New Numeracies – the Social Practice of Functional Skills and Social Justice

by

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A Thesis Submitted in Partial Fulfillment
of the Requirements for the Degree of

Master of Arts, in Education and Digital Technologies, Degree

In

The Faculty of Education Program

University of Ontario Institute of Technology

November 2011

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CERTIFICATE OF APPROVAL

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Abstract

This thesis explores how creating and performing digital numeracy texts, affords students learning opportunities in Mathematics that demonstrate their numerical social practice. In an environment that celebrates performance before competence, students explore how to design and engineer their digital understanding of social justice issues, such that they begin to connect their numeracy to socio-cultural issues in both local and global communities.

Keywords

New Numeracies; Digital Numeracy; Social Justice; Functional Skills; Performance

Acknowledgments

I'd like to acknowledge the following assistance in the completion of my thesis:

1. High Valley School: In particular, I'd like to acknowledge my year 8 class, who willingly and enthusiastically embraced both my research and their teacher as researcher. I'd also like to thank the Head Teacher, Mr. Ted Baker, and the Head of Department (2010), Mr. John Smith, who supported this in-class research with time, support, and contributions.
2. Dr. Janette Hughes: whose guidance, support, and academic passion for digital literacy, new literacies, multiple literacies, and multimodality have and continue to inspire me as a fellow academic.
3. My Partner & Family: whose continual love, support, and 'tea-making' have enabled me to complete this thesis.

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List of Abbreviations, Symbols, and Nomenclature

AQA	Assessment and Qualifications Alliance (An Exam Board in the UK)
CAT	Cognitive Abilities Test
COD	Call of Duty
ICT	Information and Communication Technology
KS3	Key Stage 3 (Students in years 7, 8 & 9 in the UK: aged 11-13)
KS4	Key Stage 4 (Students in years 10 & 11 in the UK: aged 14-16)
MMMS	Making Math Make Sense
NCTM	National Council Of Teachers Of Mathematics
QCDA	Qualification and Curriculum Development Agency

Chapter I – Introduction

Conducted in the UK with Key Stage 3 (KS3) students, aged 12-13, this thesis research focuses primarily on developing Numeracy (and Literacy) in a digital age, specifically looking at the social practice of digital numeracy through the lens of social justice. Using the idea of literacy as "social practice" rather than an "entity that you either do or do not possess" (Harste, 2003, p. 8) is revolutionary in a pedagogical sense, as it affords the opportunity to reconsider the skills students require to be successful, both in and outside of school. In the same vein, numeracy can be described as a *social practice* because "the knowledge of basic number skills and the ability to apply those skills in contexts that require high levels of literacy to interpret situations and make judgments," is the essence of successful numerical *social practice* (University of Michigan, 2005). Numeracy as a social practice, as Brown, Collins & Duguid (1989) state, requires one to understand learning as a "process of enculturation" (p.33) where "meaning and purpose are socially constructed" (p.34) through active actions rather than passive participation. While the functional requirements within both literacy and numeracy are different, the idea that numeracy needs a degree of literacy is emphasized by the National Council for Teachers of Mathematics (NCTM) *Principles and Standards* document, which strongly "reflect society's needs for mathematical literacy" (NCTM, 2000, p. 1). In this sense, it is not the intention of this research to delineate numeracy from literacy, as it is important to understand that learning and subsequent communication of such is through the *social practice* of literacy. Indeed, communication in Mathematics has become increasingly important not only because learning is context sensitive but also because it is socially constructed and developed through a "culture of practice" (Brown, Collins & Duguid 1989, p.39). Moreover, "[t]oday's children are living in a civilization that is dominated by mathematically based technology and unprecedented means of communication" (D'Ambrosio, 2001, p.308) in such a way that they should expect their education to offer opportunities that make them more employable, culturally sensitive, and socially responsible. Notwithstanding this, it will be important to identify specific numeracy indicators within this research that particularly

identify the development of Mathematical learning and understanding within this socio-cultural context.

Focusing on functional numeracy skills, which require students to "interpret and communicate solutions to practical [real-world] problems, drawing simple conclusions and giving explanations," is a key component to passing standardized exit examinations for boards such as Assessment and Qualifications Alliance (AQA) in the UK (AQA, 2009, p. 3). It is this standardized exit examination structure, which exists in some fashion in all educational settings, that requires pause to consider whether, "[b]eing proficient in a complex domain such as Mathematics, [which] entails the ability to use knowledge flexibly [and] applying what is learned in one setting appropriately in another," (NCTM, 2000, p. 20) is any different from the principles underpinning the notion of numeracy. When one considers that Mathematics makes more sense, and is easier to remember and to apply, when students connect new knowledge to existing knowledge in meaningful ways (Schoenfeld, 1988), it becomes apparent that this contextualization of Mathematics is the same basis for considering numeracy as *social practice*. Therefore, while one can acknowledge that Mathematics, as a content-driven discipline at school, is significantly different from the skill of application in a social setting, it is also possible to use the terms Mathematics and numeracy interchangeably from the perspective of this thesis: to develop the functional skills of numeracy, which allow one to understand and socially participate in the (numerical) world around them.

However, in a digital age it is also important to incorporate the use of technology in teaching and learning how to communicate ideas. Burke and Hammett's (2009) definition of digital literacy as digital "l(IT)eracy" (p. 186) is a way of acknowledging how the digital age has affected our understanding and production of literacy such that we now have New Literacies such as blogging, digital poetry, digital mash-ups, and online social networking to name a few (Lankshear & Knobel, 2008). The research contained within this thesis aims to extend the notion of l(IT)eracy into the discipline of Mathematics and focus on digital numeracies and the new numeracies this may afford. Through digital numeracies, students can access deeper Mathematical learning through an appropriate use of technology in the classroom because it affords

opportunities to explore and contextualize their numerical learning. There are many lines of current research which "support learning technology through activities that in many ways mirror that of designers and engineers seeking to solve problems or to produce new knowledge or products" (Bybee & Loucks-Horsley, 2000, p. 32). These activities that require students to be designers and engineers move beyond the idea that calculators are the primary technology in Mathematics classrooms, to one that facilitates an understanding that digital numeracies incorporate technology as multimodal tools.

Design choice and multimodal understanding of the communicative ability of how modes work in concert to create meaning, asks for producers (designers and engineers) to be critical readers of text and number in making those choices (New London Group, 1996; Jewitt, 2008; Burke and Hammett, 2009; Hughes & Tolley, 2010). Therefore, in asking students to be designers of digital numeracy texts, this thesis considers how the textual (word and number) is also related to the "six design elements in the meaning-making process: those of Linguistic Meaning, Visual Meaning, Audio Meaning, Gestural Meaning, Spatial Meaning, and the Multimodal patterns of meaning that relate the first five modes of meaning to each other" (New London Group, 1996). In creating a learning opportunity for students to be designers of digital numeracy texts, this thesis hopes to demonstrate that numeracy is a multi-modal social practice that applies "what is learned in one setting appropriately in another" (NCTM, 2000, p. 20). Furthermore, in producing "new [digital] knowledge or products" (Bybee & Loucks-Horsley, 2000, p. 32) that "communicate solutions to practical [real-world] problems" (AQA, 2009, p. 3) students are able to draw simple conclusions and give explanations that both develop their appreciation for the importance of Mathematics and allow them an understanding of how to participate successfully in society.

In this thesis, students were asked to work in a project-based environment (Borba, 2009) to design digital numeracy texts through the lens of social justice. These digital numeracy texts took the form of short videos, which were performed to the class (Gadanidis & Borba, 2008), and required students to pose questions about a social justice topic of their choice and explore relevant numerical information about it in such

a way as to contextualize their understanding and thoughts. When one considers social justice as a concern with "the distribution of advantages and disadvantages within a society" (define. 'Social Justice,' n.d.), this definition engenders an explicit learning opportunity for students to engage in the 'real-world' around them. It also offers educators the crucial opportunity to "connect that informal knowledge to the formal knowledge associated with schooling (LeFevre et al., 2009, p. 56). Exposure to numeracy-related activities in school that are about real-life social justice issues is one way to facilitate those connections. Moreover, when students engage in real-life Mathematics (real) in addition to imaginary (abstract) Mathematics, they move beyond an understanding of Mathematics, as it exists on the printed page or abstractly in their mind, to one that requires them to become personally invested in the outcome of their learning. Indeed, "culturally relevant and social justice instruction can offer opportunities for students to learn Mathematics in ways that are deeply meaningful and influential to the development of a positive Mathematics identity" (Jacqueline et al., 2010, p. 261). In accessing plausible (real) numeracy in addition to the imaginary (abstract) numeracy, they "use a domain's conceptual tools in authentic practice" (Brown, Collins & Duguid 1989, p.34). Viewing Mathematics through the lens of social justice is one option that facilitates the development of digital numeracy as *social practice* in a *real-world* context.

Background of Study/Statement of Problem

As a student of Mathematics, my experience of numeracy at school was limited to the classroom and a textbook. Even when I studied Mathematics at University, all that changed was an increase in the size of classroom and the length of time the teacher talked. It wasn't until my teacher training, when I attended a powerful seminar led by David Stocker on Social Justice in Mathematics education, that I realized I did not need to teach the way I had been taught (Gomez, Walker & Page, 2000; Zembylas, 2003). This seminar led to a pivotal change in my pedagogical practices and afforded me the opportunity to construct a teacher identity founded in digital and transformative practices that would focus on authentic numerical learning opportunities. When I

became a teacher of Mathematics, and encountered similar criticisms by students of Mathematics education that I had encountered myself, I became firmly committed to creating a learning environment dedicated to offering exposure to authentic numerical interactions and discussions of social justice issues from a mathematical perspective. As a beginning teacher, the criticisms I often encountered from my students surrounded three key tenets.

Firstly, there is often a negative student perception of this subject, with classroom comments such as “why do we need to learn this?” and “when will I ever use this?” emphasizing the student perception that Mathematics has little social and cultural relevancy to them or their lives. Students can feel that the content and skills learned in the classroom do not offer them the opportunities to be more successful in society and there is no social or cultural influence in or as a result of the subject content taught. From a teacher’s perspective, this negative student perception often leads to a process of justification of subject content, as parts of the curriculum do not overtly link Mathematical skills to the ‘real-world.’ Secondly, from a teaching perspective, based on UK standardized assessment, demonstration of learning never requires learners to use technology to problem solve and display Mathematical learning beyond that of demonstrating that they can use a scientific calculator in a standardized exit examination. While it is common to see technology used to demonstrate abstract ideas and information, it is rarely used as an analytical tool and certainly not as a critical reflection tool to talk about socio-cultural issues. As a result, students often disassociate Mathematics education with technology, leading to a student perspective that numeracy is not a functional skill in the digital age, when ironically it is the bedrock of a digital age. Thirdly, students continue to struggle to translate Mathematical concepts into a variety of contexts, resulting in an inability to utilize the basic knowledge acquired at school to new environments (Casner-Lotto & Wright Benner, 2006). Without learning how to transform abstract ideas into functional and applied skills that can be transferred from one situation to another, mathematics education fails to prepare students for entrance into the workplace.

Purpose of Study

These criticisms have led directly into developing research that focuses on functional numeracy and permits students to "interpret and communicate solutions to practical [real-world] problems, drawing simple conclusions and giving explanations" (AQA, 2009, p. 3). As a teacher of Mathematics, I feel this is an integral component of student success both in and beyond the classroom, as it permits students the opportunities to positively contribute to their local and global communities. This thesis endeavors to explore and analyze how students can learn Mathematics through self-directed learning experiences that offer them the opportunity to employ, produce, and research technology driven evidence of their Mathematical understanding of the real world. Through these affordances this thesis will examine how students use and develop functional skills by practicing their numeracy and Mathematical skills through socially and culturally relevant learning content. As a result, the purpose of this study is guided by three underlying themes: performance before competence, social and cultural relevance, and research for application and adaptation.

Performance before competence. In creating a digital numeracy text that performs their Mathematical understanding of an issue, students design solutions to problems and through the production of a final product, develop the potential to be producers and agents of change: "[t]he ability to render one's world as changeable and oneself as an agent able to direct that change " (Hull, 2003, p. 232). In demonstrating their relationship to the real world and offering an opinion on social justice issues within it, students communicate "solutions to practical [real-world] problems, drawing simple conclusions and giving explanations" (AQA, 2009, p. 3). As one of the learning principles detailed by Gee (2005), *Performance before Competence* demonstrates the importance of students performing "before they are competent" (p. 37; Cambourne, 2000). Although a stark contrast to how most schools and classrooms work, Like Gee (2005), I have observed that despite the way that students learn outside the classroom, schools continue to take a competence before performance approach. Similarly, when using this learning principle in a Mathematical context, students are often required to gain

competence through repetitive problem solving, before they can perform their understanding. However, this thesis aims to have the designers of digital numeracy texts perform their video in front of an audience. The rationale behind this theme is that if students perform, learning becomes individualized and immersive (Cambourne, 2000), which promotes a sense of success and confidence that develops "a positive Mathematics identity" (Jacqueline et al., 2010, p. 261). Furthermore, performance becomes a key element in the social practice of numeracy, as it creates a learning relationship not solely based on student-teacher interactions but one that "fosters collaboration" and moves beyond "an audience of one: the teacher," to social discussions of their personal interests and a relationship with their local and global communities (Haviland & McCall, 1999, p. 63). Therefore, performance before competence is not meant to undermine the need for numerical competence, but to assist its development. Indeed, the primary focus of this thesis is not to specifically address numerical competence in a traditional sense (computation and calculation) but through performance to develop an awareness that competence is also offered through *social practice.*

Social and cultural relevance. Extending the idea of literacy as "social practice" rather than an "entity that you either do or do not possess" (Harste, 2003, p. 8) to encompass how students communicate their understanding of Mathematics, allows students to create digital numeracy texts that simultaneously perform their digital literacy and numeracy skills. In doing this, the social practice of numeracy becomes a combination of interacting and using real-world Mathematical information to produce a piece of communication that showcases a numerical relationship between the producer and the real-world. In defining social justice as a concern with *the distribution of advantages and disadvantages within a society*, students can move beyond the traditional understanding of social justice as solely about human rights and access the underlying principle of power relations that exist in our society (Freire, 1970). This broader perspective of social justice encourages students to interact with their Mathematical learning by being involved in and producing an individual-interest driven piece of work that demonstrates their personal and collaborative analysis of real-life

scenarios that they care about. Indeed, the element of choice is a key component to inquiry-based learning as well as within a responsive education setting: “a caring and democratic culture that includes values, and challenges everyone in the school community to participate, to learn and to develop their personal best” (Gibbs, 2001, p. 13). Using the lens of social justice, this research aims to engage students with Mathematics on topics that are important, relevant, and applicable to them in an authentic and real-world way, with the planned goal of encouraging them to learn how to become responsible citizens who positively contribute to society. In doing this, Mathematical and numeracy skills become overt and are translated directly into the students’ learning environment.

Research for application and adaptation. This thesis project links to the UK’s KS3 curriculum in the following ways: 1) Personal Learning and Thinking (PLT) Skills of an Effective Participator at KS3 require “young people [to] actively engage with issues that affect them and those around them,” which necessitates the students being involved with something they care about (Qualifications and Curriculum Development Agency (QCDA), 2009, p. 2); 2) Ensuring that students produce a technology-driven piece of encoded text filled with multimodal meaning, further provides Information and Communication Technology (ICT) opportunities that promote risk-taking in their learning and produce something of value to them (Lankshear and Knobel, 2009). In the era of Web 2.0, where the emphasis is on collective intelligence, participation, and multimodal communication, participating in society is no longer simply a case of consuming information, but one of producing it; and 3) working towards skills that support successful standardized examination attainment in KS4, where they will need to “interpret and communicate solutions to practical [real-world] problems, drawing simple conclusions and giving explanations,” (AQA, 2009, p. 3). Ensuring the research is applicable and useable is an important facet of this thesis, as while it is conducted in a classroom setting, it is important that it facilitates the opportunity to be replicated and developed in other classroom settings and translates the ideas of numeracy as *social practice* into a context that is useable.

Research Question

The research question for this thesis considers the two elements of interaction and reaction to the production of digital numeracy texts.

> How might creating and performing digital numeracy texts based on social-justice themes, facilitate students' communication of Mathematical understanding of authentic real-world problems as part of their role in local and global, real and virtual communities?

Learning and understanding real-world problems serves as an interaction tool in Mathematics that allows the concept of numerical information to be contextualized; whereas the contextualization of their role in local and global communities serves as the reaction to their own and community's learning.

Theoretical Rationale

The theoretical framework of this research thesis centers on Boorstin's Performance Theory (1990). Boorstin developed performance criteria for films that included three categories: *voyeuristic, vicarious, and visceral*. Boorstin's performance theory is well suited to this thesis research, as the digital numeracy texts the students' produce are performed and showcased in a movie format. The application of Boorstin's theory in Mathematical education is also appropriate for digital numeracy texts because their creation is intended for an audience of more than one (Haviland & McCall, 1999). In addition, their performance holds the students accountable and responsible for their learning, forcing a sense of ownership for their digital numeracy text in terms of both content and effect. In identifying any development of numeracy as social practice, Boorstin's performance indicators will need to be evident in the digital numeracy texts produced as well as during their learning and research phase. However, for purposes of this thesis, the voyeuristic performance category of Boorstin's Theory (1990) will be sub-divided into two constructivist elements: surprise and sense-making. This division is important because Boorstin's (1990) description of the voyeuristic eye is at first surprise at the "joy of seeing the new and the wonderful" (p. 12), but afterwards must make

sense, "[b]ecause the voyeur's eye bores easily, it demands surprise -so long as surprise comes with a rational explanation" (p. 13).

While Boorstin's performance theory will form the basis of the theoretical framework for this thesis research, an underpinning ideology for this research will also be a multiliteracies (New London Group, 1996) approach that considers the following four elements: "*Situated Practice*, which draws on the experience of meaning-making in lifeworlds, the public realm, and workplaces; *Overt Instruction*, through which students develop an explicit metalanguage of Design; *Critical Framing*, which interprets the social context and purpose of Designs of meaning; and *Transformed Practice*, in which students, as meaning-makers, become Designers of social futures" (New London Group, 1996. p. 5). This multiliteracies approach is appropriate to this thesis research, as the creation of digital numeracy texts are akin to the New London Group's view of semiotic activity, "as a matter of Design involving three elements: Available Designs, Designing, and The Redesigned. Together these three elements emphasize the fact that meaning-making is an active and dynamic process, and not something governed by static rules" (New London Group, 1996, p. 11). In creating digital numeracy texts, semiotic processes, which offer structure for various modes of communication, will be evident in both the learning and research of their social justice issue and in the creation and design of their final product.

What is crucially important in the theoretical rationale of this thesis is how Boorstin's performance indicators and New London Group's multiliteracies approach work in tandem to afford social practice opportunities and success. Both frameworks offer a sense of fluidity in the development of numeracy (and literacy) as well as having a foundation in constructivism. Boorstin's *surprise* performance indicator is akin to the idea of cognitive conflict or a shocking moment in the discovery of new information and knowledge. Furthermore, *sense-making* is similar to the notion of knowledge construction, a concept mirrored in the meaning-making of *situated practice*. *Emotional moments* through direct experiences and subsequent design decisions of the digital numeracy texts, are afforded though *overt instruction* where students develop an "explicit metalanguage of design" (New London Group, 1996, p. 5). In designing a digital

numeracy text for the vicarious eye, the author creates a *metalanguage of design* that "puts our heart in the actor's body: we feel what the actor feels, but we judge it for ourselves" (p.67). In doing so, the students' overt instruction of the vicarious experience immerses the audience in critical and conscious discussions of the cultural locatedness of meanings and practices associated with numeracy. Finally, the *visceral sensations* of digital numeracies permit a sense of *critical framing* that promote a *transformed social practice* of numeracy (and literacy) for both the students themselves and the audience.

Chapter II – Review of the Literature

Introduction

Government policy, curriculum documents, and standardized exit examinations in the UK, are beginning to lean towards weaving literacy as social practice (Hartse, 2003) into Mathematics Education. Exam boards in the UK, such as AQA, are moving towards a focus on functional Mathematics, where students are required to 'communicate solutions to practical problems' as well as have their quality of written work (QWC) assessed. By using digital l(IT)eracy (Burke & Hammett, 2009) to offer students authentic social practice interaction with real-world scenarios, this research project aspires to meet the principles and expectations of Mathematics education in the UK, while also promoting the study of numerical social practice as one worthy of academic consideration. A thematic consideration of what constitutes literacy and digital l(IT)eracy, the functional skills of Mathematics as social practice, as well how Mathematics educational research has address the need for new numeracies to date, will inform this understanding.

Literacy and Digital l(IT)eracy

"When coupled with the notion of multiple literacies, literacy can be thought of as a particular set of social practices that a particular set of people value" (Harste, 2003, p. 8). As a result, to change "anyone's definition of literacy, the social practices that keep a particular (and often older) definition of literacy in place have to change" (p. 8). A paradigm shift in any discipline is never effortless or seamless, but the exponential growth of research into literacy, such that we now have new literacies, multiliteracies, and digital literacy to name but a few, supports the consideration for mirroring a similar paradigm shift in numeracy research. Using Harste's (2003) description of literacy as a "social practice" rather than an "entity" you either do or do not possess (p. 8), literacy becomes a functional skill that requires users to transform real-world inputs into useable and meaningful outputs. In his seminal article *what do we mean by literacy now?"* Harste (2003) targets our predispositions and traditional perceptions of literacy in order to revolutionize how language arts (literacy) programs are constructed,

developed, and implemented. In acknowledging the idea that "we need to help [students] see how 'the social' - meaning social, historical, and cultural forces - have been at play to position [ideas] in particular ways" (Harste, 2003, p. 9) literacy moves beyond "the phoneme and grapheme level" to a critical space that allows ideas of all sorts to be considered, analyzed, discussed, and their consequences thought through. This revolutionary shift in perception is also needed in our understanding and research into Mathematics education, particularly if society desires students to be actively engaged and numerically competent. Indeed "statistical literacy will one day, [if it is not already], be as necessary for efficient citizenship as the ability to read and write" (H.G. Wells, cited in Watson, 2006, p. vii). In arguing for a paradigm shift in our understanding of numeracy so that it too becomes a social practice, there is a need to further investigate some other seminal ideas in the literacy revolution and how these might be transformed into numerical social practice.

Whilst the "relationship of technology to social change is not a simple one" (Martin, 2008, p. 152), technology is a catalyst that drives this need for a paradigm shift. Using digital modes and producing digital numeracies is a stark contrast to the traditional perception and teaching strategies of Mathematics: computation and calculation, though much of Mathematics ironically surrounds the study of change: patterns and movement. In the paradigm shift for literacy, terms such as digital l(IT)eracy emphasize "the IT in the word l(IT)eracy to symbolize the bringing together theoretically of literacy and IT" (Nixon and Kerin, 2001). Burke & Hammett's (2009) recent book on *Assessing New Literacies* is a step forward for new literacies becoming valued and more legitimate insofar as providing a foundation for a discussion on how these new and developing modes of communication can be assessed for educational worth. Indeed, the "perceived validity of multiliteracies when putting the theory into practice" is still an ongoing issue for the successful inclusion of new literacies into mainstream educational use and one that new numeracies will similarly face (Hughes & Tolley, 2010, p. 6). While Burke & Hammett (2009) advocate for students to "find schools places where they learn to think critically about the digital, multimodal texts they encounter daily in their lives" (p. 190), it is the juxtaposition of mindsets that

Lankshear and Knobel (2007) discuss in their book *A New Literacies Sampler* that informs how a paradigm shift for new numeracies needs to be framed. The research in this book is taken "from a sociocultural perspective on literacy" (Lankshear & Knobel, 2007, p. 1), and supports the idea that literacy is a social practice. Their discussion of differing mindsets is one that characterizes how education's relationship with technology has not been simple and why the validity of new literacies is still a stumbling block for their inclusion into mainstream education. At a basic level mindset 1 is a traditional approach to information: one that is based on scarcity and is purpose specific. Mindset 1 situates the individual as the source of authority and the product of intelligence. In stark contrast, mindset 2 focuses on a more modern and technological approach to information: one based on dispersal of information and where "space is open, continuous, and fluid" (Lankshear & Knobel, 2007, p. 11). Mindset 2 situates the individual as part of a collective intelligence where authority is shared and accessible (Lévy, 1998: 1999). As Lankshear and Knobel (2008) point out "the idea is not that anyone's opinion is as good as anybody else's but, rather, that anyone's opinion may stand until it is overwritten by someone who believes they have a better line, and that the right to exercise this belief is constrained" (p. 18). For new literacies and new numeracies these mindsets characterize the difficulties of a paradigm shift where not only individuals have to change but institutions, like education, have to change too.

A way through the opposition of mindsets may lie in the recognition that new numeracies need to avoid reproducing familiar conventional numeracies through the use of new technologies, as this is rather like 'putting old wine in new bottles' and a characteristic of mindset 1 (Lankshear & Knobel, 2007). In this sense, digital numeracy needs to bridge the gap between one's "primary" and "secondary" discourse (Lankshear & Knobel, 2007, p. 3) and enable students to use Mathematical language and develop their numeracy (and literacy) in an individualized way "instead of a voice that they do not naturally use," (Luther, 2006, p. 68). Whether researchers considers this gap to be a digital divide or a social and cultural one, students perceive the content of Mathematics to be personally irrelevant, even though they realize that they need math skills to survive in the world of work. Thus all students want to succeed in Mathematics

academically in order to be successful in carrying out real-world applications. To do this, classrooms need to be critical spaces where ideas of numeracy need to be reconsidered and re-mixed and where educational institutions look and function similarly. Lankshear and Knobel (2008) further explain how “[r]emix means to take cultural artifacts and combine and manipulate them into new kinds of creative blends” in such a way that remix is one method of ensuring students can critically think about digital texts (p. 2). Whilst literary examples of such digital re-mix are easy to provide: graphic novels, digital poetry and digital mash-ups for example, doing something similar in a Mathematics classroom faces fierce opposition for not being an authentic display of numeracy. Viewing numeracy as an end-product, such as replicating a numerical process on paper, foregoes understanding numeracy as a learning process that has no end and whose replication is needed in real-world scenarios. It is for this reason that this thesis requires students to act as engineers and designers of digital numeracy texts that demonstrate transformative (Giroux, 1988) numerical skills as opposed to identifying them as technicians of numbers.

Gilster's (1997) original concept of digital literacy was the "ability to understand and to use information in multiple formats” (p. 33). This is a very liberating notion in comparison to the more specific and skill-set orientated definitions that others have used. Though "all information today is either digital, has been digital, or could be digital" (Lankshear & Knobel, 2008, p. 19), the idea that "we do not need 'one literacy [or numeracy] to rule them all'" (Lankshear & Knobel, 2008, p. 28) is an important and fundamental cornerstone in our understanding of what digital numeracy means.
The idea of digital or new numeracies is not a concept that should threaten other aspects of numeracy, but one that offers a "non-sequential" (Lankshear & Knobel, 2008, p. 20) element in what has traditionally been thought best developed through "linear process[es]" (Lankshear & Knobel, 2008, p. 21). New numeracies do not seek to replace the traditional perception of Mathematics in this paradigm shift: computation and calculation, but to incorporate (Borba, 2009) the study of change: patterns and movement into a social and cultural context that will facilitate a bridging between

mindsets and discourses in such a way that we develop students to be multi-sequential and numerically competent.

