A Study on the Effects of Integrating Web 2.0 Writing and Discussion Applications into Mathematics Instruction on Students' Reasoning Skills

دراسة حول تأثير دمج تطبيقات الويب 2.0 للكتابة والمناقشة في أساليب تدريس الرياضيات على مهارات التفكيرالمنطقي لدى الطلاب

By

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Abstract

Over the past couple of decades, integrating technology into mathematics class instruction has become a rich topic for research attempting to advance the effectiveness of mathematical education and encourage students to engage with their own learning processes. The purpose of this study was to explore the effects on students' reasoning skills of integrating Web 2.0 writing and discussion applications in mathematics classes by investigating the effect of such integration on students' motivation to learn mathematics, their attitudes toward writing in mathematics, and their achievement in mathematics.

A sequential mixed-methods approach was used to collect both quantitative and qualitative data via pretest and posttest surveys, student interviews, and students' end-of-term exam marks. Data analysis has revealed that Web 2.0 writing and discussion applications have a positive impact on students' needs for competence and autonomy and hence on their motivation to learn mathematics and their attitudes toward writing in mathematics class, which were found to be highly influenced by their perceptions of the advantages and disadvantages of the writing practice. Nevertheless, there was no significant effect on students' academic achievement. Finally, the study implies the need for teachers to differentiate instruction and provide meaningful feedback to effectively engage students with different learning styles and abilities.

ملخص

على مدى العقدين الماضيين، أصبح موضوع دمج التكنولوجيا في تدريس مادة الرياضيات موضوعاً غنياً للبحوث في إطار السعي لتعزيز فعالية أساليب تعليم الرياضيات وتحفيز الطلبة للمساهمة بدورفعال في عملية التعلم الخاصة بهم.

لتحقيق الهدف من الدراسة تم استخدام نهج الأساليب المتنوعة المتتابعة لجمع البيانات الكمية والنوعية اللازمة . و لاستنباط تأثير الدمج على الطلاب استخدمت الباحثة مجموعة من الأدوات و هي : استبيان ما قبل التجربة و ما بعدها ، المقابلات مع الطلاب ، بالإضافة لاعتماد علامات الطلاب في امتحاناتهم النهائية. وكشف تحليل البيانات عن أن دمج تطبيقات شبكة الإنترنت Web 2.0 للكتابة والمناقشة له تأثير إيجابي على حاجة الطلاب للشعور بالكفاءة والاستقلالية، وبالتالي على دوافعهم لتعلم مادة الرياضيات ، كما أن أن النتائج قد كشفت عن أن الأراء التي يكونها الطلاب حول كل من إيجابيات و سلبيات استخدام الكتابة في مادة الرياضيات له تأثير كبير و مباشر على موقفهم من تقبل هذا الأسلوب و الاستفادة منه . بالرغم من ذلك ، أظهرت النتائج انهم لم يكن هناك تأثير يذكر على الإنجازات الأكاديمية للطلبة. وأخيرا تحث نتائج هذه الدراسة على أهمية أن يعمل المعلمون على تنويع استخدام أساليب التعلم في مادة الرياضيات و من ضمنها تفعيل دور الكتابة و المناقشة المكتوبة مع مراعاة الفروق الفردية و التفاوت في القدرات و أنماط التعلم التي تختلف من طالب لآخر للحصول على أفضل النتائج لدى تطبيق تلك الأساليب

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Chapter One: Introduction

Educators of the twenty-first century strive to equip students with skills to succeed in a rapidly transforming world highly reliant on technology (Lee & Ge 2010). Over and above their typical responsibilities, teachers are challenged to implement contemporary techniques integrating technologies, and the conventional practice of displaying a lesson or activity onscreen in the classroom no longer suffices. Unless technology is used as an essential daily classroom tool to advance the learning process, the integration is considered incomplete (Cuhadar & Kuzu 2010).

The significant revolution in Web 2.0 tools and applications has undoubtedly facilitated their use in class like never before. Therefore, studies on the benefits and drawbacks of transforming classwork activities into computer tasks as well as teacher and student perceptions of this change dominate the field of education research (Malhiwsky 2010; Sistek-Chandler 2012). Learning is no longer restricted to the traditional forms of educational institutions; Internet cloud computing and related services have transformed it into a pervasive phenomenon that might happen anywhere at any time (Johnson, Adams & Cummins 2012). This has made people become cognisant of ways to employ knowledge and communication to enrich their learning experiences.

Recent studies in the education field have emphasised the many different ways Web 2.0 and social media can be used to enhance learning practices and positively influence both students and teachers (Heibergert & Loken 2011; Cain & Policastri 2011; Kelm 2011). Web 2.0 applications grant users the opportunity to communicate, access, broadcast, and collaboratively create in a safe and user-friendly setting (Bates 2011). The meaning of Web 2.0 as a collaborative interaction and communication tool in the classroom is grounded in Vygotsky's social learning theory (1978), through which he elucidated the significant role of social interaction and language in cognitive development and meaning making.

According to Ollis (2011), Web 2.0 applications are excellent tools to fulfil the academic and emotional requirements and obligations of learners in the twenty-first century and can provide a complete experience of learning within a group and via social interaction. Thongmak (2013) has affirmed that Web 2.0 has created innovative forms of social interaction that prove the positive impact of collaboration and gradually enhance students' learning outcomes, enrich their shared retention of knowledge, and develop their analytical and reasoning skills.

Web 2.0 technologies can provide an extensive range of possibilities to teachers establishing a collaborative mathematics class. The worldwide practice of reforming mathematics instruction has emanated from findings regarding college students and others entering the job market, who, according to recent studies, lack the competency to analyse situations despite their sometimes ample knowledge of a subject (Carbonneau, Marley & Selig 2013).

Since the adoption of electronic devices in schools, mathematicians have worked on developing technological solutions to close the gaps between research and findings in constructivist approaches to learning (Aqel 2011). First among targeted research areas is the incorporation of writing activities across different curriculum subjects, including mathematics (Hendry et al. 2011). The ability to verbalise maths problems is as crucial as the mastery of procedural calculations, allowing students to not only solve word problems but also conveniently articulate their thoughts and expand their comprehension of topics and therefore take part in higher cognitive tasks and discussions (Morris 2006; Millard, Oaks & Sanders 2002; Steen 2007).

The National Council of Teachers of Mathematics (NCTM) has published *Principles and Standards for School Mathematics* (2000), which points out that technology is one of the six main six principles of mathematics and emphasises its potential to provide a broad range of alternative solutions and approaches. Bates (2011) has also stated the importance of creating opportunities for alternative solutions, offering that teachers should motivate their students to look for unconventional ways to solve problems rather than simply following instructions. Mason and Rennie (2010) and Zgheib and Dabbagh (2012) have also stated that teachers must encourage students to discuss collaboratively and analyse alternative solutions to decide whether to accept or reject them. This research is designed to investigate the capability of Web 2.0 communication applications to stimulate learners' reasoning and develop their problem-solving skills by providing opportunities for constructive writing and professional dialogue (Bicer, Capraro & Capraro 2013; Johnston 2012; Cooper 2012; NCTM 2000).

1.1 Background

Recent studies indicate that students lack the capability to comprehend written text in mathematics and therefore struggle when solving word problems (Bicer, Capraro & Capraro 2013; Long 2012). Adams (2003) has suggested that even students who master advanced maths skills sometimes fail to analyse simple word problems because they cannot translate written text into equations and mathematical symbols. Bicer, Capraro, and Capraro (2013) have concluded that above all, a majority of students are incapable of articulating their ideas and concerns.

Jitendra et al. (2007) have argued that students consistently struggle to attain basic competence in solving word problems as a result of undeveloped reading skills. In fact, students' confusion and uncertainty with text in mathematics questions addresses a much more extensive problem, that is, insufficiency in maths communication. The NCTM (2000) has defined communication as the practice of transforming ideas into objects of reflection, debate, and improvement by conveying information and formulating thoughts into words. Stimulating students to communicate their thoughts using language enhances their interpreting and reasoning skills and develops their eloquence and precision. Mathematical dialogue involves mathematical arguments, clarification, and rationale, and it is not an absolute recital of technical steps (NCTM 2000). Furthermore, studies have shown that listening to peers express their thoughts and justify their conclusions encourages students to formulate their judgments and cultivates their abilities to put ideas into words.

The National Center for Education Statistics (NCES) (2011) has asserted that reading and mathematics are the foundations of success in education. Griffin and Jitendra (2008) have recommended focusing on teaching children to reason and make links by training them to write what they think, since this encourages them to efficiently interpret word problems. Mathematics communication must be practised effectively; it should be an instrument to transfer knowledge and reinforce understanding. Research studies have shown that collaborative work, journal writing, and class discussions are recommended practices that promote students' abilities to sharpen their thinking and develop a profound perception of their learning (Bunnett 2007).

The past twenty years have witnessed a shift towards implementing more journal writing in maths classes. In addition to plenty of studies that investigate the real effects of this practice (Johnston 2012; Pugalee 2004), some have reported that the main benefit of writing is that it can update teachers on their students' learning progress (Borasi & Rose 1989; McIntosh & Draper 2001). Other educators have brought up a deeper influence of writing: Brandenburg (2002), Baxter, Woodward, and Olson (2005), and Gibson and Thomas (2005) have agreed that it is an effective means of developing learning attitudes and is the preferable form of communication among students with limited abilities.

Nevertheless, some studies have revealed that the integration of writing is inefficient unless combined with collaborative discussion (Griffin & Jitendra 2008). Bunnett (2007) believes that active dialogue supports the development of a deeper understanding of concepts and increases students' competency as problem solvers. Some researchers believe there is a demand for further practical studies to explore best practices in implementing written communication in maths classes in a manner that students may accept (Bicer, Capraro & Capraro 2013; Speer, Smith & Horvath 2010). A small group of these studies suggest introducing writing through technology and, in particular, with the assistance of social technology and Web 2.0 applications (Murphy & Lebans 2008).

Cooper (2012) has argued that students find it uncomfortable to suddenly speak and write their process; hence, they must learn to enjoy writing as well as cultivate the confidence to share their thoughts. Most researchers in this field have highlighted the dilemma of students who avoid writing in maths class because they feel they do not need an extra bothersome task. Cuhadar and Kuzu (2010) have suggested introducing Web 2.0 technology to fill this gap. Integrating Web 2.0 applications such as forums, blogs, and chat utilities in class dialogue may reinforce the building of effective oral and written communication (Bicer, Capraro & Capraro 2013; Greenhow et al. 2009) and help students conceive of a modern viewpoint towards writing in math.

1.2 The Rationale for the Study

With the great emphasis on widening the scope of students' intellectual development, and in the wake of the NCTM's (2000) recommendation that maths dialogue should be grounded in collaborative, reflection-based tasks, it is reasonable to turn to reading and writing activities to establish a new direction in maths education. It is through writing activities that learners gain the space to elaborate their understanding of maths problems and engage in other forms of discourse that build a foundation for translating language into numbers and formulas.

In the current literature discussing both journal writing and the integration of Web 2.0 applications in mathematics teaching and learning, some have argued that incorporating journal writing in mathematics education might boost students' enthusiasm for mathematical investigation (Sanders 2009; Borasi & Rose 1989; Powell & Ramnauth 1992). Cuhadar and Kuzu (2010) and Light and Polin (2010) have affirmed that the diversity of Web 2.0 writing applications along with the opportunity to spontaneously express ideas stimulates students' reasoning. Graham and

Hodgson (2008) have reported that these applications encourage a deeper understanding of mathematical concepts; above all, the modern approach of sharing experiences has shown a positive effect on the language abilities of non-native speakers.

Not many studies have touched on the topic of incorporating writing within Web 2.0 applications. Zemelman et al. (2005) have argued that instant peer feedback can be the best incentive for students to keep participating, and Cooper (2012) has reported that the multiplicity of Web 2.0 applications provides a resourceful discussion environment that encourages shy students to formulate their opinions and perspectives. However, based on the reviewed literature, I have concluded that while there is abundant research on each utility separately, experimental studies covering the effects of their integration on students' achievements and motivation towards learning maths are insufficient.

The majority of the aforementioned research on the topic of writing in mathematics has agreed that implementing writing activities in mathematics instruction consolidates students' understanding of maths concepts. Still, this is rarely used as an instructional technique, a situation studies blame on multiple factors (Brendefur & Frykholm 2000; Johanston 2012). I aim to support students' skill development and analyse their understanding of mathematics by setting up a new model through which they can express their thoughts, reinforced by instantaneous peer and teacher feedback via virtual class communication.

1.3 Purpose and Questions of the Study

The aim of this study is to explore the effects of integrating Web 2.0 writing and discussion applications into mathematics instruction on students' reasoning skills. By targeting middle school students and by implementing consistent web-based writing activities in maths classes, this study aims to investigate the effects of integrating Web 2.0 writing and discussion activities in maths class on the following:

1. Students' psychological needs for competence and autonomy
2. Students' attitudes towards writing in mathematics
3. Students' academic achievements in mathematics

Adopting new techniques in the classroom is usually perceived to result in many positive outcomes. In fact, different scenarios can be anticipated. Firstly, students may enjoy the intervention and find it beneficial and may therefore improve academically. Secondly, students may enjoy the intervention but make no remarkable progress. Thirdly, students may find the intervention useless, perplexing, and overwhelming. Lastly, students may have different responses to the intervention based on their learning styles and their attitudes towards the subject. Based on my experience, most students hold the traditional point of view that we compute in maths and write in English, but never both in any of them (Davidson & Pearce 1988, p. 42). Moreover, students have no idea how writing could possibly be helpful in mathematics. The fact that students have never had to write in a maths exam makes them see this approach as an exhausting, time-consuming, and useless task. They believe their time is better spent practising the maths they know.

Students usually understand maths as sequences of numbers and formulas. The majority memorise the solution steps unintentionally just because they believe maths is an abstract subject, and these numbers and formulas have no other meanings. Subsequently, they fail to apply their maths skills in the real world and when solving word problems. The absence of the use of dialogue in maths class as well as the lack of interest in its use among students creates a barrier between students and the ability to understand written maths problems. Studies have found that confusion in terminology is a dominant obstacle to students' comprehension of various procedures (Zgheib & Dabbagh 2012).

1.4 Significance of Research

The concepts behind integrating writing and technology into mathematics classes are vital areas of educational research from different perspectives. Shield and Galbraith (1998) have stated that not enough explanatory studies have touched on the topic of which functional forms of writing may add to mathematics learning. Moreover, even considering the evident advantages of the two approaches, research on combining them has been minimal (Pearson 2010; Cuhadar & Kuzu 2010; Cooper 2012). My study concentrates on two main axes: students' conception of implementing writing tasks associated with technology in learning mathematics and the influence of this practice on their academic achievements.

