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The Perceptions of Teachers and Students on a 21st Century Mathematics Instructional Model

Steve Warner[a] and Abtar Kaur[b]

[a]University of the Southern Caribbean, Trinidad and Tobago, WEST INDIES; [b]Hamdan Bin Mohammed Smart University, Dubai, UAE

ABSTRACT

Facilitating learning at all levels of the education stratum to create effective 21st Century knowledge creators, inventors and innovative workers is increasingly recognized today as a primary objective of education. Presently, the rapid expansion and availability of knowledge indicates the importance of curriculum and instructions that will empower learners to process knowledge using learner centered strategies rather than merely memorizing facts infused by facilitators. The study applied a qualitative research design. Interviews were completed on teachers and students to determine their perceptions on the effectiveness of the 2T2C model. Teachers' perceptions indicated that they gained a better perspective from the teaching and learning classroom environment; high-order questioning and thinking were accomplished; the relationship between mathematics through real-world questions was realized by students; communication improved through planned cooperative and collaboration sessions; the use of technology as a resource both in and out of class provided a framework for communication and thinking; and students' confidence and self-efficacy improved as they took responsibility for their learning. This paper presents how the 2T2C Model was conceptualized and reports on teachers' and students' perceptions on the model.

KEYWORDS

21st century skills, social learning, collaborative strategies, critical thinking, creative thinking, instructional strategies

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Introduction

Education devoid of teaching and learning of thinking skills and dis-contextualized learning environments, is merely knowledge gathering and remembering. The advent of institutionalized teaching and learning, along with its critically significant summative examinations, has mainly weakened student's ability to acquire the core 21st Century skills of high-order thinking, communication, creativity and innovation, problem solving and confidence. Thus, what we have done in the education system is to emphasize a lesser

CORRESPONDENCE Steve Warner steve.warner.c@gmail.com

function of the human brain. What is needed is thinking that leads to ideas about problems for which there are no definite or right answers; thinking leading into further enquiry about economic, social, scientific and technological advancements, for which there are a series of alternatives that can be applied or assist in solving some present-day dilemma. Learning environments therefore, have the opportunity to create a new type of graduate which the 21st Century demands. As such, the goal of this paper is to present a model which will equip and inform educators with some of the skills and competencies needed to create an environment for facilitating learning, where thinking creatively, critically and innovatively, as well as other important skills, are major objectives of 21st century education. The 2T2C Model (Thinking, Technology, Communication and Confidence), has proven that it can aid in transforming classroom settings and assist in improving learners' creative, inventive and innovative thinking, indicative of pedagogy and technologies, to accomplish the dissemination of skills and competencies fitted for the 21st Century learner (Warner, 2015).

This study is derived from a larger study developed in The Republic of Trinidad and Tobago (West Indies), exploring whether using a new instructional model, 2T2C, to infuse 21st century skills, while attaining mathematical concepts and content simultaneously, will be effective and result in students acquiring skills and competencies required in the 21st century. The classroom environment was transformed to an active and interactive setting, where learning occurred cooperatively and collaboratively, and where students' efficacy was addressed and technology tools applied as resources. Real-world questions were used and high-order questioned employed in group projects and other classroom applications.

In Trinidad and Tobago, the secondary school curriculum is highly developed and the Curriculum Division for secondary school continues to make inputs, where necessary, to ensure it remains abreast with international standards (SEMP, 2002). All cognitive levels as in Bloom's Taxonomy are embedded in the curriculum (Curriculum Division and Planning, 2011). In secondary schools, teachers are continually encouraged to receive teacher training. However, despite all of this being done and instructional information placed in documents and sent to schools, the traditional modality of teacher-centered instruction continues as the major instructional approach. This is due to the summative high-stake assessment which awaits students at the end of secondary school. The key ingredient is not about learning but preparing students to perform successfully at these examinations (Campbell, 1997; Herbert, 2004, De Lisle, Seecharan & Ayodike, 2010).

The topic of the progenitor research, was therefore chosen to present and implement a model which will provide an alternative for the traditional practical teaching, where 'the teacher is the sage on the stage' and predominantly uses the lecture instructional strategy. The use of social and cognitive constructivism formed the basis of the theoretical framework. It has become imperative in the 21st century that students be taught or facilitated differently in schools via instructional strategies and techniques (Friedman, 2007). Thus, it is crucial to report the effects of the new model from teachers and students.

Literature Review

The 2T2C Model

Figure 1 depicts the 2T2C Model (Warner, 2015). The theoretical framework, using the constructivist theory, forms the basis of the model. The instructional strategies and techniques (such as problem-based learning, questioning, brainstorming, the lecture method and the think-pair-share method) are provided to teachers via the teacher training sessions. The teachers equipped with the instructional strategies and techniques and 21st Century thinking, delivers the mathematics curriculum content and concepts, using high-order thinking, technology resources, collaboration and cooperative methods, real-world projects and assisting learners with their confidence and having responsibility for their learning. Finally, the learners themselves will possess elements of 21st Century skills and competencies and be prepared for future endeavours.

Implementation of 2T2C

Facilitators were trained in instructional approaches, as to how to encourage their learners to be confident; how to enhance students' communication skills; how to integrate higher-order thinking skills; and how to use technology to achieve all the above. In such an interactive environment, mathematics conceptual teaching and learning can be accomplished effectively and efficiently.