Functional Skills and Mathematics as Social Practice

Functionality in Mathematics is essential if students are to get the most from education and training and participate fully as young adults in 21st-century society (AQA, 2009). Understanding that functional skills involve students learning how to socially practice their numeracy by interacting and using real-world Mathematical information is key to student success in Mathematics. Functional skills afford learning opportunities that use a student's primary discourse in a secondary discourse setting, moving beyond the classroom to connect the student to both local and global discussions. From a cultural studies perspective, Grossberg (1994; 1997) argues that education is caught between multiculturalism and liberation and conservatism. The situation for numeracy is similar: caught between being a multi-faceted social practice or a traditional entity. Providing an in-between third space that allows for movement and amalgamation of ideas and offers a space to see the interconnections between ideas, is not only key to cultural studies and critical literacy, but could also facilitate a social practice space for numeracy (Bhabha, 1991; Giroux & McLaren, 1994). Given that "education should lead our students to live their lives differently" (Grossberg, 1994, p. 12) this third space of social practice permits ideas of all sorts to be considered, analyzed, discussed, and their consequences thought through. Creating a space for amalgamation and interconnection to occur permits the opportunity to radically re-consider what Mathematics Education could look like in a classroom and in a socio-cultural climate. This also permits discussion of how digital numeracy functions as a skill needed in today's society and an understanding of how critical numeracy could lead to an appreciation of the power relationships that exist within society and that the students experience.

As educators then, it becomes our responsibility to create a critical third space and close the gap between a student's primary and secondary discourse by bridging this divide between the traditional ideas of numeracy (and literacy) to one that embraces a new-numeracies functional approach. Haviland and McCall's (1999) revamped research

project, using a multi-modal l(IT)eracy model allowed students to “integrate text, images and effects” in their final project while also “foster[ing] collaboration,” moving beyond “an audience of one: the teacher,” to social discussions of their personal interests (Haviland & McCall, 1999, p. 63). Encouraging their students to be “active designers and producers of information” may be the kind of social practice that needs to be harnessed within Mathematics Education (Haviland & McCall, 1999, p. 65). While the students in their action research did not record their impressions and feedback during discussions, this omission highlights the need for students in this research to show how their functional numeracy has been transformed by shaping their Mathematical knowledge through language.

A root cause of such digital divides lies in the different skill sets each domain requires. Harnessing numeracy as a social practice is key to engaging students in communicating their understanding about Mathematics “instead of [using] a voice that they do not naturally use” (Luther, 2006, p. 68). An obstacle to numeracy as social practice is that a students’ “primary” use of discourse and skills needed in their life, used with friends, family and ‘people like them,’ is drastically different from their “secondary” one, which they participate in through outside institutions like schools (Lankshear & Knobel, 2007, p. 3). The further away a student’s “secondary discourse is from [his/her] primary discourses [and subsequent] secondary discourse, […] the more students have to ‘stretch’ [their] discursive resources to ‘perform’ in that discourse” (Lankshear & Knobel, 2007, p. 3). Often, Mathematics Education places student learning and assessment in a context that “under no other circumstances, [other than school], would they attempt to produce,” rather than embed it within an authentic and real-world application (Pegram, 2006, p. 3; D’Ambrosio, 2001; Brown, Collins, Duguie, 1989). Indeed: “when do we ever count just for the sake of counting? Only in school do we count without a social purpose of some kind. Outside of school, Mathematics is used to “advance or block a particular agenda” (Tate, 2005, p. 37). While the digital divide is beginning to be bridged in literacy, with the supplement of digital and media studies in some language programs, it is a gap that continues to widen in numeracy programs and research. Addressing this divide is a fundamental concern in all school subjects,

particularly Mathematics, as our understanding of this discipline is not only "shaped through language," but also is arguably a language in itself (Brown, 2001, p. 7). Ensuring students have the opportunity to develop new numeracies, multi-numeracies, and digital numeracies, to mirror but a few, new literacy concepts, further supports the need to consider how a paradigm shift in numeracy ideology might support bridging the gap between primary and secondary discourse such that students might leave educational institutions more numerically savvy and able to be numerically competent citizens.

Working in conjunction with the need for digital numeracies is the contextualization of Mathematics within a social and cultural setting. Exposing students to social justice themes within Mathematics, provides an opportunity for relevant and applicable authentic interactions with their socio-cultural climate, as they learn that numbers and Mathematical operations can represent advantages and disadvantages within society. Teaching "students that [numbers are] a means to present new ways of seeing, new solutions to unsolved problems, [provides] them the opportunity to shift society's paradigms" (Pegram, 2006, p. 18). This ability to interact with paradigms allows students social practice skills within Mathematics Education that are also opportunities to be successful and positively contribute to society. Too often, students can "calculate how likely is it that [they'll] roll a sum of four with two dice but [they] can't explain the chances of reaching age four in Sudan" (Stocker, 2008, p. 11). This lack of applicability and relevancy detailed by Stocker is exactly the issue that leads a student's primary discourse to be so drastically different from their secondary one and which re-establishes a disconnect between the local and global communities they will need to participate in. De Freitas (2008) claims "addressing social justice issues should be a primary goal of all education – including Mathematics education (p. 43). If education is meant to inspire students to lead their lives differently (de Freitas, 2008), then any reluctance to use education as a place of inclusion and discussion of inequity is a willful participation in the continuance of those same inequities.

As a concern with "the distribution of advantages and disadvantages within a society," social justice can offer students the opportunity to understand the *Pedagogy*

of the Oppressed and access the "humanistic and historical task of the oppressed: to liberate themselves as well as their oppressors" (Freire, 1970, p. 44). In doing so, students not only learn traditional numeracy skills but also that culturally and relevant social justice discussions and research can offer opportunities to learn Mathematics in ways that are "deeply meaningful and influential to the development of a positive Mathematics identity" (Jacqueline et al, 2010, p. 261). Furthermore, the motivation for using a social justice context for learning Mathematics should not be to assist entry into the workplace, though this is obviously important; the motivation should primarily be informed citizenship and empowerment (Leonard et al, 2010). The resulting combination of functional skills and re-focusing on Mathematics as a social practice is that new numeracies can afford a sense of numerical citizenship. Indeed, "[w]hen Mathematics for social justice is understood as a tool to further social change and the emancipation of oppressed communities, it is being viewed as an extension of Paulo Freire's scholarship and his pedagogy of liberation" (Gonzalez, 2009, p. 25). Frankenstein's (1983) application of Freire's epistemology for Mathematics teachers is seminal in understanding how numeracy and social justice are vital to improving the quality of Mathematics education. Frankenstein (1983) claims that:

> Freire's theory compels Mathematics teachers to probe the nonpositivist meaning of Mathematical knowledge, the importance of quantitative reasoning in the development of critical consciousness, the ways in which Math anxiety helps sustain hegemonic ideologies, and the connections between our specific curriculum and the development of critical consciousness (p. 324).

Re-thinking numeracy so that its aim is to develop a critical consciousness reaffirms a need for a paradigm shift away from academic performance as the sole outcome to one where students need to be critically, digitally and numerically savvy citizens.

Mathematics Education Research

From the purposes of this thesis, the literature on Mathematics education that will be referenced here focuses primarily on statistical literacy (numerical literacy), digital numeracy (humans-with–media), and performance of these functional numerical skills. The triad of these research strands, serves to underpin the need to combine functional

skills with social practice and digital technology within Mathematics Education. Wallman (1993) writes that statistical literacy is “the ability to understand and critically evaluate statistical results that permeate our daily lives-coupled with the ability to appreciate the contributions that statistical thinking can make in public and private, professional and personal decisions” (p. 1). This definition of statistical literacy is important because it does not segregate literacy from numeracy but rather draws them closer together with the explicit intent of creating numerically informed citizens who “react intelligently to quantitative information in the world around them” (Ben-Zvi,& Garfield, 2004, p. 3). This research argues that widening the notion of statistical literacy (traditionally characterized by statistics) to that of numerical literacy permits the idea of all numerical information to be considered in the communication of understanding and citizenship. This expanded understanding of statistical literacy as numerical literacy is also directly tied into the UK’s National Curriculum for Mathematics where students need to be able to "make sense of someone else’s findings and judge their value in the light of the evidence they present” (QCDA, 2007, p. 160). Indeed, it is the functional skills inherent within statistics that make up the underlying principles needed for numerical literacy: “statistics has some claim to being a fundamental method of inquiry, a general way of thinking that is more important than any of the specific techniques that make up the discipline (Moore, 1990, p.134). In this sense, Mathematics Education and the notion of numerical literacy veers away from content specific instruction and replication, where students are simply required to “graph $y = x^2 - 5x + 6$,” to more challenging questions that transform understanding such as “why does the graph of $y = x^2 - 5x + 6$ look like this?” (Borba, 2009, p. 458).

This transition from Mathematics as a *technique* to *a critical practice*, capable of creating an “inter-shaping relationship” (Borba, 2009, p. 456; Brown, Collins, Duguie, 1989) between number and student is detailed in Luke & Freebody’s (2003) proposed four roles for literacy as social practice: Coding, Text-Meaning, Pragmatic, and Critical practices, which will be mirrored in this thesis as four roles for numerical literacy. These four roles for literacy are easily adapted towards an understanding of numeracy as

social practice, because they further inform our understanding of numerical literacy. In other words, “almost all information of a statistical nature in social contexts is presented in some form of text” (Watson, p. 250). Coding practices, as the ability to work out text, are directly applicable to developing numeracy as a social-cultural context, as Mathematical information is primarily presented visually and in written form. At a very basic level, individuals need to negotiate an understanding of how the numbers and symbols work, in order to engage with them. Text meaning relates to what cultural resources can be brought to the text to create meaning. In the same way, an individual’s understanding of Mathematical terminology, such as ‘averages,’ would depend upon the social cultural context of the data being interacted with, as well as the social cultural content with which it is delivered. Pragmatic practices, relate to how the individual interacts with the text as well as acknowledging how others might interact with it also. Being able to interpret numerical information so that a person might reasonably take the data as raw input and then create some meaningful output is exactly the type of numerical citizenship that numeracy as social practice advocates. Furthermore, pragmatic practices are the foundations for transforming understanding into performance of numerical literacy. Finally, critical practices require an understanding of intent and purpose within text: what is present as well as what is absent. Similarly, this critical practice is needed within numerical literacy, as an acute awareness of bias and deliberate omission, will contextualize the data being processed and affect the meaningful output being produced. Although these four roles are primarily literacy practices, they serve to form the underlying principles beneath research into numerical literacy. Borba’s (2009) research into statistical literacy highlights this need for individuals to be able to perform their numerical literacy to a diverse audience.

Digital numeracy in Mathematics classrooms primarily focuses on students becoming competent by “selecting appropriate Mathematical tools and methods, including ICT” (QCDA, 2007, p. 156). The ICT referred to in curriculum documents, such as those produced by QCDA, most notably means graphical calculators, dynamic geometry software, and spreadsheets. However, including ICT as an appropriate tool to

solve problems is only one side of an "inter-shaping" relationship between student and technology tools as "tools shape the way students know at the same time the students shape the tools and influence the design of the next generation of tools" (Borba, 2009, p. 453). As a result, this thesis proposes that one issue surrounding ICT in Mathematics education is that it is commonly used as a tool to replace computation and calculation and as a means to simply reproduce what could be done on paper (Lankshear & Knobel, 2006). Incorporating digital numeracy into Mathematics education such that numerical literacy as a social practice and functional skill is developed is key to the idea of numerical citizenship. Borba has been instrumental in discussing "the future of Mathematics education" (2009, p. 453) and offering potential insights into how this discipline might change in conjunction with the advancement of new media technologies. Such suggestions include "substantial changes in the didactical contract, as students will not likely be waiting for the teacher to initiate the teaching activity and they will be designing projects or developing activities that resemble research" (Borba, 2009, p. 460). Furthermore, Borba argues that potentially "there will be no problems, and the task will be to find problems and issues in this information-saturated environment" and discuss solutions for them, which may generate new problems (2009, p. 461). In accommodating activities that require students to be designers and project-engineers, Mathematics education moves beyond the idea that ICT is the provider of information to one that facilitates a symbiotic relationship between students and media, such that the digital numeracies, which students produce, are multimodal tools for questioning social justice issues and citizenship requirements.

Borba also proposes the idea of performance as "an alternative to the usual model of having students looking for answers to problems that are already known (2009, p. 463). Gadanidis and Borba (2008) propose that encouraging students to be "performance Mathematicians" is one way of addressing how numeracy can be produced and performed in front of an audience and negotiate this space of socially practicing Mathematics (p. 44). This informal artistic approach also reinforces Luther's (2006) notion of social practice as a natural discourse rather than a set of forced social interactions. Indeed, "students may be beginners in writing, […] or Mathematics, but

they're not beginners as human beings" (Macrorie, 1988, p.98-9). "[S]tudents should participate in the design and development of projects, rather than limiting their activities only to solving problems" (Borba, 2009, p. 461). Whilst these suggestions are forward-thinking and unsettle traditionally held values of memorization and rote learning, it is important to note that in classrooms where media co-exists with traditionally held values "one medium generally does not replace the one it competes with, but rather incorporates it and […] transforms it" (Lévy, 1993, p. 34). By incorporating media, performance, and citizenship into Mathematics education, new digital numeracies revise our sense of numerical literacy, such that students become actors on the stage of education rather than passive audience members. Indeed, Gadanidis and Hughes (2011) state that "if a student is able to discuss school mathematics with family and friends, just as one would discuss a favourite book or a good movie, then that student has experienced meaningful math learning and teaching" (p. 487; Gadanidis 2009; Gadanidis, and Borba 2008; Gadanidis, Hughes, and Borba 2008)

Conclusions

This thematic review of literature has focused on research that views numeracy from the perspective of functional skill development and social practice as opposed to formal production. In doing so, educators offer students a third space to create, negotiate and perform their own communication and application of Mathematics such that they showcase, engage and promote active social participation. Facilitating students to demonstrate their understanding of Mathematics through a performance driven piece of ICT oriented work would also enable their communication to move beyond the audience of the classroom to a global space relying on collective intelligence. In the following pages, therefore, this thesis describes how students were encouraged to learn in a project-based environment and to design digital numeracy texts through the lens of social justice. These digital numeracy texts took the form of short videos, which were performed to the class (Gadanidis & Borba, 2008), and required students to pose questions about a social justice topic of their choice and explore relevant numerical

information about it, in such a way as to contextualize their understanding and thoughts. Facilitating their discussion of solutions to social justice issues required a learning environment that primarily used the Internet as a resource as opposed to class textbooks for print resources. In using social justice issues to explore students' numerical citizenship, digital numeracy texts have the potential to make their producer an agent of social change. By performing their Mathematical relationship to the real world, students are able to engage their audience in a consideration of their own social practice of numeracy and develop a sense of critical numeracy.

Chapter III – Theoretical Framework

Introduction

Critical numeracy practice involves reflecting and critiquing the power that adept social practice holds by looking at relationships among text and numbers in the context of socio-cultural groups and practices. Being a critical social participant is an essential component to being a positive and successful participant of the community. For students to learn what it means to be a "justice-oriented citizen," (Lewison, Leland & Harste, 2007, p. 4), they need to be involved in a community that centers on creating space "to shift society's paradigms" (Pegram, 2006, p. 18) through authentic and genuine communication. While the classroom will be a teacher-made community, it will mirror the ways in which socio-cultural participants may navigate their social practices. Any successful social practice and participation is based on being able to *perform* one's competency in numeracy (and literacy).

The theoretical framework of this research thesis centers on Boorstin's Performance Theory (1990), which was originally used for film. However, as Boorstin's performance theory is at its most basic, based on interactions, it is possible to paraphrase these to suit this thesis' Mathematical context. Boorstin's book *The Hollywood Eye* postulates that movies appeal to people on three different emotional components: visceral (inclusive of sub-categories: surprise and sense-making), vicarious, and voyeuristic. Situating these performance indicators into a Mathematical context works as follows: (1a) the voyeuristic *surprise* and pleasure of experiencing the new, the wonderful and the surprising in Mathematics; (1b) the voyeuristic rationale and *sense-making* of the surprise; (2) the vicarious pleasure of experiencing *emotional* Mathematical moments (either our own, or vicariously, those of others); and (3) the visceral pleasure of *sensing* Mathematical beauty" (Gadanidis, et al, 2009). Norman (2004) notes that Boorstin's emotional categories bear direct correspondence to his work on emotional design: visceral (visceral), behavioral (vicarious), and reflective (voyeuristic). Norman's research on emotional design also is also applicable to this thesis because the students design digital numeracy texts, which aim to "engage the

viewer both cognitively and emotionally" (Norman, 2004, p.134). Boorstin's Performance Theory (1990) provides the foundation for identifying the indicators that demonstrate how students creating and performing digital numeracy texts based on social-justice themes, facilitate their communication of Mathematical understanding of authentic real-world problems as part of their role in local and global, real and virtual communities.

Performance Indicators

Situating Boorstin's performance theory (1990) into a Mathematical context in the production of digital numeracy texts affords the following performance indicators to be considered:

Boorstin's Performance Theory (1990)	**Project-Work: Research & Learning Phase**	**Project Work: Design & Performance Phase**
Voyeur: surprise	Discovery of: 1) New connections to social justice topic (numeracy and literacy). 2) New contextualization of Mathematics in socio-cultural setting.	Elements in digital numeracy text: 1) Surprise as question posed, a resolution offered, a piece of numerical understanding. 2) Design decisions and elements that support a voyeuristic eye that "is easily bored" and demands surprise (p. 13) a. Changes image often b. Create a credible flow of time and space
Voyeur: sense-making	Discovery of: 1) Verification of information. 2) Research into contributing factors of social justice topic.	Elements in digital numeracy text: 1) A re-contextualization of Mathematical understanding. 2) Structured and purposeful design of social justice topic to rationalize surprise.
Vicarious	Discovery of: 1) Emotional responses to new mathematical connections that personalize social justice issues for the author 2) Projection of emotional response to subsequent mathematical connections	Elements in digital numeracy text: 1) Multi-modal elements that *show* the author's emotional response. 2) Multimodal elements that provide the audience with an opportunity to *feel* the emotional moment

		themselves. 3) Design decisions and elements that support a vicarious eye that "sees with the heart" (p. 66) a. Images project and *show* the intense emotional reality of the author b. Emotional reality *demands* empathy from the audience.
Visceral	Discovery of: 1) A "whole new experience" of mathematical connections to social justice issues that create a student "point-of-view" (p. 107) 2) How to "re-create his or her own raw feelings directly inside the viewers head," such that it reinforces the connection to their local and global communities (p.119).	Elements in digital numeracy text: 1) Sense of 'fit' – involvement or solution – such that it becomes the only truth. 2) Reflection of their role in local and global communities. 4) Design decisions and elements that support a visceral eye that tries "to break down the barrier between us and what we're watching" (p. 106) a. Sense of depth in images, such Point Of View (POV) shots b. Images that portray emotional truth c. Sense of 'fit' in images that show patterns, recurrence or beauty

Table 1: Performance Indicators

The voyeuristic mathematician. Boorstin's (1990) voyeuristic eye for films is "the simple joy of seeing the new and the wonderful" (p. 12) and because "the voyeur's eye bores easily, it demands surprise" (p. 13). This idea of the new, the wonderful, and the surprising, is an element of education in a constructivist sense (cognitive conflict) and often serves as a starting point for learning. In researching new information on a social justice topic of their choice, new information will be in abundance and invariably cause some level of cognitive conflict with their existing understanding of how the world

works. However, while the voyeur's eye bores easily, Boorstin's (1990) voyeuristic eye also demands "a rational explanation" (p. 13) and the research conducted by the students needs to make sense of their social justice topic, offering an acceptable and plausible explanation for their new numerical connections (equilibrium). Indeed, Mathematics makes more sense, and is easier to remember and to apply, when students connect new knowledge to existing knowledge in meaningful ways (Schoenfeld, 1988). While Mathematical surprise will be evident in the student's pursuit of investigating their social justice issue, it will also be afforded in the performance of their digital numeracy text, when the audience is surprised by the Mathematical information and the way it is communicated and critically examined.

The vicarious mathematician. "The vicarious eye puts our heart in the actor's body: we feel what the actor feels, but we judge it for ourselves" and as such "there is more at stake in the vicarious transaction than the voyeuristic one […] the voyeuristic experience may be grand or clever, but the vicarious experience can be profoundly moving" (Boorstin, 1990, p. 67). In adopting the vicarious eye in a Mathematical context, emotional moments for students happen at two distinct points in the research project. Firstly, learning and experiencing what numbers mean in a socio-cultural context where students discover *who has what and why* and secondly, they vicariously experience the emotional moments of others when they watch the performance of their digital numeracy text. In encouraging individualized social justice topics, students should be easily emotionally engaged in their learning and creation, because they are personally meaningful to them and therefore relevant to their own education. Furthermore, the digital numeracy texts will showcase the students' sense of emotional judgment, as they have made sense of their surprise and used multi-modal techniques, which combine, like film, to engage the audience in an emotional viewing of the digital numeracy texts. In an educational sense, the vicarious eye has 'emotional experience' which mirrors the constructivist idea of 'direct experience' by connecting the student on an emotional level to authentic Mathematics. While the students' development of these digital numeracy texts not only showcases a reflection process that encouraged deep

learning, the performance of these pieces allows the audience 'pause for thought' and consideration of their multi-modal Mathematical experience.

The visceral mathematician. The Visceral eye needs to "stir something inside" (Boorstin, 1990, p. 113) of the audience, so that they move beyond the vicarious experience to one where we are deeply moved, where "it feels real because it is real: it is happening to you" (Boorstin, 1990, p. 114). In this sense, researching a social justice issue can have serious repercussions for the students who create and also those who watch the performance: this is the real-world. In contextualizing their understanding of Mathematics, students become aware that they could become the statistic, they may even be the statistic already. Moreover, in creating a digital numeracy text, students have to piece multimodal elements together to create a sense of purpose or 'fit' a solution to the problem. This 'sense of fit' that they create is the premise behind "Mathematical beauty" (Gadanidis, et al, 2009, p. 2) where "yes, you should be able to go back afterward and marvel at how a [text] was done, but this should not intrude upon the experience itself (Norman, 1994, p. 129).

The multiliteracies mathematician. "Just as our experiences do not come neatly divided into unique categories" so digital numeracy texts cannot be stuck neatly into these categories either (Norman, 2004, p. 128). Boorstin's performance theory will form the basis of the theoretical framework for this thesis research; however, an underpinning ideology for this research will be a multiliteracies (New London Group) approach that considers the following four pedagogical components: situated practice, overt instruction, critical framing, and transformed practice. Situated practice "draws on the experience of meaning-making in lifeworlds, the public realm, and workplaces" (New London Group, 1996, p. 5) and in this sense is the type of social practice of authentic real-world issues that this thesis aims to expose the students too. Indeed, when discussing human knowledge, as "applicable to practice," education is "situated in sociocultural settings" and requires students to "act flexibly" in various contexts (New London Group, 1996, p. 19). As a weakness of situated practice is that learners of such complex practices can "spend a good deal of time pursuing the 'wrong' leads," it will be important to monitor how the students spend their time (New London Group, 1996, p.

20). Furthermore, as situated practice "does not necessarily lead to conscious control and awareness" it is important to ask students to justify their decision making processes when discussing their digital numeracy texts (New London Group, 1996, p. 20).

Overt instruction is how students develop an explicit metalanguage of Design for themselves that affords them the ability to describe the 'what' and 'how' of their design. However, "many sorts of Overt Instruction are notorious as socializing agents that can render learners quite uncritical and unconscious of the cultural locatedness of meanings and practices" (New London Group, 1996, p.20). Through voyeuristic and vicarious learning experiences, it will be important to scaffold the development of the students' metalanguage, such that they will have the basic tools for which to develop an awareness of 'what' and 'how' their design works. This working-knowledge of the 'what' and the 'how' naturally leads to a discussion of 'why,' which is a function of Critical Framing: "to help learners frame their growing mastery in practice (from Situated Practice) and conscious control and understanding (from Overt Instruction)" in relation to the various (historical, social, cultural, political, ideological) value-centered relations of particular systems of knowledge and social practice (New London Group, 1996, p. 21). Through performance, students will be able to 'see' *what* and *how* and cultivating an environment of social practice facilitates discussions of *why.*

Lastly, the pedagogical component of Transformed Practice, "in which students, as meaning-makers, become Designers of social futures" (New London Group, 1996, p. 5) is the goal of this thesis research. The New London Group's (1996) theoretical framework of multiliteracies ensures that the fundamental purpose of education is to "ensure that all students benefit from ways that allow them to participate fully in public, community, and economic life" (New London Group, 1996, p. 60) and takes into consideration how numeracy as social practice might facilitate functional skills of justice-oriented students. In this sense, the classroom becomes the site of transformed social practice to produce justice-orientated students capable of critical thought and social participation.

Conclusion

Underpinning Boorstin's performance theory with a multiliteracies framework takes into consideration how numeracy as social practice might facilitate functional skills of justice-oriented students such that they can perform their understanding in a learning environment that is conducive to having their success and development as its heart. Researching 'real-world' Mathematics puts the students into the real-world, where they no longer watch Mathematics being traditionally produced by the teacher or engage in the negative emotions of struggling to solve a problem, to one where they create a multimodal digital text that conveys their emotional connections to their roles in local and global communities.

Chapter IV – Methodology

Introduction

The methodological framework of this research is based on a mixed methods *designed research* approach. A design research cycle typically consists of three phases: 1) preparation and design; 2) teaching experiment; and 3) retrospective analysis (Bakker, 2004, p. 37). The strength of design research (Brown, 1992; Cobb, et al, 2003) is that it is "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researcher and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang and Hannafin, 2005, p. 6-7). Founding principles of this thesis are the investigations into social practice within Mathematics and the social interactions that might be permitted as part of learning with technology. It is important that the methodology of this thesis allows us to "reconceptualize the way we teach and learn with technology […] and view them through a performative lens" (Gadanidis & Geiger, 2010, p. 100), because it will mirror the process of design-produce-re-design-re-produce that this research asks of the students (Hughes, 2008, p. 20). This approach also allows for me to create a classroom that is a "learning organization" where "people continually expand their capacity to create the results they truly desire" (Senge, 1990, cited in Smith, 2001, p. 2). This emphasis on iterative design and reconceptualization will require the social practice and functional skills of both literacy and numeracy to be evaluated using a mixed method approach.