The intervention designed for this research study was based on the need to identify instructional techniques that enhance middle school students' understanding of written mathematical problems and develop their reasoning skills. The study's objective is to investigate the possibility of implementing more writing and discussion activities in mathematics classes by means of Web 2.0 technologies and to evaluate the actual effects and quality of the outcome of this approach. Hossain and Wiest (2011) have asserted that the type of writing students carry out and their perceptible interactions are what determine the overall effects of this pedagogical approach. Heller et al. (2005) have insisted that developing a classroom practice is inconsequential until it is sustained by obvious evidence of students' engagement and a tangible transformation in students' performance. Zgheib and Dabbagh (2012) have stressed the importance of involving students in written discussion and debates in maths classes to help deepen their awareness of their own understanding, support organizing their thoughts, and stimulate their abilities for exploring new techniques.

1.5 Structure of Dissertation

This chapter has provided a synopsis of the background of the problem and has outlined the subject, rationale, purpose, and research questions of the study as well as its significance and the anticipated hypotheses. Chapter Two explores relevant literature and theoretical frameworks, scrutinising the evolution of classroom communication and its importance in developing better mathematical reasoning skills. It also discusses the role technology plays in revamping students' involvement in learning mathematics and provides an overview of proposed scenarios and expectations when blending pedagogies.

The methodology is explained comprehensively in Chapter Three, which explores the study context and setting and describes the data collection instruments and study procedure, the data analysis process, the validity and reliability of data, and any relevant ethical considerations. Chapter Four lays out the data analysis and results as well as an evaluation of the main findings and their connections to the reviewed literature. Chapter Five examines the study conclusions, recommendations, and implications in addition to impediments towards attaining the anticipated results.

Chapter Two: Literature Review and Theoretical Framework

This chapter presents a review of literature associated with the effects of integrating writing activities supported by Web 2.0 technology on students' achievements in mathematics classes. This chapter also embraces the theoretical framework of establishing written reasoning and reflection tasks in mathematics education reinforced by social networks, discussion boards, and electronic journals. Quite a few themes emerge from the reviewed literature relevant to the study and in support of the study's purpose and intervention. The literature presents the history and development of the use of both writing and technology in mathematics classrooms, the definition of mathematical communication, the association between constructive learning and class interaction, and the role of writing in learning mathematics and enhancing problem-solving skills. This chapter also introduces the concept of Web 2.0 technology in education, proposes Web 2.0 technologies that can be used in the classroom, and examines communities of practice and quality engagement using Web 2.0 technology.

2.1 Theoretical Framework

To develop a theoretical framework for understanding the effectiveness of integrating writing activities in mathematics instruction using Web 2.0 as a means of communication towards a common goal, I have drawn on three learning theories: the social constructivist learning theory, the communities of practice theory, and the self-determination theory.

2.1.1 Social Constructivist Learning Theory

The majority of collaborative learning theories are based on Vygotsky's theory of social constructivism, which considers society the source of human intelligence and describes learning as a social process generated by individuals and knowledge as an inevitable consequence of social interaction. Hence, individuals obtain knowledge when joining knowledge communities (Vygotsky 1978). Vygotsky has agreed with the theories of most of the early constructivists, like Piaget, and their assumptions regarding learning mechanisms, but he has further recognised the fundamental roles of social context and language on the cognitive development of children.

Vygotsky believes that learning occurs in two stages: the first is the acquisition of knowledge as a result of interaction with a community, and the second is the mental processing and accommodation of this knowledge. One imperative dimension of Vygotsky's theorem is the zone of proximal development (ZPD), which he developed as an extension of Piaget's theory of cognitive development, which defined children as 'lone scientists' and asserted that children possess all the required learning mechanisms and need no adult guidance. Vygotsky's ZPD is the 'distance between the actual developmental level as determined by independent problem-solving and the level of potential development as determined through problem-solving under adult guidance or in collaboration with more capable peers' (Vygotsky 1978, p. 86).

Vygotsky views collaborative learning as one very effective way of improving skills and developing cognition, where less capable students benefit from more competent peers within the ZPD. Hence, the ZPD expresses a level of assignments in which learners need support and scaffolding from a more knowledgeable person to achieve and master a subject. The expressions 'ZPD' and 'scaffolding' are now used interchangeably in the literature despite the fact that Vygotsky has never used them so. Rather, Wood et al. (1976) were the firsts to adopt these terms in education. The zone is the range in which students are ready to acquire knowledge with the assistance of social interaction and collaboration, and scaffolding is the approach to developing this intellectual knowledge (Gunawardena et al. 2009).

Vygotsky's theory of the ZPD is a convenient foundation to establish an online collaborative learning setting in which the teacher assists and all class members contribute. The outcomes of online collaboration are not only the direct outputs of applications but mostly the skills students learn from taking responsibility for their learning (Buzzetto-More 2010; Koohang, Riley & Smith 2009).

2.1.2 Self-determination Theory

Self-determination theory (SDT) represents an extensive framework for the study of internal and external forces driving human motivation. SDT originated with Edward L. Deci and Richard M. Ryan, then underwent several ameliorations by many scholars worldwide. SDT focuses on the social conditions that promote self-determined actions and the consequences of inner resources in developing different types of motivation, each type conveyed by its particular regulatory style (Visser 2010; Johanston 2012).

Ryan and Deci (2000) have organised the main four types of motivation along a continuum according to each type's level of self-regulation and have used the term 'internalisation' to describe the process of moving from one type of motivation to another within the continuum (Deci et al.

1991). The internalisation process is not necessarily linear and has been found to be beneficial to students' intellectual development and practical progression (Deci et al. 1991; Ryan & Deci 2000). It can be developed and enhanced along with students' social and personal development (Reeve & Jang 2006), persistence, and creativity (Hahn & Oishi 2006) with the aid of three psychological needs; these are competence, autonomy, and relatedness, three qualities that accompany the self-determination theory (Ryan & Deci 2000).

Competence is an indicator of an individual's confidence in his or her capability to accomplish a duty, and autonomy is an indicator of confidence in one's capability to make an appropriate choice independently (Ryan & Deci 2000; Johanston 2012). A large body of literature has supported the role of psychology in promoting intrinsic motivation (Hahn & Oishi 2006; Ryan & Deci 2000; Reeve & Sickenius 1994; Deci et al. 1991; Reeve 2005; Reeve & Jang 2006; Visser 2010; Johanston 2012). SDT suggests that dissatisfaction with any of these psychological elements within a community will cause an undesired reaction in the learning environment and in learners' inner enthusiasm and tendencies to move towards self-regulated motivation (Hahn & Oishi 2006).

2.2 Mathematics Communication

Communication is a fundamental component of the learning process, especially in mathematics. The NCTM's communication standards, issued in 1989, 1991, 1995, and 2000, have highlighted the significance of mathematical fluency in communication. Hiebert et al. (1998) have described mathematical communication as the ability to clearly and reasonably express mathematical ideas verbally or in writing along with the capacity to contribute to the discussion by sharing ideas and listening to and evaluating others' ideas. Hiebert et al. (1998) have also stressed that this fluency in communication stimulates learners' capability to gain insight into their knowledge and their peers' knowledge and formulate concepts and ideas. Pugalee (2004) has found in his exploratory study on ninth grade students that writing out problem-solving approaches has a positive effect in cultivating young learners' metacognitive structures.

This part of the literature review focuses on writing and discussion as effective types of class communication to enhance students' abilities to explain and comprehend their thoughts and doubts. Bicer, Capraro, and Capraro (2013) have described mathematical communication as the act of consolidating a variety of cognitive and social activities to boost critical thinking and logical reasoning. Steele (2001) has referred to the association of writing and discussion in mathematics as the employment of a sociocultural classroom environment with the intention of formulating mathematical structure based on cognitive reasoning.

2.3 Constructivist Learning and Interaction

The classroom environment is influential in education as an imperative context in which actual learning takes place based on productive interactions between students and instructors (Beavers et al. 2015). The social constructivist learning theory suggests that individuals generate knowledge using their cognitive development through social interaction, relating prior knowledge to new experiences. Constructivism refers to the learning process and focuses on students as active participants with teachers and other students (Buzzetto-More 2010; Beavers et al. 2015). Vygotsky claims that social constructivism and individual cognition occur in social contexts where more knowledgeable peers and adults structure information and transfer this information via language (Cuhadar & Kuzu 2010).

Social constructivism affirms the significance of social contexts and the collaborative quality of knowledge acquisition and defines learning as integrating individual knowledge with experiences and interaction outcomes, in contrast with the individual adaptation of knowledge in cognitive constructivism (Buzzetto-More 2010). In social constructivism, intellectual functions of differing levels of difficulty are related to the social development of individuals and to cooperation with knowledgeable peers or adults (Cuhadar & Kuzu 2010).

Vygotsky (1978) has proposed that scaffolding occurs in the social context when learners acquire assistance from instructors, adults, or more experienced peers. Storch (2007) has suggested that the move from the student-centred classroom is an evident trend in today’s world. In constructivist education, the teacher is a facilitator who performs planning and provides support for students. Pedagogical instruction is now more transactional, where students accept more responsibility for their learning, such as assimilating and accommodating learned knowledge and developing the necessary language to achieve this (Beavers et al. 2015; Kenney, Shoffner & Norris 2014).

2.4 Writing for Learning and for Problem Solving

Principles and Standards for School Mathematics (NCTM 2000) has suggested reinforcing written and verbal mathematical dialogue as teachers' responsibilities shift from traditional to constructivist practices. Starting in the 1970s, researchers called for the incorporation of writing in mathematics curricula and investigated the benefits of this approach (Emig 1977). In 1992, Countryman released the revolutionary publication *Writing to Learn Mathematics*, which was considered one of the most influential in providing a comprehensive description of several approaches for integrating writing into mathematics (Kenney, Shoffner & Norris 2014; Beavers et al. 2015). Countryman (1992) suggested that writing helps students develop their sense of reasoning, analyse their abilities and qualities, find gaps in their understanding, realise misconceptions, and reflect critically on their learning (Wilson & Clarke 2004).

Students are expected to give comprehensive and coherent explanations while analysing maths problems. However, many students can achieve correct answers in maths but lack the ability to justify their methods. According to Beavers et al. (2015), having students translate their mathematical comprehension into writing develops their literacy, provides insights into their understandings, and stimulates their metacognition to meet higher-order thinking questions and tasks, like evaluation and creation (Beer, Capraro & Capraro 2013).

Studies about this approach have found many benefits aside from improving reasoning skills. Kenney, Shoffner, and Norris (2014) have described writing as a reproductive expressive procedure that encourages students to develop knowledge and abilities, directs them to distinguish what they know, and motivates them to explore what they don't. Adams (2010) has noted that not only is students' cognition in mathematics positively affected by writing activities, so are their communication skills, capability to reflect on both work and abilities, and motivation for teamwork (Capraro, Capraro & Rupley 2011). This section covers the two primary types of writing activities used to perform this study.

2.4.1 Mathematical Journals

Educators have exploited several approaches to motivate students to use writing in mathematics. Journals seem to dominate that field of research. Kostos and Shin (2010) have suggested that pedagogic research does not provide a clear definition for 'journal writing'. Instead, mathematicians customarily define it according to the nature of its practice and intended outcome.

Johnston (2012) believes different definitions agree that journal writing involves a personalised, informative, and purposive document that educates students by encouraging them to think critically and analytically about their work in progress.

Journal writing is an opportunity for students to present and organise acquired knowledge in their very own ways. It is an exceptional method to reflect on learning with summaries, questions, comments, and feedback (Kostos & Shin 2010). Students should be given the opportunity to observe and reflect on communication skills and participate in active learning situations (Leonard 2008). According to Carter (2009), students should be explicit with mathematical discourse and be able to interpret other people's mathematical logic, and the use of maths journaling is an efficient way to meet both demands. Johnston (2012) and Craig (2011) have asserted that students do not currently write within mathematics instruction to document their learning procedures from their perspectives, supported by their doubts and certainties, and that the literary quality of this writing should not affect the quality of the content.

A large body of literature has supported the use of journaling in mathematics as an efficient technique to enhance students' reasoning and critical thinking skills. Research in this field has mostly based this instructional approach on the constructivist theory of learning and has focused on its connection to Vygotsky's sociocultural learning theory (1978). Vygotsky's theories strongly emphasise the significance of social interaction, language, and scaffolding in the development of cognition and linking prior knowledge to acquired knowledge. Vygotsky (1986) has described language as a tangible form of thinking, the means by which one can make meaning (Beavers et al. 2015; Kenney, Shoffner & Norris 2014).

Nowadays, mathematics educators recognise the importance of showing solution steps and strategies, as students are expected to be able to justify their answers and explain their reasoning. Leonard (2008) has mentioned that maths journals help students explain their thoughts to the teacher adequately and, more importantly, make sense of those thoughts. Cooper (2012) has indicated that teachers can encourage students to be more persuasive when explaining their understanding and more precise when evaluating their learning through journaling in mathematics.

2.4.2 Mathematics Technology

New technologies have been implemented in maths classrooms since the arrival of Web 2.0. Early computer-assisted instruction showed the many advantages of different software but also highlighted a lack of human interaction. New technology has opened many doors for classroom inclusion, as applications like chat rooms, forums, and blogs can easily be used to implement writing activities, since they match young learners' technological interests and do not require formal writing (Cooper 2012).

Writing in maths using technology involves deep understanding and requires no immediate response. Rather, students depend on their communication and writing skills to gain insights into their learning, whereas teachers are responsible for creating tasks that ensure student engagement. Sunstein et al. (2012) have conducted a study to investigate the effects of writing in mathematics on 86 high school students from two different schools in two completely different areas and cultural environments. The project was based on having students collaborate to solve mathematical problems via email. The two groups of students were supposed to only exchange their mathematical knowledge and information, but after a short while, they started to share their life experiences and varied lifestyles, connecting those elements to the mathematical topics at hand. Sunstein et al. (2012) concluded that their students gained more benefits from technology than planned or anticipated, as aside from enriching their mathematical information, students got the chance to cultivate and develop communication and language skills.