Thinking is a cognitive process, which can be described in many ways. Here, thinking skills will be described using higher-order thinking skills schemata. The ability to reason at higher levels is accepted and considered as a major instructional goal of education and is regarded as a motivating force behind efforts to reform education over the past two decades (Costa, 2001). However, teaching using higher-order thinking (HOT) is complicated and difficult as some educators have determined especially when standardized testing makes teaching for HOT even more demanding and taxing (Ravitch, 2010). The implication here is that this standardized test primarily focuses on low-order thinking (LOT).

In general, it is difficult to give a precise definition of higher and lower order thinking, but as Resnick (1987) and Marzano et al. (1988) illustrated, LOT and HOT can be identified when each occurs in practice. It is therefore necessary to differentiate between LOT and HOT. LOT is often categorized as the remembering of information or the application of concepts or knowledge to well-known and familiar situations and concepts (Thompson, 2011). Schmalz (1973) remarked that LOT tasks require a student "… to recall a fact, perform a simple operation, or solve a familiar type of problem; it does not require the student to work outside the familiar" (p. 619). Senk, Beckmann & Thompson (1997) characterized LOT as solving tasks where the solution requires applying a well-known algorithm, often with the student having no justification, explanation, or proof required, and where normally only a single correct answer may be meant to be possible. overall, LOT is regarded as solving tasks while working in familiar situations and contexts or applying well-known algorithms familiar to the students and which was taught or presented in the classroom by a teaching professional.

