3A			
4A			
5A			
6A			
7A			
8A			
9A			
10A			

Evening

(from dinnertime until just before you went to sleep)

What happened? Episode Name	Time it Began	Time it Ended	Notes to yourself: What did you feel?
1E			
2E			
3E			
4E			
5E			
6E			
7E			
8E			
9E			
10E			

Please look over your diary once more. Are there any other episodes that you'd like to revise or add more notes to? Is there an episode that you would want to break up into two parts? If so, please go back and make the necessary adjustments on your diary pages. If not, you may go on to Packet 3.

Thank You

You may now start on Packet 3

Packet 3

How did you feel yesterday?

Before we proceed, please look back at your diary pages.

How many episodes did you record for the Morning? _____

How many episodes did you record for the Afternoon? _____

How many episodes did you record for the Evening? _____

Now, we would like to learn in more detail about how you felt during those episodes.
For each episode, there are several questions about what happened and how you felt.
Please use the notes on your diary pages as often as you need to.

Please answer the questions for every episode you recorded, beginning with the first episode in the Morning.
To make it easier to keep track, we will ask you to write down the number of the episode that is at the beginning of the line where you wrote about it in your diary.
For example, the first episode of the Morning was number 1M, the third episode of the Afternoon was number 3A, the second episode of the Evening was number 2E, and so on.

It is very important that we get to hear about all of the episodes you experienced yesterday, so please be sure to answer the questions for each episode you recorded.
After you have answered the questions for all of your episodes, including the last episode of the day (just before you went to bed), you can go on to Packet 4.

First Morning Episode

Please look at your Diary and select the <u>earliest</u> episode you noted in the Morning.

When did this first episode begin and end (e.g., 7:30am)? Please try to remember the times as precisely as you can.

This is episode number _____, which began at ______ and ended at _____.

What was the main thing you doing? (please check all that apply)

__ commuting	__ working
__ shopping	__ studying
__ doing chores	__ preparing food
__ eating	__ praying/worshipping/meditating
__ socializing	__ watching TV
__ nap/resting	__ computer/internet/email
__ on the phone	__ exercising
__ other (please specify)	

____

What else were you doing at the same time?

____

Where were you?

__ At home __ At school __ Somewhere else (please specify) ______

Were you interacting with anyone (including on the phone, or IM)?

__ no one -> *skip next question.*

If you were interacting with someone (please check all that apply)

__ mother	__ teacher(s)

__ father

__ sister(s) or brother(s)

__ other relatives

__ others (who? ______________________)

__ classmates, peers

__ other adult (coach, etc.)

__ friend(s) How many? __ females __ males

Were you doing this main activity because you . . . . (check all that apply)

__ wanted to __ had to __ had nothing else to do

Overall, how satisfied were you during this main activity (please circle your response)?

Not at all									completely
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

How did you feel during this main episode?

Please rate each feeling on the scale given. A rating of 0 means that you did not experience that feeling at all. A rating of 6 means that this feeling was a very important part of the experience. Please circle the number between 0 and 6 that best describes how you felt.

Impatient for it to end	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Happy	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Frustrated/annoyed	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Depressed/blue	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Competent/capable	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Hassled/pushed around	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Warm/friendly	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Angry/hostile	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Worried/anxious	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Enjoying myself	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Criticized/put down	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Tired	**0**	**1**	**2**	**3**	**4**	**5**	**6**

If you were talking with people, please answer the following 3 questions (circle your response):

	Not at all	**A Little**	**Somewhat**	**Very Much**
Were you able to express your opinion?	**0**	**1**	**2**	**3**
Were others really listening to what you had to say?	**0**	**1**	**2**	**3**
Did you care about what others had to say?	**0**	**1**	**2**	**3**

Next Episode

Now look at your Diary and select the episode that immediately followed the one you just rated.

This is episode number _____, which began at ______ and ended at _____.