Morris (2006) has stated that for many years, students solved mathematical problems without a true understanding of their processes or reasoning, and while that was sometimes acceptable, the idea behind letting students clarify their procedures or thoughts is to help them tackle higher-level thinking tasks and questions. This can easily be connected with the aid of technological media because of students' familiarities with these applications. Writing to peer audiences and expecting feedback and interaction inspire students to elucidate concepts, develop their awareness, and simplify ideas within an authentic context (Chen et al. 2013).

2.5 Web 2.0 Technologies in Education

Education has witnessed a significant transformation in the past several decades, from accentuating the duties of teachers to pointing out the crucial role of learning. Recent studies have shifted towards facilitating instruments and approaches by which students have more control of their own learning processes (Zakaria 2013). Discussion of the efficient use of Web 2.0 applications to raise students' engagement in their learning has comprised a large share of these studies. Brown and Adler (2008) have stated that the power of Web 2.0 tools lies in their capability to boost the efficiency of class discussion by providing suitable collaboration platforms.

Additionally, the massive amount of research studies on the topic of Web 2.0 has led to the recognition of an explicit and inclusive definition of ‘Web 2.0’ itself (Fuchs 2010). According to Zakaria (2013), Web 2.0 technologies might have different definitions depending on context. However, all definitions agree unanimously that Web 2.0 applications are characterised by their power to provide effective collaboration mediums and reinforce the involvement of users, unlike earlier forms of technology, wherein users were mostly passive receptors. Tim O’Reilly (2005) initially created the term ‘Web 2.0’ and used it to describe the change in the information technology world that brought the Internet to users as a platform for creation and personalisation by means of accessible publishing tools. Web 2.0 technologies comprise any Internet tools and features that allow the user to be a social producer. O’Reilly (2005) believes that Web 2.0 applications gained popularity as their active users’ imitated social interactions from offline.

Web 2.0 technology offers various intriguing ways to implement more effective collaborative learning. Clark et al. (2009) have claimed that the use of Web 2.0 tools in the classroom not only promotes constructive learning but also widens the scope of traditional teaching and learning approaches and fills gaps between theories and practice. Rethlefsen, Piorun, and Prince (2009) have found that knowledge exchange within classroom discourse works more effectively with the use of Web 2.0 technology. While Mason and Rennie (2007) have stated that the appropriate use of different Web 2.0 tools consolidates group work conception and cultivates students’ collaboration abilities, they have also noted that shared working spaces and group communication excite young people and therefore should motivate them to learn.

With the rapid growth of Web 2.0 tools and applications, the expectations of schools and college graduates experienced with the use of this technology, some of whom have even improved it, have increased as well. Albion (2008) and Hazari and North (2009) have stated that students are expected to master technological skills while studying other subjects as long as the use of technology forms an essential part of their learning routine. Early use of Web 2.0 technology in education focused on using each tool for the explicit purpose it was designed for: presentation, reading, or writing. In no time, educators started to call for the direct use of this technology to enhance students’ motivation and engagement. Kemker, Barron, and Harmes (2007) have found that students’ motivation to solve problems considerably increases when they use technology in reading, writing, and data analysis. Similarly, Jakubowicz (2011) has shown that the use of Web

2.0 technology comes first among teachers' options to raise students' motivation for reading and writing.

In this context, Web 2.0 technologies also function to enhance many essential skills for a productive and motivated classroom. For instance, Web 2.0 can help teachers differentiate their instruction in class and afford equal learning opportunities to students with different learning styles (Jakubowicz 2011). It also encourages students' interest in topics and enhances cognitive thinking and problem solving, along with communication and contextual learning abilities (Barlow 2008; Greenhow, Robelia & Huges 2009; Gooding 2008).

2.6 Web 2.0 Technology in the Classroom

Web 2.0 technology can be applied in the classroom in various ways and forms, three of which are addressed for the purposes of this study.

Electronic Journals

Electronic journals allow for the documentation of personal viewpoints and reflection on certain topics. They can be an open space for learners to add input or a private forum for expression of thoughts to be seen only by the instructor (Jakubowicz 2011). Some students hesitate to speak their minds in front of the class and find writing safer, and journals give them enough time to formulate their opinions to avoid embarrassment. As such, electronic journals are a way for students who can't respond spontaneously in the classroom to take part in the class community and collaborative problem-solving teams.

Discussion Boards

Discussions boards are virtual spaces where many learners can contribute to the same online conversation. Online classrooms influence learning processes positively when managed and directed in a way that allows all participants to take place. Xia, Fielder, and Siragusa (2013) believe that discussion boards are the best ways to build productive communities of practice because of their ability to promote peer interaction and enrich collaborative learning. Employing discussion boards in instruction can provide the scaffolding needed to enhance active learning. Miyazoe and Anderson (2010) have argued that discussion boards reinforce the building of a constructive learning environment through cooperative knowledge and the immediate feedback students most often receive from their teachers and peers.

According to Khoshneshin (2011), class online social interaction under teacher supervision encourages productive teamwork and collaborative problem solving and grants students the chance to be in charge of their learning by building their conceptual understanding through debates and reflection. Xia, Fielder, and Siragusa (2013) have found that continued participation on class discussion boards has an evident positive effect on teamwork quality and students' final grades.

Social Networking

Buzzetto-More (2012) has defined social networks as computer-assisted communities that facilitate complex connections between users through applications that enable communication, presentation, storage, and interaction. Chen and Bryer (2012) have addressed the use of social networking as a pedagogical element of Vygotsky's social constructivism theory (1978), as Vygotsky built his theory on the belief that learning is a social activity and that effective learning happens through engagement in a collaborative problem-solving environment organised by the teacher.

The use of social networking as a platform for learning challenges teachers to create interesting concept-related tasks to stimulate students' desire to contribute and reflect on their learning practices. The use of social networks enriches learning by making it more student centred and accessible at all times and by providing a suitable environment for constructive, reflective, collaborative, informative, and personalised activities (Al-Kathiri 2014; Fogg et al. 2011; Zaidieh 2012). At the beginning of the e-learning revolution in education, many educators raised the lack of human interaction as a great obstacle towards supporting this innovation (Firpo & Ractham 2011). Social networks have resolved this issue and many others successfully and have also increased teachers' interest in e-learning, especially through closed and nonthreatening social networks (Zaidieh 2012).

2.7 Motivation in Mathematics

With the aim of establishing a link between the integration of Web 2.0 writing applications and students' motivation to learn mathematics, it is important to briefly define motivation. Wæge (2010) has defined it as the capability to control and direct actions, mentioning that this capability is regulated by demands and objectives. With their self-determination theory, Ryan and Deci (2000) have argued that humans are motivated by external and internal factors, and they have designated three essential psychological needs that may impact students' intrinsic motivation to learn: autonomy, competence, and social belonging or relatedness. The need for competence describes the desire to take on challenging tasks and execute them successfully to attain mastery, whereas the need for autonomy describes the desire to make decisions when carrying out a task and to experience freedom (Niemiec & Ryan 2009).

Wæge (2010) has stated that students' need for competence inspires them to solve challenging mathematical problems and feel accomplishment at their mastery of skills, while the need for autonomy is associated with a willingness to engage in several tasks while feeling free to make meaningful choices. Johnston (2012) believes teachers should attempt to prompt students' intrinsic motivation by providing challenging tasks, opportunities for decision making, and systems of rewards. Students' motivation to learn mathematics can be influenced by a constructive teaching approach, collaborative work, and student-centered teaching. Under supervision of the teacher, students can develop a sense of freedom and mastery (Wæge 2010; Niemiec & Ryan 2009; Kahn et al. 2013).

Self-determination theory describes motivation as a range starting with intrinsic motivation, moving toward extrinsic motivation, and ending with amotivation, which, according to Deci and Ryan (2000), is the absence of any interest in a task. Green-Demers et al. (2006) have suggested four main reasons for amotivation, these being low self-confidence, effort assumptions, a history of academic achievement, and the nature of the task undertaken. A wide range of studies in mathematics motivation have agreed that the consideration of diverse learning approaches, along with dynamic collaboration, teacher influence, and autonomy support, is a significant factor in motivating student learning (Maulana et al. 2011; Kim, Murayama et al. 2013; Kahn et al. 2013; Wæge 2009).

Chapter Three: Methodology

The aim of this study is to explore the effect on students' reasoning skills of integrating Web 2.0 writing and discussion applications into mathematics instruction. This chapter describes the methodology of the research. Creswell (2011) has claimed that the chapter on method is the most vital component of a research paper, as it gives insight into how a study has been accomplished and provides sufficient details for other researchers who wish to replicate or extend that study. This chapter describes the methodology employed to complete this study and demonstrates the research design, context, participants, and setting. It also provides an elaborate and precise characterization of the instruments used in addition to an explanation of the procedure and the framework of the implemented intervention.

3.1 Research Design

The main goal in conceiving of a research procedure is to guarantee the authenticity of results by collecting data that describes the study problem efficiently (Ary et al. 2010). Research design is the procedure for gathering data through a research study and then processing that data by analyzing, explicating, and reporting the results (Creswell 2013). Employing only one approach when collecting data does not provide sufficient information to develop several standpoints that give a better overall understanding of and comprehensive answers to the study questions. Therefore, the present study uses an explanatory sequential mixed method, or the two-phase model, developed by Creswell and Clark (2011). In this model, the researcher employs qualitative data to explain his or her initial quantitative results.

The intention of this study is to investigate whether integrating writing and discussion activities based on Web 2.0 in mathematics classes has a beneficial effect on students' autonomy, competence, and academic achievement in mathematics, along with their reasoning skills and their attitudes toward the subject. This study has made use of a sequential mixed methods design to determine whether engaging students through several discussion and writing Web 2.0 applications could have a significant effect on their reasoning skills in mathematics topics. Mixed method studies intentionally combine and integrate quantitative and qualitative approaches as research components, though the use of these approaches can occur at different points in the process (Caruth 2013; Creswell 2011; Ponce 2011).

A mixed methods approach is typically used when the researcher needs both types of data, quantitative and qualitative, to provide a better understanding of the research problem and to build on the strengths of both categories. Creswell (2011) has explained that even with the highly consistent and quantifiable data quantitative methods can provide, and the fact that this data can thus be generalized to a larger population, their inability to deliver reasons and explanations for the phenomena under study calls for the need to enrich and clarify outcomes using qualitative data. Combining the two methods offsets the weaknesses of one with the strengths of the other.

The instruments used were pre and post surveys, end-of-term exam marks, and general interview guides along with different forms of communication and writing Web 2.0 tools throughout the term. Creswell (2011) and Ponce (2011) have stated that explanatory sequential mixed designs are used when qualitative data is needed to elucidate the relevance and significance of results from the first quantitative phase and to explore more deeply the initial general picture resulting from that phase. In this study, students from three grade nine classes participated as a group. No randomization techniques were used to distribute the students; rather, students had been assigned to their classes by the school.

A survey was administrated first to collect quantitative data. Throughout the course, all participants engaged in different activities both in and out of class. The intervention was designed based on research adopted from Hossain and Wiest's (2011) blogging model and Powell and Ramnauth's (1992) "multiple-entry logs" model. Blogging and discussion activities using Web 2.0 instruments aim to help students investigate and interpret their understanding of a certain topic through others' ideas and justifications. According to Creswell (2012), pretest and posttest experiments measure the effect of an implemented intervention by determining the degree of resulting development. The strength of the pretest-posttest approach lies in its ability to account for multiple treatments and hence provide comparisons through the use of post tests to measure knowledge (Cohen et al. 2011).

The dependent variables were students' autonomy, competence, attitudes toward using Web 2.0 applications in mathematical writing, and academic achievement in mathematics, using end-of-term exam marks as pre and posttests. The independent variables were two interrelated forms of Web 2.0 writing schemes: a daily online class discussion and an electronic journal term project. End-of-term (EOT) exams were used to determine students' academic progress and achievement, and the reliability of these exams was tested using Cronbach’s alpha. Twenty student participants were interviewed by the end of the implementation phase using the general interview guide.

McNamara (2009) believes the general interview guide approach suits qualitative research best because it grants the researcher the chance to cover equivalent areas of information from each participant and to understand complex behaviors and responses. The conversational nature of the general interview guide allows the researcher to react to particular differences (Patton 2002), and Alvarez and Urla (2002) have claimed this is a very useful approach in studies seeking to gather information about people’s opinions on innovative running activities. This makes it the most appropriate approach for this study, which strives to capture the perspectives of young learners about implementing novel blogging and chatting activities in mathematics classes. The three student groups were taught by the same instructor, which sustained the validity of the procedure and ensured consistency of classroom conditions.

The mixed methods approach is suitable for the purpose of the current study as it provide the integration of the strengths of both approaches (Cresswell, 2008; Patton, 2002), which is needed to answer the research questions. No single type of data can provide the full picture leading to a better understanding of research problems than either approach alone.

Qualitative approach will be employed to provide an overall picture to the research problem while Quantitative data are required to plug the gaps and clarifies ambiguous results in the qualitative study which customarily emerge as an outcome of the complexity of human experience that makes controlling all the variables challenging somehow. On the other hand quantitative researches frequently generate inconsequential findings of little significance due to the restriction and the controlling of variables, hence quantitative researches fails to take account of people's unique ability to interpret their experiences (Cohen et al. 2011;Creswell 2011; Ponce (2011). The sequential mixed methods approach suits this study as well, allowing the researcher to prioritize quantitative data collection and analysis and determine when each kind of data is collected in two distinct stages. Sequential mixed data collection designs encompass collecting data in one phase to provide more data about results from the previous phases and widen the analysis and selection range or to generalize findings by verifying and boosting outcomes from distinct participants (Creswell & Plano Clark 2007). The first stage of this study entails collecting quantitative data to provide a general picture, followed by the second stage of gathering supporting qualitative data, which aims primarily to clarify the results from the first stage. This clarification reveals an insightful analysis of dominating patterns as well as extremes to develop themes and create comparisons (Creswell 2012).

3.2 Context

The study was conducted in a government-owned secondary school for students in grades eight through twelve in the United Arab Emirates (UAE). The selected school provides education to over six hundred students, all female, ranging in age from twelve to fourteen for grade eight students and thirteen to fifteen for grade nine students. The school is one of fourteen other campuses under the same educational institution, founded in 2005, while the school where this study took place was established in 2012. All campuses follow an American curriculum with core subjects in association with cluster programs to fulfill the requirements of a career-oriented technical education. The school district offers the core subjects in two levels, regular and advanced, and students are enrolled in either stream according to their abilities. Apart from Arabic and Islamic studies, all core and cluster subjects are taught in English.