Methodology

Design research as a methodological approach, promotes experiments that develop theories rather than simply 'what works' (Cobb et al, 2003). There are five main features of design experiments: they develop theory, are highly interventionist, which result in both the creation and confrontation of theoretical practice, have an iterative design process, and any theory developed must be representative of the issues practitioners in the domain face (Cobb et al, 2003). Many authors associate design science with action research (Burstein & Gregor 1999; Cole et al. 2005), "since both

attempt to change the world" (Bukvova, 2009, p. 53). Susman and Everet's (1978) definition of action research has six characteristics: 1) *future oriented*, aimed at "creating a more desirable future," (p. 589) 2) *collaborative*, creating "interdependence between the researcher and the client system," (p. 589) 3) *implies system development*, "(1) alleviating the immediate problematic situation, and (2) generating new knowledge about system processes," (p. 590) 4) *generates theory grounded in action*, "by taking actions guided by theory and evaluating their consequences for the problems members of organizations face," (p. 590) 5) *agnostic*, acknowledging that every situation is unique and may be "subject to reexamination and reformulation," (p. 590) 6) situational, as "many of the relationships between people, events, and things are a function of the situation as relevant actors currently define it" (p. 590). Though there are differences between design research and action research, such as design research adopting a "materialistic ontology" as opposed to the "nominalistic, idealistic and constructivist ontology" adopted by action research (Iivari, 2007, p. 53), they are not "mutually exclusive" (Iivari, 2007, p. 54). Iivari (2007) states that "action research may well be used to evaluate artifacts developed in design science, and it may also provide information on how to improve those artifacts (p. 54). A "methodology combining design-based research with action research testing," can be used to create educationally based knowledge that is both "relevant and rigorous" (Andriessen, 2007, p. 7). In this sense, action research testing of a design based research strategy can develop general solutions that professionals can modify and adapt to their own specific needs.

Design. This thesis research followed a design research cycle that consisted of three phases: 1) preparation and design; 2) teaching experiment; and 3) retrospective analysis (Bakker, 2004, p. 37). The methodological design of this thesis relies heavily on the preparation and design of materials to be used in the research project. The four-week research project with the class had the following overall design:

Week	Day	Lesson Aims & Objectives
Prior		[1] Give Parent-Student Consent Letter [2] Give copy of School's Wireless Network Code of Conduct & Application Form (directly returned to ICT Technician at School)
1	Mon	[1] Collection of Parent-Student Consent Letters [2] Complete Preliminary Project Online Survey [3] Introduce Project: PPT □ Talk about social justice □ Project Outline / Requirements (Booklet) [4] Assignment Booklet: Picture Activity
	Wed	[1] Assignment Booklet: Evaluate videos – what worked / what didn't [2] Assignment Booklet: Multi-modally discussion & show theme multi-modally [3] Class Carousel – feedback / criticism
	Thu	[1] How to research – start process [2] Assignment Booklet: Description & Requirements □ Documents to complete before using computers □ Documents to complete after digital numeracy text finished
2	Mon	[1] Continue Research
	Wed	[1] Working on Videos
	Thu	[1] Working on Videos
3	Mon	[1] Working on Videos [2] Ensure they know how to finish text & save it onto USB Stick
	Wed	[1] Last day to work on Videos
	Thu	[1] Present Videos to class [2] Peer Evaluations
4	Mon	[1] Present Videos to class [2] Peer Evaluations
	Wed	[1] Complete Post-Project Online Survey [2] Group Activities [3] Student interviews
	Thu	[1] De-Brief of Class Project

Table 2: Overall four-week project class objectives and aims

The first week had the overall objective of ensuring that students understand how modes of communication work in concert with each other to create meaning. This was a fundamental stepping-stone in the project because it encouraged them to think creatively and non-sequentially. With the students having a 'specific instructional goal' based on the "theoretical intent" this research is able to understand the affordances of creating and performing digital numeracy texts based on social-justice themes (Cobb et al, 2003, p. 11). In addition, a key aspect to understanding numeracy as social practice

was developing a collaborative class understanding of social justice and its application to the field of Mathematics, as well as what a digital numeracy text might look like. A large portion of the first week was also dedicated to setting up the assignment and ensuring the students had an idea of what a digital text might look like. As detailed in Appendix 5: Assignment Booklets, their digital numeracy text needed to contain at least four pieces of Mathematical information and contextualize them in a way that makes the audience 'get it.' In this sense, the design of the research is in the 'teaching experiment' phase, as students needed overt instruction (New London Group, 1996) to understand the ideas of new numeracies and multimodal numeracies. Indeed, being the teacher-researcher affords a deeper "understanding of the phenomenon under investigation while the experiment is in progress" (Cobb et al, 2003). Ensuring the students understood the contextualization of numbers and how multiple modes of communication can work in concert to enhance or subdue the impact of numerical information was also important at this stage. Weeks two and three were dedicated to starting the research process and creating the digital numeracy texts. The latter part of week three, and the majority of the final week, was dedicated to performing the digital numeracy texts and completing the evaluation of the project. This phase of the design research is the 'retrospective phase' where students perform their digital numeracy texts and are allowed the opportunity to develop their critical numeracy and literacy practices through discussions, interviews, and self-reflection. Due to the cyclical nature of the design research methodology, this is also a reflective time for the teacher-researcher, whereby actual outcomes affect future decision-making. During the presentations, the Head Teacher and Head of Department were present and watched the presentations as along with the other students and myself. Enabling these other teachers to ask questions of the students' performances moved beyond "an audience of one: the teacher," to social discussions of their personal interests and a relationship with their local and global communities (Haviland & McCall, 1999, p. 63). In the final stages of week four, I had another teacher in the classroom substituting for me, so that I could extract students to interview them on their digital numeracy texts. As this teacher

was also the head of department, he walked round the groups and discussed with them what they gained from this experience without me being in the room with them.

Ethical considerations. As participants in this research project were drawn from among students that I, as teacher-researcher, teach three times a week, the following measures were taken to avoid a sense of coercion and to protect anonymity. Firstly, responses to the project consent forms were placed in a sealed envelope and not opened until after the completion of the project and all final grades for the term were submitted. Secondly, none of the students' grades were calculated using any of their work in this research project, so their participation (or lack of participation) in the research study did not impact their grades. Thirdly, although every student in the class completed the unit with all of the tasks (including the digital numeracy texts) to ensure inclusion, only students who had given consent to participate in the research had their work analyzed and were requested to participate in a one-on-one interview with the teacher-researcher. These formal interviews were conducted with selected participants after the project had finished and all grades were submitted.

Procedure. After getting the required ethical approval from the Research Ethics Board (REB) at the University of Ontario Institute of Technology (UOIT) (Appendix 9 REB Approval 10-024), the following research procedure was followed. The research was conducted over a 4-week period in-class time and did not inhibit the students following the department's scheme of learning or revision for any key summative assessments. Students were given a letter about the project, example provided in Appendix 1: Participant Requisition Letter, by the teacher-researcher and asked whether they would give their formal consent to have the work they produced as part of this thesis used for dissemination in this thesis. Students were advised that any work they produced or comments they made would be anonymous in the dissemination of the research and pseudonyms would be used instead of their real names. As this research was set up as a class project, students would participate in the activities whether they consented to have their work used or not, as this ensured that students did not feel discriminated against if they chose not to be a participant. Students placed their reply slips to the Participant Requisition Letter in an envelope at the front of the class throughout the

first week of the project. After each lesson, the envelope was sealed to protect anonymity and set aside in a locked filing cabinet at the back of the room: a new envelope was provided for each subsequent class. As only one student in the class did not consent to their work being used as part of this research, there was no higher favour presented to students who did choose to participate. As it was a concern that students would feel compelled to be part of this research and have their work used, it was explicitly stated by myself several times throughout the initial stage that students did not have to provide their consent. The students were advised that there would be no repercussions (they would still do the project with everyone else).

This 4-week unit culminated in students individually creating a digital numeracy text that focused on a social justice issue that was important, relevant, and applicable to them. In order to create these digital numeracy texts, students needed access to computers. As the school has wireless capabilities, students were asked if they would like to bring in their own laptops to complete class activities and create their digital numeracy text. The school has a standardized wireless network code of conduct and application form, a copy of which is provided in Appendix 2: High Valley School's Wireless Network Code of Conduct and Application Form. As only 30% of the class chose to bring in their own mobile technology, an ICT lab was the primary location for all classes where students needed access to the Internet to complete work. After setting up the requisition for participants and the option for personal mobile technologies to be used in the classroom, it was important to survey the students ahead of starting the project to see how they felt about the themes of the research: Mathematics, social practice, and digital technologies. This preliminary online survey, provided in Appendix 3: Preliminary Project Online Survey, was conducted without a project introduction to ensure that, where possible, students' opinions were not influenced by the teacher-researcher. The link to the online survey was provided on the class website, which was hosted by the schools own intranet, a screenshot of which is provided in Appendix 4: Class Website.

An assignment booklet, see "Appendix 5: Assignment Booklets," was provided for each student where class-work, assignment descriptions, and justifications of

decisions could be written down. At the start of the research project, students were asked to make choices about their work arrangement (individuals, pairs or in groups (max 4)) in order to investigate, participate, and produce a technology driven piece of work that demonstrates their understanding of multimodality. However, when students worked on their digital numeracy texts, they were asked to produce this individually, although they could research and collaborate on similar social justice topics in pairs or small groups. The first week of the research project was dedicated entirely to setting up the project, evaluating existing digital texts, understanding the research process, and the ideas behind multimodality and design concepts. The second and third weeks were dedicated to researching and creating their digital numeracy texts. Students were asked to produce their digital numeracy texts in any ICT format they felt comfortable with (photostory, movie-maker, etc). Finally the fourth week was dedicated to presenting their digital numeracy texts (links for those discussed in this paper are provided in Appendix 9: Digital Numeracy Texts), completing post-project online surveys (Appendix 6: Post-Project Online Survey and being interviewed by myself and another teacher (Appendix 7: Student Interview Questions and Appendix 8: Transcripts from Student Interviews).

Setting. Jersey is the largest of the Channel Islands at 8 KM long by 14.5 KM wide. It sits in the English Channel but is much closer to France than it is to England. Jersey is part of the British Isles, rather than Great Britain (England, Scotland and Wales) or the United Kingdom (Great Britain and Northern Ireland) and is classed as a British Crown Dependency. Jersey is “self-governing and has its own financial and legal systems” (Jersey Facts & figures, 2011) and while the curriculum in Jersey “closely follows the UK National Curriculum, there are some changes which take into account Jersey’s unique environment, culture and history” (Understanding the Curriculum, 2011). High Valley School is located in the west of the island in a parish called St. Brocade and has several school aims which “stress the importance of students reflecting on, and taking responsibility for, their own progress, behaviour and learning” (Our School Aims, 2011). This type of school environment is conducive to students being

"designers and engineers seeking to solve problems or to produce new knowledge or products" (Bybee & Loucks-Horsley, 2000, p. 32).

Participants. The research in this thesis used a Year 8 Key Stage 3 (KS3) Mathematics class of 27 students, which I taught at High Valley School, Jersey, Channel Islands, UK in 2011. The participants were aged 12-13 years old with a class ratio of boys to girls of 1:2 and are set 2 of 7 in the year group. A KS3 class was chosen, as they had no impending standardized examinations (GCSEs) to study for and because the current functional changes of literacy based questions in examinations will affect this year group upon entering KS4. Demographically, they are primarily white Caucasian (81%) students, native to Jersey, with a small exception (19%) of non-native non-Caucasians: there are no English Language Learners. The average Cognitive Abilities Test (CAT) score for this year group is 98, with this particular class having a mean average of 105. The CAT is "an assessment of a range of reasoning skills. The test looks at reasoning with three types of symbols: words, numbers and shapes or figures, i.e. verbal, quantitative and non-verbal reasoning " (Satsguide, 2009). Ninety Nine percent of the population "score between 60 and 140" and the UK national "have a mean of 100 and a standard deviation of 15, which shows how widely spread the data are around the mean of 100" (CAT Overview, 2010, p. 1). The higher the CAT score is in each test the more likely students are to achieve better GCSE grades:

- Mean CAT score of 85 to achieve 5+ A*-G grades (inc. English and Maths)
- Mean CAT score of 99 to achieve 5+ A*-C grades
- Mean CAT score of 120 to achieve 5+ A*-A grades (CAT Overview, 2010, p. 6)

To put this information into a Mathematical context, the quantitative reasoning score, which looks "at the same processes but use[s] numbers as the symbols," (Satsguide, 2009) is primarily used by Mathematics Departments to predict Mathematics GCSE grades for students. The mean average quantitative score for this particular year group is 93, with this particular class having a mean average of 101. It is important to note that the range in CAT scores from this class is 23, a spread starting at 90 and ending at 113. This information demonstrates that the class has a significant range of abilities, with 46% of the class having a mean quantitative CAT score of less than 100.

The sample selected for interviews and or video analysis consisted of three boys and three girls, of which three of them produced work using their own laptop brought in from home and three who produced their work on standard school computers. These students were purposefully selected (Patton, 1990) based on being academically representative of the class as a whole and because they represent "information-rich cases which can be studied in depth" (Hoepfl, 1997, p. 51). This research used a maximum variation type of purposeful sampling, because it captures central theme and principal outcomes that are representative of the research as a whole (Patton, 1990). While a potential criticism of this sampling is that the students may demonstrate some level of heterogeneity, "any common patterns that emerge from great variation are of particular interest and value in capturing the core experiences and central, shared aspects or impacts of a program" (Patton, 1990, p. 172). Due to the nature of numeracy as a social practice, a sampling strategy that identifies shared patterns will be of particular interest to understanding how social practice develops students' numeracy (and literacy).

Methods

This thesis research employed a mixed methods approach, which is the combination of quantitative and qualitative methods. There was an emphasis on qualitative methods, because this research draws primarily on descriptive case studies (Merriam 1998; Stake 2000) from an entire class project. However, incorporating some quantitative methods in analysis provides insights into the phenomenon of digital numeracy texts that neither type of analysis could provide alone (Russek & Weinberg, 1993). Indeed, as Greene (1989; 2001) highlights, the major benefits to this type of evaluation of data include: triangulation of validity and credibility, comprehensiveness of findings, more insightful understanding, and increased consciousness and diversity. The analysis of data, qualitative and quantitative, focused on the voyeuristic, vicarious, and visceral performance indicators outlined in Boorstin's (1990) Performance Theory.

Qualitative data collection and analysis. The qualitative portion of my research employed a variety of strategies in order to capture students' social practices of

numeracy (and literacy) occurring in the Mathematics classroom. The collaborative nature of the work will enable a qualitative research approach that encompasses descriptive case studies (Merriam 1998; Stake 2000), participant observations (Erickson 1984), and sideshadowing, and semi-structured interviews (Welch 1998; McClay 2005; Patton, 1990) with the students in their school environment (classroom and ICT lab). A case study method is suitable for collecting in-depth stories of student learning and studying a 'bounded system' (that is, the thoughts and actions of participating students) so as to understand it as it functions under natural conditions (Hughes & Tolley, 2010; Stake 2000). Case study research is particularistic in that it focuses on a particular situation, event, program, or phenomenon and is important for what it reveals about the phenomenon and for what it might represent. This specificity of focus makes it an especially good design for questions, situations, or puzzling occurrences arising from everyday social practice. A case study methodology is well suited to this research. In addition, a content analysis of the transcribed interviews, audio-taped interactions, and the digital/physical artifacts created by the students in order to identify themes that inform a conceptualization of how authoring a social justice themed piece of work might change the way students construct Mathematical texts and how the shift in process might reorganize or restructure their thinking about what they are learning. As forms of social interaction, an analysis of the digital numeracy texts created and performed by the students is "most fruitfully analyzed from a framework that recognizes the dialectical relationship 'between performance and its wider social sociocultural and political-economic context'" (Bauman and Briggs, 1990, p. 61)). Indeed, using Bauman and Briggs' (1990) sociocultural and political-economic view of performance, performance of digital numeracy texts becomes "a mode of social production" and through the act of decontextualizing and recontectualizing text is "an act of control" where issues of "social power" can arise and be discussed (p. 76). As digital stories have "multiple media and modes" (Hull and Katz, 2006, p. 47) of meaning-making, digital performance is more complex than an analysis of the single modes of meaning-making. As New London Group (1996) point out there are "multimodal patterns of meaning that relate the first five modes of meaning to each other" (p. 4).

Therefore, in analyzing the digital numeracy texts it is vital to look for performance indicators, as identified in Table 1: Performance Indicators, using Boorstin's (1990) performance theory, that specifically address how the voyeuristic, vicarious, and visceral eye develops and acts on the issues of social power being discussed.

Data sources. The data sources collected through this research were as follows: 1) analysis of the digital numeracy texts produced by the students; 2) the written self-evaluations of their digital numeracy text, included in their justification document in the assignment booklets; 3) student interviews with myself as researcher; 4) the verbal 'open' responses to the preliminary and post-project surveys; and 5) the commentary of the other teacher who watched the digital performances and discussed the project with the students.

Quantifiable data collection & analysis. The strengths of quantitative research from the perspective of this thesis are that "research results are relatively independent of the researcher" (Johnson & Onwuegbuzie, 2004, p. 19). Mitigating the teacher-as-researcher effect in the classroom is an important theme to address in this research. As "data collection using some quantitative methods is relatively quick" (Johnson & Onwuegbuzie, 2004, p. 19), the preliminary and post-project surveys provided a quick and rich source of data. The purpose of complementing the qualitative research portion of this thesis with quantifiable data is that the goal of mixing is not to search for corroboration but rather to expand one's understanding (Onwuegbuzie & Leech, 2004). Indeed, similar to the idea that "we do not need 'one literacy [or numeracy] to rule them all'" (Lankshear & Knobel, 2008, p.28), no research methodology or method is beyond reproach and does not seek to overrule the other, but to enhance and further ideas. The quantifiable data source for this thesis comes in the form of the students' anonymous responses based on their participation and attitudes to this project both before and after the project had finished. The quantifiable data for this research was comprised of a questionnaire that had non-numerical measurements (position on a scale indicating a level of agreement e.g. Likert rating scale) which produced ordinal data (numerical values are assigned in accordance with a qualitative scale e.g. in coding a questionnaire for computer analysis, the responses 'very good', 'good', 'poor' and

'very poor' are coded '4', '3', '2' and '1' respectively). This questionnaire was given at the beginning of the course, as well as at the end in order to gauge the development of functional skills throughout the experience (Appendices 3 and 6 detail the pre and post project online survey questions).

Methodological Limitations

Some limitations for a methodology based on a design research approach include the following factors: immature design, applicability and feasibility, paradigm shift, data utilization, all of which were discussed in the introduction. However, there are two further limitations, referred to as *The Hawthorne Effect* and *The Reality Principle,* which need further discussion and mitigation.

The Hawthorne effect. The Hawthorne Effect is a limitation born out of an experiment conducted by Roethlisberger & Dickson (1939) "at the Hawthorne plant of Western Electric in the 1920s," where the standard interpretation of their findings was that "the mere presence of the research team will lead to enhanced performance because of the motivational effect of the attention received by the 'subjects' (Brown, 1992, p. 163). As the sole teacher-researcher for this thesis research, the Hawthorne Effect may affect the interpretation of the results or findings because the student participation and performance is exaggerated and enhanced by the 'mere' idea of their work being used and published. Moreover, it may be difficult to "predict which performance would improve" in terms of distinguishing between development in either their literacy or numeracy skills (Brown, 1992, p. 163). In this sense, there is a loss of control by the researcher of the interventions or experiment being conducted. However, as Brown (1992) discusses "this illusion of control, or real control, is one of the things I want to happen in my classrooms. I want students to act as consultants, to be co-investigators of their own learning" (p. 165). As a result, this thesis argues for the same 'illusion' to be present in the classroom of this research, because it desires the Hawthorne Effect to be present. If the students have an 'enhanced performance,' if they feel a 'motivational effect' and 'act as consultants' in their own learning and social

practice, then this research will have created a cooperative learning environment based on a theoretical rationale which develops literacy and numeracy as social practice.

The reality principle. The Reality Principle, based on "the shelf life of successful interventions" concerns whether this research will have any lasting effect (Brown, 1992, p. 163). "The argument is that successful intervention are a chimera or at least are extremely fleeting and fragile, not readily transportable to settings outside the innovator's control" (Brown, 1992, p. 171). Basing the idea of digital numeracy texts, new numeracies, and critical numeracy, in the plethora of new literacies, multiliteracies, and multimodality is encouraging due to the widespread dissemination of this methodology. 'In reality' this thesis is not arguing for reinvention, but to "reconceptualize the way we teach and learn with technology [in Mathematics] and view [Mathematics] through a performative lens" that encourages social practice and participation in local and global communities (Gadanidis & Geiger, 2010, p. 100),

Conclusion

The Methodology of this chapter is based on a design research approach and focuses on three phases: 1) preparation and design; 2) teaching experiment; and 3) retrospective analysis. This design research method has limitations that are mitigated by the theme of this research, which is to develop numerical social practice. The strength of design is that it is "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researcher and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang and Hannafin, 2005, p. 6-7). As this research argues for a paradigm shift in our conceptualization of numeracy, to an extent an immature design is to be expected, because of its newness in the field of education.

Chapter V – Results

Introduction

There were 28 students in the class selected for this thesis research. The findings being reported in this thesis fall into five categories: 1) Preliminary Project – Online Survey (23 students completed); 2) The Digital Numeracy Texts Produced (two students selected); 3) Interviews with the Students (four students selected); 4) Post Project – Online Survey (ten students completed); and 5) Synopsis of project experience from the then Head of Department at the school. My own observational notes and commentaries are used in the discussion portion of this thesis. It is important to note that the school had recently installed a wireless-internet system, enabling students to connect their own mobile technologies to the Internet at school. Some of the activities engaged in prior to commencing the research were: 1) requesting parents to consider allowing students to bring in their own mobile technologies to class; 2) requesting students and parents to sign up to the wireless code of conduct; and 3) requesting the students' laptops be registered onto the school's monitoring system.

Preliminary Project Online Survey.

It was important to gauge the students' responses to the thematic ideas of the project they were to embark upon and as such the survey was split into four sections: 1) personal information; 2) preliminary perceptions of Mathematics; 3) preliminary perceptions of social justice; and 4) preliminary perceptions of Information and Communication Technologies (ICT) and the Project, from what little they might have gleaned about the project from myself. A copy of the preliminary online project survey is supplied in Appendix 3. The preliminary survey was compared and contrasted against the post project survey; however, due to the anonymous nature of the survey it was not possible to compare individual student responses.

Section 1: project preliminary survey – personal information. Of the 23 students who completed the preliminary survey, 35% were boys and 65% were girls. Although 43% (10) of the 23 said they were bringing in their own laptops, only 29% (8) of the 28 students in the class actually did, with a further two students eventually

deciding not to bring in their own mobile technology and using the school's equipment instead. A thematic analysis of the reasons why 57% (13) of the 23 students did not bring in their laptops to school was primarily that, a) they were not allowed (38%); or b) they did not have a laptop (54%).

The amount of time the students spent on the Internet at home is as follows:

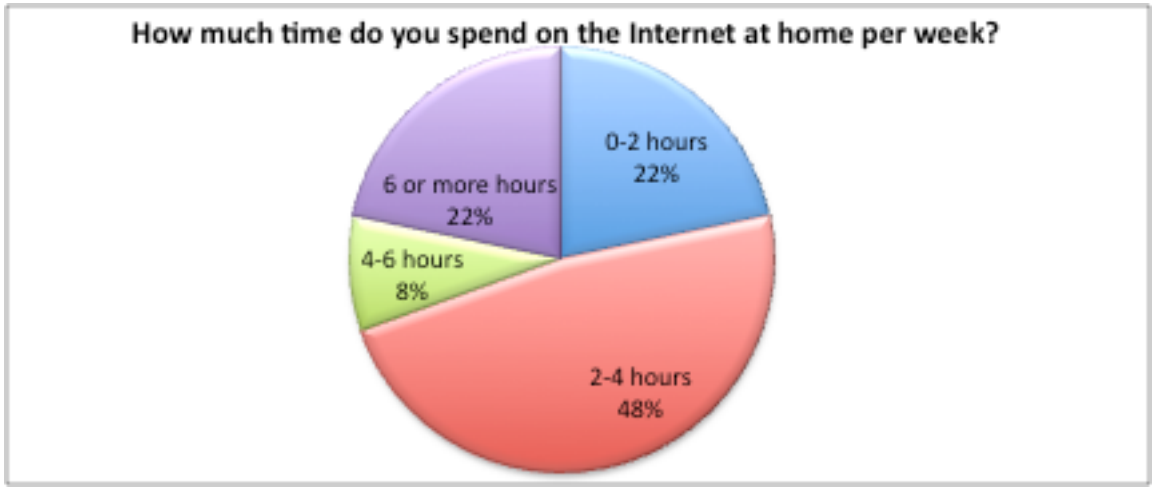


Figure 1: Question 3 from the preliminary survey (Appendix 3)

However, when asked about how much of their homework they did on their computer, the results showed similar trends in the percentage of students using their computer 'some' of the time to do homework: 50% for 'other' subjects and 48% for Mathematics:

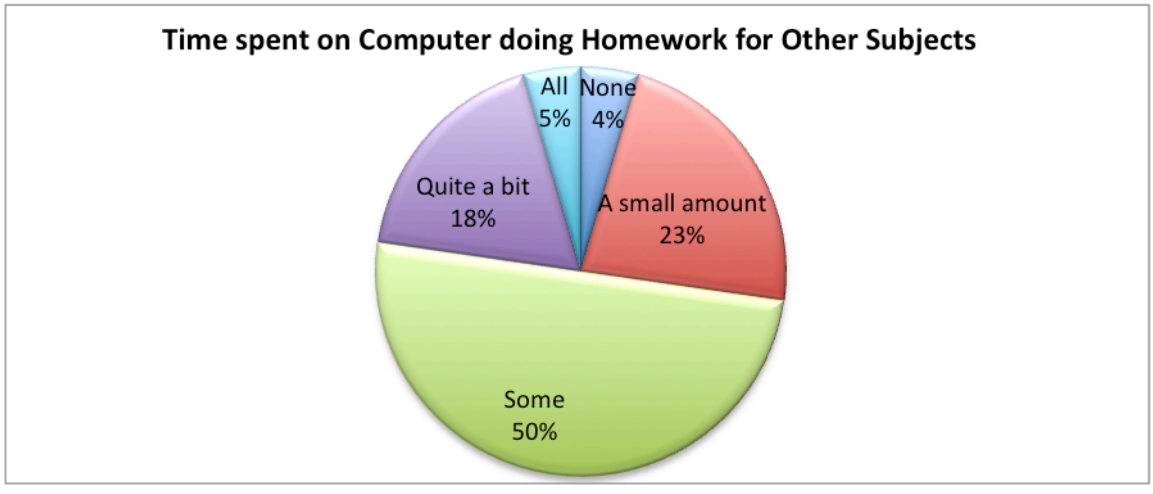


Figure 2: Question 4 (Part 1) from the preliminary survey (Appendix 3)

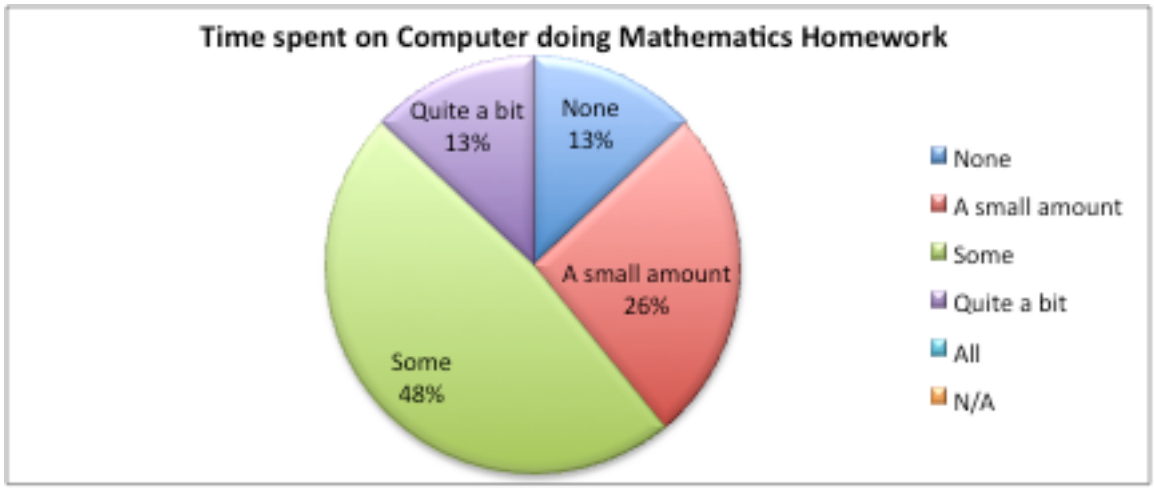


Figure 3: Question 4 (Part 2) from the preliminary survey (Appendix 3)

Section 2: project preliminary survey – Mathematics. A thematic analysis of the open responses students provided when thinking about Mathematics prior to starting this class project is as follows:

What are the first three things that come to mind when you think of 'Maths'?			
Thematic Analysis of Individual Responses		**Response Percent**	**Response Count**
Operations	Adding, Subtracting, Multiplying, Dividing	24.6%	14
Number	Numeracy	19.3%	11
Emotions	Hard, Work, Scary, Confusing, Boring	15.8%	9
Strands	Shape, Data, Algebra, Number	19.3%	11
Skills	Thinking, Intelligence	5.3%	3
Association	School; Teachers; Calculators	10.5%	6
Learning Style	Questions	3.5%	2
Other	Square Paper	1.8%	1
		Answered question	**57**
		Skipped question	**12**

Table 3: Question 5 from the preliminary survey (Appendix 3)

A large proportion of these thoughts about 'Maths,' were thematically subject-based: number-work, operations, or types of Mathematics (63%). Furthermore, all emotional responses to 'Maths' were negative in connotation: hard, work, scary, confusing, or boring. When students were asked to give examples of where Mathematics is used in the 'real world,' a thematic analysis of the open responses is as follows:

Please give three examples of where you see Mathematics being used in the 'real world'?			
Thematic Analysis of Individual Responses		**Response Percent**	**Response Count**
Place of Work	Bank, Shop, Office	46.6%	27
Money Management	Bills, Shopping, Travel	34.5%	20
Jobs	Astronauts, Builders, Accountants	13.8%	8
Design	Measurements, Design Technology	3.4%	2
Other	Internet, Car, Cooking	1.7%	1
		Answered question	**58**
		Skipped question	**11**

Table 4: Question 6 from the preliminary survey (Appendix 3)

To supplement this question, students were asked how they would likely use Mathematics when they left school. Their open responses resulted in 100% of the 20 students who answered this question stating either money management (50%) or jobs (50%) as their personal use for Mathematics. This ties into their examples of Maths being used in the 'real world' as their associations are typically money or job related. While only one student claimed to have read a book or online text relating to Mathematics, 95% (19) of the 20 students who responded to this question had an idea of how the Internet could assist them in problem solving (Google or specific website). Finally, when asked to rate how important Mathematics is to their education, the students either said 'quite important' (45%) or 'very important' (55%).