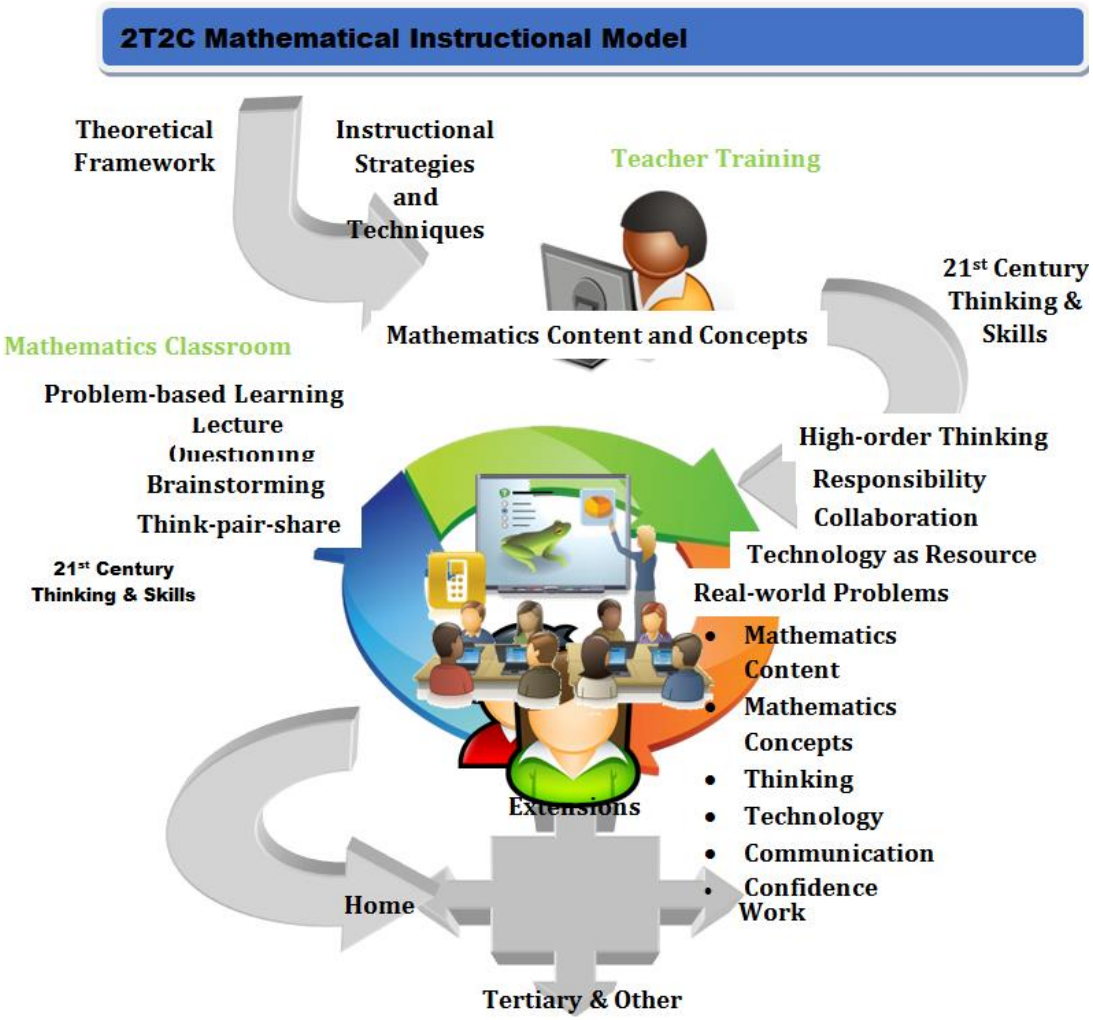

Figure 1. The 2T2C Model

Components of 2T2C Model

Thinking Skills

In contrast, Resnick (1987) deemed HOT as requiring subtle judgment and being non-algorithmic which means that the solution is not known or specified beforehand. Likewise, Stein & Lane (1996) depict HOT as "the use of complex, non-algorithmic thinking to solve a task in which there is not a predictable, well-rehearsed approach or pathway explicitly suggested by the task, assigned instruction, or a worked-out example" (p. 58). Senk et al. (1997) categorized HOT as solving tasks where no algorithm has been taught, where justification or explanation are required, and where more than one solution may be possible. In mathematics for instance, what distinguishes a non-routine problem from a routine problem, or an exercise or project, is whether the student already knows an algorithm that, when applied, will lead to a solution (Charles & Lester, 1982).

In the main, HOT involves solving tasks where an algorithm has not been taught or using known algorithms while working in unfamiliar contexts or conditions. In other words, HOT allows students to develop their creative and cognitive abilities.

Brookhart (2010) defines HOT in three categories: in terms of transfer, critical thinking and problem solving. Anderson & Krathwohl (2001) states that two of the most crucial educational goals stems from promoting retention and transfer – which when they are being experience, constitutes meaningful learning. Norris & Ennis (1989) envisioned HOT as "reasonable, reflective thinking that is focused on deciding what to believe or do" (p. 3). Barahal (2008) defines HOT as "artful thinking" (p. 299), which includes reasoning, questioning and investigating, observing and describing, comparing and connecting, finding complexity, and exploring viewpoints. In terms of problem solving, Nitko & Brookhart (2007) describes this process as a desire by the student using one or more higher-order thinking developments.

Technology

Technology is an ever-progressing component of our global society and has become ubiquitous in one form or another in learning institutions. Studies on the effects of integrating technology in teaching and learning have begun to provide evidence on students' achievement. Simplico (2002) believes that this should gain the attention of teachers to transform their teaching methodologies as it is a major ingredient in the lives of youths all over the world.

To determine the relationship between computer use in classroom instruction and mathematics achievement, among fourth and eighth graders, Wenglisky (1998) found that "higher mathematics scores were related to adequate access to computer technology in conjunction with teachers trained in technology use and the use of computers to learn new high-order concepts" (p. 2). Learning and teaching higher-order concepts and skills are main goals of newly developed performance based instruction (Georgia State Department of Education, 2006). Memorizing facts is no longer the most effective approach to learn. Making connections from the classroom to the real world is more of what teaching today encapsulates. The infusion of technology can assist in bridging this gap.

What is required is the proper infusion of technology in the teaching and learning process. The articulate and skillful use of technology by teachers will enhance and improve student learning and can easily transform the classroom environment into a place where learners can be able to be analyzers and synthesizers of real-world problems and be fitted with 21st Century skills (Wagner, 2008).

Communication

Interaction and dialogue are key components of learning according to the social learning theory (Bandura, 1971). Social constructivism emphasizes the conciliation of meaning and construction of shared understanding through dialogue (Jonassen, Howland, Marra & Crismond, 2008). Vygotsky's (1978) view on learning as a social process that occurs within the zone of proximal development (ZPD) also position's interaction as crucial to the development of thought and behaviour. Communication is so crucial in the 21st Century that

both the cooperative and collaborative approaches to learning depicted by Bandura (1971), Vygotsky (1978) and Jonassen et al. (1998) need to be integrated into any teaching and learning methodology.

Cooperative learning as defined by Slavin (1982) is an instructional method whereby students in small groups of two or more individuals, carried out as a team, specific common learning goals and objectives. All the members of a group are expected to be actively committed to working mutually to achieve the established objectives for the activities to be called cooperative learning. Similarly, Johnson and Johnson (1991) defined cooperative learning as the instructive use of small groups for students to work together and maximize their own learning and that of the others members of the group. Johnson and Johnson (1983) also stressed that cooperative learning encourages the use of higher reasoning strategies and greater thinking capabilities as students participate and work as a team.

Similarly, Sadker & Sadker (2000) defined cooperative learning as an approach in which students are instructed to work in small, heterogeneous groups to achieve a common learning goal and a collaborative rapport among participants. Students work together, helping one another master the learning objective. Researchers have examined this instructional approach to find the most profitable strategies for the classroom and the learning experience of all involved. These studies show that a variety of benefits may emerge from using this method effectively. Among these benefits are increased academic achievement, enhanced social skills, and improved self-esteem for many students (Slavin, 1995). Collaborative learning refers to learning whereby assistance is provided by an individual or group of individuals to another individual or group of people to attain the desired learning goals (Mastropieri, Scruggs, Spencer, & Fontana, 2003). Piaget (1928) argued that social life is a necessary condition for the development of logic. Social interaction is a central theme in Vygotskian theory. He suggested that it is not possible to appreciate an individual's cognition in isolation from the social constructs in which they are situated. A student learns first through social interaction and, in turn, internalizes this knowledge on a psychological level, which allows for further individualistic cognitive development (Vygotsky, 1981).