The school environment is technologically rich, with well-equipped classes and laboratories deliberately designated for use by both students and teachers. In addition to iPads, students have easy access to the internet to enable them to make full use of Web 2.0 technologies. Student applicants must be Gulf Cooperation Council or UAE nationals and are subject to an entrance exam and two interviews, one in Arabic and the other in English. The majority of students have completed their previous education in public schools and have never studied mathematics in English before, while students who have transferred from private schools generally have a better background in learning different school disciplines in English.

This research study was conducted during the third term of the academic year 2014–2015, between April 2015 and July 2015. Students from three of the six grade nine classes in the school were involved in the study, one studying the advanced mathematics program and the other two studying regular mathematics. All instruction took place during students' regular mathematics classes on a schedule of eight lessons per week. Each lesson was 45 minutes and was taught by the same mathematics teacher for all participants from the three classes sampled to ensure students had similar experiences, teacher quality, and resources (Creswell 2012).

The core course topics included factoring polynomials, data analysis and probabilities, and similarity, whereas the advanced course addressed right triangles and trigonometry and three-dimensional figures and volume in addition to the aforementioned topics.

3.3 Participants

A total of 70 ninth grade female students participated in this study, 25 of whom were in the advanced program and 20 and 25 of whom were in the other two classes, respectively. No participants were screened out of the data analysis process, and none of the students in the three classes declined to participate in the study.

Table (3.1). Student participants

Class groups	***Total number of students***	***Students with experience studying math in English***		***Students with experience studying math in English***	
		Number	*Percentage*	*Number*	*Percentage*
Group 1	25	6	24%	19	76%
Group 2	20	4	20%	16	80%
Group 3	25	7	28%	18	72%
	70	17	24.3%	53	75.7%

3.4 Instruments and Materials

Student participants were taught mathematics using Houghton Mifflin Harcourt's *Holt McDougal Algebra 1* (2011) and *HMH Fuse: Algebra and Geometry* (2012), both approved by the board district. Instruction integrating technology is a fundamental component of each class and is every teacher's duty as per the school district's vision.

3.4.1 Pre and Post Surveys

A survey adapted from the work of Ryan and Deci (2000) was implemented to determine students' levels of competence and autonomy (Kosko 2010, 2011) and attitudes toward integrating writing into mathematics class (Johnston 2012). This survey contained 26 items categorized into three subdivisions: competence (eight items), autonomy (ten items), and attitude toward writing (eight items). Some items were reverse coded to maintain compatibility between subdivisions. The complete survey is provided in Appendix A.

Cronbach's alpha was used to calculate the reliability of subdivisions regarding internal consistency. Table (3.2) shows the Cronbach's alphas for both pre and post surveys for each subdivision. Competence Cronbach's alphas were all found to be above 0.90, which is considered excellent (Creswell 2012), and the Cronbach's alphas for both autonomy and attitude toward writing were all found to be between 0.80 and 0.90, which is considered good (Tavakol & Dennick 2011; Cohen et al. 2011).

Table (3.2). Cronbach's α for the Variables for Pre-Course and Post-Course

	Pre-test	***Post-Test***
Competence	0.92	0.91
Autonomy	0.82	0.83
Attitude toward writing	0.85	0.94

3.4.2 End-of-Term Exams

Course achievement was determined through students' end-of-term (EOT) exam grades. EOT exams are assessments based on criteria developed by the school district's assessment unit under the supervision of the curriculum development unit. All participants in the study completed the test on the same date and were given the same time limit (Creswell 2012). The exam comprised both constructed-response and multiple-choice questions. All questions related to the content discussed in the textbook chapters. The assessment was given in a pencil and paper format with an allotted timeframe of 90 minutes. Content validity was established by content experts (McGraw-Hill 2011). Upon students' completion of the assessment, a committee of mathematics teachers graded the tests and documented those grades in the district's electronic recordkeeping system. Grades then became accessible by students, parents, and administrators.

The EOT exam was a preferred benchmark of students' achievement in mathematics since it was a comprehensive unified final exam written by all grade nine students on all campuses throughout the school district. EOT testing is required and administered every term to all students to measure their academic progress in each subject.

3.4.3 Facilitation of Class Communication

Heller et al. (2005) have recommended using various channels to engage learners in mathematical communication activities by stimulating students' reasoning skills. A collaborative teaching-learning environment was built based on Hossain and Wiest's (2011) model, which is suitable for middle school mathematics classes since it has the potential to create a professional discussion medium under the supervision of the teacher, who initiates, organizes, and controls the activity. To form this collaborative environment, two Web 2.0 applications were used:

1. Edmodo is a microblogging platform exclusively devoted to educational use. Users can communicate within preassigned and approved groups, which gives the teacher full control over online interaction (Waters 2011). Edmodo has been used as a social networking systems platform for its remarkable ability to boost student participation and enhance the quality of classroom communication. Edmodo had been introduced to students earlier in the previous school term, and an Edmodo account had been created for each of the three classes. A group code had been given to the students to join those classes, and all potential features of Edmodo had been explained to students previously. The platform was used mainly as a safe communication environment in which to post announcements, share documents, and turn in assignments. During this course, Edmodo was used for the same purposes in addition to microblogging and creating short quizzes and polls to gain immediate anonymous feedback. The teacher also used it to post relevant links to direct class communication to other applications to work in or out of class, and students were able to use it to post questions out of class.
2. Padlet is an online virtual bulletin board that allows users to create discussions using a simple drag-and-drop system. An unlimited number of users can contribute to a Padlet wall. With a Padlet account controlled by the teacher, the teacher generates different walls for different tasks and discussion in the classroom. After the teacher creates a wall with the aim of discussing a task in class, he or she shares a link to that wall on the class Edmodo page, through which students can easily navigate to the wall and start participating. The teacher must approve all notes prior to publication on the wall. Padlet was used in this class for two purposes:

i. Creating KWL charts. In the middle of every lesson, after explaining some examples and solving an adequate number of exercises, the teacher created a KWL chart that students could contribute to by filling in each column: “What do you know?” “What do you want to know?” and “What did you learn?” Students had the choice to contribute anonymously to encourage shy students to take part.

ii. Class discussion. Two times a week, the teacher initiated a class discussion about one of the lesson's key ideas on a new Padlet board and posted the link to that board on the Edmodo class page. Class discussion took place during lesson time and under teacher supervision. A total of twenty discussion boards were created by the end of the term. Students worked in pairs to talk over the posted problems, and each group posted a final opinion. The fact that students were able to simply read one another's entries made it easier for them to articulate their thinking and formulate their opinions. Through this virtual discussion board, students are expected to discuss their inferences, explain their thoughts, and evaluate peers' assumptions and solutions. These activities play important roles in allowing students to develop their reasoning and analysis skills as well as enrich collaboration abilities. Figure (1) shows one sample of a Padlet board.

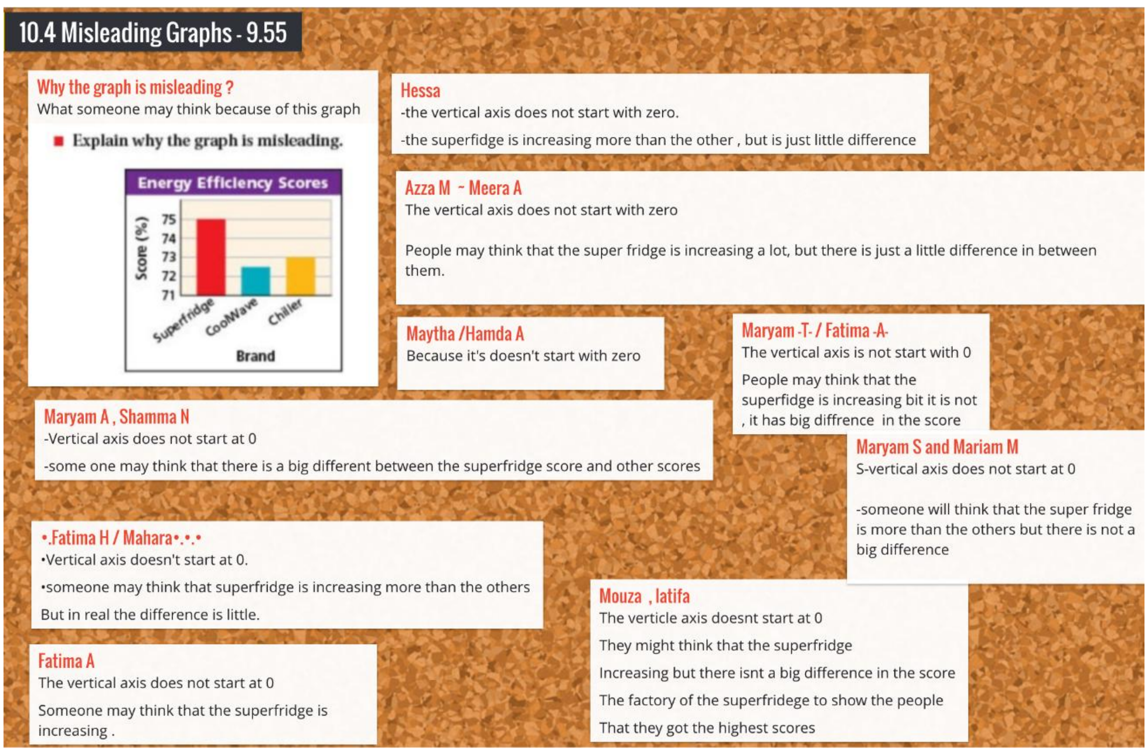

Figure (1). An example Padlet board

3.4.4 The Electronic Journal Project

During the third term, students completed weekly assignments as part of their journaling term projects. The project was described to students at the beginning of the term, and the outline description included the objectives, procedures, expectations, and format of the electronic journals. It also provided students the required prompts from which they would choose to write two reflections, a timeline, and an example journal entry. Students were introduced to the journaling procedure in class.

The journaling term project is based on the multiple-entry logs model designed by Powell and Ramnauth (1992). Students were requested to create electronic journals in any form of their choosing. To create each weekly entry, students selected two problems from the assigned weekly homework and provided step-by-step solutions and explanations for those problems using their vocabulary, if necessary, in addition to a short reflection on each problem based on the writing prompt suggested by the teacher in the journaling project outline. The teacher read these weekly entries.

The journaling project outline specified prompts for students to use when writing their reflections. The seven prompts were sorted into two categories, analytical and functional. Analytical prompts were meant to help students evaluate their understanding of concepts and focused on stimulating students' intellectual abilities and granting them space to think deeply about what they were learning. Functional prompts enabled students to contemplate their solving tactics, objectives, and expectations and directed students to formulate their perspectives about math. Students wrote two reflections for each problem, one from each group. The electronic journal project comprised four analytical and three functional prompts.

Group I: Analytical Writing Prompts

- Describe in detail the process you used to solve this problem. What steps did you take to solve it, and why did you choose those steps?
- Describe the idea of this problem. What are the theoretical ideas of this problem?
- Write a message to your teacher explaining what you do understand about this problem and what needs to be clarified.
- Find something that you did while solving this problem that was similar to something you already knew or learned in a different topic in math. Write about these similarities.

Group II: Functional Writing Prompts

- Summarize the solution of this problem. Why did you choose to solve it this way? What do you know exactly in this solution, and what are you not sure about?
- How successful do you feel you were in solving this problem? Why? Do you feel you would be successful in solving a similar problem? Why or why not?
- How did solving this problem make you feel about doing mathematics?

- Choose one problem that you got wrong the first time. What process did you use until you succeeded?

The full electronic journal project description and outline is provided in appendix B

3.4.5 Interviews

After the ten-week activity, twenty students were subjected to interviews. In general, interviews are a common and preferable method for identifying personal experiences, perceptions, and attitudes and collecting rich data to serve the qualitative perspective of a study (Creswell 2007). In-depth interviewing, also known as unstructured interviewing (Thorpe & Holt 2008), is a flexible strategy that grants researchers the opportunity to gather the data required to draw up an inclusive conception of the interviewee's standpoint. In this study, interviews were conducted using a general interview guide (Patton 2002). The general interview guide approach comprises both the capability to create an organized and inclusive interview as well as the flexibility to delve into a topic whenever the researcher perceives a need to further investigate important areas and issues brought up during the interview (Gall, Gall & Borg 2006).

In the general interview guide approach, the researcher outlines key topics and concerns in advance, but the order and phrasing of questions are typically subject to the flow and development of the interview (Cohen et al. 2011). This undeniably assists researchers in anticipating data gaps and ensures that the data obtained falls under the same information areas, but this method can still be problematic, as it may lead to significant variation in responses, making the data less likely to facilitate an impartial comparison (Cohen, Manion & Morrison 2011).

To overcome the lack of consistency in interview question outcomes, informal pilot student interviews were conducted to assist the researcher in determining the strengths and weaknesses of the interview design and its flaws (Kvale 2007). The pilot interviews were carried out with study participants two weeks before the formal interviews (McNamara 2009) and thus allowed further exploration of the suitability of the questions. Creswell (2007) has suggested developing follow-up questions and guiding interviews according to participants' responses. Some questions were therefore reformulated and others added during the pilot interviews. Patton (2002) has explained that pilot interviews are the best illustration of participants' experiences, as they rely utterly on spontaneous reactions of the interviewer to the interview context.

The interviews aimed to determine the following from students:

- Attitudes toward writing in mathematics

- Experience of using Web 2.0 applications
- Attitudes toward implementation of Web 2.0 application activities in mathematics

A complete list of the students’ interview questions is provided in Appendix C

3.5 Course Workflow

In the first week of the third term in the academic year, the journaling term project outline was uploaded to each class’s Edmodo page. During the first week, the teacher discussed the project outline with each group during regular class time and explained the purpose and expectations of the journaling project. The outline included a sample entry of what students were anticipated to include in their final work.

The workflow of the implementation phase followed a rotation blended learning approach (Staker & Horn 2012). Four face-to-face class sessions were scheduled for delivery in the classroom. Throughout the execution of the ten-week intervention, students were exposed to daily comprehensive in-class face-to-face discussions as well as online discussions through the Padlet platform two to three times per week. Short tutorials and instructions to ensure the quality of the intervention were regularly employed as per the process requirements. Students were engaged for an average of 30 minutes of the total class time of 90 minutes, meaning between 60 and 90 minutes per week, sufficient to ensure full engagement in the task according to Rick et al. (2011).

By the end of each week, the teacher highlighted the topic of the weekly entry, which was related to the lessons covered during the week, via a class discussion and directly connected the topic to all class face-to-face and online interactions. After this session, the teacher opened an assignment link on the Edmodo class page for students to turn in their journal entries for the week and receive the teacher’s comments and feedback. Students were required to submit their complete work by the end of week ten in any electronic format.