Section 3: project preliminary survey – social justice. A key facet to this thesis research is the notion of social justice as a concern with *the distribution of advantages and disadvantages within a society,*" rather than explicitly linking it to a discussion of human rights. As the teacher-researcher, it is likely that I may have mentioned this definition to the class ahead of officially starting the research project. Nevertheless, when students were asked to describe what social justice meant, 74% (14) of the 19 students who responded said they 'didn't know.' Similarly, when asked about whether that had created any videos on something they cared about, 100% of the 19 students who responded said they had not. Though only 19 students responded to the preliminary online survey, all 28 students in the class created a video. These 28 students

in both their project books and in discussions with the researcher created a text about something they cared about. However, when students were given the definition of social justice used in this thesis and asked to rate whether they thought this was important, their responses were as follows:

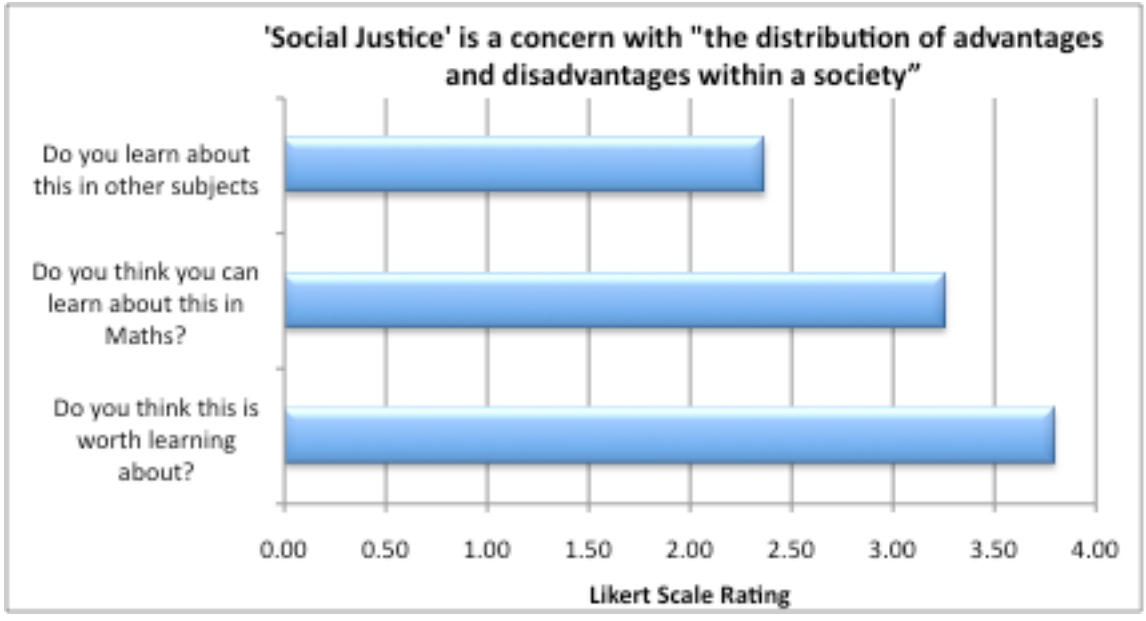


Figure 4: Question 14 from the preliminary survey (Appendix 3)

The scale used along the bottom of this chart is the average Likert Rating, which runs from 1 – 5, corresponding to the verbal responses: No, A Little, Neither No or Yes, Quite A lot, Yes, respectively.

Section 4: project preliminary survey – ICT and project. This section of the survey aimed at finding out more about the class's ICT preferences and skills as well as how they felt about starting this research project. A thematic analysis of how students spent their online time revealed that the majority, 58% (11) of the 19 students who answered this section, went on popular websites (Facebook, Google, YouTube, MSN), while 21 % spent time on games and 11% (2) spent time specifically talking to friends, or (11%) doing their homework. When asked whether they shared the things they found online with others, there was a stronger tendency towards sharing than not:

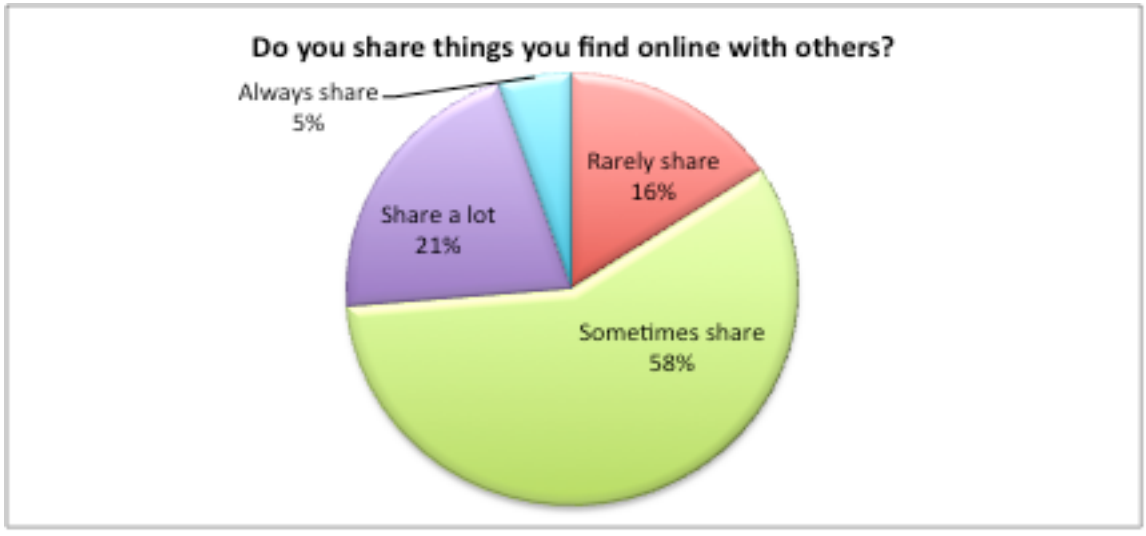


Figure 5: Question 16 from the preliminary survey (Appendix 3)

This translated into 68% (13) of students saying that they felt comfortable using a computer, with only one student saying that they were not comfortable at all. A similar trend was seen in the students being comfortable at creating videos, with 74% (14) of the students feeling 'OK,' 'quite comfortable,' or 'very comfortable' with this aspect of the project. The next set of questions was aimed at establishing how students felt about the project, with an emphasis on trying to determine specifically why they felt that way. It was important to ask students about the opposite of each emotion in order to ensure they had representative questions for how they may be feeling. When the students were asked if they felt excited about the project and their reasons for feeling that way, the students responded as follows:

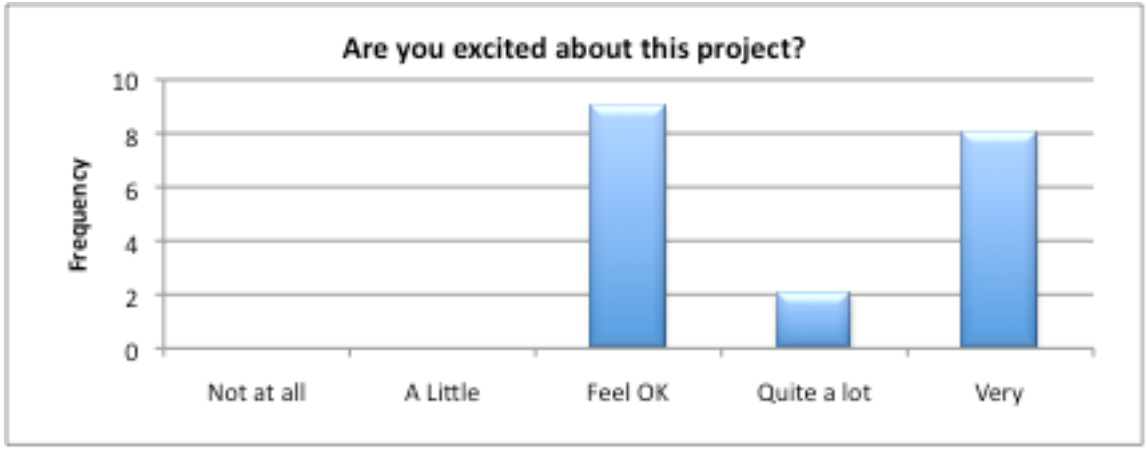


Figure 6: Question 19 from the preliminary survey (Appendix 3)

Figure 7: Question 22 (Part 1) from the preliminary survey (Appendix 3)

Whereas, when they were asked if they were anxious (nervous / confused) about the project and their reasons for feeling this way, the students responded as follows:

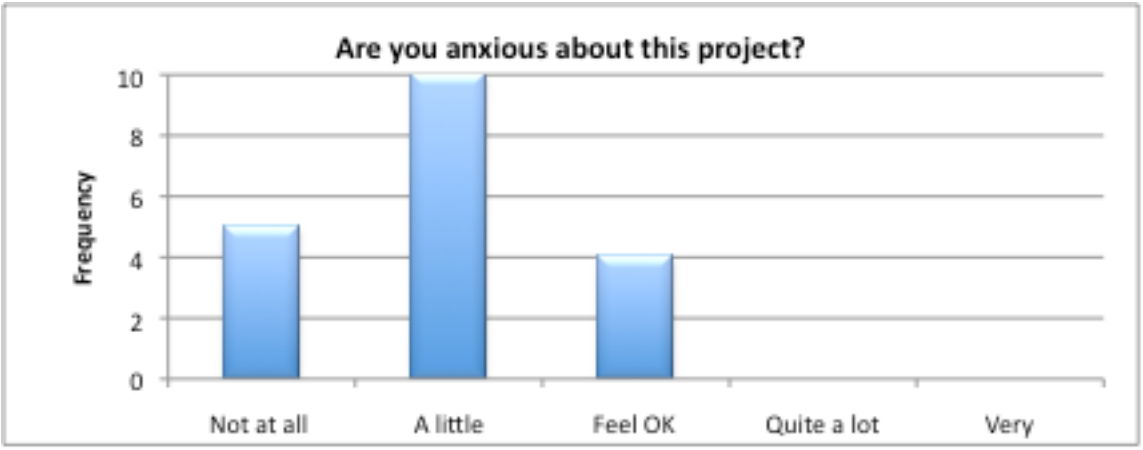


Figure 8: Question 21 from the preliminary survey (Appendix 3)

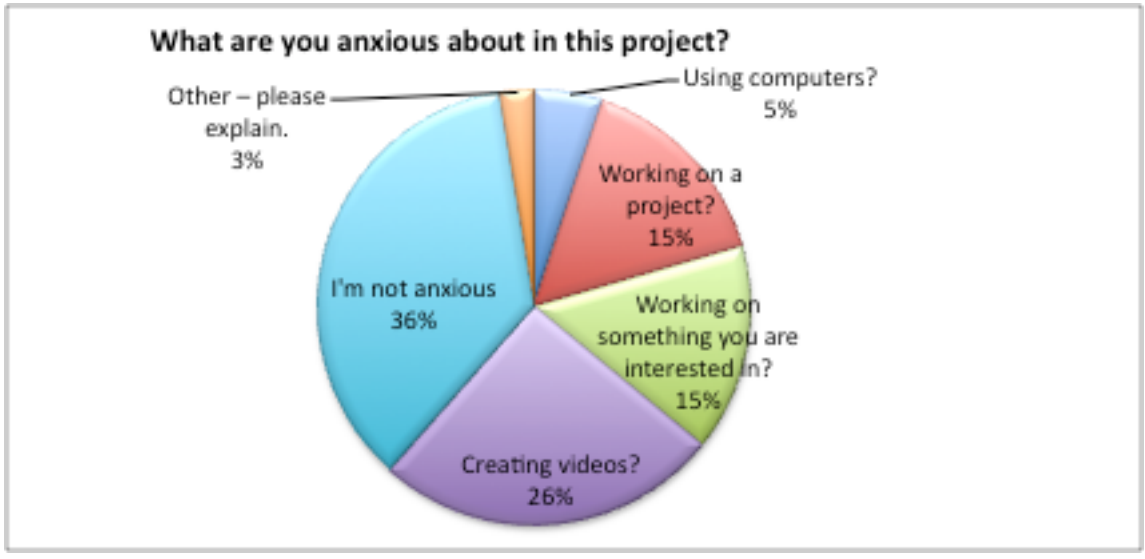


Figure 9: Question 22 (Part 2) from the preliminary survey (Appendix 3)

This data highlights, that the majority students were predominately excited, as opposed to anxious, about starting the project. In addition, their main reasons for being excited were to use computers (42%) and to create videos (29%).

Issues. There were several issues that were encountered during the preliminary online survey phase of data collection. Firstly, not all students answered all of the questions within the survey, which is why the actual numerical values of students have been provided in addition to any statistics, so that there is transparency in reporting. Secondly, there were a few editing mistakes: 1) question 20 was repeated again in question 21; and 2) The response for Question 22 in part 2 read “Nothing is exciting” rather than “I’m not anxious.” These minor errors were captured when the first students began to complete the survey and work-around solutions were implemented: 1) only answer question 20 and skip question 21; and 2) please consider this response as “I’m not anxious.” Finally, when students responded ‘other’ invariably some did not write answers in full sentences or their answers were duplicates and so meaning has had to be inferred from the words that they did write. For example, the two responses that were given as ‘other’ in whether students were anxious were: 1) I’ve never made a video, but I want to; and 2) I am not really that anxious. Furthermore, to ensure transparency, themed coding as well as specific answers, were provided in Tables 2 and 3, to ensure that the data represented were as accurate as possible.

Digital Numeracy Texts

The digital numeracy texts were part of a culminating assignment dedicated to ascertaining how creating and performing digital numeracy texts based on social justice themes, facilitates students' communication of Mathematical understanding of authentic real-world problems, as part of their role in local and global, real and virtual communities. Using the performance indicators from Boorstin's Performance Theory (1990) detailed in Table 1, screenshots were taken from two examples of thesis digital numeracy texts, which serve as case studies for analysis and discussion. These two case studies were purposefully selected (Patton, 1990) based on being academically representative of the class as a whole and because they represent "information-rich cases which can be studied in depth" (Hoepfl, 1997, p. 51).

Case study 1: body image. The first case study presented as findings for this research is that of a female student, called Annabelle (a pseudonym), who created a digital numeracy text focusing on body image. Annabelle is a quiet student in class, who rarely raises her hand to answer teacher-initiated questions, and who struggles to bring her homework in on time. From an academic point of view, my perception of her is that she isn't reaching her full potential: an opinion informed by test results being lower than the standard of her class work and her negative self-perception about Mathematics. This negative perception was supported in her interview, when she commented: "when you're [meaning me, the teacher] doing normal Math's (sic), I get kind of bored" (Respondent 4, Annabelle).

Annabelle's video starts off with a question "what happens when you can't do anything about your own problems?" It then proceeds to repeatedly flash a series of five images at the viewer: 1) a self-shot taken in the classroom of her holding a piece of paper that reads "just won't EAT;" 2) a plate of food (as seen below in Table 5); 3) a self-shot taken at home of her measuring her waist (as seen below in Table 5); 4) a picture taken from above of her feet in the grass, with a computer-drawn yellow flower in the top left hand corner; and 5) another self-shot of her looking down (as seen below in Table 6). These images are set in time to a fairly upbeat music track, whose beat sounds

like a heartbeat and at this point doesn't have any lyrics. Annabelle's video then proceeds to document certain facts about anorexia to the same music track, which now has the lyrics "feel the fire burning, burning. Feel the love calling, calling. I can see you coming, coming. Can you feel it in the air." Some of her numerical facts deal with a-typical information about anorexia: "most people think it's just females but 5 to 15% of them are males" Throughout all of these facts, the same five images detailed above are repeated, which continues throughout the next phase of the video which deals with how society assists those with eating disorders in terms of treatment. The next sequence asks: so why do you think I care?" to which she details her plans to be a photographer who does not promote the *skinny is beautiful* ethos. Her final phase returns to the problem of anorexia, resulting in her final question: "do you care…?"

Screenshots of her video have been selected below in order to discuss the performance indicators highlighted in the theoretical framework of this thesis:

Indicator	Screen Shots	Design & Performance Phase
Voyeuristic: Surprise		Elements of surprise exist, as Annabelle questions her numerical connection to measuring size and weight. In this sample screen shot, which Annabelle advised the me during class observations was a self-shot taken at home, Annabelle surprises the audience by contextualizing her social justice topic in a personal and unique way.
		Other elements in this digital numeracy text that a voyeuristic eye may be drawn towards exist in the design choices made my Annabelle. For example, in this sample screen shot, the structure of food on the plate is visually surprising, as this colour image is only one of two in an opening sequence primarily created in black and white. While this design decision supported by images flashing in synch to the beat of the music, support a performance that is visually interesting and dynamic, the small quantity of food on the plate also furthers her new numerical connection to food.

Table 5: Case Study 1 – Voyeuristic 'Surprise' Performance Elements

The voyeuristic elements in the performance of the digital numeracy text enhance the aspects of Mathematics, which make it pleasurable: "*The pleasure of experiencing the new, the wonderful, and the surprising in Mathematics*" (Gadanidis, et al, 2009, p. 2). Annabelle's design decisions support a voyeuristic eye that "is easily bored" (Boorstin, 1990, p. 13) as the images change often. The phases of her video also create a credible flow of time and space so that the audience sees a structured and purposeful social justice argument.

Indicator	Screen Shots	Design & Performance Phase
Voyeuristic: Sense-Making		While a surprising choice to immerse herself into her digital numeracy text, being an actor in her own movie allows Annabelle to recontextualize her new connections to Mathematics, such that her personal presence and measurements allow her (and the audience) to make sense of the question she poses about body image.
		The design decisions Annabelle makes are, on one hand, visually dynamic, but on the other, provide a rationale that is needed to support her shock-tactics. In setting her digital numeracy text as a story about eating disorders, she is able to engineer a numerical argument founded by knowledge the audience may already have about the issue.

Table 6: Case Study 1 – Voyeuristic 'Sense-Making' Performance Elements

However, by also ensuring voyeuristic elements of sense-making, the audience is able to rationalize the surprising new numerical connections being offered in this digital numeracy text and continue to suspend their disbelief, such that Annabelle's digital numeracy text is able to both voyeuristically control and discuss her issue of concern.

Indicator	Screen Shots	Design & Performance Phase
Vicarious (Emotional) Moments		In this sample screen shot, Annabelle again situates herself in her digital numeracy text. As a close-up, this screen shot shows Annabelle's emotional response to the word 'thin' in the top right. With her face looking down, the audience is drawn into an empathic state where we feel her negative emotions associated with this word. In using this design decision, Annabelle is able to both show and demand empathy from the audience about her emotional connections to the issues of body image.
		This self-shot screen shot also shows vicarious elements. In choosing another close-up, Annabelle's emotional connection to her numerical measurements is "so present" and creates a "world so real" that is "profoundly disorientating" for the viewer. Through images like these, we are able to feel what Annabelle is feeling, but judge and connect It to our own world.

Table 7: Case Study 1 – Vicarious Performance Elements

This self-shot of Annabelle looking down creates a negative perception of thin through several modes of communication: 1) Annabelle is unwilling to make eye contact with the audience, which promotes a sense of fear and disappointment; 2) the 'I' in thin seems to be larger than the rest of the letters, creating a sense of isolation; 3) the image is a close-up of her face, creating a sense of importance in focusing on the emotion being displayed (Boorstin, 1990). The vicarious elements in the performance of the digital numeracy allow the opportunity for the audience to both see Annabelle's emotional reality, while at the same time, feeling emotionally involved themselves in the social justice issue at hand. In a sense, the audience enjoys "*the pleasure[s] of experiencing emotional Mathematical moments (either our own, or vicariously, those of others)* (Gadanidis, et al, 2009, p. 2). Annabelle's design decisions support a digital numeracy text that entices the vicarious eye that "puts our heart in the actor's body: we feel what the actor feels, but we judge it for ourselves" (Boorstin, 1990, p.67).

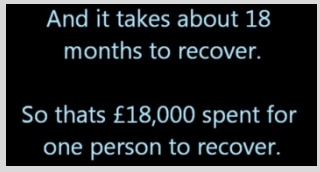
Indicator	Screen Shots	Design & Performance Phase
Visceral Sensations		As an example of a visceral sensation, this sample screen shot creates a sense of 'solution' in Annabelle's digital numeracy text. In using money as a primary statistic, Annabelle's movie begins to break down the barriers between the audience and the text through a sense of familiarization with the 'solution' she is offering. In putting across her point of view, her thoughts and reasoning become the only source of information on the topic.
		This screen shot is an example of how Annabelle has spent time reviewing her thought patterns and considered her role in her local and global communities. In going on to discuss how she wants to be viewed as a photographer in the future and the emotional intent behind creating this video - not to say that skinny is beautiful – she portrays an emotional truth, whose purpose is clear.

Table 8: Case Study 1 – Visceral Performance Elements

The visceral sensations in the performance of this digital numeracy text are clear in Annabelle's use of her new numerical connections, which support her argument, as she asks the audience to review their understanding of body image. Annabelle also shows how an analysis of numbers can translate into social responsibility and subsequently transform our perception of what roles we play in local and global communities.

Recontextualizing the numerical information in a digital numeracy text offers "a critical and reflexive perspective from which to examine our own scholarly practice" (Bauman & Briggs, 1990, p. 78). Annabelle's multimodal recontextualization of her Mathematical understanding of anorexia constitutes an examination of her own social values such that she makes a decision about her future career and moral values. Annabelle is able to engage the viewer through voyeuristic, vicarious, and visceral performance indicators that are designed purposefully to communicate her social and cultural awareness and numerical understanding of anorexia.

Case study 2: war. The second case study presented as findings for this research is that of a male student, called Leo (a pseudonym), who created a digital numeracy text

on war. Leo is similar to Annabelle in being quite a quiet student, who sits in the front row of seats in the classroom. However, Leo is a bright student who is very mature for his age and is doing well both academically and socially. When this project was detailed to the students, Leo was extremely enthusiastic about bringing in his own laptop and had many technology-related questions for me from the beginning. He decided fairly early on that he wanted to create his own animation for his video and said that he had software on his laptop to enable him to do this. Though this was considered to be a fabulous idea, he was cautioned by myself that this might require more of his time than was allotted during class-time and that there would undoubtedly be technological issues that we would need to work to resolve. As a teacher who is quite tech-savvy, I was at an advantage in this research as I am quite familiar with a variety of software programs and am not adverse to trouble-shooting technological issues and creating workable solutions. Indeed, in the first few lessons, we encountered the issue of importing his animation into his video-making software. In the end, he needed to download an alternative program that would allow him to record his animation and create a digital video at the same time (Camtasia).

Leo's digital numeracy text begins with a self-created image of 'war' that is crossed out like a road sign. His music track instantaneously begins and is a wartime song with marching drums in the background. As the focus of his digital text begins to unfold, it is apparent that he has centered on historical wars and this period music becomes increasingly appropriate. His first animation scene (as seen below in Table 8) simulates a fight between two sides (red and black) and questions: why can't everyone just get along?" He then moves on to a discussion of some facts about war, where he displays the "37 million" people who died in World War 1 (as seen below in Table 9) as 37 red stick men. He continues this discussion by exploring why people fight. This discussion leads to his second animation sequence, where his animated characters act out the reasons people fight: for food and for territory. Then he boldly questions on an orange coloured screen: "but is this really all worth fighting for???" This question prompts his third animation sequence where he describes the evolution of fighting and war: from using their "fists, teeth and legs" to "lazer (sic) guided weapons of mass

destruction." His penultimate section of his digital text deals with the idea that "even thought (sic) in some countries war is long over, there are still remains of it…" such as landmines, which kill "24,000 people a year." This ironically leads Leo to question: "so after a war has ended, what do people achieve?" with his answers, such as poverty, being interwoven with emotionally evoking images of what these words mean. He finishes his video questioning: "So, what are you going to do?" and provides proposed solutions on both the global and local level: celebrating World Peace Day on 21st September (global) and "making a difference by not pulling your sisters [sic] hair, or giving some money to a life-saving charity (local)."