Confidence

Without confidence/self-efficacy in one's ability, students cannot perform to their potential or at their highest standard. It is even possible that learners with lesser abilities, but with confidence, can outperform higher ability students because belief in oneself can be a powerful influence. Bandura (1986), refers to situation-specific 'self-confidence as self-efficacy, which is the strength of an individual's belief that they can successfully perform a given activity or task. The concept of confidence has often been used interchangeably with the concept of self-efficacy and self-confidence.

Self-efficacy, also called perceived ability, refers to the confidence students have in their abilities for success in each task (Bandura, 1997). If they possess the ability to successfully perform, then that task will be attempted. The task will be avoided if it is perceived to be too difficult (Bandura, 1986, 1997). Although inefficacious students usually avoid challenging tasks, when they do attempt them they give up more easily than students with high self-efficacy.

When inefficacious individuals fail, they attribute the unsuccessful result to a lack of ability and tend to lose faith in their capabilities. When they succeed, they are more likely to attribute their success to external factors (Bandura, 1997, 1986). If students master a challenging task with limited assistance, their levels of self-efficacy or confidence rises (Bandura, 1986)

The Need for 21st Century Skills and Competencies

Twenty-first century skills include teamwork, communication, innovation, and creativity and have as corollaries, creating, evaluating and analyzing, challenging the learner, promoting active participation, argumentation, problem solving, conducting investigations and tackling subject matter that is complex (ATCS, 2010). It involves a new classroom culture that caters for learners being at the center of learning and being fully involved in social and collaborative learning.

Twenty-first century skills from The Framework for 21st century Learning (Partnership for 21st Century Skills, 2009), consists of critical thinking and problem-solving, communication and collaboration, and information communication technology literacy and application. The solution to making 21st century skills have an important effect on learners is to transmute them into learning applications connected to curriculum content and assessment (Jacobs, 2010). Regan (2008) corroborates that the infusion of 21st century skills must be a primary element of teaching and learning and not placed as add-ons to the curriculum.

It is easy to articulate a commitment to the development of 21st century skills but is more demanding to translate this commitment into action. How do we develop curriculum for learning environments and facilitating and learning strategies that both addresses subject matter content and emphasizes 21st century skills? Such a curriculum will encompass student taking responsibility for their own learning, and having confidence in their abilities to perform the assigned tasks.

Beers (2011) and Greenstein (2012) ask the following questions concerning the importance of 21st century skills: as educators, what do we need to do to prepare our students for the rapidly changing, technology-rich, interconnected global community? What does it mean to be literate in today's world? Can our students question and critically evaluate the information they view? Are they able to work together to solve problems? What do they do when faced with new problems? Are they able to understand and synthesize multiple perspectives? To effectively and efficiently survive and prosper today, students will need well thought out applications of 21st century skills.

It must be noted and emphasized that these 21st century skills have always been important for students; however, they are particularly and significantly crucial in our present information and knowledge-based economy and society. To be able to hold information-age jobs, graduates need to think deeply about issues, solve problems creatively, work in teams, communicate clearly in many media, learn ever-changing technologies, and deal with a flood of information (Friedman, 2005). The rapid changes in our world require students to be flexible, to take the initiative and lead when necessary, and to produce something new and useful.

Friedman (2007) and Wagner (2008) states that employers in the twenty-first century stipulate that employees be critical thinkers, effective collaborators, innovators, and excellent communicators. Bellanca & Brandt (2010) also agrees that twenty-first century companies, organizations and countries are interested in finding the most qualified human capital to contribute to the advancement of knowledge creation. Hence, there is a challenge for educators to transform how they prepare learners for the inevitable and impending workforce. In other words, learning institutions should approve and permit the empowering of students to obtain 21st Century skills and knowledge to meet the demands of a knowledge-based economic workforce.

Instructional Models

An instructional model is a well-developed way of teaching that not only has a strong rationale, but lines of research into their workings and into what is expected once it is used (Joyce, Calhoun & Hopkins, 1997). It is imperative therefore, that instructional models are identified that assist facilitators to assist their learners in acquiring the 21st century skills derived from instruction. Students have different learning preferences and learn at different rates. Joyce, Weil and Calhoun (2009) advocates that teachers must not only be knowledgeable about the content they teach, but must also know and be committed to making decisions that involve the use of a variety of instructional models, their accompanying strategies and techniques, and approaches suited for purposes and appropriate to meet the diverse learning needs of students. Illustrating from major philosophical and psychological theories regarding how humans learn, Joyce, Weil, and Calhoun (2009) described four families of instructional models, namely: The Informational-Processing Family, The Personal Family, The Social Family, and the Behavioral Systems Family.

Information-Processing Family consists of several sub models, which were derived from their developers and then redevelopers, namely, inductive thinking; concept attainment; the picture-word inductive model; scientific inquiry and inquiry training; mnemonics; synaptic; and advance organizers. Aspects of the sub-models which were suited for this study were concept formation and inductive learning, concept attainment advance organizers and scientific enquiry. In concept formation and inductive learning, students are expected to ingest and process information - mathematical concepts of the various topics – and go beyond them, via real-world questions, to produce creative thinking and solve problems. The teacher arranges the classroom environment and gives specific task to students so that they can form and use the concepts presented.