The development of the course workflow (timeline) was structured in five phases corresponding to ten working weeks, as shown in Table (3.3).

Table (3.3). Course workflow

Phase		Activity
Two weeks before starting		• Pre Survey • EOT two exam
Implementation phase	Week 1	• Introduction to the journal project • Introduction to the communication activities
	Week 2 through Week 9	• Formal learning, face-to-face sessions (four times per week, six hours) ❖ Course material ❖ Class activities ❖ Class discussions and notetaking • Collaborative web-based learning (two to three times per week) ❖ Online discussion ❖ Content sharing ❖ Collaborative authoring • Informal learning (once per week) • Journal project entries
	Week 10	• Student interviews
After completing the treatment		• Post Survey • EOT Three Exam

3.6 Ethical Considerations

Ethical matters were taken into consideration during data collection and analysis. Cohen et al. (2011) have accentuated the rights of privacy and confidentiality of participants and have also highlighted that researchers are obligated to inform participants of their right to refuse to take part in a study. The confidentiality and anonymity of all participants were confirmed, as no personal or private data was recorded during the study.

Creswell (2012) has asserted that publishing students' individual scores is considered a violation of the right to privacy and confidentiality, and research papers should hence include only statistical measures. In this study, data collection took place in the classroom and was stored on the district's electronic platform; the whole procedure was thus safe and sought to cause no harm to research participants. Permission to use the archived testing data was received from the authorized person at the school before the data was used (Creswell, 2012). A guarantee of anonymity came from the removal of any identifying data from the test scores, which were also stored in a secure location to ensure confidentiality. The school district required a copy of the researcher's institutional request, and a detailed description of the research subject and procedure of data collection and interpretation was handed over to the person responsible for approval before commencing the implementation.

This chapter has introduced and examined the theoretical approach of this research paper, scrutinizing the structure and appropriateness of the design in answering the research questions. The research is designed to investigate the effect on students' reasoning skills of using Web 2.0 technologies as a communication medium in math class. This chapter has also introduced a comprehensive exploration of the study approach and the implementation of the quasi one-group design as well as an explanation of data collection and study instruments and a description of the study participants, context, and setting. Chapter Four presents the results and findings of the research in detail.

Chapter Four: Results

This chapter reports findings based on the interpretation of data collected on the effects of different Web 2.0 communication tools on students' reasoning skills and attitudes toward learning mathematics. The participants were 70 ninth grade female students from three different classes in the same school in the UAE. Data collected from the self-determination survey, students' mathematics journals, and individual interviews was analyzed to address the central research question: What are the effects of integrating Web 2.0 writing and discussion activities in math class on the following?

1. Students' psychological needs for competence and autonomy
2. Students' attitudes toward writing in mathematics
3. Students' academic achievement in mathematics

Both quantitative and qualitative data were collected and analyzed. The quantitative data was coded using the summed score approach and processed using descriptive data analysis after clustering with the Statistical Package for the Social Sciences (SPSS 22). Results obtained from the SPSS were used to create illustrative tables to facilitate a better understanding of the research findings. The qualitative data was analyzed according to the constant comparative method based on the grounded theory by Glaser and Strauss (1967). Interview data was coded, organized, and scrutinized through three coding levels (Kolb 2012), and data from participant responses was compared and clustered into core categories that emerged following systematic validation of the relations, dimensions, and concepts developed through the coding process.

The purpose of this coding procedure is to combine pieces of information to create meaning from the raw data. Data analysis within the current research context progresses in the following order: First, quantitative data is analyzed and outcomes determined, followed by the same for qualitative data. The findings of the research study are then compared with the content of pre and post surveys, students' scores on EOT exams, and interview responses.

4.1 Quantitative Results

The effectiveness of Web 2.0 discussion and writing activities was assessed via pre and post surveys and was supported by students' EOT exam scores. The fundamental factors evaluated were the effects of incorporating Web 2.0 writing and discussion activities on students' psychological needs for competence and autonomy, their attitudes toward writing in mathematics, and their achievement in mathematics.

Descriptive data analysis related to competence, autonomy, and attitudes toward writing in both pre- and post-course surveys is demonstrated in Table 4.1. The scores on the pre and post surveys range from 1 to 6, and the means and standard deviations for achievement are also presented.

Table 4.1. Descriptive Statistics

				Pre-course Survey		**Post-course Survey**	
	No.	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Mean**	**Std. Deviation**
Competency	70	1.00	6.00	3.06	1.52659	3.462	1.67196
Autonomy	70	1.00	6.00	2.995	1.67292	3.254	1.66809
Attitudes to writing	70	1.00	5.63	2.198	1.36043	2.817	1.68334
Achievement	70	24	100	49	19.7	53.6	18.6

Descriptive data analysis reveals that participants had a midlevel sense of competence in the pre-course survey (M = 3.06) and a slightly higher sense of competence in the post-course survey (mean! = 3.46). The same can be said about both autonomy and attitudes toward writing. On average, students were found to have a midlevel sense of autonomy in the pre-course survey (M = 2.995), which increased in the post-course survey (M = 3.254). Similarly, students were found to have a relatively passive attitude toward writing in the pre-course survey (M = 2.198), which increased in the post-course survey but remained passive, closer to neutral (M = 2.817).

These differences in pre and post surveys for factors such as competency (0.39), autonomy (0.25), and attitudes toward writing (0.62) could be due to the effects on students' reasoning skills of integrating Web 2.0 writing and discussion applications into mathematics instruction. To more closely examine the quantitative data, a *t*-test was applied to determine whether the differences appearing in the descriptive data analysis are significant. Results for the *t*-test are shown in Tables 4.2, 4.3, and 4.4.

Table 4.2. T-test Results for Competence

Competence	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1, Pre–Post	−.39643	.56745	.06782	−.53173	−.26113	−5.845	69	.000

Table 4.2 shows that the significance value is less than 5%, which indicates a significant difference between pre and post competence levels among students. This shows that integrating Web 2.0 writing and discussion applications into mathematics instruction has a statistical positive effect on students' sense of competence.

Table 4.3. T-test Results for Autonomy

Autonomy	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1, Pre–Post	−.25857	.58297	.06968	−.39758	−.11957	−3.711	69	.000

From Table 4.3, it can be interpreted that integrating Web 2.0 writing and discussion applications into mathematics instruction also has a positive effect on students' sense of autonomy. There is a statistical significant difference at the alpha level .05 (t = 3.711)

Table 4.4. T-test Results for Attitudes toward writing

Attitudes toward Writing	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1, Pre–Post	−.61964	.88579	.10587	−.83085	−.40843	−5.853	69	.000

Table 4.4, which illustrates the results of the paired *t*-test regarding students' attitudes toward writing, again indicates a statistical significant difference between pre- and post-course surveys, as the significance value is less than 5%. Thus, integrating Web 2.0 writing and discussion applications into mathematics instruction affects students' attitudes toward writing in mathematics positively, and students showed more acceptance of writing as a part of mathematics instruction following the intervention.

Table 4.5. T-test Results for Achievement in Mathematics

Achievement in Mathematics	Paired Differences					*t*	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			
Pair 1, Term 2–Term 3	−4.250	20.840	2.491	−9.219	.719	−1.706	69	.092

The last *t*-test results regarding students' achievement in mathematics, shown in Table 4.5, demonstrate that the significance value is greater than 5%. Hence, there is no significant difference between Term 2 results and Term 3 results. The integration of Web 2.0 in student learning had no significant effect on students' achievement in mathematics despite its remarkable influence on their levels of competence and autonomy and their attitudes toward writing.

4.2 Qualitative Results

The qualitative results are based on a constant comparative analysis of student interviews. Such an analysis helps describe the relationship between the implementation of different Web 2.0 writing activities and students' psychological needs for competence and autonomy as well as their attitudes toward using Web 2.0 applications as writing tools in mathematics. Therefore, the interview results are presented according to the four major components examined in this study: students' competence, autonomy, attitudes toward writing in mathematics, and achievement in mathematics.

4.2.1 Students' Need for Competence

The two forms of writing activities incorporated in this study required students to demonstrate their understanding and reflect on their learning experience by using several methods to respond to questions meant to foster diverse levels of cognition. Based on the interview data, students' contributions to class discussions took two primary forms, initiation and hesitance. Descriptive examples of these two types of students are provided in the following section.

1. Initiators. Most participants categorized as initiators were very motivated and positive. Three of them had high levels of confidence in their ability to do well in mathematics, and they used phrases like "The content of the course is being regularly reviewed during discussion," "You can master the lesson through these discussions," and "I'm pretty sure I know all of it, and I can excel at it." Almost all initiators except two specified that they were most motivated to find answers when the teacher posted challenging questions. They also picked what seemed like higher-order thinking problems for their weekly electronic journal entries, as apparently these experiences supported their need for competence.

Some students responded, "Writing your thoughts makes you think deeper about them," "I enjoyed solving questions that seemed harder than others," and "I liked it when I was one of the first to post the answers to especially hard questions." When asked which type of writing was, in their opinion, more beneficial to them, five participants identified electronic journal writing, although they also mentioned that virtual class discussions helped them understand the concepts they were studying. Responses were focused on time constraints and the option to choose a question and how to respond. Answers contained phrases like "Writing the problem out helps you understand it," "I had enough time to think of the problem, unlike in class discussions," and "I tried each of the given prompts at least once, and that gave me more confidence."

The rest of the initiators believed both experiences were useful and enjoyable, and all eight initiator students mentioned that they had always been good in mathematics and that was probably why they were comfortable applying new techniques while learning. They also agreed that both activities helped them improve their confidence in mathematics. Some of their answers were as follows: "I now know better how to think of these problems," "It's good to learn how everybody in your class thinks. That taught me a lot," "The more I write about the challenging topics, the more they start to seem easier," and "I feel more able to analyze complicated problems." There was a sense of achievement in initiator students' responses, which demonstrated their confidence.

2. Hesitators. The rest of the interviewees seemed to have very little confidence in their ability to easily pass this mathematics course. Some believed writing activities in all forms were overwhelming and did not add to their mathematical problem-solving skills. Responses were focused on the time-consuming nature of the writing tasks and the fact that students had never experienced writing in math before and had always struggled with higher-order thinking problems. Some of the responses were as follows: “I’m not confident. The teacher said writing activities would help us analyze hard problems, but I don’t feel I am doing better,” “I always choose to solve easy and direct problems,” and “I never choose hard problems, neither for the electronic journal nor in class. I know I can’t do them.”

4.2.2 Students’ Need for Autonomy

Incorporating writing into mathematics class was designed precisely to allow students to gain insight into their learning styles and problem-solving strategies. Therefore, students were granted some freedom to choose the manners through which they wanted to demonstrate their knowledge. The intervention also aimed to direct students to think more about decisions they make when solving problems that seem new to them. The interview data allowed for the classification of students according to their senses of autonomy as generally independent learners, moderately independent learners, and dependent learners.

1. Generally independent learners. Few participants out of the total twenty included in the interview stage were classified as generally independent learners. These students showed extensive understandings of the roles they played in class discussion as well as the choices they made while completing their journals. Responses were focused on decision making, freedom of choice, teacher guidance, and the authority to direct the lesson toward what they wanted to learn. Some of the responses were “You don’t have to answer the question if you’re not sure. The teacher wants us to keep trying,” “The KWL charts were very helpful to specify what exactly we needed the teacher to focus on,” “You can choose how to contribute to the class discussion,” “I usually can tell what is confusing me, and I know the teacher wants to know,” “In the electronic journal weekly entry, we were able to pick any problem and decide which prompt to write about,” and “We had the choice whether to solve in detail, explain, or reflect, whatever was more convenient in each situation.”

Independent learners demonstrated that they experienced freedom of choice when practicing writing activities. When asked about whether any of the writing forms helped them experience more freedom in their mathematics class, all five answered positively. Independent learners recognized the available choices and their meanings and appreciated the instructor's role in their learning experience. One student said, "When you don't understand something, that doesn't mean you are not good enough. You should just work harder." Another student said, "You don't always have to be the first to post on the discussion board. Reading other people's answers helped me more than once to decide." These students were able to take advantage of the experience in different ways and find new sources of information, which shows that diverse Web 2.0 writing applications support students' need for autonomy.

2. Moderately independent learners. Students with moderate dependency were those who were mostly aware they could make choices but did not always do so, either because they preferred not to take risks, because they sometimes chose the easiest way, or because the activities were of low priority for them. When asked which activity they practiced most during class discussions, the majority said they posted solutions only when they thought they were right, and they rarely read others' answers and almost never commented on anyone's opinions. Although they knew they had that option, some students responded, "I don't read what my classmates post because I don't know if it is wrong or right," "The teacher usually states the correct answer and sometimes posts it. That's what I usually wait for," "There's always a final answer, and that's all I need to study for my test," "In the KWL, I wrote what I learned, but I'm rarely sure of the other two columns. I left that to the other group members," "I don't comment on other people's answers because that's the teacher's job," and "In the electronic journal we were allowed to pick from eight prompts, but I kept using the same two."

Moderately independent leaners were aware of the choices they had, but it seemed those choices were meaningless for them. Sometimes they took advantage of those options, but mostly when doing so made the work easier. When asked whether they believed Web 2.0 writing applications gave them more freedom in mathematics, students fluctuated in their responses. Some felt the applications did not help at all, and some felt that perhaps they did, but not significantly. Responses included statements about extra work, the fact that exercises were sometimes confusing and that students felt they could write anything, and worries that these skills would never come up in the exam. These students agreed that writing was a fun task, and they didn't mind doing so now and then. Still, they did not see it as helpful.

3. Generally dependent learners. An analysis of the interview data revealed that some students were not aware of their option to make choices while engaging in class Web 2.0 discussions or while writing their electronic journal entries. When asked about the activity they practiced most, dependent learners' responses lacked words like "choose" and "decide." Some responses were as follows: "We have to answer the question the teacher posts, don't we?" and "We don't comment, we just answer. Sometimes I copied what others posted." When describing the electronic journal assignment, most students answered something like "We have to pick a question and show how to solve it."

It is obvious that these students did not experience choice during any Web 2.0 writing activities. When asked whether Web 2.0 writing activities helped them experience more freedom in mathematics, students generally responded with statements like "It's another assignment you have to do," "Why do we have to write in mathematics?" and "Participating is compulsory." These students perceived written discussion and reflection as a new burden in addition to the rest of their school duties. They also did not experience a sense of autonomy, as they felt they did not have the option to choose between problems.