Screenshots of his video have been selected below in order to discuss the performance indicators highlighted in the theoretical framework of this thesis:

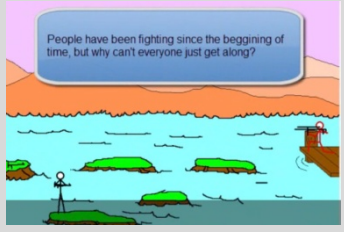
Indicator	Screen Shots	Design & Performance Phase
Voyeuristic: Surprise		Voyeuristic elements of surprise are captured in this screen shot, as Leo was the only member of the class to produce his own animation sequence. In creating his own animation, Leo was able to purposefully design specific situations that would contextualize his social justice topic. Furthermore, with the animation being visually appealing (bright colours) and dynamic in movement (stick men fighting each other), Leo is able to continually engage the voyeuristic eye that "bores easily" (Boorstin, 1990, p. 13).

Table 9: Case Study 2 – Voyeuristic 'Surprise' Performance Elements

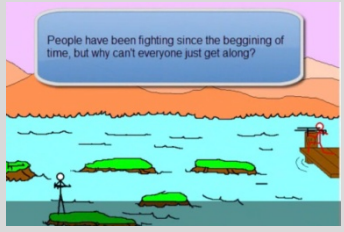
Indicator	Screen Shots	Design & Performance Phase
Voyeuristic: Sense Making		While initially surprising, the animated introduction sequence is quickly made sense of when Leo presents fact about historic wars. In situating his digital numeracy text in history, he is able to create a credible flow of time and space, affording his audience the opportunity to continue to suspend their disbelief, despite the fact that his text is animated as opposed to 'real-life.'

Table 10: Case Study 2 – Voyeuristic 'Sense-Making' Performance Elements

While visually appealing and pleasing to the voyeuristic eye, the seriousness of the topic is quickly addressed with his question that facilitates the audience making sense of what they see before them. In addition, the panoramic scope of these sequences, create the sense that it is not "defined by its own boundaries – but part of our everyday world" (Boorstin, 1990, p. 105). This purposeful effect serves to create the sense that although the animation is not real, the sentiment behind it is very real and part of our local and global socioculture.

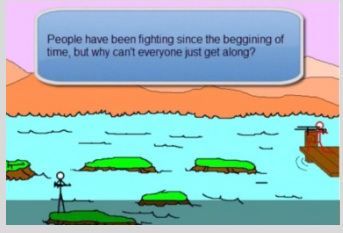
Indicator	Screen Shots	Design & Performance Phase
Vicarious (Emotional) Moments		The vicarious performative elements in this digital numeracy text are demonstrated through Leo's use of multimodal Mathematical information. In this sample screen shot, Leo represents the death toll in World War Two both numerically and visually. He emotionally engages his audience with the idea that the 37 red stick men represent the 37 million people, who died in World War 2. In doing so, this screen shot shows Leo's emotional connection to his social justice issue, while also demanding empathy from the audience for both his own cause and for those who died in World War Two.
		By using wide-angle shots, like in this sample screen shot, Leo is able to create a three dimensional space that extends beyond the peripheral vision of the audience. In doing so, the viewers are able to feel for themselves the emotional moments in his digital numeracy text and personalize each one for themselves.

Table 11: Case Study 2 – Vicarious Performance Elements

Leo's digital numeracy text has many vicarious moments, which allow for the audience to not only to feel what Leo intended, but to connect emotionally with the historical information that he is presenting. His choice of music in this performance was similarly historical with lyrics that at times aided the emotional plight of this text. Leo's music track was a combination of the chorus to *Pack Up Your Troubles* by George and Felix Powell, and *It's a Long Way to Tipperary*, by Jack Judge and Harry Williams, both songs

synonymous with the First World War. Choosing historically accurate songs aids the perspective that his digital text is similarly accurate, as well as emphasizing the magnitude of the social justice issue he is discussing.

Indicator	Screen Shots	Design & Performance Phase
Visceral Sensations		While Leo's text has several questions throughout, it is the "so after a war has ended, what do people achieve?" that is most appropriate as an ending. As a sample screen-shot, this serves to illustrate the visceral sensations which Leo's digital numeracy text creates. His apathetic tone creates a sense of solution that resonates with the audience. In contextualizing this further, by using the familiarity of a global peace day, he is able to portray his thought patterns, which lead him to his role in local and global communities, while also showing his emotional truth.

Table 12: Case Study 2 – Visceral Performance Elements

In contextualizing his understanding of Mathematics in a historical war setting, Leo has pointed to his awareness that statistics can be human. The "Mathematical beauty" (Gadanidis, et al, 2009, p. 2) that he portrays is a single date, where he demonstrates knowledge of his and global responsibility: World Peace Day, as well as his local responsibility to be more charitable: not pulling his sister's hair and donating to life-saving charities,

Leo's design decisions support a vicarious experience that "is not bound by iron bands of logic but by silken cords of emotional truth" (Boorstin, 1990, p. 67). The animation sequences in Leo's video do not seek to ring true with the audience in a real-way – they seek to demonstrate a parallel between local and global communities such that despite being far removed from a war zone, "we feel what the actor feels" and judge it for ourselves (Boorstin, 1990, p. 67).

Interviews with Students

The interviews with four students from the class, two girls and two boys, were conducted following a weekend, so it became important to re-watch the digital

numeracy texts with the students prior to asking them questions about them. These four students were chosen because their videos had caught the imagination of the class and inspired the greatest number of questions and discussions after their performances. It was also important to ensure that each gender was represented equally. Interviewing these students aided the sideshadowing that had been conducted through observations in the classrooms. The interview questions were prepared in advance, serving to guide the conversation (Appendix 7: Student Interview Questions). Respondent 1 (Casie) produced her digital numeracy text on body image; Respondent 2 (Bradley) produced his digital numeracy text on racism; Respondent 3 (Byron) produced his digital numeracy text on *Call of Duty* (COD); and Respondent 4 (Annabelle) produced hers on body image also. Respondent 4's video was also used in the digital numeracy text analysis. A thematic analysis of the transcripts for these interviews (Appendix 8) examines the information provided on: 1) their design decisions; 2) their use of numerical information; and 3) their choice of social justice topic. These themes serve to provide findings that explore how creating and performing digital numeracy texts based on social-justice themes facilitated their communication of Mathematical concepts of authentic real-world issues.

Purpose of interviews. As part of the qualitative research portion of this thesis research, the purpose of the one-to-one interviews with selected students was to begin to try to understand the digital numeracy texts from the point of view of the student. In addition, these interviews would allow this research the opportunity to uncover the meaning of their experiences and any logic and rationale behind their decision-making processes. Each interview was guided by a semi-formal set of sample questions (Appendix 7), which were used as a starting point in open-ended discussions with the students. These pre-designed questions were not meant to be exhaustive. Many of the research interviews did not head in any particular or intended direction and did not satisfy any pre-determined objective – their use was to capture the students' views and experiences of participating in this project. The interviews offered insights into the phenomena and peculiarities of a classroom based research project on social justice in Mathematics with their teacher-as-researcher. Boorstin's (1990) performance theory

was not used as a lens in these interviews, because it was determined that where possible the students should try to lead the discussion and try to tell the teacher-research in their own words their own experiences.

Design decisions. A common theme in design decisions for the students interviewed was one of emphasis. Multimodal design choices were made to "make it more, not outstanding, but more effective" (Respondent 1: Casie) or to make "it stand out" (Respondent 2: Bradley). Throughout all the interviews conducted, students wanted to add emphasis to ensure that their point was loud and clear. Byron was quite clear in his comparative design decisions because it meant he could "show that there is actually COD and people actually killing somebody" and that "your (sic) actually killing somebody basically" every time you play the game. However, these design decisions were often not applied to numerical information, with the majority being displayed as written text, albeit using colour to contrast the information with the background.

Numerical information. A significant theme for the students interviewed was the validity of the information they used in their texts. While on one hand Annabelle complained "there were so many numbers on the internet" that she didn't know how to fully digest all the information, a common cross checking approach was implemented. Byron mentioned that he "went on, like, two websites" to check that the information was exactly the same before he committed to using it safely This process of verification was not discussed during the project, as this was left to each individual student. However, the reputation of sites was discussed with the students, who volunteered ideas to the class about how to ensure the information and research they collected was reputable. For example, sites on which anyone is eligible to edit the information on the screen might not be the best source of information for academic information on a topic. In addition, the students were advised that it was important for them to document their sources in a bibliography at the end of their class workbook to avoid copyright infringement. And although Casie stated that "you don't know whether they are right or wrong, so you've just basically got to try and just put them down, hoping that they are right," when questioned about what she could do, she replied: "check a couple of web-sites, [and] make sure the websites can't be edited by people." The validity of the

Mathematical information that proved the biggest challenge for the students, with Casie saying that “making sure the information is right” was her most challenging task.

Social justice choices. Allowing the students to choose their own social justice topic gave them a sense of agency when spending their time on this project. It wasn’t important to this research what topic the students chose, but it was communicated to them that if they were going to invest time in something it would be a good idea to ensure they had an interest in it. This personal investment came through as a consistent theme in their initial decision making processes. Casie commented that she chose her topic because she didn’t feel the distribution of food was “fair,” while Bradley said that he chose to explore racism because “quite a lot of problems in the world are due to it” and could see the repercussions of this discrimination in other aspects of his local and global community. Byron was quite vocal about his choice to create something on COD as conversations of real-life violence had been discussed in his friendship circles. He explained that, “the day before, we were actually talking about the things, like, it was happening but like in another country, it was actually happening there.” Perhaps, most important was Annabelle’s reason for choosing her topic of body image: “because, like, if you were going to show it [digital numeracy text] to other people, then they will all know that someone does care about the things that most people think are silly.” Her comments directly link her personal interest in body image with the end result of performance: knowing she had to perform her text made her invest the time in not only her text but in ensuring peers knew how much she cared about it.

Post Project Online Survey

Unfortunately, due to time constraints and technical issues it was not possible to get as many students to complete the post-project survey as anticipated. In the end, only ten students were able to complete this survey. The findings are discussed in terms of a comparative analysis with the preliminary online survey findings. The post-project online survey was similar to the preliminary project online survey; however, in some instances the question tense had to be altered to reflect that they had completed the project. Nonetheless, the questions were still based on the thematic ideas of the

project: 1) personal information; 2) perceptions of Mathematics; 3) perceptions of social justice; and 4) perceptions of Information and Communication Technologies (ICT). A copy of the post-project online survey is accessible in Appendix 6 of this thesis. As this post-project survey was also anonymous, it was not possible to compare individual student responses.

Section 1: post-project survey – personal information. Of the 10 students who completed the post-project online survey, 20% were boys and 80% were girls. As previously mentioned, only 29% (8) of the 28 students in the class brought in their own laptops, with a further two students eventually deciding not to bring in their own mobile technology and using the school's equipment instead. The revised amount of time the students spent on the Internet at home per week is demonstrated as follows:

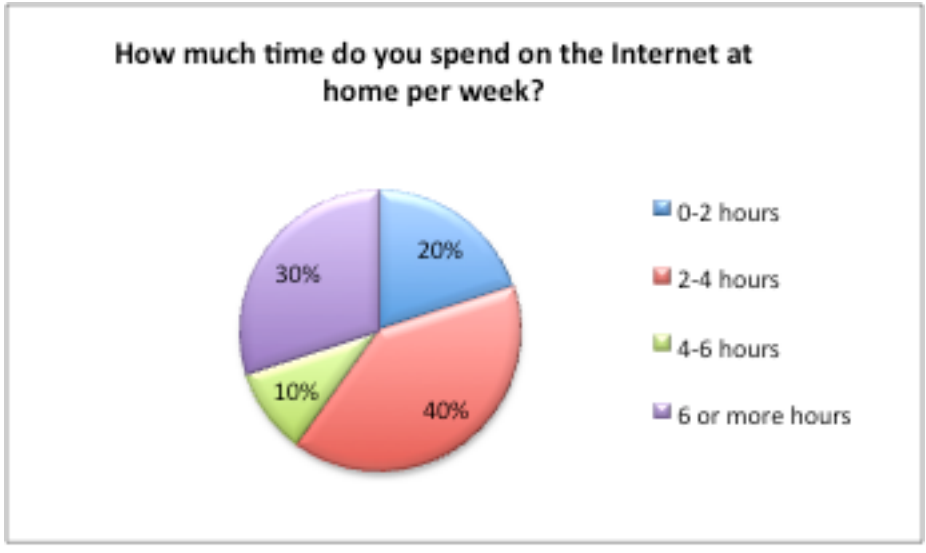


Figure 10: Question 5 from the post-project survey (Appendix 6)

In comparison with the answers provided in the preliminary survey, there was no significant difference in the proportionality of answers provided between the option choices; however, there was a tendency for students to indicate that they did spend more time on the Internet at home per week:

Survey Option	0-2 hrs	2-4 hrs	4-6 hrs	6 + hrs
Pre-Project Survey Response	22%	48%	8%	22%
Post-Project Survey Response	20%	40%	10%	30%
Difference	**-2%**	**-8%**	**+2%**	**+8%**

Table 13: An Analysis of Student Response for Time Spent on Internet per week

Students were then asked about whether they thought the Internet could help them do more of their homework, a question based on the preliminary project survey results about time spent on the computer for homework. In the preliminary survey, at least half of the students responded that they only spent 'some' of their time on the computer for their homework: 50% for 'other' subjects and 48% for Mathematics. Encouragingly, the majority of students responded that the Internet could be more utilized for assisting them with their homework, with 75% responding 'quite a bit' for its use in other subjects and 70% responding similarly for Mathematics:

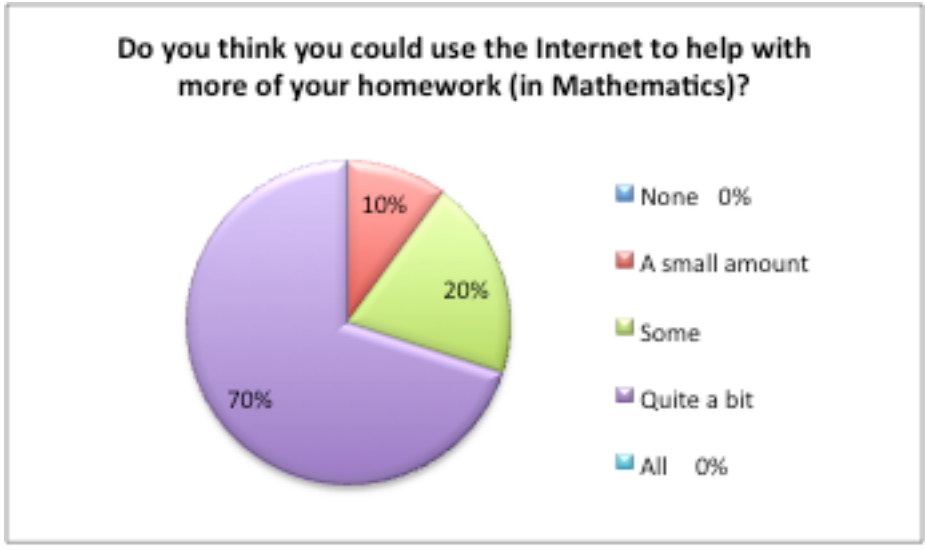


Figure 11: Question 7 Part 1 form the post-project survey (Appendix 6)

A significant finding from the comparative analysis of the two surveys suggests that students increasingly recognized the Internet as a source of information and assistance to them in their learning, as demonstrated by their increased time spent on the Internet and recognition of its helpfulness with their homework.

Section 2: post-project survey – Mathematics. When asked, "What are the first three things that come to mind when you think of 'Maths'?" prior to starting this class project, students' responses were predominantly number (19%), operations (25%), or strand (19%) based. Emotional-based responses (16%) were most commonly negative: hard, work, scary, confusing, boring. However, in a similar thematic analysis of open responses that students provided when thinking about Mathematics after completing

this project the results are as follows (any additional responses that have been added have been formatted bold for ease of reference):

What are the first three things that come to mind when you think of 'Maths'?			
Thematic Analysis of Individual Responses		**Response Percent**	**Response Count**
Number	Numbers; **Statistics; Fractions**	30.0%	9
Operations	Adding	3.3%	1
Emotions	**Confusing, Boring, Fun, OK**	26.7%	8
Strands		0.0%	0
Skills	Thinking; **Problem-Solving; Challenges**	10.0%	3
Association	**Jobs/Bills; Global Community**	16.7%	5
Learning Style	Questions; **Internet as Assistant**	13.3%	4
Other		0.0%	0
		Answered question	**30**
		Skipped question	**0**

Table 14: Question 8 from the post-project survey (Appendix 6)

Whilst the predominant answers were still number (30%) and emotion (27%) based, there was a distinct shift in the type of emotional response the students offered, with 50% of the 8 responses the students provided being positive: fun or OK. Moreover, there was an increase in the association of Mathematics with other aspects of life. Prior to the project 11% of students had responded with some type of association: school, teachers, calculators, and while there was a slight increase in 17% of students making associations of Mathematics to the 'real-world' the most significant shift was in the type of association – to the global community – through answers like: 'real-life,' 'the world's problems,' and 'helping others.' Furthermore, when students were asked to give examples of where Mathematics is used in the 'real world,' a thematic analysis of the open responses demonstrates a significant shift in students' connection of Mathematics to the real-world and their local and global communities (additional responses are bold):

Please give three examples of where you see Mathematics being used in the 'real world'?		
Thematic Analysis of Individual Responses	**Response Percent**	**Response Count**

Place of Work	Bank; Shop; Office; **Town**	40.0%	12
Money Management	Shopping, Travel	13.3%	4
Jobs	**Jobs; Teachers**	13.3%	4
Design	**Telling Time; Speed Calculations**	6.7%	2
Other	**Making us think; Facts; Poverty; Games; Competitions; Home; Politics**	26.7%	8
		Answered question	**30**
		Skipped question	**0**

Table 15: Question 9 from the post-project survey (Appendix 6)

Seemingly, in stark contrast to their preliminary responses which show obvious connections of Mathematics to places, jobs, and interactions where money is the direct link to Mathematics, the post-project responses show a trend towards alternative associations of local and global issues: poverty and politics. There was no change in the open responses to how students will use Mathematics when they leave school: all students continued to state either money management (50%) or jobs (50%) as their personal use for Mathematics. Additionally, when asked to rate how important Mathematics is to their education, the students continued to follow the trend of 'quite important,' (60%) or 'very important' (40%).

Section 3: post-project survey – social justice

A key idea to this project was that students understood what social justice was and how it might link to Mathematics education. In the preliminary survey, 74% of the students said they 'didn't know' what social justice was. This drastically shifted in the post-project survey to 100% of the student being able to give some level of description for this term. While this isn't significant in itself, what was notable was that 50% of the students had their own definition of the term, rather than the one used in this research, with two in particular being of significance:

- It is like being able to have what everyone else has. And being accepted. It is having the right to be aloud de (sic) a human being and have some freedom. It is your advantages and disadvantages (anonymous).
- Unfairness around the world quite often where we can help (anonymous).

These two were interesting responses because they were clearly personal with their use of pronouns and concerned with the idea of being a human being on a global scale. It

was important to gauge how much the students cared about their social justice topic, to see if this awareness translated into an understanding of authentic real-world issues towards which that they felt responsible. The students were asked: How much did you care about the topic in your digital numeracy text? Thirty percent of students felt 'quite a bit' of care towards their social justice issue, with the other 70% stating 'a lot.' Furthermore, when students were given the definition of social justice used in this thesis and asked to rate whether they thought this was important, their responses were as follows:

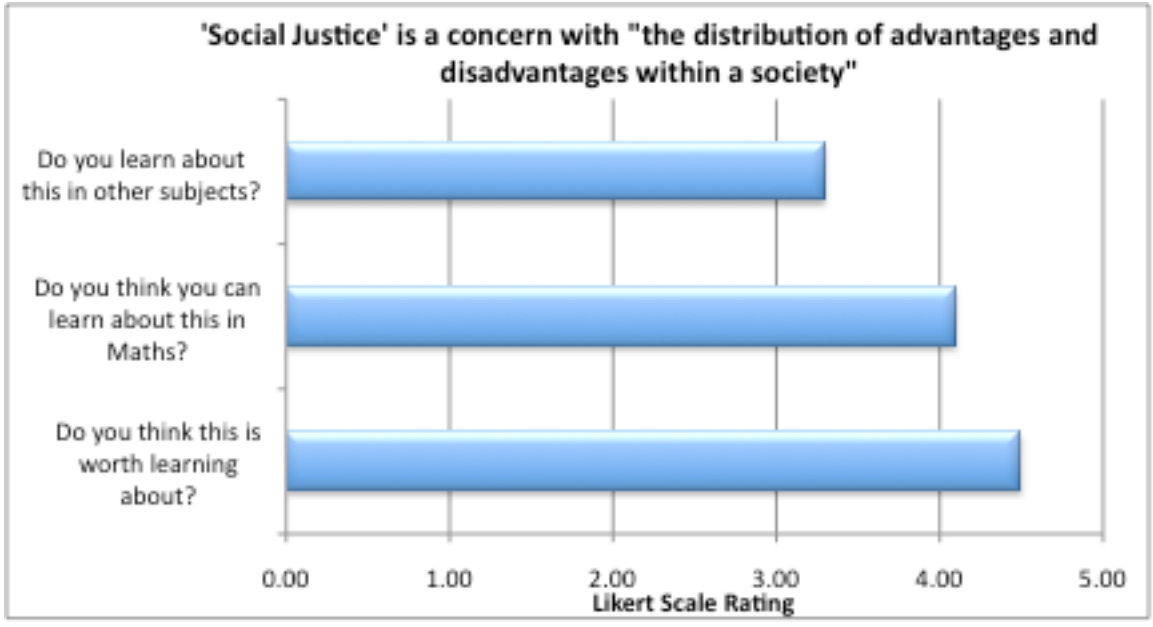


Figure 12: Question 16 from the post-project survey (Appendix 6)

The scale used along the bottom of this chart is the average Likert Rating, which runs from 1 – 5, corresponding to the verbal responses: No, A Little, Neither No or Yes, Quite A lot, Yes, respectively. The overall trend did not change, but the average weighting did.

Survey Question	Pre-Project	Post-Project	Difference
Do you learn about this in other subjects?	2.37	3.3	**+0.93**
Do you think you can learn about this in Maths?	3.26	4.1	**+0.84**
Do you think this is worth learning about?	3.8	4.5	**+0.7**

Table 16: An Analysis of Student Response for the importance of Social Justice in Education

This demonstrates that not only on average, did the response increase towards students considering social justice to be an important topic in their education, but the

students' responses also indicated an increased awareness and perception that they could learn about social justice issues in other subjects, including Maths, and that it is a topic worth learning about at school.

Section 4: post-project survey – ICT and project. In the preliminary project, students were asked whether they shared the things they found online with others. While there was a stronger tendency for students to respond that they did, it was important to gauge whether students demonstrated this tendency in the project itself:

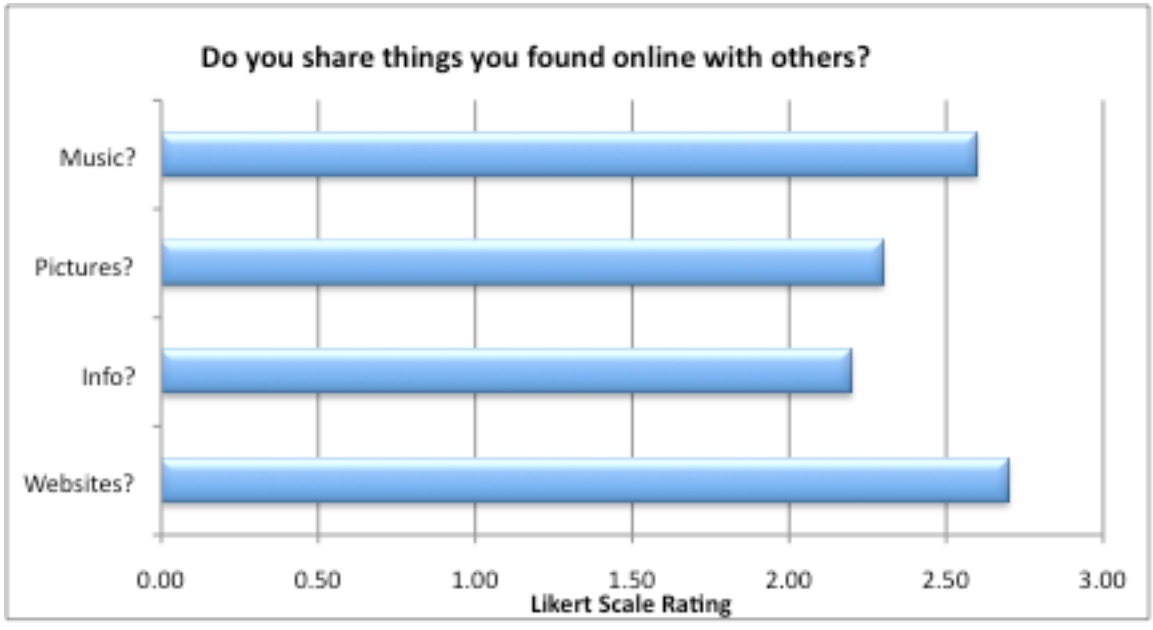


Figure 13: Question 17 from the post-project survey (Appendix 6)

Overall, the results from the post-project survey support this willingness to share; however, the numbers do not suggest that this is common practice. Prior to starting this project, 68% of students said that they felt comfortable using a computer, with only one student saying that they were not comfortable at all. A similar trend was seen in the students being comfortable at creating videos, with 74% of the students stating that they felt: 'OK,' 'quite comfortable,' or 'very comfortable' with this aspect of the project. The level of ease with computers only continued to increase throughout this class project, with all students who completed the post-project survey saying they were either 'quite comfortable' or 'very comfortable' with using a computer to make videos and conduct research. In order to ascertain how students had spent their time on this

project, question 20 required the students to apportion their time into the various aspects of creating their digital numeracy text:

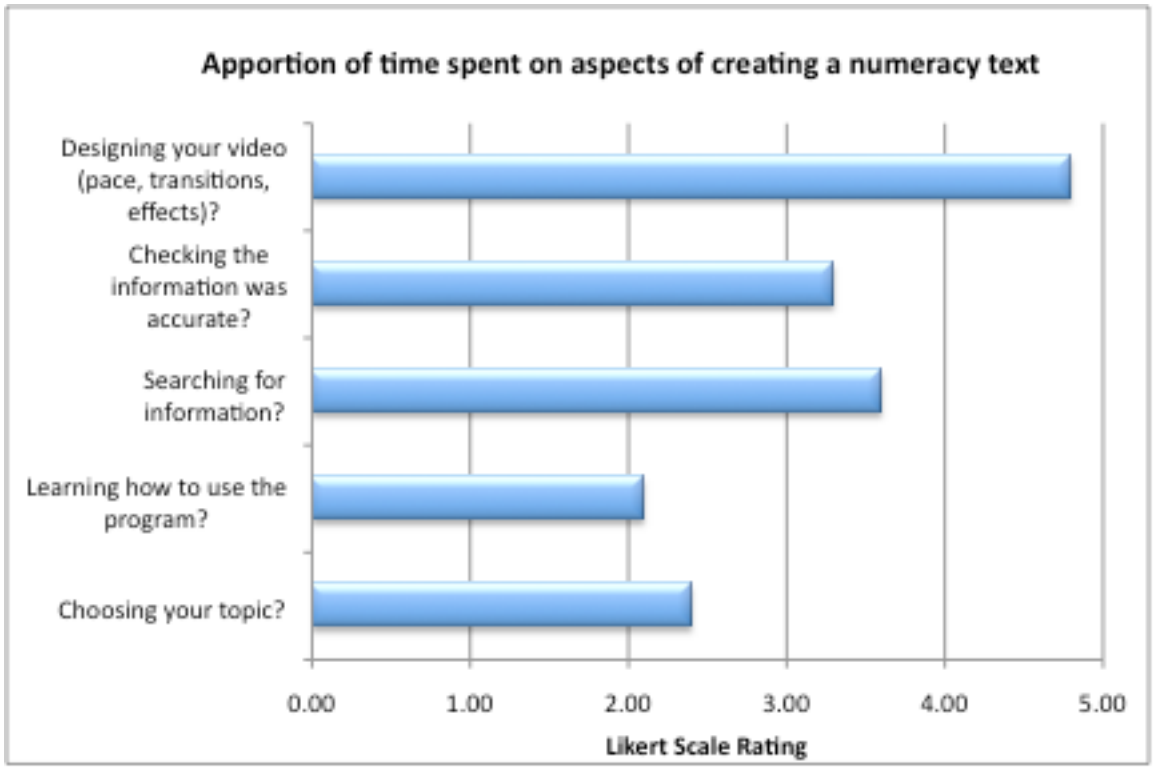


Figure 14: Question 20 from the post-project survey (Appendix 6)

Interestingly, the lowest amount of time was spent on choosing a topic and learning how to use the program they had selected. Quite a bit of time was dedicated to searching for information and checking its accuracy. However, the greatest amount of time was spent designing their video and putting all the pieces together to create their final digital numeracy text. These findings contrast with one of the perceived weakness of situated practice: that learners of such complex social practices can "spend a good deal of time pursuing the 'wrong' leads" (New London Group, 1996, p. 20). Indeed, many students spent the shortest amount of time making their initial decisions and spent the longest amount of time following these decisions through to completion. Indeed, though situated practice "does not necessarily lead to conscious control and awareness" (New London Group, 1996, p. 20), it would seem that the creation of digital texts required the greatest amount of time. While these results show larger portions of time being spent by students designing and engineering their final product, they also

suggest that students were heavily involved in this project, spending vast amounts of time ensuring that the end result was what they visualized. Further explaining this trend is the students' description of how involved they felt in the project:

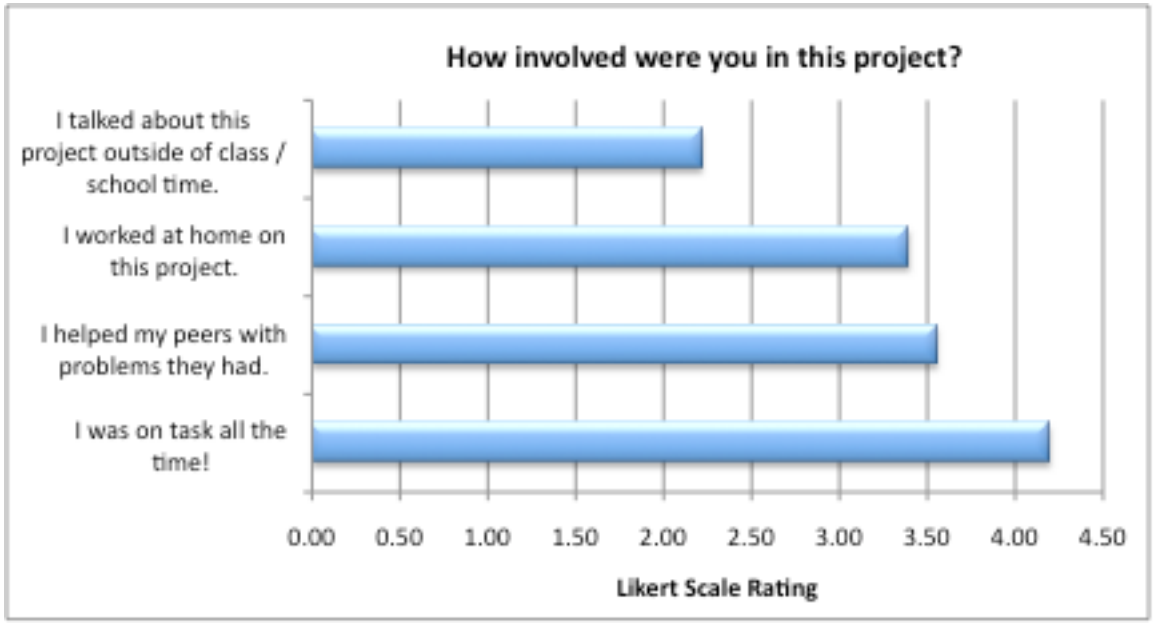


Figure 15: Question 21 from the post-project survey (Appendix 6)

The next set of questions, were aimed at establishing how important performing their digital numeracy text was, what aspects of the process they would like to do again, and what they will do with their digital numeracy text or about their social justice issue in the future. The students' responses varied in this regard, with a fairly even response between 'a little' (30%), 'some' (30%) and 'very important' (40%). Though this question did not arise in the student interviews, the students were asked what they would do with the videos after they had finished them. Casie took her video home and showed it to her immediate family, while Bradley showed it to friends from other classes. Leo mentioned in his justification document that he would: 1) show it to his friends; 2) post it on You Tube; and 3) post it on Facebook. However, both Byron and Annabelle were unsure of what they would do, if anything, with their videos. Seemingly, while it is important who sees the video, it wasn't important how many people saw the video.

However, when it came to aspects that they wanted to do again in the future the results were as follows:

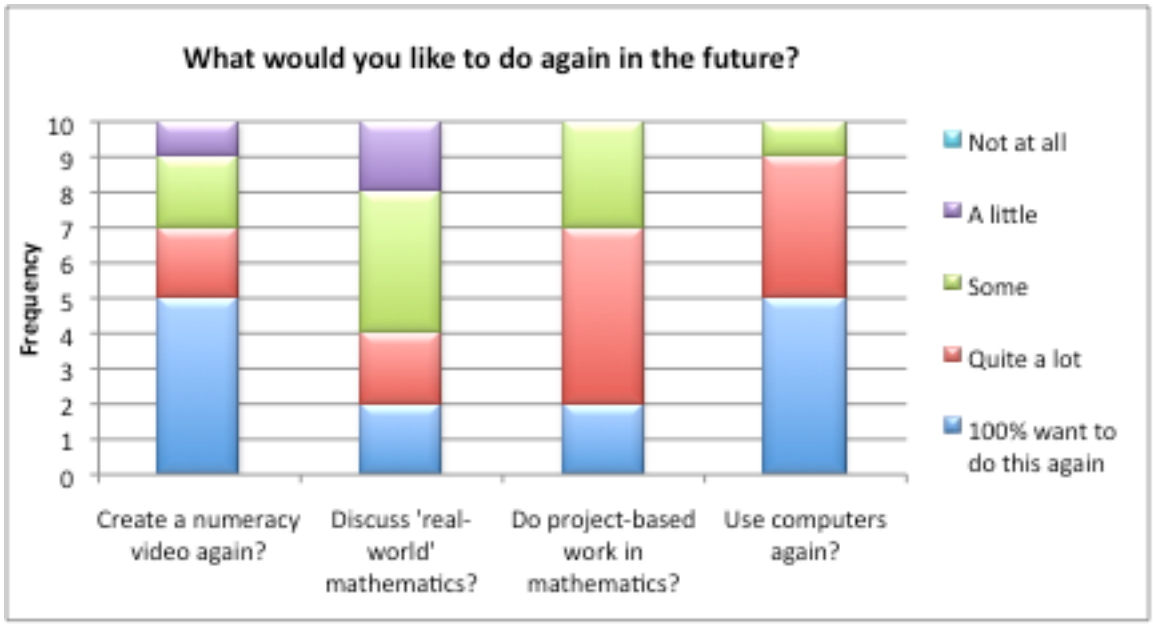


Figure 16: Question 25 from the post-project survey (Appendix 6)

When asked what they would do with the text after, responses were evenly split between: keeping it saved on their computer, showing it to others (family), and doing nothing with it – one student said he/she would probably try to improve it. When they were asked about what they could or would do in the future about their social justice issue all students expressed an interest in doing some charity work or trying to help in some way – whether they would raise money with their friends (short-term) or eventually go to the country to assist with the issues (long-term).

School Feedback: Head of Department

Finally, having watched the class performances and discussed the project with the students, while the teacher-researcher was absent from the room, the then Head of Department, provided the following written synopsis of his thoughts on this project:

> It was apparent that all students had actively and enthusiastically engaged with the task. There was a very real feeling of community and support in the classroom and appreciation shown by the students during the video presentations. Students had evidently put effort into creating quality products; carefully structuring images, text and synchronizing with music. When asked whether they felt the project had been useful, many students responded that

> their passion and interest in their chosen themes had focused their mind on the Mathematical objectives.
>
> While the data chosen by students tended to support the argument or dialogue in their presentations, many of the statistics were questionable and few students had taken steps to consider the authenticity of data sources and to take steps to verify figures using other 'reliable' sources. Nonetheless, the opportunity to debrief and discuss these issues during the presentations has led to a clear understanding by all students of the dangers of statistics, the use of misleading information and the means by which students can obtain reliable information and verify sources.
>
> The majority of the Mathematical content comprised percentages. Some statistics were extrapolated and placed into a worded context relevant to the class; these were perceived as [sic] the students as the most graphic in terms of conveying a message to the audience (this means that 1 in every 4 people will …). The Mathematical content, however, was limited in all cases and no student could communicate what they had learned in terms of Mathematical learning objectives. I do believe from my observations, nevertheless, that the whole process of preparing and performing digital numeracy texts can be used enormously effectively to consolidate and further Mathematical understanding with some adaptation of the Mathematical criteria.

This synopsis highlights a couple of key points that need to be discussed further: 1) Mathematical learning objectives; 2) consolidation of Mathematical learning and opportunity for debrief; and 3) feeling of community and support in the classroom, and I will do so in the discussion chapter.

Summary

The findings of this research were as follows: 1) Preliminary Project – Online Survey (23 students completed); 2) The Digital Numeracy Texts Produced (all completed); 3) Interviews with the Students (4 students selected); 4) Post Project – Online Survey (10 students completed); and 5) Synopsis from Head of Department at the school who details his thoughts about the project. These findings are analyzed and discussed further in the following chapter with a view to understanding how creating and performing digital numeracy texts based on social-justice themes facilitate students' communication of Mathematical understanding of authentic real-world problems as part of their role in local and global, real and virtual communities.

Chapter VI – Discussion

This thesis endeavors to investigate, explore, and analyze how students can learn the social relevance of Mathematics through self-directed learning experiences that offer them the opportunity to research, participate, and produce technology driven evidence of their Mathematical understanding of real world issues that are important to them. Embedding this research in a classroom environment that honours students' use and development of functional skills, by practicing their numeracy and literacy through socially and culturally relevant learning content, this discussion aims to understand:

> How might creating and performing digital numeracy texts based on social-justice themes, facilitate students' communication of Mathematical understanding of authentic real-world problems as part of their role in local and global, real and virtual communities?

Guided by three underlying themes: performance before competence, social and cultural relevance, and research that can be used and adapted in other classrooms, this chapter frames the discussion of both: 1) the communication of Mathematical understanding of real-world problems; and 2) the communication of students' perceptions of their roles in local and global communities, through their research on social justice issues, through an analysis of the creation and performance processes behind the digital numeracy texts.

Mathematical Understanding of Real-World Problems

The students' ability to communicate mathematical understanding of real world problems demonstrates an increased awareness of their socio-cultural connections to Mathematics, from a subject taught at school to real-world issues. Evidence of a socio-cultural connection between Mathematics and the students exists in: 1) student responses to the surveys; 2) an analysis of the digital numeracy texts for vicarious (emotional) performative indicators; and 3) the literature on primary and secondary discourses.

The students' response to whether they thought social justice was an important topic to study in Mathematics changed significantly from the preliminary to the post-

project survey. As detailed in Table 15 (An Analysis of Student Response for the importance of Social Justice in Education), on average students increased their preference for studying this topic within the discipline of Mathematics. This suggests that after exposure to the themes of this research, students felt that social-cultural themes, such as social justice, were worthy of study in a Mathematics classroom. Furthermore, this socio-cultural connection between social justice and numeracy is evident in the vicarious (emotional) connections of the students to their digital numeracy text theme. In the case studies analyzed for Boorstin's (1990) vicarious performative indicators, both videos evoked a sense of emotion from the audience through their connection to the authors' emotional intentions. While on one hand, the first case study demonstrated how injecting themselves, as authors, into the text can evoke a sense of emotion; the second case study demonstrated the emotional impact of contextualizing what numbers mean in a humanistic sense. Given that "education should lead our students to live their lives differently" (Grossberg, 1994, p. 12) the cultural theory literature argues for classrooms to create a *third space* of social practice that allows ideas of all sorts to be considered, analyzed, discussed, and their consequences thought through. In creating a *third space*, emotional responses to ideas also need to be acknowledged and worked through. The key to engaging students in communicating their understanding about Mathematics, in this *third space*, is that "instead of [using] a voice that they do not naturally use" (Luther, 2006, p. 68) students can personalize their learning experiences. By researching, creating, and performing their digital numeracy texts, in a *metalanguage* they felt comfortable using, students overcame the disparity between their "primary" and "secondary" discourses (Lankshear & Knobel, 2007, p. 3). Indeed, rather than asking students to learn in a secondary discourse context, the creation of the digital numeracy text did not ask students to create something that "under no other circumstances, [other than school], would they attempt to produce," (Pegram, 2006, p. 3) but rather to embed it within their primary and authentic discourse.

In addition the students increased awareness of their socio-cultural connections to Mathematics, is the personal investment into their research of Mathematical

information. The personal investment of time demonstrates that through their research of numerical information on their topic and their design choices in their digital numeracy text, they considered their 'end-product' a piece of Mathematical information that communicated their concern for their socio-cultural environment. This personal investment of time to create something worth performing is evidenced in: 1) student responses to the surveys and interviews; 2) an analysis of the digital numeracy texts for voyeuristic performative indicators; and 3) the literature on shifting paradigms.

Student responses to how they spent their time, as graphically shown in Figure 13 (Question 20 from Post-Project Survey (Appendix 6), detail a classroom environment where decisions were made quickly, research was done thoroughly, and an end-product was carefully constructed. Though students said that "making sure the information [was] right" (Respondent 1: Casie) was the most challenging part of this project, the fact that they cared enough to spend time making sure it was, is indicative of the personal investment this class project inspired and contrary to the Head of Department's comments. The change in students' emotions from predominantly negative: Hard, Work, Scary, Confusing, Boring (Table 3: Question 5 from Preliminary Survey (Appendix 3)) to 50% of the 8 responses the students provided in the post-project survey being positive: fun or OK (Table 13: Question 8 from Post-Project Survey (Appendix 6)), further underpins the shift in student perceptions of Mathematics. Indeed, during the interview with Byron it was noted by myself that: I normally struggle to get you to do work, and you and [another student], I don't think I heard a peep out of you for six straight lessons [laughs]." This notable shift in student characteristic in the classroom showcases how engaged the students were in producing their digital numeracy text. This dedication to on-task behaviour is also evidenced in the digital numeracy texts themselves, which are filled with voyeuristic indicators, simultaneously showcasing the authors' personal dedication as well as deliberate attempts to keep the audience engaged. As Boorstin (1990) points out "the voyeur's eye loves to be outwitted but can't stand being duped because […] it requires a thudding sense of the reality of things, of the plausibility of actions" (13). This sense of *reality* and *plausibility* that Boorstin highlights is promoted through the use of multimodality that literature on new literacies

promotes. Keeping the voyeuristic eye busy with *reality* and *plausibility* through multimodal techniques and communicating their social commentary on social justice issues is a complex task. Indeed, facilitating students' learning "that [numbers are] a means to present new ways of seeing, new solutions to unsolved problems, [provides] them the opportunity to shift society's paradigms" (Pegram, 2006, 18) is exactly what the digital numeracy texts facilitated.

Student Perception of their Roles in Local and Global Communities

For students to communicate their perceptions of their roles in local and global communities, through their research on social justice issues and their digital numeracy texts, an analysis of research findings would need to show: 1) a personal investment of time in designing and engineering a digital numeracy text such that the issue and possible solution would inspire change; and 2) that numbers actually mean something in the real-world. Demonstrating a personal investment in designing and engineering their digital numeracy texts is evidenced in: 1) student responses to the surveys and interviews; 2) an analysis of the digital numeracy texts for voyeuristic performative indicators; and 3) the literature on meaning-making through multimodal design.

In combination with the results of Figure 13 (Question 20 from Post-Project Survey (Appendix 6), that show the majority of students spent the greatest amount of time on *designing their video*, Figure 14 (Question 21 from the Post-Project Survey (Appendix 6)) demonstrates that the majority of students said they were "on task all the time!" These findings suggest that not only did students feel personally invested in creating their digital numeracy text, but they were personally invested in the social justice issue they were discussing: at the local and global levels. In her interview, Annabelle's comments also underpin the idea that designing a performance shows how much you care about your social justice issue: "if you were going to show it to other people, then they will all know that someone does care about the things that most people think are silly" (Respondent 4: Annabelle). Though the class was split on whether performance beyond "an audience of one: the teacher," (Haviland & McCall, 1999, p. 63) was important to them, the thought that it would get presented in front of their

peers was a contributing factor in many informal discussions with the class about: how to create certain effects and getting feedback and opinions from peers on whether something worked during the creative process. In knowing that their digital numeracy text would be performed in front of an audience, students increased their attention towards the voyeuristic indicators in their text that they could create through multimodal discourse. The use of design principles and multimodal elements, such as those seen in the case studies, work in concert with each other to create a sense of purpose or 'fit' a solution to the problem. This 'sense of fit' the students create is the premise behind "Mathematical beauty" (Gadanidis, et al, 2009, p. 2), not in the sense of the wondrous, but in the sense of students finding their place, their role, their responsibilities in their local and global communities. Indeed, while a detailed analysis of how each of the modes – "those of Linguistic Meaning, Visual Meaning, Audio Meaning, Gestural Meaning, Spatial Meaning, and the Multimodal patterns of meaning that relate the first five modes of meaning to each other" (New London Group, 1996, p. 4) – in the digital numeracy texts might further emphasize their communication of Mathematical understanding, "this should not intrude upon the experience itself" (Norman, 1994, p. 129).

For students to show their understanding of numbers having meaning in the real-world, they would need to use multimodality to demonstrate an alternative context for numeracy other than its traditional perspective. In recontextualizing Mathematics, students are able to transform their learning beyond the classroom to local and global community settings that they participate within. The evidence of this exists in: 1) the digital numeracy texts themselves; the visceral performative sensations the texts promote; and 3) the literature that supports the re-contextualization of students' understanding of Mathematics. The digital numeracy texts in the case studies used in this thesis each showcase how students have used multimodal means to re-contextualize Mathematics. For example, Annabelle uses several images on a repetitive basis at the beginning of her text. While repetition is one of many design principles, it is the specific images themselves that require further analysis. Her image of a tape measure round her own waist humanizes the Mathematical implications of negative

body image. This image creates a visceral sensation because it shows her reflection on her own body image, not just of those who suffer from body-image disorders. As stated earlier, Stocker's (2009) criticism of Mathematics is that students can "calculate how likely is it that [they'll] roll a sum of four with two dice but [they] can't explain the chances of reaching age four in Sudan" (p. 11). Annabelle has made this transition towards socially and culturally relevant Mathematics by moving beyond the simple task of measuring her body to considering the implications that size has on young adults' perceptions of themselves: for Annabelle her digital numeracy text embodies her understanding of the social justice issues she discusses. Seemingly, reconceptualizing the way the Mathematics Classroom uses technology through a performative socio-cultural lens (Gadanidis & Geiger, 2010) has afforded students a view of their education both as socially and culturally relevant as well as facilitating an opportunity to learn about their roles in local and global communities.

Limitations of Study

The methodological framework of this research is based on *designed research*. A design research cycle typically consists of three phases: 1) preparation and design; 2) teaching experiment; and 3) retrospective analysis (Bakker, 2004, p. 37). While the strength of design research (Brown, 1992; Cobb, et al, 2003) is that it is "a systematic but flexible methodology aimed to improve educational practices through iterative analysis, design, development, and implementation, based on collaboration among researcher and practitioners in real-world settings, and leading to contextually-sensitive design principles and theories" (Wang and Hannafin, 2005, p. 6-7). However, there are methodological limitations of design research, which fall into four main groups: immature methodology, applicability and feasibility, paradigm shift and data utilization (Wang and Hannafin, 2005). While these limitations apply to this thesis, they will also, where possible be mitigated.

Immature design. Prefacing this research were two pilot projects, which permitted an iterative design process for this thesis to be conducted. In part, there is limited research on digital numeracy texts, which makes determining the success of them difficult. In

addition, due to the localized context of this research "it may prove difficult [for] valid design principles [to] be generated" (Wang and Hannafin, 2005, p. 19) such that the research can be replicated and effective beyond these local contexts. Finally, as "design-based research comprises a collection of multiple research frameworks" it has been possible for me to act as practitioner, researcher, and teacher at any one time, making it difficult to "identify a specific methodology to guide [further] research and design" (Wang and Hannafin, 2005, p. 19). In order to mitigate the limitations associated with the immature design of design research, it has been necessary to involve other practitioners and teachers in the research process. This has facilitated the opportunity to get alternative views of the research and digital numeracy texts and provided an opportunity to access the specifics associated with the success and limitations of parts of this research.

Applicability and feasibility. Having relied heavily on new literacy research as the foundation to research into new numeracies, the applicability of this research may not satisfy Mathematicians. In a similar vein the iterative nature of design research may not satisfy the requirement for scientific and mathematically based research. Moreover, like the difficulties new literacies research faces against the traditional approach entrenched in schools and curriculum, new numeracies similarly faces a perception that is distracting or intrusive in a content-driven scheme of learning. Finally, as a researcher in the classroom, my presence may have affected or constrained design decisions in the creation of digital numeracy texts. To counter the limitations of applicability and feasibility, this thesis research has needed to focus not on distracting from the scheme of learning but of showcasing a method to approach teaching existing curriculum elements. Indeed, the National Curriculum for Mathematics at both KS3 and KS4 says that Mathematical competence is through "applying suitable Mathematics accurately within the classroom and beyond; communicating Mathematics effectively; and selecting appropriate Mathematical tools and methods, including ICT" (QCDA, 2007, p. 156).

Paradigm shift. "Design-based research methods both share and extend conventional evaluation approaches. In some cases, the extensions are significant and

represent fundamental changes in goals, scope, and methodology" (Wang and Hannafin, 2005, p. 20). A limitation exists, however, in this type of research particularly when one considers the traditional notion of assessment and evaluation in Mathematics in which teachers simply wish to determine whether students' answers are right or wrong. This thesis moves significantly away from this view of numeracy to consider the relevance and applicability of real world and social issues in mathematics education. In the discussion of this research it has also become evident that there are significant iterations needed in its design when facilitating opportunities for students to become better versed in statistical literacy. Nevertheless, this thesis is not aiming for the perfect design, but merely to begin the discussion of digital numeracies and the new numeracies this may afford.

Data utilization. The final aspect of methodological limitations for this thesis surround the "large amounts of data" that are traditionally collected in design experiments (Collins, et al., (2004, p. 19). While in one sense, this limitation is true for this research, which has collected: online surveys, workbooks, and digital numeracy texts, as well as observation notes from both a colleague and myself. The dissemination of this research, where possible, will aim at full disclosure and analysis of all data collected. It is unlikely that all digital numeracy texts produced will be analyzed and a careful selection process of exemplars will be made that will aim to be representative of the class. A better analysis of how digital numeracy has been developed would be through students to re-producing their digital numeracy texts, either as part of an extended editing phase or as a repeated opportunity. An additional limitation of this classroom-based research is that the opportunity to re-produce or re-edit their digital numeracy texts was not possible within the time frame of this research project.

Chapter VII – Conclusion

In conclusion, the following points are considered to be the most noteworthy in this research. Firstly, this research facilitated students communicating their Mathematical understanding of real-world problems and as such bridged the gap between Mathematics, as a subject taught at school, to one that discusses real-world issues. In affording them the opportunity to create their own self-directed numerical experiences, the gap between their primary authentic-discourse became validated in their secondary discourse setting. Their personalized learning experience offered them the opportunity to design and engineer a digital performance of their understanding of social justice issues important to them. Secondly, the result of their personal investment in discussing issues affecting their local and global communities culminated in a digital performance that had the specific intent of demonstrating their numerical competence as social practice. Students veered away from discussions of computation and processes to ones of explanation and validation of numerical understanding. Focusing on performing their Mathematical understanding of real-world issues instead of Mathematical content and competence enabled students to act as agents able to direct change.

Thirdly, in a learning environment that honours individualized and immersive numeracy as social practice, the students' personal investment in these digital numeracy texts promoted "a positive Mathematics identity" (Jacqueline et al., 2010, p. 261). All students, for whatever reason: working on computers again, creating a video again, discussing real-world Mathematics, or working in a project-based environment, wanted to have the opportunity to encounter this type of experience again. Though arguably the result of the Hawthorne Effect, addressing the negative perception of Mathematics as culturally and socially irrelevant to one that positively promotes Mathematical content and numeracy, as social practice, is the intended outcome of this thesis. Lastly, designing and engineering information for a specific purpose, through multimodal techniques, demonstrates an alternative context for numeracy other than its traditional framework. The progression from print to screen underpins the

development of numeracy as a digital social practice that allows a deeper learning experience:

Numeracy Practice	Print-Page	Screen-Page
Logic	Linear sequence of events	Multi-sequential patterns of events
Design	Binary contrast of print on page	Multimodal and multi-colored Contrast
Depth	2D print on page	Multiple layers of information
Operations	→ Singular one-Way relationship → No discussion / feedback → Self-production	→ Multiple interactive relationships → Discussion & feedback possible → Collaborative production
Reasoning	Pre-determined pathway	Self-generated pathway
Evidence	Computation and process	Performance and social practice

Table 17: Digital Numeracy Practices

On a print-page, there is a linear sequence of events that have a pre-determined pathway to navigate. The content is presented in black and white (except for the addition of pictures) in a two-dimensional fashion that creates a one-way relationship between information and students (replicated by the teacher-student relationship) that focuses on computation and process. Whereas using a digital page to express learning, multi-sequential patterns of understanding are permitted. Using multimodal tools, multiple layers of information are created that permit the user to generate their own pathway and draw on multiple interactive relationships to assist them performing their numerical social practice.