The social family group of models aims at building learning communities and purports to develop productive ways of interacting in a democratic setting. Also, under the behavioral systems family's social learning model, created by Bandura (1971), purports strategies and techniques to support teacher to student and student to student learning methodologies. These models also emphasize that social learning occurs in interactive environments and through modeled behaviours and communal exchanges. These strategies and techniques are clearly cognitive in nature. They emphasize ways of enhancing students' innate desire to make sense of the world by acquiring and organizing information, solving problems, and thinking at higher levels. Other techniques

consistent with cognitivism are discovery learning, reception learning, and reciprocal teaching.

One of the most difficult tasks in teaching mathematics is assisting students whose confidence has sunk to a level where they wallow in failure or where they do not believe that they can do mathematics or where they do not see its relevance. The personal and social families are consistent with enhancing confidence/self-esteem emphases on holistic learning and the development of human potential. The personal models of learning begin from the perspective of the selfhood of the individual. Teachers who use the approach to enhance student's confidence/self-esteem attempt to develop a classroom atmosphere that promotes the accomplishment of affective as well as cognitive outcomes seek to increase students' self-awareness and sense of responsibility. These teachers often also take a nondirective teaching approach and act as a facilitator who helps students clarify goals and participate in developing avenues for reaching those goals.

It is important to note that if students cannot commit knowledge or skills to memory, and somehow apply them in their daily experiences or see them being applied, even briefly, how can we know they have learned the knowledge or skill? This invokes visions of the cartoon where two boys are talking. One boy, with his dog at his side, says, "I've taught my dog how to whistle," and the other little boy says, "Great! Let me hear him whistle." This prompts the first boy to say, "I said I taught him how to whistle. I didn't say he learned it!" (Banikowski, 1999). Educators must ensure that students attend to learning, attach new learning to previous learning, actively engage in learning, construct meaning, and demonstrate their learning.

Educators' goals should thus be to have their learners organize, store, and retrieve knowledge and skills. By applying what we know about how the brain functions and remembers, educators can focus on the learning aspect of the teaching/learning process. All this can only happen if facilitators have the knowledge and experience and use the correct instructional models, strategies and techniques. Instructional strategies and techniques for facilitation must thus be provided to facilitators to ensure that they have these skills and competencies. It is thus imperative that a facilitation model for the 21st Century be considered and constructed. This invariably led to the development of 2T2C.

Theoretical Framework

Constructivist theories stand out clearly as the most suitable to examine the infusion of twenty-first century skills by mathematics teachers of secondary schools. This constructivist theory of learning attributes most of its foundational principles to the works of Piaget (1950) and later Vygotsky (1978). The following discussion depicts the cognitive learning theory and the social learning theory of constructivism and how well known proponents such as Piaget, Vygotsky, Papert, Bruner, and Ausubel, demonstrates its importance in the process of learning. Teachers and learners will therefore be guided via active, collaborative and cooperative measures and strategies to accomplish high-order thinking, confidence, technology competencies, and communication skills, through real-world problem solving tasks, in the form of projects, to attain the skills related to twenty-first century skills and competencies.

Constructivism is a theory with its foundation on observation and scientific study about how humans learn cognitively. It states that people construct their own understanding and knowledge of the world personally and this through experiencing things and reflecting on these experiences (Huitt, 2003). Constructivism as a process of learning can be explained when an individual encounter something new for the first time (Kaur, 2001). This new item of knowledge first must be reconciled with previous ideas and experiences, and may change what was believed, or maybe discard the new information as irrelevant. Thus, constructivism involves actively creating our own knowledge by asking questions, and exploring and accessing what we know.

Vygotsky's theory formed the core for social constructivism, which emphasized the importance of social interaction and culture in the construction of knowledge and learning. According to Vygotsky, knowledge and learning are constructed through human interaction with one another. Knowledge is a human product that is socially and culturally constructed (Gredler, 1997). Learning is not simply the assimilation and accommodation of new knowledge but is acquired by actual relationships between learners.

The development of 2T2C took into consideration the need to prepare students for work and/or further studies after secondary school. At the core of the 2T2C model are its four pillars, thinking, technology, communication and confidence. The 21st century requires a different type of graduate who should possess skills to live, function and work in a highly technological and dynamic world. With this backdrop and the need to create learning environments that assist students to acquire 21st Century skills, 2T2C was developed.

The Teaching of Mathematics at WSS

There are 6 mathematics periods per week at WSS each lasting 40 minutes. The mathematics curriculum is based on following the Caribbean Examinations Council (CXC) topics in preparation for the Caribbean Secondary Education Certificate (CSEC) examinations. Each school year consists of three terms which begins in September and ends in June. There are topics to be covered each term and there is time for the infusing of 21st Century skills and competencies simultaneous while the teaching of mathematics is being facilitated (Warner, 2015).

Purpose of the Study

As explained earlier, this study is a derivative of a bigger study, and its main goal is to explore the perceptions of teachers' and students' of the experiment group of the 2T2C model.

The specific research question is:

What are teachers' and students' perceptions of the instructional model in the teaching and learning of mathematical content and concepts?