What was the main thing you doing? (please check all that apply)

__ commuting	__ working
__ shopping	__ studying
__ doing chores	__ preparing food
__ eating	__ praying/worshipping/meditating
__ socializing	__ watching TV
__ nap/resting	__ computer/internet/email
__ on the phone	__ exercising
__ other (please specify)	

____

What else were you doing at the same time?

____

Where were you?

__ At home __ At school __ Somewhere else (please specify) ______

Were you interacting with anyone (including on the phone, or IM)?

__ no one -> *skip next question.*

If you were interacting with someone (please check all that apply)

__ mother	__ teacher(s)
__ father	__ classmates, peers
__ sister(s) or brother(s)	__ other adult (coach, etc.)

__ other relatives __ friend(s) How many? __ females __ males

__ others (who? ______________________)

Were you doing this main activity because you . . . . (check all that apply)

__ wanted to __ had to __ had nothing else to do

Overall, how satisfied were you during this main activity (please circle your response)?

Not at all									**completely**
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**

How did you feel during this main episode?

Please rate each feeling on the scale given. A rating of 0 means that you did not experience that feeling at all. A rating of 6 means that this feeling was a very important part of the experience. Please circle the number between 0 and 6 that best describes how you felt.

Impatient for it to end	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Happy	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Frustrated/annoyed	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Depressed/blue	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Competent/capable	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Hassled/pushed around	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Warm/friendly	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Angry/hostile	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Worried/anxious	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Enjoying myself	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Criticized/put down	**0**	**1**	**2**	**3**	**4**	**5**	**6**
Tired	**0**	**1**	**2**	**3**	**4**	**5**	**6**

If you were talking with people, please answer the following 3 questions (circle your response):

	Not at all	**A Little**	**Somewhat**	**Very Much**
Were you able to express your opinion?	**0**	**1**	**2**	**3**
Were others really listening to what you had to say?	**0**	**1**	**2**	**3**
Did you care about what others had to say?	**0**	**1**	**2**	**3**

NOTE: Subsequent episode detail sheets prompt for next recorded episode, until all episodes have been detailed.

Have you rated all of your episodes, including the last episode of the day, just before you went to bed? If so, you may go on to Packet 4.

Packet 4

A Few More Questions About Yesterday

Now that you have told us about your day in detail, we have a few more general questions.

Now we would like to know overall how you felt and what your mood was like yesterday. Thinking only about yesterday, what percentage of the time were you

In a bad mood ____%
A little low or irritable ____%
In a mildly pleasant mood ____%
In a very good mood ____%
Sum 100%

Now we'd like to know how typical yesterday was for that day of the week (i.e., for a Monday, for a Tuesday, or so on). Compared to what that day of the week usually is like, yesterday was (please circle one)

Much Worse	Somewhat Worse	Pretty Typical	Somewhat Better	Much Better
1	2	3	4	5

Now we would like to know overall how you felt and what your mood was like at school yesterday. Thinking only about the time you spent at school yesterday, what percentage of the time were you

In a bad mood ____%
A little low or irritable ____%
In a mildly pleasant mood ____%
In a very good mood ____%
Sum 100%

Now we'd like to know how yesterday compares to a typical day at school. Compared to a typical day at school, my time spent at school yesterday was (please circle one)

Much Worse	Somewhat Worse	Pretty Typical	Somewhat Better	Much Better
1	2	3	4	5

You have now completed the survey. Please review each packet to be sure you have answered all the questions. Thank you very much for participating.

After you have checked your answers, put all of the numbered packets (except the diary if you wish to keep it) in the large envelope. Return your large envelope to the workshop facilitator the next morning.

Appendix B: Engagement Versus Disaffection with Learning – Workshop Facilitator Report

Behavioral Engagement

1. In the workshop, this participant works as hard as she can.
2. When participating in workshop activities, this participant appears involved.
3. When I explain new concepts, this participant listens carefully.
4. In the workshop, this participant does more than required.
5. When this participant experiences difficulty with an activity, she works harder.