Albert Einstein said “we can’t solve problems by using the same kind of thinking we used when we created them” (Fisch & McLeod, 2009). In this vein of logic, education is a dynamic entity that continues to change and alter depending on its socio-cultural reference. Similarly as a founding skill, our definition of numeracy needs to be prepared to shift with not only the social and cultural values it is embedded in, but also to be responsive to the perceived future requirements that the students of today will inherit. Defining numeracy as a social practice may be as innovative as when literacy was also defined this way; however, we need to be just as innovative with the teaching/learning strategies and assessment employed or else we risk too wide a disparity between what society wants and needs and what students are capable of producing.

Recommendations

Recommendations for future educational study based on the content of this thesis stem from the limitations and possible extensions of this research. Firstly, in addressing the potential criticism of Mathematical content needing to be targeted specifically in the creation of digital numeracy texts, it would be possible to design and engineer a similar project that focused equally on content as it did on context as means of learning and possibly teaching mathematics multimodally. In addition to assuaging the criticism of superficial Mathematical content, it would underpin the production of Mathematical information in a digital performance rather than a printed computation piece of text. Secondly, as mentioned above, this research was primarily used as a metacognition tool for contextualizing Mathematics in the real-world; however, it would also be important to repeat this experience with these students and consider what affordances this might offer students without the anxiety of this being the first time. This repetition would also assuage the variety of variables that contributed to the students' excitement and possibly allow further limitations of the Hawthorne Effect.

From a social practice point of view, extensions to this research might focus on students designing, creating and engineering tools that discuss and teach other students the contextualization of Mathematics. In doing so, the links to local and global communities would be strengthened and a variety of perspectives on social justice issues could be explored. From a design point of view, in anonymously coding the students' responses in their preliminary and post-project surveys, more meaningful and descriptive changes in perception of the themes in this research might be gained. In creating this opportunity, this research could also require further research into using digital numeracy texts as a means of assessment of social practice, such that content and contextualization of new numeracies might be investigated further. Finally, in conducting a longitudinal study of how these multimodal authentic learning opportunities affect students, one could study which students continue to explore social justice issues in their learning and whether this impacts on their local and global communities.

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Appendices

Appendix 1: Participant Requisition Letter

Les Quennevais School
St. Brelade, Jersey, JE3 8JW.
Telephone: (01534) 743171.
Fax: (01534) 741323.
Headteacher: Mr. John Thorp, B.A.

Dear Parent

7 March 2011

Subject: New Numeracies – the Social Practice of Functional Skills and Social Justice

I am a teacher at Les Quennevais School and an MA graduate student researcher at the Faculty of Education at the University of Ontario Institute of Technology (UOIT), Ontario, Canada. With the approval of the UOIT Research Ethics Board (REB #10-024) and Mr. John Thorp, Head Teacher at Les Quennevais School, I am about to embark on a project designed to learn more about the relationship between digital numeracy and students' engagement with social justice issues. We are interested in particular in the following research question:

1. How might creating and performing digital numeracy texts based on social-justice themes, facilitate students' communicating mathematical understanding of 1) authentic real-world problems; and 2) socio-cultural contexts of mathematical concepts as part of their role in local and global real and virtual communities?

We anticipate using this information in the development of digital numeracy and literacy projects that honour students' out-of-school practices and interests. Data results may also be published in journals and presented at conferences.

I am asking for both your consent and that of your son/daughter to participate in this study. Data will be collected from students in the class, during an extended three-week Mathematical Investigations Unit already part of the scheme of learning for Year 8. This Unit will be a part of the regular classroom program and will focus on students using the mathematical skills that they have learnt to date in a real-life 'authentic' activity. Students will study a variety of mathematical concepts, some of which will be print-based and some of which will be digital. The culminating project will be student presentations of their understanding of these mathematical concepts using digital media.

Data will be collected using the following methods:

- **A questionnaire** will be administered at least a week before the Unit to capture students' past experiences and current perspectives on both digital numeracy and social justice issues. A content analysis of student responses will be conducted to identify themes that emerge. The findings will be summarized and presented to the students in the first class of the Unit, for discussion and further elaboration. This data will be used as a baseline for exploring how students' thinking and views of digital numeracy and global issues might be reshaped during the Unit.
- As the researcher in this instance, I will be acting as a participant-observer in the class and collect data using **observation notes and audio taping** of all whole-class sessions, and **videotaping** of selected classroom proceedings.
- At key points in the unit, selected students will be **interviewed** by myself and another staff member, to gain more in-depth perspective of noteworthy classroom events identified through observation.
- As a culminating activity, students will be producing a **digital numeracy text** on a social justice theme of their choice. This digital numeracy text will be used and analysed as part of the research.
- All student work completed during this investigation unit, such as group work and discussions, brainstorming activities, etc, will be collected and reviewed for any themes and supporting evidence.

- In the last class of the Unit, students will revisit their original responses in the questionnaire administered prior to the Unit, record any changes that might have occurred, and discuss these in small groups and in a whole class setting. A sample set of questions for the discussion is attached for your information.

All students in my Year 8 class will participate in this Mathematics project, but only those who consent will have the information they provide used. It is important to note that:

- Your child may **withdraw** from the study **at any time** without penalty and can choose not to answer specific questions.
- The information your child provides will be **anonymous** and will be combined with the responses of other students into a summary report.
- The tapes and transcripts of classroom proceedings, as well as any other data collected, will be stored securely under my supervision and will be destroyed after the findings are published in my thesis.

Your signature on the consent form indicates that you have read this letter, understand its contents, and authorize the participation of your son/daughter in this research project. Please note that your child's signature is also required. If you have questions about this project, feel free to call Miss Tolley at 01534 743171, the Head Teacher, Mr John Thorp or UOIT's REB Ethics and Compliance Officer Sascha Tuuha at compliance@uoit.ca, who can provide answers to pertinent questions about the research participants' rights. Thank you for considering your child's participation in this research study.

Yours Sincerely,

Miss Tolley
LQS Mathematics Teacher
s.tolley@lqs.sch.je

New Numeracies – the Social Practice of Functional Skills and Social Justice

CONSENT FORM

Students Name: ……..…… **Form:** ……

I have read the Letter of Information relating to the above-titled project, I understand the proposed research and my questions have been answered to my satisfaction.

If I choose for my child to participate, I understand that I have the right to withdraw my son/daughter from the study at any time. I understand my child has the right to withdraw from the study at any time and I understand that the information collected is for research purposes only.

Parental Consent – please tick the appropriate box:

□ I **would like** my child to participate as a research participant in this Maths project
□ I **would not like** my child to participate as a research participant in this Maths project

Parent/Guardian Signature: _____

Date: _____

Student Consent – please tick the appropriate box:

□ I **would like** to participate as a research participant in this Maths project
□ I **would not like** to participate as a research participant in this Maths project

Student Signature: _____

Date: _____

Appendix 2: Wireless Network Code of Conduct & Application Form

High Valley Mobile Computing Network

Code of Conduct

All students who request permission to register their mobile device for use on the network must read, agree to and sign this code of conduct. Parents are also asked to sign to indicate they are aware of its content. This Code of Conduct supplements the Acceptable Use Policy for use of our school network, the provisions in which also apply to the wireless network.

Your mobile computing device

- **All devices are brought into school at the student's own risk. You are responsible for the security of the device and any software or files it contains. You are responsible for ensuring that it is protected against viruses or other malicious software. You must not download or bring into school on your mobile device any materials or files which are illegal, offensive or inappropriate. Any breach of this condition will lead to the confiscation of your device, its removal from network access, and possible referral to the police or other sanctions.**
- Your mobile device should be brought to school fully charged, Recharging will not be permitted in school.
- **The safety and security of your mobile device is your responsibility. In particular you should ensure your mobile device is fully protected against malicious and damaging software, such as viruses, by having good, regularly updated ant-virus software installed and active.** The Wi-Fi network does not provide protection against viruses, though many may be filtered out, so you must be aware f the risks, protect your device and backup your data regularly
- **By bringing your mobile device into school you agree that members of staff may search your device should there be any concerns that it contains inappropriate or illegal material**

Access to the Network

- Each mobile device is identified by its MAC address, which you will register as part of your application.
- You must not attempt to use another person's logon details to try to access or delete files.
- You must not allow anyone else to use your mobile device to access the network – you are responsible for all usage of the mobile device in school.
- If your mobile device is mislaid, lost or stolen you must inform our ICT technicians immediately so its access rights can be deleted from the network.

Use of the Network

- The network should only be used for appropriate school work
- Do not try to infect the network in any way with a virus, worm, Trojan horse or other nuisance program.
- You must not deliberately switch off a computer that is being used by someone else.
- You must not try to bypass school security in any way.

Internet and Email

- Access to the Internet should only be used for educational purposes.
- All activity on the network is logged and monitored. You should avoid trying to access sites, which are considered unsuitable due to their content. This includes files, which contain pornographic material, are racist, inflammatory, contain obscene language or are in any way likely to offend others. These rules also apply to messages and breaches will be rigorously investigated.
- Do not use any unauthorised forum or chat line,
- Do not use of form of file-sharing or peer-to-peer network software
- Never give out your name, home address, telephone numbers or any personal information to anyone without giving considering the possible consequences and being sure it is safe
- Do not send threatening messages within or outside the school.
- Do not attempt to play games (other than those with a recognised educational purpose) or download them from the Internet.
- Respect copyright and trademarks laws. You cannot use the words or pictures that you see on an Internet site without giving credit to the person that owns the site.
- You must not copy text or pictures from the Internet and hand it in to your teacher as your own work.

Printing

When we make printing available

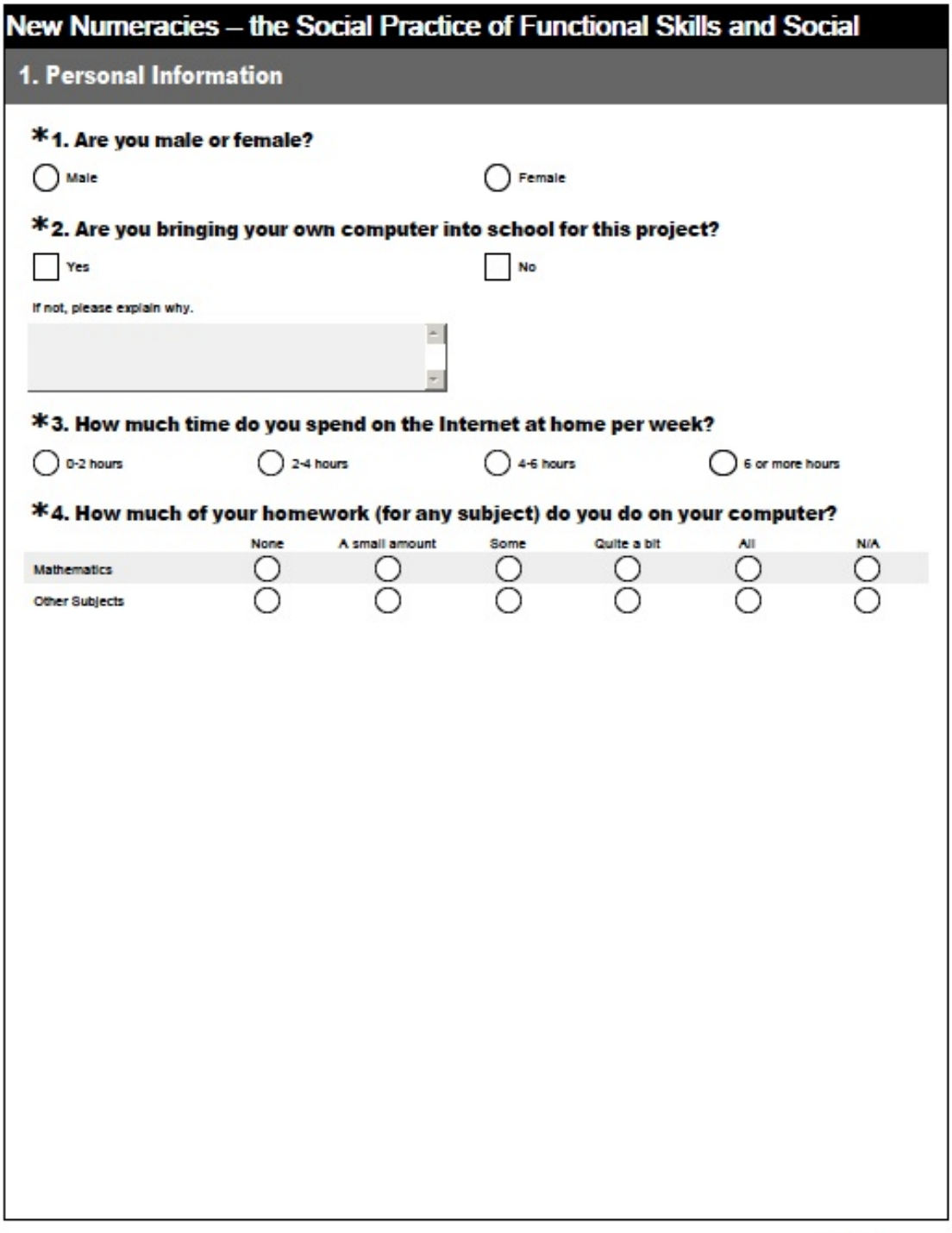
- Do not waste paper by printing unnecessary work or printing more than one copy of work.
- You must only use a printer for school-related work.
- You will be issued with printing credits and careless or deliberate wasting of paper will result in your printing facility being withdrawn.

I accept and agree to follow the Code of Conduct and request that my wireless device, MAC number have the necessary software installed to operate on the school wireless network.

Name of student: **Form:** **Signature:**

Name of parent: **Signature of parent:** **Date:**

Appendix 3: Preliminary Project Online Survey



New Numeracies – the Social Practice of Functional Skills and Social

1. Personal Information

*1. Are you male or female?

Male Female

*2. Are you bringing your own computer into school for this project?

Yes No

If not, please explain why.

*3. How much time do you spend on the Internet at home per week?

0-2 hours 2-4 hours 4-6 hours 6 or more hours

*4. How much of your homework (for any subject) do you do on your computer?

	None	A small amount	Some	Quite a bit	All	N/A
Mathematics						
Other Subjects						

Page 1

New Numeracies – the Social Practice of Functional Skills and Social

2. Project Preliminaries: Maths

This section helps ascertain your feelings towards Mathematics.

***1. What are the first three things that come to mind when you think of 'Maths'?**

One

Two

Three

***2. Please give three examples of where you see Mathematics being used in the 'real world' (not in the classroom)?**

Example 1

Example 2

Example 3

***3. Please give three examples of where you see Mathematics being used in the 'real world' (not in the classroom)?**

Example 1

Example 2

Example 3

***4. How do you think you will use Mathematics when you leave school?**

5. Have you read books or online materials on Mathematics?

◯ Yes ◯ No

◯ If Yes, please explain

New Numeracies – the Social Practice of Functional Skills and Social

***6. If you were stuck on a Maths problem, which websites would you visit?**

- ◯ I would do a google search
- ◯ I don't know
- ◯ The website I'd visit is....

7. How important do you think Mathematics is to your education?

	Not at all important	A little important	Neither important or unimportant	Quite important	It is very important
Mathematics	◯	◯	◯	◯	◯

New Numeracies – the Social Practice of Functional Skills and Social

3. Project Preliminaries: Social Justice

This section helps ascertain your feelings towards Social Justice.

***1. Can you describe what 'social justice' means in your own words?**

- ◯ Don't Know
- ◯ Social Justice is...

***2. Have you created any videos on something you are concerned about before?**

- ◯ Yes
- ◯ No

If Yes, please explain.

***3. Social Justice is a concern with the distribution of advantages and disadvantages within a society.**

	No	A little	Neither No or Yes	Quite a lot	Yes
Do you think this is worth learning about?	◯	◯	◯	◯	◯
Do you think you can learn about this in Maths?	◯	◯	◯	◯	◯
Do you learn about this in other subjects	◯	◯	◯	◯	◯

Please explain

New Numeracies – the Social Practice of Functional Skills and Social

4. Project Preliminaries: ICT & Project

This section helps ascertain your feelings towards the project and using computers.

***1. What kinds of things do you do when you go online?**

***2. Do you share things you find online with others?**

	Never share	Rarely share	Sometimes share	Share a lot	Always share
Share?	◯	◯	◯	◯	◯

***3. How comfortable are you using a computer**

	Not comfortable	A little comfortable	Feel OK	Quite comfortable	Very comfortable
Comfortable?	◯	◯	◯	◯	◯

***4. How comfortable are you at creating videos on your computer**

	Not comfortable	A little comfortable	Feel OK	Quite comfortable	Very comfortable
Videos?	◯	◯	◯	◯	◯

***5. Are you excited about this project?**

	Not excited at all	A little excited	Some excitement	Quite excited	Very excited
Excited?	◯	◯	◯	◯	◯

***6. Are you anxious (nervous / confused) about this project?**

	Not at all	A little	Feel OK	Quite a lot	Very
Anxious?	◯	◯	◯	◯	◯

***7. Are you anxious (nervous / confused) about this project?**

	Not at all	A little	Feel OK	Quite a lot	Very
Anxious?	◯	◯	◯	◯	◯

8. What are you excited / anxious about before this project starts?

	First Choice	Second Choice
What is exciting about this project?		
What is making you feel anxious (nervous / confused) about this project?		

Other (please explain)

Appendix 4: Screen-Shot of Class Website

School ::: Subjects ::: Maths ::: TEACHERS ::: Miss Tolley ::: 03/04/2011 15:54

Homepage | General information | Quick links | ESC Resources

8MAB1

Homepage

School > Subjects > Maths > TEACHERS > Miss Tolley >

Year 8 Website

Homepage
News
Calendar
Wireless network conduct agnd application
Uniservity help
Subjects
Learning support
Examinations
Staffroom
Teaching/Learning
Learning and revision
Careers
School community
Year groups
House pages
Prefects
Charities
Showcase
Information
Contact us
School trust
Student information
About the school
Joining
Stay safe online
Activities Week
Literacy
D of E Award Scheme
Trident
Canoeing
Wireless network
Eco-Team
LQS Book Club
ClickView
Data protection
CLC help and advice
School Site map

New Numeracies – the Social Practice of Functional Skills and Social Justice

[1] Questionnaire Monday 14th March (Before):https://www.surveymonkey.com/s/DLPFZJN

[2] Videos Wednesday 16th March

Video 1 - Dove Comercial:http://www.youtube.com/watch?v=iYhCn0jf46U

Video 2 - Students for Human Rights:http://www.youtube.com/watch?v=DHlnUBKX18I

Video 3 - Declaration for Human Rights:http://www.youtube.com/watch?v=hTlrSYbCbHE&feature=related

Video 4 - A World with no Numbers:http://www.youtube.com/watch?v=NLpfcKwHkrM

Video 5 -Pacific Garbage Patch:http://teachertube.com/viewVideo.php?video_id=223294&title=Ocean_s_Garbage_Patch

Video 6 - If I could change the world:http://www.youtube.com/watch?v=wuRURJ9E3iQ

Thursday 17th March
(Room:)

. Starting to Research
. Storyboard

Homework:

Can you participate in my MA project? Get letter signed.

Page 1 of 2

Appendix 5: Assignment Booklet

New Numeracies Miss Tolley

Y8

Math that Matters

Y8 | 2011

New Numeracies Miss Tolley

"A picture is worth 1000 words"

What Math is happening in this picture?

New Numeracies Miss Tolley

What Math questions do you have about this picture?

Are there any social justice issues in this picture?

New Numeracies Miss Tolley

Pick a picture

Year 8 | 2011

New Numeracies Miss Tolley

1. What Math is happening in this picture?

2. What Math questions do you have about this picture?

3. Are there any social justice issues in this picture?

New Numeracies Miss Tolley

Watch these videos

Video 1: http://www.youtube.com/watch?v=iYhCn0jf46U (dove video)
Video 2: http://www.youtube.com/watch?v=DHInUBKX18I (Students for Human Rights)
Video 3: http://www.youtube.com/watch?v=hTlrSYbCbHE&feature=related (Declaration for Human Rights)
Video 4: http://www.youtube.com/watch?v=NLpfcKwHkrM (a world with no numbers)
Video 5: http://teachertube.com/viewVideo.php?video_id=223294&title=Ocean_s_Garbage_Patch (Pacific Garbage Patch)
Video 6: http://www.youtube.com/watch?v=wuRURJ9E3iQ (if I could change the world)

Choose One (1) Video

1. What worked?

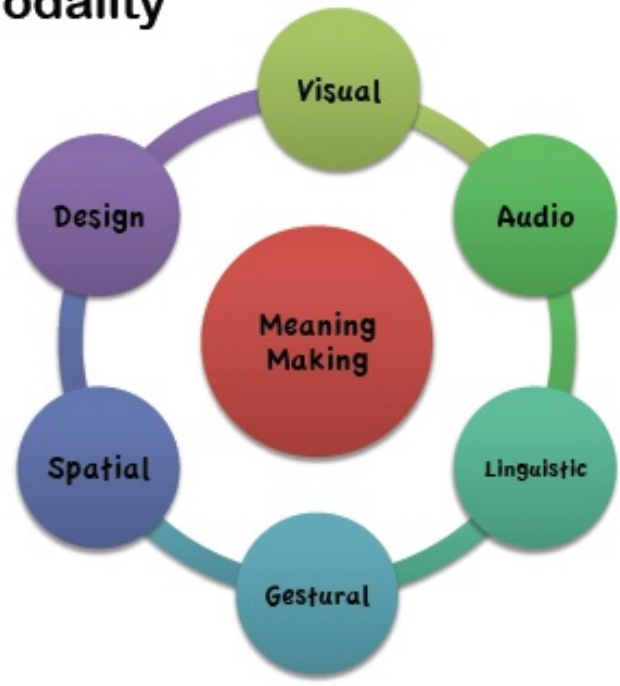
2. What didn't work so well?

3. How could it have been done better?

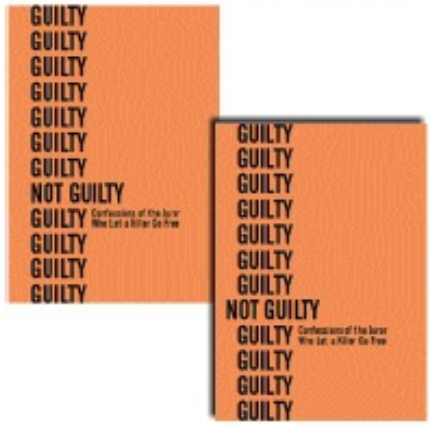
4. What would you have done differently?

New Numeracies Miss Tolley

Multi-Modality



Design Principles

Proximity		Closeness
Contrast		Colour
Alignment		L→R
Repetition		Unusual

New Numeracies Miss Tolley

Choose one of the following topics and as a group / individually represent this in a short video:

Love
Loss
Greed
Faith
Panic
Anger

You need to consider:

- Pictures
- Sound
- Words
- Design
- Actions
- Timing
- Copyright: document your sources

New Numeracies

Miss Tolley

Ideas / Brainstorming

Year 8 | 2011

Project

1. Create a digital numeracy text (video) on a social-justice topic of your choice
2. **Must contain/be:**
   a. At **least four (4) pieces** of mathematical information
   b. A question about your topic that you answer
   c. Sound / Images / Words, etc
   d. ≈ 3 minutes

- The task is **individual**
- You may use **any software** you like:
  - moviemaker, photostory, i-movie, etc
- You should aim to take your own pictures. However, if you don't, you must write down where you got them from on the internet: **bibliography**
- You need to complete the **storyboard and justification** document

Timeline

Day / Date	Activity	Homework
Thursday 17-Mar-11	Start Project Research / Storyboard	Chose your social-justice topic & research at home
Monday 21-Mar-11	[1] Continue Research / Storyboard [2] Start working on video	
Wednesday 23-Mar-11	[1] Working on Videos	
Thursday 24-Mar-11	[1] Working on Videos	Work on video to ensure it is complete
Monday 28-Mar-11	[1] Working on Videos	
Wednesday 30-March-11	[1] Finish Video & Save on USB stick in finished format [2] Finish Justification Document	
Thursday 31-Mar-11	Present Videos in Class	
Monday 04-Apr-11	[1] Interviews about project [2] Online Questionnaire	

New Numeracies Miss Tolley

Project Research

Brainstorm Ideas:

My Topic Choice is:

I care about this because:

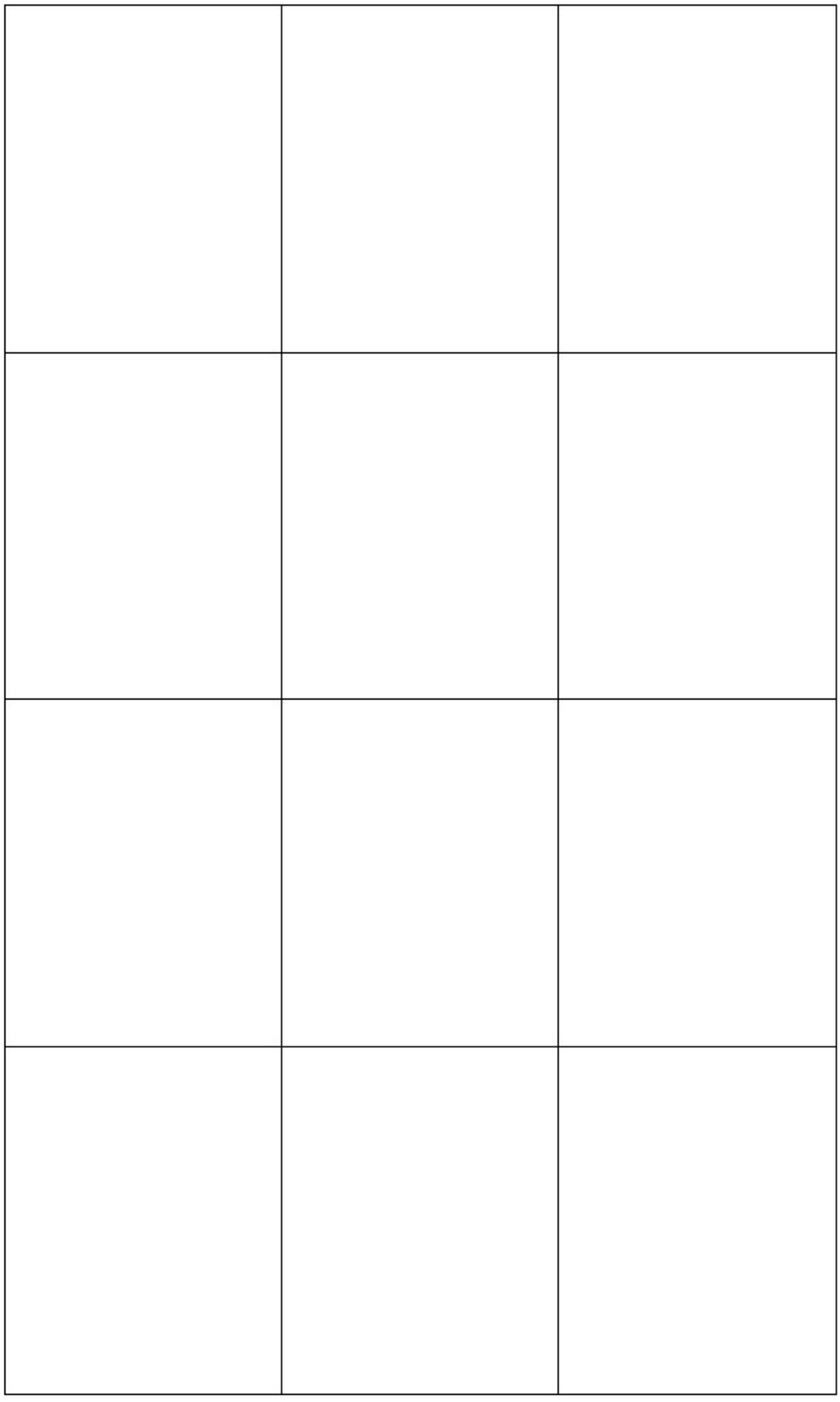
What are some of the social-justice issues surrounding this topic?