Research Methodology

Qualitative research designed was used in the study whereby two teachers of the experiment group were trained for 9 weeks to implement the 2T2C model. Students were interviewed using one-on-one and focus group approach. The teachers were interviewed. Specifically, semi-structured interviews, consisting of

a list of open-ended questions, determined how teachers and students perceived the tenets of the instructional model in terms of acquiring 21st Century Skills and understanding mathematical concepts simultaneously. The open-ended nature of the questions provided opportunity for the researcher and interviewees to discuss their experiences in greater detail. When the interviewees had difficulties in answering a question or hesitated, the researcher was able to probe further. Three types of probes were used, as stated by Barriball & White (1994), namely, the detailed-oriented probe, the elaboration probe and the clarification probe.

The sample was selected from a total of 50 teachers and 765 students from Waterloo Secondary School (WSS), which has four departments, including the Mathematics and Computer Science Department. The sample was then selected from a total of 8 mathematics teachers (there are only 8 mathematics teachers at WSS) and 117 Form Four students (students between the ages of 14 and 16 years). The Four teachers were chosen based on the Head of Department allocation choices and their eligibility to teach in these Forms by the Ministry of Education. Also, there are 4 distinct Form Four classes at WSS, namely, Business, Science, General and Modern and one mathematics teacher is assigned to each. The classes met at the same time for the duration of the 12-week study. Two teachers were chosen for the control group and 2 for the experiment group.

Result and Analysis

Teacher Perceptions

Focus group interviews were conducted with the 2 teachers with the following questions posed:

Question 1: How different was facilitating using the model from your strategies in the past, as it pertains to the teaching and learning of mathematical concepts?

Both teachers stressed how different facilitating was for them during the duration of the study. They also suggested that they were surprised by the outcome of the students and how welcoming and creative their students responded. The following excerpts represent teacher responses to the question posed:

To begin, I must say that although it is easier to teach using the lecture method, the results were more pleasing. For the first time in my 7 years of teaching mathematics I actually think that students in my class understand maths. Let me give you an example. In September I was struggling to really come to terms with preparing to implement the model and I did not know what to expect from the class, it being a new class also. Then I decided to make them feel comfortable and let them know how this term will be. And instead of just thinking about the exams [CSEC] I concentrated on learning and getting the children to understand the [mathematical] concepts. The response was positive and although there were some students who mentioned the exams [CSEC], the concepts were well received. [Teacher X, recorded November 27th 2013]

When questioned further by what Teacher X meant about saying that it is easier to teach using the lecture method, it was further explained:

What I meant to say is that it is easier to prepare to teach using the lecture method because there is less preparation to deliver or teach a lesson. Teaching conceptually means that plenty time has to be spent preparing the lessons beforehand. And as I mentioned earlier, the new model [2T2C] demands that if we want our students to learn then we have to [be] aware of the different types of learners in our classrooms and different instructional methods. And this requires more time and thus it is easier to just walk to class with a marker and duster and some content in ones' head or on paper and teach. [Teacher X, recorded November 27th 2013]

The following is Teacher Y initial response to question 1:

Well my experience was a bit different in that there were a few students who were very vocal and once they 'buy-into' [agreed to the term's work] what I wanted to do, it was 'smooth sailing'. I agreed with Teacher X in that I was kind of apprehensive about the model [2T2C] but the students starting showing interest in wanting to understand the [mathematical] concepts. And this made the implementation 'cool' [good]. In the end, I think the students of my class left understanding mathematics more; and maybe liking or appreciating it in a new way. [Teacher Y, recorded November 27th 2013]

Both teachers admitted that their approach to facilitating mathematics concepts using the 2C2T model was in stark contrast to what they were accustomed. They commented that they gave their students time to be heard and to be an active participant rather than a mere recipient of what the teacher had to say and explained. Teacher Y said that allowing students to think and answer questions was a crucial part of teaching mathematics, while Teacher X highlighted that the entire fabric of the lesson invited everyone to participate – "*.. because we were using strategies to include the entire class, such as group work, discussion and questioning and providing real-world problems – help students to think when normally they might not be called upon to think."* Both teachers summarized that their lessons encouraged all students to grasp mathematical concepts. Both teachers were amazed that they could complete the schemes of work with the time allotted with the many activities that engaged the students during the term.

Question 2: What challenges did you encounter in implementing the model in terms of your students acquiring mathematical concepts?

Teaching mathematics by giving students all what they need to pass an exam and then trying to have them understand it is two different things. So it was a challenge for some of my students to think and try to get the concepts. They were simply wanted me to give examples and show them what type of questions came for the exam [CSEC]. The model's activities though kind of force them to want to know and as the class went on they came around. [Teacher X, recorded November 27th 2013]

At first when I started asking questions it was difficult to get the kind of answers which will tell me that they are understanding the concepts. But with the different teaching methods I had at my fingertips to experiment with, things got better. Very soon I did not have to call on students to answer and share what they understood. I think that with the change of the classroom environment where I will normally be just talking and giving answers to one

where the answers are coming from the class was different and, well, good. [Teacher Y, recorded November 27th 2013]

Both teachers agreed that the communication sessions (collaboration and cooperative), though presenting some challenges at first, assisted the majority of students in understanding and applying mathematical concepts – this through real-world problems and projects. Despite the technical challenges in the schools' computer laboratory, the teachers agreed that the blogging and sharing on the wikis assisted many students in gaining a better understanding of the mathematical concepts presented during the term.