Emotional Engagement

1. In the workshop, this participant is enthusiastic.
2. In the workshop, this participant appears happy.
3. When we start something new in the workshop, this participant is interested.
4. When working on activities, this participant seems to enjoy it.
5. For this participant, learning seems to be fun.

Behavioral Disaffection

1. When we start something new in the workshop, this participant thinks about other things. (-)
2. In the workshop, this participant comes unprepared. (-)
3. When faced with a difficult problem or activity, this participant doesn't even try. (-)
4. In the workshop, this participant does just enough to get by. (-)
5. When we start something new in the workshop, this participant doesn't pay attention. (-)

Emotional Disaffection

1a. When we work on something in the workshop, this participant appears to be bored. (-)

b. When doing work in the workshop, this participant looks bored. (-)
2a. When working on workshop activities, this participant seems worried. (-)
b. In the workshop, this participant is anxious. (-)
3a. In the workshop, this participant seems unhappy (-)
b. In the workshop, this participant appears to be depressed. (-).

4a. In the workshop, this participant is angry. (-)
b. When working on workshop activities, this participant appears frustrated. (-)
5a. When I explain new concepts, this participant doesn't seem to care. (-)
b. When working on workshop activities, this participant seems uninterested. (-)

Observational Details: (Note specific activities or concepts that seem to contribute to both engagement and disaffection for individual participants)

Appendix C: Creativity Support Index – Digital Storytelling Workshop

Circle the smiley that best fits your answer

What I was able to make using Scratch was worth the effort I had to give to make it.

Highly Disagree -- Highly Agree

I was able to be very creative while doing this activity.

Highly Disagree -- Highly Agree

It was easy for me to try out different ideas using Scratch without becoming bored.

Highly Disagree -- Highly Agree

I was very absorbed in the activity – I enjoyed it and would do it again.

Highly Disagree -- Highly Agree

It was easy to work with other people using Scratch.

Highly Disagree -- Highly Agree

Appendix D: Workshop Feedback Survey

Please fill out the evaluation form below: your feedback will help us make better future workshops for you!

Gender (please circle): M F

Age: _____

1. How would you rate your overall experience in the Game Design Workshop? Please circle your answer below: 1 = poor to 5 = excellent

1 2 3 4 5

Poor Excellent

2. At the end of the workshop, I feel I: (Circle all that apply)
   a) Have programming knowledge I wouldn't have had otherwise
   b) Have knowledge about game design I wouldn't have had otherwise
   c) Understand the technology used to create games
   d) Could help others use game creation software like Scratch
   e) Have confidence using the computer and computer software

3. What were the 3 things you liked best about the workshop?

____

____

____

4. What are 3 things you would change about the workshop if you could?

____

____

____

5. What workshop set-up do you prefer? (Circle your response)

a) Separate workshops for boys and girls
b) Boys and girls together for workshop sessions

THANK YOU!!

Appendix E: Sample Participant-Created Game Survey

#1 Are you a male or female?

M	F

#2 Do you enjoy playing games?

Yes	No

#3 What game level do you like to play?

Easy	Simple	Hard

#4 What kind of gaming system do you own?

PS	
PS2	
PS3	
PSP	
Wii	
DS	
DS I	
XBOX	
Gameboy	
Other	
None	

#5 How often do u play games?

Sometimes	**Never**	**Often**	**Always**

Appendix F: Data Tables

Time-Use (Leisure)

Figure 48. Time Spent in Primary Leisure Time Activities (Disaggregated by Gender)

Activity	M (*Mean* Hours)	% Reporting (M)	F (*Mean* Hours)	% Reporting (F)
TV	1.24	0.73	1.28	0.6
Video Games	0.77	0.4	0.92	0.33
Computer (General)	0.63	0.13	0.89	0.4
Computer (Social)	0	0	0.65	0.47
Computer (Total)	0.63	0.13	1.1	0.6
Telephone	0.75	0.07	0.36	0.13
Hanging Out	1.66	0.33	0.61	0.4
Reading	0	0	0.52	0.27
Organized Sport	1.46	0.13	1.25	0.4
Enrichment	2.11	0.2	1.83	0.2
Listen to Music	0	0	0.83	0.07
Art & Culture	1.25	0.07	0.83	0.07