What is the question I want to present / pose / answer:

What 4 pieces of Math's information am I going to use and why?

Key Words for Research:

Storyboard



New Numeracies Miss Tolley

Justification

What was your social-justice topic?

Why did you choose this?

What music did you use and why?

Choose three images and explain why you chose to use these

Image 1: _____

Image 2: _____

Image 3: _____

New Numeracies Miss Tolley

What was the question that you asked yourself / in the video?

What do you hope your video achieves?

What do you think you will do with the video?

Will you do anything about your social-justice topic in the future?

What did you find difficult / challenging about this project and why?

What did you find enjoyable about this project and why?

_____

_____

_____

_____

Choose 2 of the 4 pieces of mathematical information in your video and explain why you chose to use these.

- **How do they support your video?**
- **How did you make them understandable in your video?**
- **Why were they important to include?**

Math Info 1: _____

_____

_____

_____

_____

Math Info 2: _____

_____

_____

_____

_____

Is there anything else that you would like me to know about your video or how you felt about this project?

_____

_____

_____

_____

_____

_____

New Numeracies Miss Tolley

Bibliography

Number	Picture Description	Source (Link)
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		

Digital Numeracy Video Peer Evaluation

My Name:

My Video is on:

My Peer Assessor's Name:

Technical Requirements	Yes / No	Comments
Did the video use pictures that were related to the topic?	Yes / No	
Did the video contain pictures taken by the creator?	Yes / No	
Did the video have a soundtrack?	Yes / No	
What was the song choice?		
Did the lyrics match up to any pictures in particular?	Yes / No	
Was there any narration?	Yes / No	
Did they use any video or just still pictures?	Yes / No	
Have they used a minimum of 4 pieces of Maths?	Yes / No	
Is their video ≈ 3 minutes long?	Yes / No	
What was the question they posed in the video?		

Design Elements	Please rate the element	Comment?
How was the pace of the video? Was there enough time to read everything?	☆ ☆ ☆ ☆ ☆	
How clear was the text in the video? Was the contrast strong enough?	☆ ☆ ☆ ☆ ☆	
Was there Mathematical Information understandable? Did you understand what it meant?	☆ ☆ ☆ ☆ ☆	
Were the transitions between images good?	☆ ☆ ☆ ☆ ☆	
What was the overall design of the video like?	☆ ☆ ☆ ☆ ☆	

Comments

To improve you could:

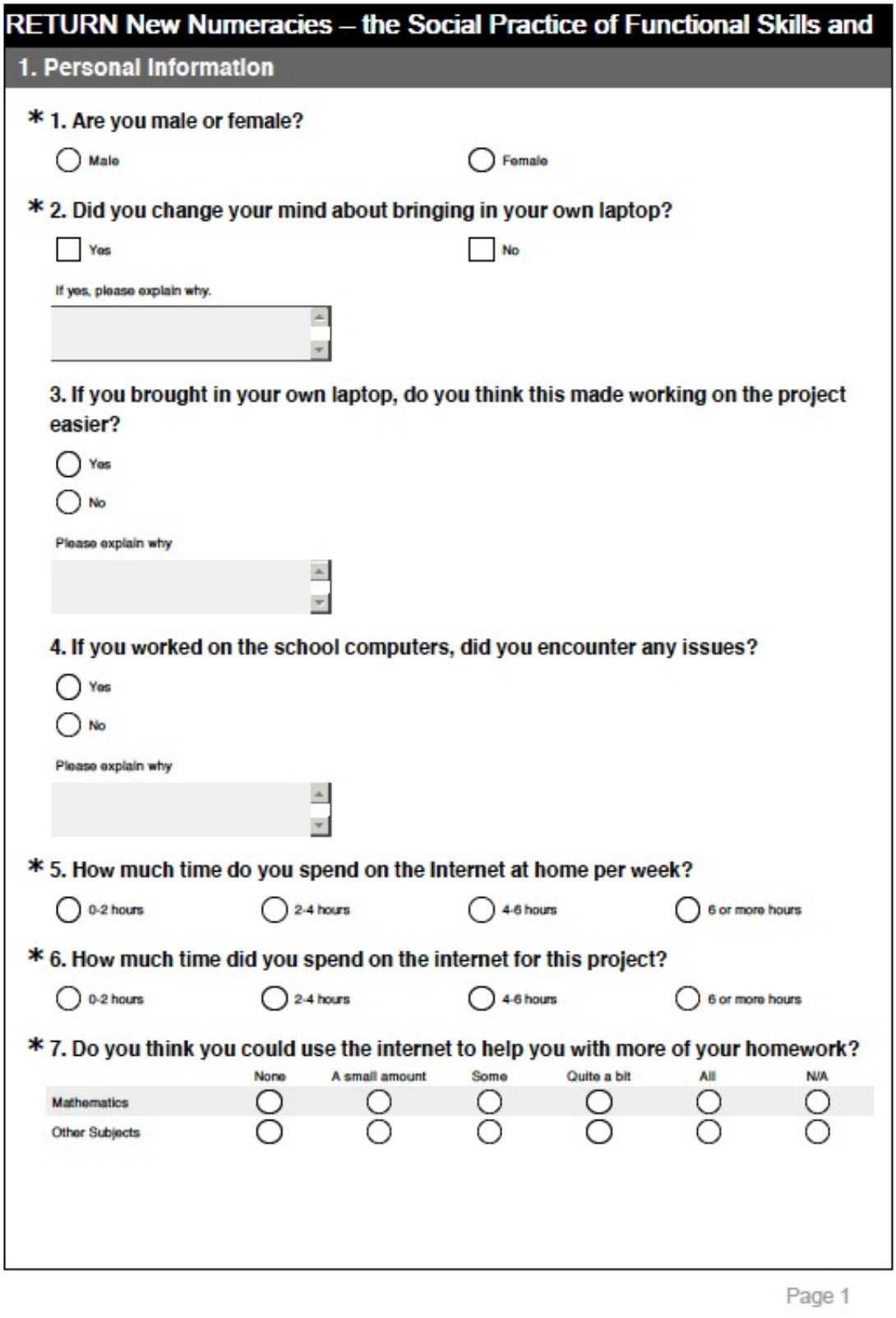
The best thing about your video was:

I have worked on the following since my peer evaluation:

Your teacher would like to add:

☆ ☆ ☆ ☆ ☆

Appendix 6: Post Project Online Survey



RETURN New Numeracies – the Social Practice of Functional Skills and

1. Personal Information

* 1. Are you male or female?

Male Female

* 2. Did you change your mind about bringing in your own laptop?

Yes No

If yes, please explain why.

3. If you brought in your own laptop, do you think this made working on the project easier?

Yes

No

Please explain why

4. If you worked on the school computers, did you encounter any issues?

Yes

No

Please explain why

* 5. How much time do you spend on the Internet at home per week?

0-2 hours 2-4 hours 4-6 hours 6 or more hours

* 6. How much time did you spend on the internet for this project?

0-2 hours 2-4 hours 4-6 hours 6 or more hours

* 7. Do you think you could use the internet to help you with more of your homework?

	None	A small amount	Some	Quite a bit	All	N/A
Mathematics						
Other Subjects						

Page 1

RETURN New Numeracies – the Social Practice of Functional Skills and

2. Project Changes: Maths

This section helps ascertain your feelings towards Mathematics after the project.

*** 1. After completing this project, what are the first three things that come to mind when you think of 'Maths' now?**

One
Two
Three

*** 2. Please give three examples of where you see Mathematics being used in the 'real world' (not in the classroom)?**

Example 1
Example 2
Example 3

*** 3. How do you think you will use Mathematics when you leave school now?**

*** 4. If you were stuck on a Maths problem, which websites would you visit now?**

- ◯ I would do a google/bing search
- ◯ I don't know
- ◯ The website I'd visit is....

5. After completing this project, how important do you think Mathematics is to your education now?

	Not at all important	A little important	Neither important or unimportant	Quite important	It is very important
Mathematics	◯	◯	◯	◯	◯

6. Can you give three examples of how mathematics is useful to you.

Example 1
Example 2
Example 3

RETURN New Numeracies – the Social Practice of Functional Skills and

3. Project Changes: Social Justice

This section helps ascertain your feelings towards Social Justice after the project.

*** 1. Can you describe what 'social justice' means in your own words?**

- ◯ Don't Know
- ◯ Social Justice is...

*** 2. How much did you care about the topic in your digital numeracy text?**

◯ Not at all ◯ A small amount ◯ Some ◯ Quite a bit ◯ A lot

*** 3. Social Justice is a concern with the distribution of advantages and disadvantages within a society.**

	No	A little	Neither No or Yes	Quite a lot	Yes
Do you think this is worth learning about?	◯	◯	◯	◯	◯
Do you think you can learn about this in Maths?	◯	◯	◯	◯	◯
Do you learn about this in other subjects	◯	◯	◯	◯	◯

Please explain

RETURN New Numeracies – the Social Practice of Functional Skills and

4. Project Chages: ICT & Project

This section helps ascertain your feelings towards the project and using computers after we've completed the project.

*** 1. Did you share things you found online with others?**

	Never share	Rarely share	Sometimes share	Share a lot	Always share
Websites?	◯	◯	◯	◯	◯
Information?	◯	◯	◯	◯	◯
Pictures?	◯	◯	◯	◯	◯
Music?	◯	◯	◯	◯	◯

2. Please describe how you found most of the information in your video?

*** 3. How comfortable are you using a computer now?**

	Not comfortable	A little comfortable	Feel OK	Quite comfortable	Very comfortable
To make videos?	◯	◯	◯	◯	◯
To research?	◯	◯	◯	◯	◯

*** 4. How much time did you spend:**

	Not much time	A little time	Some time	Quite a bit of time	Most of my time
Choosing your topic?	◯	◯	◯	◯	◯
Learning how to use the program?	◯	◯	◯	◯	◯
Searching for information?	◯	◯	◯	◯	◯
Checking the information was accurate?	◯	◯	◯	◯	◯
Designing your video (pace, transitions, effects)?	◯	◯	◯	◯	◯

*** 5. How involved were you in this project?**

	Not at all	A little	Some	Quite a lot	All the time.
I was on task all the time!	◯	◯	◯	◯	◯
I helped my peers with problems they had.	◯	◯	◯	◯	◯
I worked at home on this project.	◯	◯	◯	◯	◯
I talked about this project outside of class / school time.	◯	◯	◯	◯	◯

6. Please explain, if anything, what you found enjoyable or pleasurable about this project?

RETURN New Numeracies – the Social Practice of Functional Skills and

7. Please explain, if anything, what you found frustrating or challenging about this project?

8. How important to you was it that someone else, other than your teacher, saw your digital numeracy video?

- ◯ Not at all
- ◯ A little
- ◯ Some
- ◯ Quite a bit
- ◯ Very important

Please explain why

*** 9. Given the opportunity, please rate how much you would like to do the following:**

	Not at all	A little	Some	Quite a lot	100% want to do this again
Create a numeracy video again?	◯	◯	◯	◯	◯
Discuss 'real-world' mathematics?	◯	◯	◯	◯	◯
Do project-based work in mathematics?	◯	◯	◯	◯	◯
Use computers again?	◯	◯	◯	◯	◯

10. What, if anything, will you do with your finished video?

11. What, if anything, could/will you do about your social justice theme in the future?

Appendix 7: Student Interview Questions

Mathematics – the Social Practice of Functional Skills and Social Justice

Sample 1-1 Questions –Students

These are sample questions that would be used as a starting point in open-ended, semi-structured discussions. This list is not meant to be exhaustive.

Student and I will re-watch the video they have produced together.

Student Questions:

1. Tell me why you chose this topic and why it is important to you?
2. Do you think if you had more time whether there would be anything you would do again?
3. Do you think mathematics is important to your life outside of school? Why or why not?
4. Do you think it is important to learn about issues of concern, such as poverty or environmental concerns in school? Why or why not?
5. Can you tell me why you made this design decision (specifics based on video to be produced).
6. How does the digital aspect of your creation change the process and the product? Contribute to the meaning-making?
7. How did your thinking process change/differ than usual?
8. What literacy skills in your life outside/inside school did you draw upon?
9. What numeracy skills in your life outside/inside school did you draw upon?
10. When thinking about your finished product, what relationship between text, number, image, and sound did you use in the creative process?
11. If you had experts all around you, in an ideal situation, what would you need from them in terms of collaboration?
12. Has your view of numeracy/Mathematics education shifted?
13. What was the most important thing you will take from this project about global issues?
14. Would you like to do a project like this one again? Why or why not?
15. In what ways has this project inspired/encouraged you to take action on the issues that concern you?

Appendix 8: Transcripts of Student Interviews

Interviewer: Is there any reason that the music stops there?
Respondent 1 (Casie): well … [pause] …
Interviewer: When you showed the fat people [brings image up on computer], why did you choose to add the 'wobbly' effect?
Respondent 1: Because I think it makes it more, not outstanding, but more effective and it just shows how some people out there are greedy and want to be fat and then some people are out there, like, starving, and don't want to be anorexic.
Interviewer: So why is that important to you, that topic, because you could have chosen anything?
Respondent 1: Cos I don't think it is fair how, … because we hear a lot on the news how people are starving…"
Interviewer: Did you find it easy to find information on your topic?
Respondent 1: Well it's hard because the figures, you don't know whether they are right or wrong, so you've just basically got to try and just put them down, hoping that they are right, because you can't really do anything else.
Interviewer: What do you think you could do to check that they are right?
Respondent 1: Check a couple of web-sites, make sure the websites can't be edited by people.
Interviewer: Do you think it is important to learn about those type of topics at school – the ones that you are interested in?
Respondent 1: No, because I don't think we'd be able to have a lesson on how to be, um, feed yourself properly, because I think you can learn that at home.
Interviewer (Re-words Question): No, perhaps I didn't word it right, in terms of looking at issues like that, and looking at problems, and looking at the numbers and the data, that's important?
Respondent 1: so we know where to go, if we want to live a happy life and how happy we are.
Interviewer: what will you do with your video now?
Respondent 1: um…well I've shown people at home, but apart from that, I don't think…
Interviewer: what did they think?
Respondent 1: well my mum was shocked at some of the pictures on there, and my dad didn't really…well he didn't really like it, cos he doesn't like seeing things
Interviewer: OK, so it was because it was really graphic or it contained really harsh images?
Respondent 1: yes
Interviewer: what did they think about you'd actually done? What did they say
Respondent 1: Well afterwards [laughs] my Mum said it was really good, but I don't know what I will with it after…
Interviewer: what do you think you might do about the issues that you talked about, because when you were watching it you said "I don't know how you can let yourself get to that point." So, how has it affected you, doing the project on that topic?
Respondent 1: to make sure I don't a life full of rubbish, like crisps and junk.

Interviewer: Do you think you would like to do something like this again?
Respondent 1: Yes, definitely.
Interviewer: What was it that was the most enjoyable thing?
Respondent 1: Researching and finding…and actually seeing some shocking photos that show me how bad it actually is
Interviewer: What was the most challenging part?
Respondent 1: Making sure the information is right
Interviewer: Why is that important to get that right?
Respondent 1: Because people in the audience are questioning it, and they want to know exact figures
Interviewer: Do you think some of the math you used could have been shown in another way? For example the 6 million Americans, could you have shown that in a different way other than writing it on the screen?
Respondent 1: Well, it's a bit hard, because you know what [other student] did and then she had each year, but I could have done a child crossed out, but it's a bit hard with 6 hundred million.
Interviewer: Do you think if you could go back to this, is there anything that you would want to change, or are you happy with it?
Respondent 1: Um, not as much writing and to talk through it
Interviewer: to narrate it?
Respondent 1: Yes.

Interviewer: So what do you think about watching it now?
Respondent 2 (Bradley): Um, probably could have done a bit better.
Interviewer: Yeah? Why do you say that?
Respondent 2: Cos, like, looking at the others in the class, they're better
Interviewer: Why are they better?
Respondent 2: because they have more information in them
Interviewer: Did you find it challenging to find information?
Respondent 2: Yeah, lots of stuff was blocked.
Interviewer: OK, so you had some really interesting statistics, if I go back [shows screen shots], 13.5% Black, 12.9% European White. What did you think about those, were you surprised?
Respondent 2: I wasn't really surprised, because Africa's probably bigger than Europe…so… I thought they'd be more Black African's than White Europeans
Interviewer: Did you think it would be way more?
Respondent 2: Um…yeah
Interviewer: so why did you choose racism?
Respondent 2: because there is quite a lot of problems in the world like due to it and it separates villages and that
Interviewer: and how do you know that?
Respondent 2: because we did research on past times and the future
Interviewer: and what subject was that?

Respondent 2: in history and Pebble – we did Nelson Mandela in South Africa
Interviewer: So you are using all of that stuff you've learnt before to create something?
Respondent 2: yeah
Interviewer: Do you think it is important to have Maths in something like that? Or would you have preferred not to have the Math?
Respondent 2: Um, it's quite important, because it shows the statistics of it all and how many
Interviewer: Why do you think it is important to have math?
Respondent 2: probably because like, it like, gives you a better, like view, cos if you say these people are black or white, you wouldn't know how many
Interviewer: do you think that any of the numbers that you used, because you used quite a bit of statistics, […] do you think you could have shown that in any different way, because you wrote it on the screen, do you think you could have represented it differently?
Respondent 2: yeah, maybe like images and do like a key and show where bits are
Interviewer: why didn't you do that?
Respondent 2: because I didn't think of it at the time
Interviewer: Would you like to do something like this again?
Respondent 2: Err, yeah, because I have the experience of doing it
Interviewer: So it would be easier a second time round?
Respondent 2: yeah
Interviewer: What have you done with the video since finishing it?
Respondent 2: I've showed it to the class?
Interviewer: Anyone else?
Respondent 2: I've shown it to people in Pebble [another class at school]
Interviewer: What did they say when they watched it?
Respondent 2: They said it was good and they liked it
Interviewer: What do you think you will do with the video now?
Respondent 2: um…not sure really.
Interviewer: will you show it to anybody?
Respondent 2: yeah, I'll take it back home on a memory stick
Interviewer: At the end, you have the racism is wrong, with the is in red, why did you chose to do that?
Respondent 2: because it stands out, and like, the red, and it's good because it is my own image that I, like, made.
Interviewer: why did you choose the I and the S to be red?
Respondent 2: because if it wasn't it would just be racism wrong and as the I and the S are close together so 'IS'…so racism IS wrong

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Interviewer: So, why did you choose to do it on COD? Other than the fact you could and it was exciting.

Respondent 3 (Byron): That wasn't the only reason, it was like, because the day before, we were actually talking about the things, like, it was happening but like in another country, it was actually happening there
Interviewer: What were you discussing?
Respondent 3: Well, you know how in Pebble we're doing Poverty and everything, that's what I was thinking about, the fact that, like, if two carpet bombs were dropped, there was four already done in COD
Interviewer: Yeah, so what do you think about the numbers? Cos when you started looking into that, were you surprised by anything you saw?
Respondent 3: Yeah, I thought it was basically the same
Interviewer: So, what do you infer from that? How do you make sense of that?
Respondent 3: It's basically a game that's real-life as well
Interviewer: Do you think that makes it …
Respondent 3: …worse...
Interviewer: makes it worse? Why does that make it worse?
Respondent 3: like, because it is basically the truth
Interviewer: so every time you're doing something [in the game] that's' actually happening in reality?
Respondent 3: your actually killing somebody basically
Interviewer: why did you choose to do pictures of COD and pictures of real-life? Why did you make that design decision?
Respondent 3: comparing them both together
Interviewer: what do you think helps by doing that?
Respondent 3: like it shows that there is actually COD and people actually killing somebody
Interviewer: so they're almost exactly the same?
Respondent 3: [affirmative nod]
Interviewer: how did you check, did you check any of the statistics before you put them on?
Respondent 3: yeah
Interviewer: How did you do that?
Respondent 3: I went on, like, two websites
Interviewer: yeah, and did two websites … that's …
Respondent 3: yeah
Interviewer: and they were exactly the same?
Respondent 3: yeah
Interviewer: Do you think it is important to do things like this in class?
Respondent 3: yeah
Interviewer: why?
Respondent 3: because, like, people actually do the work, they don't sit there and chat, they actually do it
Interviewer: yeah, I noticed, I normally struggle to get you to do work, and you and Rafael, I don't think I heard a peep out of you for six straight lessons [laughs]
Respondent 3: [laughs]

Interviewer: So, what do you think helps by using math's, because you could of created a video like this and not necessarily used any math's whatsoever? How do you think the Maths helps?
Respondent 3: yeah, like, it helps, doing statistics
Interviewer: and why are they important?
Respondent 3: because it is the maths
Interviewer: but why is math's important? because you could of created a video like this and not used math's al all.
Respondent 3: we wouldn't be able to tell, like, what is was about, without numbers or anything
Interviewer: so it kind of helps you to …
Respondent 3: understand
Interviewer: ok, have you done anything with the video, since showing the class?
Respondent 3: [negative nod]
Interviewer: do you think you might do anything with it?
Respondent 3: no [laughs]
Interviewer: you're not going to show it to anybody?
Respondent 3: no
Interviewer: why?
Respondent 3: I dunno

Interviewer: OK, so why did you choose that topic?
Respondent 4 (Annabelle): um, because, like, when you flick through a photography book, you see all these models, but they've like changed it so much, so it's not really …
Interviewer: How important, do you think, was it that you do something that you cared about?
Respondent 4: Um, quite important, cos [laughs]
Interviewer: why did you choose this, cos I'm sure that you care about lots of other things as well, why did you choose this one?
Respondent 4: because, like, if you were going to show it to other people, then they will all know that someone does care about the things that most people think are silly
Interviewer: So it is important that people know you care?
Respondent 4: yeah
Interviewer: how do you think the Math helped you communicate that you cared about it?
Respondent 4: what do you mean?
Interviewer: well, you used lots of math in there [in the video] in terms of £1000 a day to get treatment and how many people need treatment and all those things, how do you think that helps you put that point across that its important
Respondent 4: um, well, I'm not sure.
Interviewer: OK, so you write things like £1000 a day, do you think you could have represented that any other way?

Respondent 4: yeah, like, the way you did yours [referring to example teacher-research presented to class during multimodality learning session]
Interviewer: so why didn't you do that? And I'm not saying that mine was better or anything like that, how come you didn't choose, why did you want to have it written instead of …
Respondent 4: because, like, it is easier to understand
Interviewer: so is it easier to read math than it is to see it? Like is it easier to see £1000 [written] than it is to see a wodge of money and infer that it is £1000
Respondent 4: yeah
Interviewer: Would you want to do something again?
Respondent 4: mm [affirmative sound]
Interviewer: why?
Respondent 4: because, like, when you're doing normal maths, I get kind of bored
Interviewer: [laughs] no no carry on
Respondent 4: sorry…and then with this, it was quite fun
Interviewer: what made it fun? What was the funniest bit?
Respondent 4: just the way you were making it, not, like, counting and stuff …
Interviewer: ok, you could pull in different elements?
Respondent 4: [affirmative nods]
Interviewer: what was the most challenging part?
Respondent 4: probably, the research
Interviewer: why
Respondent 4: because there were so many numbers on the internet, and I like, wanted to half it but I couldn't, even though it sounded really easy, it had some really hard bits
Interviewer: so it was difficult to digest all that information that you had?
Respondent 4: yeah
Interviewer: why did you think bringing in your own laptop helps?
Respondent 4: yeah
Interviewer: did you think it was easier?
Respondent 4: yeah
Interviewer: how come?
Respondent 4: because I wasn't really, like, up to date with it, and then I didn't have to stay after school or at lunchtime to finish it
Interviewer: cos you could take it home?
Respondent 4: yeah
Interviewer: do you think if the school had like a dropbox, you know where you can drag and drop files, do you think you would have brought in your laptop then?
Respondent 4: mmm [thinking] probably not
Interviewer: so if there was an easier way of doing it in school, you wouldn't have brought in your laptop
Respondent 4: no

Appendix 9: REB Approval 10-024

UOIT
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RESEARCH ETHICS BOARD
OFFICE OF RESEARCH SERVICES

Date: October 15th, 2010

To: Sarah Tolley (Student PI), Janette Hughes (Supervisor), Jim Greenlaw (Supervisor)

From: Raymond Cox, REB Chair

File #: 10-024

Title: New Numeracies: the Social Practice of Functional Skills & Social Justice

The University of Ontario Institute of Technology Research Ethics Board has reviewed the above research proposal. The application in support of the above research project has been reviewed by the Research Ethics Board to ensure compliance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS) and the UOIT Research Ethics Policy and Procedures.

DECISION: Approved

COMMENTS AND CONDITIONS:

This project has been approved for the period of **October 15th, 2010 until October 15th, 2011 and is** subject to full REB ratification at the Research Ethics Board's next scheduled meeting. The approval may be extended upon request.

Please note that the Research Ethics Board (REB) requires that you adhere to the protocol as last reviewed and approved by the REB. The Board must approve any modifications before they can be implemented. If you wish to modify your research project, please contact REB Administration, to obtain the Change Request Form.

Adverse or unexpected events must be reported to the REB as soon as possible with an indication of how these events affect, in the view of the Principal Investigator, the safety of the participants and the continuation of the protocol.

If research participants are in the care of a health facility, a school, community organization or other institution it is the responsibility of the Principal Investigator to ensure that the ethical guidelines and approvals of those facilities or institutions are obtained and filed with the REB prior to the initiation of any research protocols.

Section F, Article 1.13, Review Procedures for Ongoing Research of the TCPS http://www.pre.ethics.gc.ca/english/policystatement/policystatement.cfm requires that ongoing research be monitored. A Final Report is required for all projects, with the exception of undergraduate projects, upon completion of the project. Researchers with projects lasting more than one year are required to submit a Renewal Request annually. Contact REB Administration to obtain a copy of the Renewal Request/Final Report form.

Please quote your REB file number on all future correspondence. Thank you.

REB Chair Dr. Raymond Cox, FBIT raymond.cox@uoit.ca	Ethics and Compliance Officer Sascha Tuuha, (905) 721-8668 ext. 3693 compliance@uoit.ca

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