4.2.3 Students' Attitudes toward Writing in Mathematics

The effect of Web 2.0 writing applications on students' attitudes toward writing in mathematics is based on their perception of the advantages and disadvantages of these activities.

1. Writing advantages. Students pointed out quite a few features they perceived as advantages of writing in mathematics class. Three main themes emerged from the interview data: knowledge sharing, increased interaction, and encouragement of deep thinking.

    i. Knowledge sharing and useful feedback. All participants but two emphasized the role of written communication as a valuable tool for sharing knowledge. The fact that students could read their classmates' answers seemed compelling to them. Some responses were "Some of my classmates explain nicely, and some others even add more information that I never knew," "It was helpful reading people's answers. Many times, they helped me verbalize mine," and "I don't always understand what people say in class. Reading the responses was more efficient." Some students used the term "useful feedback," which can also be categorized under the sharing of knowledge. They stated that immediate feedback was a vital and meaningful part of the class discussion experience, and responses focused on the fact that feedback gave the students more confidence, helped them to study later for the test, and encouraged them to spot common mistakes and misconceptions immediately.

ii. Increased interaction. Students stated that these discussions increased class interaction to a noteworthy level. Information exchanges frequently involved students directing questions to one another through the board, which led to curiosity that sometimes went beyond the posted question and facilitated new discussions that happened face to face or remained within the Web 2.0 environment. Students stated that they started to post questions on the blog environment (Edmodo) if they faced problems while studying at home or if they missed class for any reason. Some responses were “It is a good way to ask questions and receive multiple answers,” “We started to talk more about mathematics. I didn’t think I would like it, but I did,” and “It was nice that we could communicate through these boards. I feel like I know everyone in the class more now.”

The opportunity to communication in this way helped students confirm their relationships, and that made them feel more comfortable participating and had a positive influence on their progress in the course in general, according to students’ interview responses.

iii. Encouragement of deep thinking. Students described writing in mathematics as a chance to think more about their answers and work. Most perceived this aspect more in the electronic journal activity, yet they agreed that writing in all forms, considering the needs of a reading audience, entails contemplating one’s thoughts to some extent. Some students also added that deep thinking helped them better understand the subject and prepare for assessments. Some responses were “You slow down and think before you write,” “Everyone is going to read it; it better make sense,” “I tried to choose a different prompt every time, but it didn’t always work. It depends on the problem you choose,” “Writing makes me understand the process,” “I like how we sometimes relate the problem to other math topics; it makes more sense then,” “When you are thinking about the proper words to write, you start to relate things,” and “Because I have to write, I must go back and read my notes more than once sometimes.”

2. Writing disadvantages. Students also expressed several negative views regarding the integration of writing through Web 2.0 applications in mathematics, and, to some extent, what seemed an advantage to some was considered a disadvantage by others. Three students indicated no disadvantages of the writing experience. Another two main themes emerged for this section: ambiguity of objectives and extra time and effort needed.

i. Ambiguity of objectives. While some students referred to the freedom they were granted in both class communication and electronic journals as an advantage, others perceived it to be ambiguous in its objectives and expectations. Some responses were “I never knew why we were doing that,” “I didn’t always participate because I was afraid to answer wrong and lose grades,” “I didn’t know what was expected of me to answer the math or to explain it,” “I lost points in the electronic journal because I didn’t know what to write,” “It has nothing to do with the mathematics we study. I mean, it’s not solving,” and “It sounded more like an English task for me than math.” Those students believed not enough structure or specific instructions had been provided for writing tasks, and those tasks were thus meaningless for them.

ii. Extra time and effort needed. The extra work associated with the writing applications was emphasized as a major disadvantage. Important aspects categorized under this theme were the time it took to read several posts in class and try to respond whenever appropriate and to do extra homework, as in the electronic journal, which sometimes required extra research. Some responses were “It’s extra work, and I’m not sure why we need it,” “Some questions seemed like they were from a different topic, and here, where you have to search for answers, that usually distracts me,” “Some problems were clear enough; I saw no point in writing more about them,” and “I am not good in writing anyway. I like mathematics more when it’s only about solving so I don’t have to struggle.”

Chapter Five: Conclusions, Discussion, and Recommendations

This research study has explored the effects on students' reasoning skills of integrating Web 2.0 writing and discussion applications in mathematics instruction. Innovative Web 2.0 technologies challenge the educators of today to adequately integrate those tools into class instruction as effective components of advancing learning practices. Jakubowicz (2011) has affirmed that what determines the efficiency of this integration is the level of student engagement and motivation and the quality of opportunities the integration provides students to create and manage their own digital learning materials. This chapter is divided into three main sections. The first identifies and discusses key findings to answer the research questions and link them to the current literature, the second recaps the conclusions of the study, and the last describes the recommendations and limitations of the study.

5.1 Discussion

A quantitative data analysis of students' pre and post surveys indicates an overall difference in rate of change regarding levels of competence and autonomy, attitudes toward writing, and achievement in mathematics. However, the interpretation of this data suggests that other factors, each of which is addressed and supported in the following sections, may impact these variables.

The quantitative and qualitative data suggest that participating students' levels of confidence that they could easily pass their mathematics course ranged widely. Quantitative results showed a significant difference in students' levels of competence after utilizing Web 2.0 applications, and qualitative analysis indicated that students' confidence levels are largely associated with two main factors: positive support and previous experiences. This is consistent with the literature (Wæge! 2010; Niemiec & Ryan 2009; Broeck 2010; Kahn et al. 2013). Niemiec and Ryan (2009) and Wæge (2010) have linked achieving personal goals and skills mastery to intrinsic motivation. Both students' abilities to solve, analyze, and reflect on higher-order thinking problems and their trust in those abilities based on their history in math classes sustain intrinsic motivation and satisfy the psychological need for competence (Wæge 2010; Kahn et al. 2013). In addition, Ryan and Deci (2000) and Bandura (1977) have asserted that regular feedback and contextual praise from peers help meet this need.

Initiator students showed high levels of confidence in their abilities to excel in their mathematics course and often chose to challenge themselves with what they perceived to be hard and unfamiliar problems. They enjoyed posing questions, initiating new discussions, and reflecting on complicated problems, and in return they received encouragement and positive feedback from their instructor and their peers, thereby experiencing personal mastery (Bandura 1977; Ryan & Deci 2000; Niemiec & Ryan 2009). Meanwhile, hesitant students always chose to solve problems they were sure they knew and would not start solving until they had received approval from more knowledgeable peers or the instructor. They therefore did not have the chance to experience personal mastery (Bandura 1977; Ryan & Deci 2000; Niemiec & Ryan 2009). Qualitative data provides further insight into students' experiences, revealing that when students choose to challenge themselves by writing and reflecting on challenging problems, Web 2.0 writing and discussion activities support students' need for competence. The hesitant students, in general, did not trust their abilities to make progress in mathematics, so they chose to participate when they were sure they knew the answer and did not try to challenge themselves.

The sense of autonomy among student participants also ranged widely, starting with generally independent students, who had almost full control over their learning processes, and ending with generally dependent students, who had almost no control. A sense of independence is also associated with two main factors: awareness of available choices and their meanings (Katz & Assor 2007; Yelverton 2014) and encouragement and praise from the instructor (Reeve & Jang 2006). Quantitative data reveals significant differences in students' senses of autonomy, and the qualitative data supports this result and provides advanced insight into students' experiences. It suggests that from the three categories of students, only independent learners, who recognized the choices they could make and understood their meaning, felt the freedom to inquire through independent work, and the Web 2.0 writing and discussion applications therefore seemed to meet their need for autonomy (Yelverton 2014). For students, taking responsibility for learning is an imperative part of developing a sense of autonomy (Wæge 2010; Katz & Assor 2007). The other two groups of students either relied on authority figures, meaning the teacher or more knowledgeable peers, to provide guidelines and answers or chose to always do the same work rather than exploring and developing new skills (Kahn et al. 2013; Ryan & Deci 2000).

Based on both a quantitative data analysis and a descriptive analysis of that quantitative data, this study reveals that the incorporation of Web 2.0 writing and discussion applications has an effect on students' attitudes toward writing in mathematics. However, the *t*-test results indicate that this difference is not significant. More factors associated with students' attitudes toward writing in mathematics can be determined through an examination of the qualitative data and an analysis of student interviews. The list of advantages and disadvantages described by students is consistent with previous literature, which indicates that using Web 2.0 technology motivates students to engage in more writing activities in mathematics class (Al-Kathiri 2014; Fogg et al. 2011; Zaidieh 2012) and that the extensive features and consequences correlated to the use of these tools might have different effects on students according to their abilities and learning styles (Jakubowicz 2011; Barlow 2008; Greenhow, Robelia & Huges 2009; Gooding 2008).

Students appreciated the new source of information and instant feedback provided by this powerful tool as well as its role in consolidating their social relationships, which had a positive impact on the class environment aside from improving the quality of the collaborative class experience (Clark et al. 2009; Rethlefsen, Piorun & Prince 2009). The time factor was perceived differently by different students; while some considered the time required to think deeply before presenting thoughts in front of classmates a positive aspect that forced them to explore their thoughts (Sunstein et al. 2012), others considered it a distraction that wasted their time on non-curricular tasks, in their opinion.

Quantitative analysis indicates that there was no significant change in student participants' achievement in mathematics after integrating Web 2.0 applications in mathematics instruction. Quantitative data analysis supports these results to some extent. Some students indicated that they felt more confident in their abilities to solve complicated mathematics problems, and others stated that these applications helped them to study and prepare for their exams. Previous studies (Kenney, Shoffner & Norris 2014; Bicer, Capraro & Capraro 2013; Beavers et al. 2015) have indicated that collaborative writing activities with peers lead students to deeper understanding, enhance their mathematical investigation capabilities, and improve their reasoning skills, resulting in better academic achievement. On the other hand, some students felt these new instructions were not useful in improving their grades and enhancing their learning practice. This might be a result of the traditional point of view people hold about mathematics (Chen, Hand & McDowell 2013; Kenney, Shoffner & Norris 2014), which is that it is procedure oriented, so students will never have to discuss problems during their exams.

The results regarding achievement in mathematics are consistent with the literature. Beavers et al. (2015), Bicer, Capraro, and Capraro (2013), and Rosen and Tager (2013) have emphasized teachers' central roles in providing diversified writing and discussion tasks to engage students with different learning styles and academic abilities. Murphy and Lebans (2008) and Fuchs (2010) have asserted that the desired Web 2.0 learning model is one that provides learning based on individual needs and works to establish maximum class engagement instead of isolating students with higher learning abilities from other average or low achievers. Engaging students in writing and discussion activities may not have a direct influence on their school grades, especially in the short term, but it might indeed open their minds to perceive mathematics differently (Chen, Hand & McDowell 2013; Beavers et al. 2015).

5.2 Conclusions

Based on an analysis of pre and post survey data collected from three grade nine sections during the third academic term, interviews with participants, and results from exams at the ends of terms two and three, a significant difference in students' competence and autonomy levels was noticed. The same can be said about students' attitudes toward writing in mathematics. Regarding students' achievement in mathematics, quantitative data indicates that there was no significant effect. However, qualitative data has clarified the diverse points of view of participants regarding the effects of Web 2.0 writing and discussion applications on their academic achievement in mathematics. An analysis of these multiple sources of data can be summarized as follows:

1. When students take the initiative to solve higher cognitive order mathematical problems and succeed in doing so, that helps them experience personal mastery and achieve personal goals (Bandura 1977; Ryan & Deci 2000; Niemiec & Ryan 2009; Wæge 2010). Web 2.0 writing and discussion applications therefore meet students' need for competence.

2. When students show the ability to take charge of their learning, evaluate options, and make choices and decisions whose meanings and implications they understand, in addition to seeking help when appropriate (Ryan & Deci 2000; Wæge 2010; Kahn et al. 2013), Web 2.0 writing and discussion applications meet students' need for autonomy.

3. Students' attitudes toward writing and integrating Web 2.0 writing and discussion applications in mathematics instruction are highly associated with the advantages and

disadvantages of this approach and its tools aside from their own perceptions of their learning practice priorities (Fogg et al. 2011; Zaidieh 2012; Clark et al. 2009; Sunstein et al. 2012).

4. Students' achievement in mathematics is affected by the type of applications integrated and their links to students' abilities and learning styles. When implemented with different types of activities with a varied range of objectives, Web 2.0 writing and discussion applications can have a positive effect on students' achievement in mathematics.

5.3 Limitations

The study had the following limitations, which must be considered when reviewing the final results and findings:

1. The study comprises only three grade nine classes. Thus, the sample size is moderately acceptable, and all participants were female.
2. The implementation of Web 2.0 applications was limited to one type of communication tool because of class time constraints.
3. The project study was restricted to one general math course combining both algebra and geometry as categorized by the school curriculum.

5.4 Recommendations

The model described in this research incorporates two types of writing synchronously to advance students' comprehension of learned mathematical tasks. Both the online discussion and blogging activity and the journal project have quite a few potential benefits that can be considered by teachers wishing to include this strategy effectively in their future practice. The results of the current study advocate those of the majority of the literature presented earlier in Chapter Two, which indicates a positive impact of integrating Web 2.0 writing and discussion applications into mathematics instruction on students' abilities to deal with higher-order mathematical problems.

5.4.1 Recommendations for Students

The results conclude that implementing math journaling into mathematics instruction through Web 2.0 writing and discussion applications can have a positive impact on students' motivation toward mathematics as well as their academic achievement. Collaborative work assisted by the ease of participation provided by this technology may motivate students to exchange knowledge, investigate, and find resources. It can also help boost students' levels of conceptual understanding by engaging them in brainstorming within small groups and providing them with beneficial instruction and feedback (Beavers et al. 2015). When students are given the opportunity to explore and make decisions, they are more likely to better analyze a situation, evaluate options and possibilities, make assumptions, and reject hypotheses (Fogg et al. 2011; Kahn et al. 2013).

Following this model, students have more freedom to personalize their learning instead of having to answer certain repeated questions. Writing in mathematics helped students determine their levels of understanding independently while transferring their thoughts into a written context and relating those to their previous knowledge (Beavers et al. 2015; Bicer, Capraro & Capraro 2013). Students can use this model to find new resources by sharing useful links and websites with their classmates on their own blogs, or they can make their own tutorials and share those within the school platform or via any other appropriate means of broadcasting (Hossain & Wiest 2011).