Activity Study Context Probes

Table 18. Context of Experience at School

Activity Class	Gender	Duration (*Mean* Hours)	Why (motivation to participate *Mean*)	Interaction *Mean*	*Mean* Level of Satisfaction	Affect Rating
Studying/In	**All**	5	**Had to:**	**With Others:**	5.56	**Net Affect:**

Class			1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	1.00 **No One:** 0.00		2.51 **Tired:** 3.22 **Competent:** 2.78
	M	5	**Had to:** 1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	**With Others:** 1.00 **No One:** 0.00	5.6	**Net Affect:** 2.57 **Tired:** 2.00 **Competent:** 2.2
	F	5	**Had to:** 1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	**With Others:** 1.00 **No One:** 0.00	5.5	**Net Affect:** 2.5 **Tired:** 4.75 **Competent:** 3.5
Socializing	**All**	0.49 (29.4 min.)	**Had to:** 0.38 **Wanted to:** 0.62 **Had Nothing Else to Do:** 0.10	**With Others:** 1.00 **No One:** 0.00	7.29	**Net Affect:** 3.64 **Tired:** 2.6 **Competent:** 2.87
	M	0.45 (27.2 min.)	**Had to:** 0.44 **Wanted to:** 0.44	**With Others:** 1.00 **No One:** 0.00	7.25	**Net Affect:** 3.00 **Tired:** 1.89

			Had Nothing Else to Do: 0.11			**Competent:** 2.33
	F	0.54 (32.14 min.)	**Had to:** 0.33	**With Others:** 1.00	7.33	**Net Affect:** 3.92
			Wanted to: 0.67	**No One:** 0.00		**Tired:** 3.67
			Had Nothing Else to Do: 0.00			**Competent:** 3.67
Sports	**All**	0.77 (46 min.)	**Had to:** 0.06	**With Others:** 1.00	8.67	**Net Affect:** 3.41
			Wanted to: 0.94	**No One:** 0.00		**Tired:** 4.0
			Had Nothing Else to Do:			**Competent:** 4.25
	M	0.83 (50 min.)	**Had to:** 0.00	**With Others:** 1.00	9.5	**Net Affect:** 4.67
			Wanted to: 1.00	**No One:** 0.00		**Tired:** 2.5
			Had Nothing Else to Do: 0.00			**Competent:** 4.0
	F	0.69 (41.4 min.)	**Had to:** 0.14	**With Others:** 1.00	7.0	**Net Affect:** 2.14
			Wanted to: 0.86	**No One:** 0.00		**Tired:** 5.5

			Had Nothing Else to Do: 0.00			**Competent:** 4.5
Extra-curricular (Other)	**All**	0.83 (50 min.)	**Had to:** 0.00	**With Others:** 1.00	7.5	**Net Affect:** 4.71
			Wanted to: 0.87	**No One:** 0.00		**Tired:** 2.79
			Had Nothing Else to Do: 0.13			**Competent:** 4.38
	M	0.72 (43 min.)	**Had to:** 0.00	**With Others:** 1.00	7.22	**Net Affect:** 4.33
			Wanted to: 0.75	**No One:** 0.00		**Tired:** 2.33
			Had Nothing Else to Do: 0.25			**Competent:** 3.5
	F	0.95 (57 min.)	**Had to:** 0.00	**With Others:** 1.00	7.86	**Net Affect:** 5.08
			Wanted to: 1.00	**No One:** 0.00		**Tired:** 3.25
			Had Nothing Else to Do: 0.00			**Competent:** 5.25

Table 19. Context of Experience at Home

Activity Class	Gender	Duration (*Mean* Hours)	Why (motivation to participate *Mean*)	Interaction *Mean*	*Mean* Level of Satisfaction	Affect Rating