The teachers admitted that in their own discussions and their continuous collaborations with each other, and the researcher as advisor at times, that they were assisted tremendously in dealing with most of their challenges. This through sample questions and project meetings and the sharing of experiences throughout the term, as to what worked and what did not, and what may work. Thus, the teachers suggested as part of what the model fitted them with that they themselves began to collaborate and cooperate more to accomplish their tasks. They cited that the sharing was not only for their students but for them as well, as they implemented their duties and responsibilities.

In terms of the teaching option of implementing the model so that students can understand the mathematical concepts, the teachers admitted having the challenge of having to spend more time and effort to prepare for the teaching and learning of the mathematical concepts of the topics to be taught. However, they suggested that when they were fully prepared for the class it was easier to explain to the students in a palatable fashion so that students can benefit.

Question 3: What strategies and techniques did you use in your classroom instructions to ensure that the mathematical concepts were acquired by your students?

The teachers stated that the many strategies and techniques presented to them in the training sessions were very valuable to them. They commented that in their lesson planning it was crucial that they had a variety of strategies and techniques at their disposal.

I want to say this before I answer because it is important. I have not done Dip Ed [teacher training] yet but during the training sessions and learning all about the different methods of teaching and the various techniques, was good for me. The part about questioning and group work and brainstorming and others was responsible for my change in attitude and maybe it help my students want to learn and understand maths more. I am not certain but in my reflections I did note the interest and change in my students and myself. So, to answer your question, yes, both my students and I had a new experience and maths came alive for me and most of my students [Teacher X, recorded November 27th 2013]

From hearing you speak again about your experiences, I thing we had similar ones [experiences]. And I agree with what you said. However, you must admit that the preparation time to get all of this done is far more than using the normal method [lecture method]. But yes, it did benefit me and my students and the variety of approaches were good too. So yes, interest was there for most students and mathematics [concepts] was received by the students. [After

looking at his portfolio entries he further stated] …And I observed them after class and before class talking about maths and I felt really good. [Teacher Y, recorded November 27th 2013]

Thus, despite all the challenges of preparing and implementation using the various instructional strategies and techniques, the teachers suggested that the mathematical concepts presented to their students were well received and that most of them benefited from the 2C2T model.

Students Perceptions

The following two questions are examples of real world questions considered in the study:

1. The basic one-way air fare for a child aged between 3 and 10 years costs half the regular fare for an adult. The reservation charge is the same on the child's ticket as on the adult's ticket. One reserved ticket for an adult cost $216 and the cost of a reserved ticket for an adult and a child (aged between 3 and 10) costs $327.

What is the basic fare for the journey for an adult?

1. A small restaurant in Freeport serves a vegetarian and a chicken lunch special each day. Each vegetarian special is the same price. Each chicken special is the same price. However, the price of the vegetarian special is different from the price of the chicken special.

- On Thursday, the restaurant collected $467 selling 21 vegetarian specials and 40 chicken specials
- On Friday, the restaurant collected $484 selling 28 vegetarian specials and 36 chicken specials.

What is the cost of each lunch special?

Focus group interviews were conducted with the 2teachers with the following questions posed:

Question 1: How would you describe your mathematics experience this term?

All the respondents commented that the term's work in mathematics class was different and that the thinking sessions, with the challenging real-world questions and projects were demanding. Some mentioned that the motivation by their teacher was helpful and the teamwork in groups assisted and supported them in understanding the mathematics topics.

To be honest I do not consider myself a good math student but from the beginning of the class this term, she [Teacher X] motivated me to believe that I can do math and perform well in the class. My marks in the past weren't good but I believe this term it will be better. I give myself a chance now to solve problems that I will not even try before. Math class was real good and yes I appreciated the efforts of her [Teacher X] and my group mates [EGONE1, recorded November 26th 2013]

I now understand why we do mathematics in school and I finally got a chance

[opportunity] to use my computer for school work. I cannot wait for next term to reach. Besides struggling with the real-world problems, the class was different. A bit noisy at times but fun with my new group friends – I even made some closer friends from the group work [EGONE6, recorded November 26th 2013]

At first I thought that Miss [Teacher X] was not interested in preparing us for our exam [CSEC is the external examination for certification after 5 years of secondary school] but then I understood. I enjoyed the group work and my group [student Smiling]. We did not have sufficient time to use the computer during class time because it [time] went so quickly but we made up outside of class. [EGONE7, recorded November 26th 2013]

Most of the students who said that the class was different mentioned the skills and confidence they gained to solve real world problems. Others stated that the collaborative activities were different in terms of the structure and that the think-pair-share method worked for them. Still others said that the real-world questions did add meaning to them doing and understanding mathematics.