5.4.2 Recommendations for Teachers

Teachers can introduce this model in earlier school years to get students used to the fact that they need to express their comprehension of mathematics verbally. This model would be an appropriate one through which mathematics teachers could present topics requiring in-depth analysis of properties and investigation of mathematical relations and patterns (Jakubowicz 2011; Hossain & Wiest 2011). Educators may attempt to implement mathematical writing through many different strategies with the aid of unlimited Web 2.0 applications. It is recommended that teachers endeavor to determine students' interests, levels of motivation, learning styles, academic levels, and general attitudes toward writing (Maulana et al. 2011; Kahn et al. 2013; Wæge 2009). This provides teachers insight into possible effective topics and practices to include within writing activities to foster a positive impact on students' reasoning and analysis skills instead of discouraging them from engagement in these activities (Kemker, Barron & Harmes 2007).

Students' perceptions of the advantages and disadvantages of writing highly affected their acceptance of the implementation. Teachers should comprehensively explain the instructions for activities and their objectives and should address their expectations clearly, as students need to have insight into why they must practice mathematics differently for the implementation to have its intended effect. Instructors also have to work on differentiating their instruction and providing diverse tasks to small group that challenge all students, not only certain types of learners. The model should provide all students with equal opportunities to advance their learning (Niemiec &

Ryan 2009; Johnston 2012; Ryan & Deci 2000). Finally, instructors need to take into consideration the importance of effective and meaningful feedback to motivate learners to engage in what they might perceive as a challenging task (Kahn et al. 2013; Johnston 2012). Educators should be prepared to give instructions about the writing and reflection process, as well, since students will not likely be fully ready to express their justifications and analyses through writing prior to this.

5.4.3 Recommendations for Researchers

Research examining the effect of integrating Web 2.0 writing and discussion applications into Mathematics instructions could be remarkably extended. The absence of demographic distribution doesn't give sufficient indicators on the efficiency of the treatment and restrict chances to generalize the results. Future researches could attempt to incorporate students from different grade levels and both gender, and might also endeavor to study the different influence of the intervention according to gender. Another limitation of the current study is the incapability to engage the students in various types of communication applications, for future researches it is recommended to engorge the students to participate in an expanded form of discussions like blogs and electronic forums outside the classroom, where they might have more time to build ideas and express opinions. They also can create their blogs using a different kind of personalized applications from their choice.

The study used students' end of term marks to determine the impact of the intervention on students' academic achievement, which is moderately not an adequate measure of students' actual gain from the integration procedure. Future studies might attempt to utilize value-added modeling or an observational study to find more insight on the actual effect of this application. Finally, future research could attempt to implement this model for a longer period and track the students' academic process and achievements and compare them.

References

Al-Kathiri, F., 2014. Beyond the Classroom Walls: Edmodo in Saudi Secondary School EFL Instruction, Attitudes and Challenges. *English Language Teaching*, *8*(1), p.p189.

Ary, D., Jacobs, L. C., & Sorensen, C. K. (2010). *Introduction to research in education* (8^{th} ed.). Cengage Learning

Badawy, A.H.A., 2012. Students Perceptions of the Effectiveness of Discussion Boards What can we get from our students for a freebie point.*arXiv preprint arXiv:1210.1178*.

Beavers, A., Fox, B.L., Young, J., Bellows, E.M. and Kahn, L., 2015. Integrating Writing in the Middle-Level Mathematics Classroom: An Action Research Study. *MLET: The Journal of Middle Level Education in Texas*, *2*(1), p.4.

Barlow, T. (2008). Web 2.0: Creating a classroom without walls. *Teaching Science, 54*(1), 46-48. (Document ID: 1460988431).

Brodahl, C., Hadjerrouit, S. and Hansen, N.K., 2011. Collaborative writing with Web 2.0 technologies: education students' perceptions.

Brown, J. S., & Adler, R. P. (2008). Minds on fire: Open education, the long tail, and learning 2.0 (Vol. 43, pp. 16): Educause.

Brendefur & Frykholm (2000) *Journal of Mathematics Teacher Education* **3:** 125–153, 2000.© 2000 *Kluwer Academic Publishers. Printed in the Netherlands.*

Brendefur, J. and Frykholm, J., 2000. Promoting mathematical communication in the classroom: Two preservice teachers' conceptions and practices. *Journal of Mathematics Teacher Education*, *3*(2), pp.125-153.

Broeck, A., Vansteenkiste, M., Witte, H., Soenens, B. and Lens, W., 2010. Capturing autonomy, competence, and relatedness at work: Construction and initial validation of the Work-related Basic Need Satisfaction scale.*Journal of Occupational and Organizational Psychology*, *83*(4), pp.981-1002.

Buzzetto-More, N. (2012). Understanding social media. In C. Cheal, J. Coughlin, & S. Moore (Eds.), *Transformation in teaching: Social media strategies in higher education* (pp. 1-18). Santa Rosa, CA: Informing Science Press.

Carbonneau, K.J., Marley, S.C. and Selig, J.P., 2013. A meta-analysis of the efficacy of teaching mathematics with concrete manipulatives. *Journal of Educational Psychology*, *105*(2), p.380.

CHEN, Y.C., Hand, B. and McDOWELL, L.E.A.H., 2013. The Effects of Writing-to-Learn Activities on Elementary Students' Conceptual Understanding: Learning About Force and Motion Through Writing to Older Peers. *Science Education*, *97*(5), pp.745-771.

Christiansen, C., 2010. *CREATING CLASSROOM COMMUNITIES OF PRACTICE: STUDENTS AS PRACTIONERS OF CONTENT* (Doctoral dissertation, The Evergreen State College).

Clark, W., Logan, K., Luckin, R., Mee, A., & Oliver, M. (2009). Beyond Web 2.0: Mapping the technology landscapes of young learners. *Journal of Computer Assisted Learning, 25*(1), 56-69.

Cooper, A. (2012). Today's technologies enhance writing in mathematics. *Clearing House: A Journal of Educational Strategies, Issues and Ideas, 85*(2), 80-85.

Corbin, J., & Strauss, A. (2008). *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory.* 3rd ed. Los Angeles, CA: Sage.

Craig, T.S., 2011. Categorization and analysis of explanatory writing in mathematics. *International Journal of Mathematical Education in Science and Technology*, *42*(7), pp.867-878.

Cresswell JW (2008) Research Design: Qualitative, Quantiative, and Mixed Methods Approaches (Third edition), SAGE Publications Inc, Thousand Oaks, CA.

Cresswell JW, Plano Clark VL (2007) Designing and Conducting Mixed Methods Research, SAGE Publications Inc, Thousand Oaks, CA.

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Boston, MA: Pearson Education Inc.

Creswell, J. W. (2011). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* ISBN-13: 978-0131367395

Cuhadar, C. and Kuzu, A., 2010. Improving Interaction through Blogs in a Constructivist Learning Environment. *Turkish Online Journal of Distance Education*, *11*(1), pp.134-161.

Davier, A.A. and Halpin, P.F., 2013. Collaborative problem solving and the assessment of cognitive skills: Psychometric considerations. *ETS Research Report Series*, *2013*(2), pp.i-36.

Dick, T. P., & Hollebrands, K. F. (2011). Focus in high school mathematics: Technology to support reasoning and sense making. Reston, VA: NCTM.

Froiland, J.M. (2011). Parental autonomy support and student learning goals: A preliminary examination of an intrinsic motivation intervention. *Child and Youth Care Forum, 40*(2), 135-149.

Froiland, J.M., Oros, E., Smith, L. and Hirchert, T., 2012. Intrinsic motivation to learn: The nexus between psychological health and academic success.*Contemporary School Psychology: Formerly" The California School Psychologist"*, *16*(1), pp.91-100.

Fuchs, C., 2010. Web 2.0, prosumption, and surveillance. *Surveillance & Society*, *8*(3), pp.288-309.

Furrer, C., Skinner, E. and Pitzer, J., 2014. The influence of teacher and peer relationships on students' classroom engagement and everyday motivational resilience. *National Society for the Study of Education*, *113*(1), pp.101-123.

Gall, M. D., Gall, J. P., & Borg, W. R. (2006). *Educational research: An introduction* (7th ed.). Pearson ISBN-13: 978-0205488490

Galligan, L., Hobohm, C. and Loch, B., 2012. Tablet technology to facilitate improved interaction and communication with students studying mathematics at a distance. *Journal of Computers in Mathematics and Science Teaching*, *31*(4), pp.363-385

Gooding, J.. (2008). Web 2.0: A vehicle for transforming education. *International Journal of Information and Communication Technology Education*, *4*(2), 44-53. (Document ID: 1407624951).

Green, J., Camilli, G., & Elmore, P. (2006). Handbook of complementary methods in education research. New Jersey: Lawrence Erlbaum Associates, Inc.

Gunawardena, C.N., Hermans, M.B., Sanchez, D., Richmond, C., Bohley, M. and Tuttle, R., 2009. A theoretical framework for building online communities of practice with social networking tools. *Educational Media International*, *46*(1), pp.3-16.

Heller , J.I., Curtis, D.A., Jaffe, R., & Verboncoeur, C.J. (2005). *Impact of Handheld Graphing Calculator Use on Student Achievement in Algebra I.* Unpublished manuscript, Oakland, CA

Henning, J.E., McKeny, T., Foley, G.D. and Balong, M., 2012. Mathematics discussions by design: creating opportunities for purposeful participation. *Journal of Mathematics Teacher Education*, *15*(6), pp.453-479.

Jewett, P. and MacPhee, D., 2012. Adding collaborative peer coaching to our teaching identities. *The Reading Teacher*, *66*(2), pp.105-110.

Jakubowicz, J., 2011. *Using Web 2.0 Technology in the Classroom: Blogging for Motivation* (Doctoral dissertation, St. John Fisher College).

Kahn, S., Feldman, A. and Cooke, M.L., 2013. Signs of Autonomy: Facilitating Independence and Inquiry in Deaf Science Classrooms. *Journal of Science Education for students with disabilities*, *17*(1), p.2.

Kolb, S.M., 2012. Grounded theory and the constant comparative method: Valid research strategies for educators. *Journal of Emerging Trends in Educational Research and Policy Studies*, *3*(1), p.83.

Kenney, R., Shoffner, M. and Norris, D., 2014. Reflecting on the Use of Writing to Promote Mathematical Learning: An Examination of Preservice Mathematics Teachers' Perspectives. *The Teacher Educator*, *49*(1), pp.28-43.

Lasker, R.D. and Weiss, E.S., 2003. Broadening participation in community problem solving: a multidisciplinary model to support collaborative practice and research. *Journal of Urban Health*, *80*(1), pp.14-47

Lee, B., & Ge, S. (2010). Personalisation and sociability of open knowledge management based on social tagging.*Online Information Review, 34*(4), 618-625.

Liang, S., 2014. College mathematics classroom for pre-service teachers: developing students' ability of communication that promotes deeper learning.*Scientific Journal of Pure and Applied Sciences*, *3*(1), pp.21-25.

Lofland, J., Snow, D., Anderson, L., & Lofland, L.H. (2006). *Analyzing Social Settings: A Guide to Qualitative Observation and Analysis.* Canada: Thomson Wadsworth

Malhiwsky, D.R., 2010. Student Achievement Using Web 2.0 Technologies: A Mixed Methods Study. *ProQuest LLC*. University of Nebraska Lincoln, Nebraska.

Maulana, R., Opdenakker, M. C., den Brok, P., & Bosker, R. (2011). Teacher-student interpersonal relationships in Indonesia: Profiles and importance to student motivation. *Asia Pacific Journal of Education*, *31*(1), 33-49.

McNamara, C. (2009). *General guidelines for conducting interviews*. Retrieved January 11, 2015, from http://managementhelp.org/evaluatn/intrview.htm

Mischo, C. and Maaß, K., 2013. The effect of teacher beliefs on student competence in mathematical modeling–an intervention study. *Journal of Education and Training Studies*, *1*(1), pp.p19-38.

Murphy, J., & Lebans, R. (2008). Unexpected outcomes: Web 2.0 in the secondary school classroom. *International Journal of Technology in Teaching and Learning, 4*(2), 134-147. *Janet Murphy*

Nenthien, S. and Loima, J., 2016. Teachers' Motivating Methods to Support Thai Ninth Grade Students' Levels of Motivation and Learning in Mathematics Classrooms. *Journal of Education and Learning*, *5*(2), p.250.

NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS. (2000). *Principles and standards for school mathematics*. Reston, VA, National Council of Teachers of Mathematics

Nenthien, S. and Loima, J., 2016. Teachers' Motivating Methods to Support Thai Ninth Grade Students' Levels of Motivation and Learning in Mathematics Classrooms. *Journal of Education and Learning*, *5*(2), p.250.

Niemiec, C.P. and Ryan, R.M., 2009. Autonomy, competence, and relatedness in the classroom Applying self-determination theory to educational practice. *Theory and Research in Education*, *7*(2), pp.133-144.

Ollis, J. C. (2011), Web 2.0 at A Non-Traditional Charter School A Mixed Methods Study. A Thesis, Master of Science, the Florida State University College of Education.

Patton, M.Q. (2002). *Qualitative Research and Evaluation Methods.* Thousand Oaks, CA: Sage.

Ponce, O. and Pagán-Maldonado, N. (2015). Mixed Methods Research in Education: Capturing the Complexity of the Profession. *IJEE*, 1(1), pp.111-135.

Powell, W. W. & Snellman, K. (2004). The Knowledge Economy. Annual Review of Sociology,30, 199-220

Pugalee, D. K. (2004). A comparison of verbal and written descriptions of students' problem solving processes. *Educational Studies in Mathematics, 55,*27-47.

Renfro, A. (2011, December 22). 8 social media strategies for your classroom [Web log post]. Retrieved from http://gettingsmart.com/cms/blog/2011/12/developing-asocial- media-strategy-for-your-classroom/

Reeve, J., 2012. A self-determination theory perspective on student engagement. In *Handbook of research on student engagement* (pp. 149-172). Springer US.

Rick, J., Marshall, P. and Yuill, N., 2011, June. Beyond one-size-fits-all: How interactive tabletops support collaborative learning. In *Proceedings of the 10th International Conference on Interaction Design and Children* (pp. 109-117). ACM.

Roicki, J., 2008. *Effects of discussion and writing on student understanding of mathematics concepts* (Doctoral dissertation, University of Central Florida Orlando, Florida).

Rollett, H., Lux, M., Strohmaier, M., Dösingerm, G., & Tochtermann, K. (2007) The Web 2.0 way of learning with technologies. *International Journal of Learning Technology*, 3(1), 87-107.