Chores	**All**	0.42 (25.25 min.)	**Had to:** 1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	**With Others:** 0.33 **No One:** 0.67	5.14	**Net Affect:** 2.53 **Tired:** 4.16 **Competent:** 2.18
	M	0.45 (27.2 min.)	**Had to:** 1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	**With Others:** 0.2 **No One:** 0.8	4.8	**Net Affect:** 2.47 **Tired:** 3.67 **Competent:** 2.17
	F	0.39 (23.3 min.)	**Had to:** 1.00 **Wanted to:** 0.00 **Had Nothing Else to Do:** 0.00	**With Others:** 0.47 **No One:** 0.53	5.47	**Net Affect:** 2.59 **Tired:** 4.64 **Competent:** 2.18
Homework	**All**	1.41 (84.37 min.)	**Had to:** 0.9 **Wanted to:** 0.07 **Had Nothing Else to Do:**	**With Others:** 0.13 **No One:** 0.87	5.6	**Net Affect:** 3.17 **Tired:** 2.9 **Competent:** 3.1

	M	1.26 (75.88 min.)	**Had to:** 0.87	**With Others:** 0.2	5.2	**Net Affect:** 2.82
			Wanted to: 0.13	**No One:** 0.8		**Tired:** 1.8
			Had Nothing Else to Do: 0.00			**Competent:** 2.2
	F	1.55 (92.86 min.)	**Had to:** 1.00	**With Others:** 0.07	6.0	**Net Affect:** 3.52
			Wanted to: 0.00	**No One:** 0.93		**Tired:** 4.0
			Had Nothing Else to Do: 0.00			**Competent:** 4.0
Free Time	**All**	1.1 (66.51 min.)	**Had to:** 0.00	**With Others:** 0.53	6.43	**Net Affect:** 4.46
			Wanted to: 0.9	**No One:** 0.47		**Tired:** 3.16
			Had Nothing Else to Do: 0.1			**Competent:** 3.07
	M	1.16 (69.76)	**Had to:** 0.00	**With Others:** 0.33	6.86	**Net Affect:** 4.43
			Wanted to: 0.87	**No One:** 0.67		**Tired:** 3.57
			Had Nothing Else to Do: 0.13			**Competent:** 3.14
	F	1.1 (63.25 min.)	**Had to:** 0.00	**With Others:** 0.73	6.0	**Net Affect:** 4.38
			Wanted to:	**No One:**		**Tired:**

			0.93	0.27		2.75
			Had Nothing Else to Do: 0.07			**Competent:** 3.0

Table 20. Context of Experience Outside of Home and School

Activity Class	Gender	Duration (*Mean* Hours)	Why (motivation to participate *Mean*)	Interaction *Mean*	*Mean* Level of Satisfaction	Affect Rating
Structured Free time Activities	**All**	1.72 (103.34 min.)	**Had to:** 0.23	**With Others:** 1.00	6.28	**Net Affect:** 3.44
			Wanted to: 0.77	**No One:** 0.00		**Tired:** 3.2
			Had Nothing Else to Do: 0.00			**Competent:** 2.84
	M	1.88 (112.5 min.)	**Had to:** 0.13	**With Others:** 1.00	6.88	**Net Affect:** 3.22
			Wanted to: 0.87	**No One:** 0.00		**Tired:** 2.0
			Had Nothing Else to Do: 0.00			**Competent:** 2.67
	F	1.57 (94.17 min.)	**Had to:** 0.33	**With Others:** 1.00	5.67	**Net Affect:** 3.65
			Wanted to: 0.67	**No One:** 0.00		**Tired:** 4.4
			Had Nothing Else to Do: 0.00			**Competent:** 3.0
Unstructured Free Time	**All**	1.02 (61.6 min.)	**Had to:** 0.00	**With Others:** 0.97	7.13	**Net Affect:** 4.51

Activities			**Wanted to:** 0.83	**No One:** 0.03		**Tired:** 3.38
			Had Nothing Else to Do: 0.17			**Competent:** 3.46
	M	1.16 (69.5 min.)	**Had to:** 0.00	**With Others:** 1.00	7.0	**Net Affect:** 4.23
			Wanted to: 0.73	**No One:** 0.00		**Tired:** 3.5
			Had Nothing Else to Do: 0.27			**Competent** 2.17
	F	0.9 (53.75 min.)	**Had to:** 0.00	**With Others:** 0.93	7.25	**Net Affect:** 4.79
			Wanted to: 0.93	**No One:** 0.07		**Tired:** 3.25
			Had Nothing Else to Do: 0.07			**Competent:** 4.75

Content Analysis (Programming Features)

Table 21. Maze Game Project (Programming Feature by Project)

Tot. Displaying Feature	Seq.	Loop	Cond.	Var.	Threads	Sync.	Bool.	Events	OOP	UI	Data Types
All	23	13	21	19	20	4	1	23	12	0	17
% of Tot. (A)	1.0	0.57	0.91	0.83	0.87	0.17	0.04	1.0	0.52	0.0	0.74
M	14	9	12	11	11	3	1	14	6	0	10
% of Tot. (M)	1.0	0.64	0.86	0.79	0.79	0.21	0.07	1.0	0.43	0.0	0.71

F	9	4	9	8	9	1	0	9	6	0	7
% of Tot. (F)	1.0	0.44	1.0	0.89	1.0	0.11	0.0	1.0	0.67	0.0	0.78
Total Projects Reviewed	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)	23 (A) 14 (M) 9 (F)

Table 22. Final Project (Programming Feature by Project – In Progress Games)

Tot. Displaying Feature	Seq.	Loop	Cond.	Var.	Threads	Sync.	Bool.	Events	OOP	UI	Data Types
All	11	7	8	3	7	2	1	11	3	1	8
% of Tot. (A)	1.0	0.64	0.73	0.27	0.64	0.18	0.09	1.0	0.27	0.09	0.73
M	7	5	5	2	4	1	1	7	3	1	5
% of Tot. (M)	1.0	0.71	0.71	0.29	0.57	0.14	0.14	1.0	0.43	0.14	0.71
F	4	2	3	1	3	1	0	4	0	0	3
% of Tot. (F)	1.0	0.50	0.75	0.25	0.75	0.25	0.00	1.0	0.00	0.00	0.75
Total Projects Reviewed	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)	11 (A) 7 (M) 4 (F)

Table 23. Final Project (Programming Feature by Project – Finalized Games)

Tot. Displaying Feature	Seq.	Loop	Cond.	Var.	Threads	Sync.	Bool.	Events	OOP	UI	Data Types
All	9	6	9	4	8	5	4	9	9	9	8
% of Tot. (A)	1.0	0.67	1.0	0.44	0.89	0.56	0.44	1.0	1.0	1.0	0.89

M	5	4	5	2	4	2	2	5	5	5	5
% of Tot. (M)	1.0	0.8	1.0	0.4	0.8	0.4	0.4	1.0	1.0	1.0	1.0
F	4	2	4	2	4	3	2	4	4	4	3
% of Tot. (F)	1.0	0.5	1.0	0.5	1.0	0.75	0.5	1.0	1.0	1.0	0.75
Total Projects Reviewed	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**	**9 (A) 5 (M) 4 (F)**

Creativity Support Index Rating for Scratch

Table 24. CSI Rating for Scratch (Digital Storytelling Workshop: Surrey Children's Festival)

	Item 1	Item 2	Item 3	Item 4	Item 5
Mean	4.69	4.64	4.64	4.83	4.78
SD	0.56	0.76	0.68	0.52	0.58
CI (upper, lower)	4.83, 4.55	4.83, 4.45	4.81, 4.47	4.96, 4.70	4.93, 4.64
CSI = (Item 1 + Item 2 + Item 3 + Item 4 + Item 5)*4 **CSI for Scratch = 94.32/100**					

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