Rosen, Y. and Tager, M., 2013. Computer-based assessment of collaborative problem-solving skills: Human-to-agent versus human-to-human approach. *Research & Innovation Network, Pearson Education*.

Sanders, K. (2012). *An examination of the academic networking site Edmodo on student engagement and responsible learning*. (Doctoral dissertation). Retrieved from Pro Quest Dissertations and Theses, 89.on 25/1/2016 http://ezproxy.marshall.edu:2048/docview/1038138655?accountid=12281. (1038138655).

Schwalje, W. (2011). Knowledge-based Economic Development as a Unifying Vision in a Post-awakening Arab World. Munich Personal RePEc Archive (MPRA), Paper No. 30305.

Shannon, D.E., 2009. *Avoidance behaviour in a mathematics 10 classroom*(Doctoral dissertation, Faculty of Education-Simon Fraser University).

Sistek-Chandler, C. (2012). Connecting the digital dots with social media and web 2.0 technologies. *Journal of Research in Innovative Teaching 5*(1), 78-87. *Publication of National University*, *78*

Staker, H., Horn, M. 2012. Classifying K-12 Blended Learning. Innosight Institute, San Mateo. by Donald Ary (Author), Lucy Cheser Jacobs (Author), Christine K. Sorensen (Author), David Walker (Author) (2009) Introduction to Research in Education 8th Edition ISBN-13: 978-0495601227 -ISBN-10: 0495601225

Stein, M.K. and Smith, M., 2011. *5 Practices for Orchestrating Productive Mathematics Discussions*. National Council of Teachers of Mathematics. 1906 Association Drive, Reston, VA 20191-1502.

Steinbring, H. (2005). Analyzing mathematical teaching-learning situations – the interplay of communicational and epistemological constraints. *Educational Studies in Mathematics, 59*, 313-324.

Stuart, E.A. and Rubin, D.B. (2007). Best Practices in Quasi-Experimental Designs: Matching methods for causal inference. Chapter 11 (pp. 155-176) in *Best Practices in Quantitative Social Science*. J. Osborne (Ed.). Thousand Oaks, CA: Sage Publications.

Tatsis & Koleza, (2008)Social and socio-mathematical norms in collaborative problem-solvingEuropean Journal of Teacher Education Vol. 31, No. 1, February 2008, 89–100

Tavakol, M. and Dennick, R., 2011. Making sense of Cronbach's alpha.*International journal of medical education*, *2*, p.53.

Thongmak, M., 2013. Social Network System in Classroom: Antecedents of Edmodo© Adoption. *Journal of e-Learning and Higher Education*.

Thorpe, R., & Holt, R. (2008). The SAGE Dictionary of Qualitative Management Research (8th Eds.) London, United Kingdom: SAGE Publications Ltd. doi: ISBN: 9781412935289

Visser, C., 2010. Self-determination theory meets solution-focused change: Autonomy, competence and relatedness support in action. *InterAction-The Journal of Solution Focus in Organisations*, *2*(1), pp.7-26.

Vygotsky, L. S. (1987). Thinking and speech. In Reiber, R. W. & Carton, A. S. (Eds.), *The collected works of L. S. Vygotsky*. New York: Plenum Press, 39-243.

Wæge, K., 2010. Motivation for learning mathematics in terms of needs and goals. *CERME 6–WORKING GROUP*, *84*.

White, H., & S. Sabarwal (2014). Quasi-experimental Design and Methods, Methodological Briefs: Impact Evaluation 8, UNICEF Office of Research, Florence.

Xia, C., Fielder, J. and Siragusa, L., 2013. Achieving better peer interaction in online discussion forums: A reflective practitioner case study. *Issues in Educational Research*, *23*(1), pp.97-113.

Yackel, E., & Cobb, P. (1996). Sociomathematical norms, argumentation, and autonomy in mathematics. Journal for Research in Mathematics Education, 27, 458-477.

Yelverton, R.M., 2014. Motivation and Engagement across the Kindergarten Transition: A Self Determination Perspective. *Dissertations and Theses.* Paper 2026.

Zakaria, M.H., 2013. E-learning 2.0 experiences within higher education: theorizing students' and teachers' experiences in Web 2.0 learning.

Zaidieh, A.J.Y., 2012. The use of social networking in education: challenges and opportunities. *World of Computer Science and Information Technology Journal (WCSIT)*, *2*(1), pp.18-21.

Zgheib, G. and Dabbagh, N., 2012. Exploring Perceptions of Faculty and Students' Use of Social Media in Higher Education. *Unpublished manuscript, Graduate School of Education, George Mason University, Virginia, United States*.

Appendices

Appendix A: Students' Survey

<u>Kindly respond to the following survey with (√) under the most suitable answer</u>

The following questions deal with your views, feelings, and actions in **your mathematics class**.

Please indicate how often each statement is true for you.

		Strongly Agree	Agree	Slightly Agree	Strongly Disagree	Disagree	Slightly Disagree
1.	I can make a lot of decisions in how I solve math questions.						
2.	My classmates tell me I am good at math.						
3.	I regularly do well in mathematics.						
4.	I prefer working alone in math class.						
5.	In math class, I feel personal freedom to do things my way.						
6.	When I am solving math, I regularly do not feel very talented.						
7.	I can easily express my thoughts and opinions about math within my math group						
8.	When discussing problems in math class, my ideas are taken into consideration.						
9.	Mathematics is not one of my strengths.						

10.	I feel I can do math the way I want to do it.						
11.	I do not feel that I am very good at math.						
12.	Mathematics is more difficult for me than many of my classmates.						
13.	I don't think I can solve math problems in my own way.						
14.	I feel I can do math only in the way the teacher explains						
15.	I am confident I can do an excellent job on my math assignments.						
16.	During math class, I feel pressured.						
17.	I like to try my own ways in solving math problems.						
18.	Writing solutions to problems in math class helps me understand better						
19.	Explaining my understanding of math to my classmates help me relate better to the topic						
20.	I like to write about mathematics.						
21.	Writing about problems in math class helps me think						

	about what I'm learning in other topics in mathematics.						
22.	It is important to write about problem solutions in math class.						
23.	When I do not understand a topic in mathematics in the beginning of the lesson, I know that I will never understand it.						
24.	Explaining my answers in writing in math class has no effect on my learning of mathematics.						
25.	I feel more confident in math class when I use writing to express my thinking through writing.						
26.	Writing in math class is a waste of time.						
27.	I understand math concept better, when I write about concepts from math class						
28.	I don't have much opportunity to decide for myself how to do math						

Appendix B: The Electronic Journal Project

What is a Mathematics journal?

A journal is a weekly assignment in which you will turn in one problem (you choose from a given range of the book exercise for your assigned lessons) and write two ***reflections*** about that problem.

What is the Reflection (Reflective Writing?)

Reflection is:

- A form of personal **feedback** to experiences, situations, events or new information.
- A processing phase where thinking and learning take place.

The reflective thinking process starts with **YOU**, you need to pause and identify and examine your own thoughts; doing this involves going back to your previous knowledge and information of the subject area you are reflection on . It also involves considering how and why you think the way you do. The examination of your beliefs, standards, attitudes and assumptions forms the foundation of your understanding.

Reflective writing is NOT:

- Just turning over information, instruction or argument
- Pure description, though there may be descriptive elements

Why to Do This?

The objective of the journal is to increase your understanding of the topics that you are covering this course. The goal of the course is not for you to repeat steps and procedures without understanding what they mean and why they are important.

These journals will help you make connections to previous mathematics classes, give you insights about what you are learning in this class, and allow you to develop your mathematical understanding and confidence.

How will you do it?

The Mathematics Journal will have a specific format: two columns. In the column on the left, you will solve one problem – showing ALL your work. In the column on the right, you will write a reflection of your understanding of that problem.

This is unfamiliar to most of you, so let's break it up into pieces. What goes into a reflection?

There are a number of things that you can "reflect" about in your homework journal. The following are suggestions for you to choose from:

Group I:

- Describe in detail the process you used to solve this problem. What steps did you take to solve it, and why did you choose those steps?
- Describe the idea of this problem. What are the theoretical ideas of this problem?
- Write a message to your teacher explaining what you do understand about this problem and what needs to be clarified.
- Find something that you did while solving this problem that was similar to something you already knew or learned in a different topic in math. Write about these similarities.

Group II:

- Summarize the solution of this problem. Why did you choose to solve it this way? What do you know exactly in this solution, and what are you not sure about?
- How successful do you feel you were in solving this problem? Why? Do you feel you would be successful in solving a similar problem? Why or why not?
- How did solving this problem make you feel about doing mathematics?
- Choose one problem that you got wrong the first time. What process did you use until you succeeded?

Instructions

- You do not have to answer every question listed above in your journal; however, you must answer at least one of the questions from each group listed above in for each problem you chose. (one question from group I, one question from group II for each problem)
- You have to use <u>each</u> of the suggested questions at least three times

Here's an example of a journal reflection about one exercise from term II
(Geometry book - lesson 6.4- Ex16)

This is similar to what you will be expected to turn in…..

Problem	**Reflection**
Step 1 Show that $\overline{PR}$ and $\overline{QS}$ are $\cong$. $PR = \sqrt{11^2 + 5^2} = \sqrt{146}$ $QS = \sqrt{5^2 + 11^2} = \sqrt{146}$ Since $PR = QS$, $\overline{PR} \cong \overline{QS}$. **Step 2** Show that $\overline{PR}$ and $\overline{QS}$ are $\perp$. slope of $\overline{PR} = \frac{-5}{11} = -\frac{5}{11}$; slope of $\overline{QS} = \frac{-11}{-5} = \frac{11}{5}$ Since $\left(-\frac{5}{11}\right)\left(\frac{11}{5}\right) = -1$, $\overline{PR}$ and $\overline{QS}$ are $\perp$. **Step 3** Show that $\overline{PR}$ and $\overline{QS}$ bisect each other. mdpt. of $\overline{PR} = \left(\frac{-4+7}{2}, \frac{0-5}{2}\right) = \left(\frac{3}{2}, -\frac{5}{2}\right)$ mdpt. of $\overline{QS} = \left(\frac{4-1}{2}, \frac{3-8}{2}\right) = \left(\frac{3}{2}, -\frac{5}{2}\right)$ Since $\overline{PR}$ and $\overline{QS}$ have same mdpt., they bisect each other. Diags. are $\cong \perp$ bisectors of each other.	This problem requires applying three rules; the distance, the slope, and the midpoint I did it this way because the teacher solved a similar problem on the board I know that the two numbers (answers)for steps one and three have to be equal, but for the slop they must be inverse reciprocals and I also know that I have to write a conclusion at the bottom line. What I don't understand is: do we always have to use the three formulas ? and how do I choose the points ?

- Create an iBook to include all your reflections, you can also add screenshots from the class virtual discussions that helped you to reflect on this problem

<u>The list of the exercises you can choose from for each lesson is provided below</u>

ALG 1 7	**7.2**	(Pages 467 to 469) Exercises	**64, 65, 66, 70, 71, 72, 73, 74, 75, 77, 80.**
	7.3	(Pages 476 to 479) Exercises	**52, 53, 54, 72, 73, 74, 75, 77, 80, 81, 83.**
	7.4	(Pages 484 to 486) Exercises	**64, 68, 70, 76, 77, 78, 79, 80, 82, 85, 87, 88.**
ALG 1 10	**10.1**	(Pages 691 to 694) Exercises	**19 to 26 (Graphs only) 35, 37 to 39**.
	10.2	(Pages 698 to 701) Exercises	**2, 4, 5, 6, 8, 9, 10, 11, 14, 16, 18 to 21.**
	10.3	(Pages 706 to 709) Exercises	**41, 42, 50, 51, 52, 55, 56, 57, 58.**
	10.4	(Pages 718 to 721) Exercises	**12, 15, 16.**
GEO 7	**7.1**	(Pages 469 to 471) Exercises	**18, 27, 28, 30, 33(a, b).**
	7.3	(Pages 486 to 489) Exercises	**10, 19, 26, 29, 30, 32, 33,** 34 to 37, 40.
	7.4	(Pages 498 to 501) Exercises	8 to 11, **12,** 25, 26, 27, 30, 32 to 36.
	7.5	(Pages 505 to 508) Exercises	**2, 12, 13, 14,** , **33,** 36, 39 to 42.

Appendix C: Students' Interview Questions

Follow up questions (indented) will be used to gather additional information from participants.

Personal Background

1. Please describe your previous experiences in mathematics classes.
2. Have you ever experienced writing and discussion board activities in mathematics classes? If yes, what did you feel about that?

Motivation

1. During this term in mathematics class, do you feel motivated to…?
    - Do your electronic journal project weekly task?
    - Study for tests?
    - Engage in class face-to-face discussions?
    - Engage in the class virtual online discussion?
2. Why or why not? (for all of the above questions)
3. Do you feel confident about your capability to comprehend the required material in mathematics and achieve well in the end of term exams? Why or why not?

Writing in Mathematics

1. In your opinion, did writing activities in mathematics help you to :
    - Feel more confident in your learning of mathematics? Why or why not?
    - Gain a better understanding of mathematics? Why or why not?
    - Express your own thought and understanding of mathematics? Why or why not?
    - Feel more freedom in your mathematics class? Why or why not?
2. What other benefits do you think there might be to writing in mathematics?
3. Would you want to write in a future mathematics class? Why or why not?
4. In your opinion, which form of writing was more beneficial for you; class online discussion or the electronic journal project?

The Electronic journal Project

1. Describe the electronic journal project?
2. Do you think the electronic journal project is fun, overwhelming, useful, or neutral? explain
3. What did you like about the electronic journal project?
4. What didn't you like about the electronic journal project?
5. What were the advantages and disadvantages of these discussion boards?

Using of Web 2.0 Writing Application

1. Do you think the in-class virtual discussions is fun, overwhelming, useful, or neutral? explain
2. After participating in these virtual discussion activities do you hope to have them in your next math classes? Explain
3. Do you think multiform of online discussion was worth the time and effort it involved or you think the face to face discussion was enough to get the same results? Explain
4. Which of the following you enjoyed more
    - Reading solutions that my classmates posted on the discussion board?
    - Commenting on your classmates' contributions to the discussion boards?
    - Posting solutions to the discussion board?

5. Which you did most and which you did least? (for all of the above questions)
6. What were the advantages and disadvantages of these discussion boards?
7. Is online discussion similar to group work to you? Which you prefer more? Why?
8. Were online class discussions beneficial to complete your electronic journal project assignment?