Despite most students being interviewed commenting on the various aspects of the classroom sessions, most of them had concerns about if they were being prepared and will be ready for their CSEC assessment at the end of their tenure in the upper school. Some students iterated that:

I was enjoying myself so much that I asked Teacher X what about preparing

for CXC [CSEC examination]. I wanted to know if I will be ready for CXC. Preparing for CXC is important and I just wanted to know that at the end I will be fully ready… my teacher gave me the assurance though that I will be. [EGONE5, recorded November 26th 2013]

…my concern was if I was being made ready for CXC. I just wanted to know that the problems were similar to what will be asked for CXC. I was told by Sir [Teacher Y] that I will be ready and that I should not worry. At some occasion Sir [Teacher Y] had to stop the class and explain to assure us. [EGONE2, recorded November 26th 2013]

Question 2: What did you enjoyed most about the activities in your mathematics class this term?

The student's responses were varied but centered on the active classroom environment facilities used and the teaching model employed. The students all noted that the collaborative atmosphere and the real-world challenging questions were at the forefront of their responses. In describing what was most enjoyable and different about the term's work this is what some of the interviewee stated:

The sessions were generally good and it did help me to be more motivated. I am motivated already and the earliest sessions prepared me for what was to come. I loved the group work in that I was allowed to think by myself and then share with my group members. The fact that I was given the chance to think was special. And the use of the computer to communicate with my group members outside of class solving problems was nice. The questions were

challenging and kept my group busy throughout the term, in and out of class. [EGONE4, recorded November 26th 2013]

What I enjoyed most was being able to work challenging questions out like never before. At first I was not sure [about solving the real-world problems] but as the class continue I was able to give it a shot [try] and was able to solve some problems; with my friends and of course by myself. And let me add also that the use of the computer to add sharing was nice … I had some issues with one or two of my group friends at first but afterwards things went well… maybe it was the work we all had to do [EGONE1, recorded November 26th 2013]

Question 3: What are your views of the computer sessions as it pertains to you learning mathematics this term?

Most of the students hinted that the computer sessions in the computer laboratory were helpful as it reiterated that there was so much information on the internet and that the wikis and blogs allowed them to put the pieces together as a group to solve the project problems. Some however saw the sessions in class as non-productive as the internet access was too slow. They however valued the use and purpose of wikis and blogs as presented by their teachers. EGONE3 and EGONE6 commented that the technology sessions were good because it took them out of the normal classroom session and use a resource which they were accustomed too.

…despite the internet being slow, the usefulness of the wiki seem to be something we can use. Also the change of classroom is good and using the computer is also a plus and a joy to us [EGONE3, recorded November 26th 2013]

…to have mathematics classes in the computer room is fun. The internet gave some trouble because it was slow today but we did learn something new, which we can try at home and use to be connected with our group members [EGONE6, recorded November 26th 2013]

Students admitted that despite the computers were slow, the change of environment to do mathematics and use the computer as a resource was an encouraging feature. The use of wikis and blogs also meant that they had the opportunity to extend the class when they are mobile or at home.

Question 4: What do you think about the real-world questions presented this term in mathematics class?

All the students commented that the real-world problems were challenging and made them think more than they ever had to think before in any mathematics class. They also said that they were happy that they had the group to assist them. In the end, most of them said that the thinking cause them to see the relevance of real-world questions. EGONE4 and EGONE7 said that their teachers' portrayal of the need to solve problems that were not linear or non-algorithmic l was well received as they saw the need for doing so.

I understand the relationship between mathematics and real-world problems. I find myself looking to working-out [solving] problems of every day by myself and with my friends out of class – my parents were even surprised. I actually surprise myself by continuing to relate math with my house work. [EGONE4, recorded November 26th 2013]

I never thought that this [mathematics] was so important and well, relevant. It's like it is found everywhere and in everything. I know now that maths is used to solve traffic issues and other social problems. This was new to me and my friends and I talk about it all the time… now that I know why I am doing maths, it have brought new meaning to this and other subjects… so school is not just about learning for learning sake… [EGONE7, recorded November 26th 2013]

Question 5: What are your views on the collaborative sessions of mathematics class this term?

Most of the students agreed that the collaborative activities were different and well-structured from other group work which they encountered in the past. The "think-pair-share" method of performing group work was one of the procedures most referenced and most saw it as a novel and outstanding experience.

…I like the think and the pair part of the group work as it was different and made me really think to have something to share with my pair [pair colleague]

I actually got the opportunity to quietly think and share what I think in a maths class and my group was serious to the job [of solving the problems] [EGONE6, recorded November 26th 2013]

I hope that this method [think-pair-share] can be done in all my classes. I gained a whole lot from this and I tried this with my brothers at home and other friends. [EGONE2, recorded November 26th 2013]

The students also seem to suggest that the teacher's control of the classes during the group activities was manageable and accounted for the "think-pair-share" method to be a success. Some of the students hinted this when they said:

…although there was some noise at times in the class during group work it [the noise] did not stop us from learning and thinking and sharing too. The class space was good also for the group work and I learned a great deal. [EGONE4, recorded November 26th 2013]

… the classroom group work was well participated by most although some wanted to work by themselves. Teacher X had some problems at the beginning of the term but as the term went on all [students] participated [EGONE5, recorded November 26th 2013]

Question 6: Do you think that you have the skills to solve or attempt to solve real-world mathematics problems?

Most students retorted that they understood the process involved; as there were varied responses. Some suggested that they are in a better position to attempt to solve any mathematics problem; others said that they are gaining the confidence to believe they can solve any mathematics question presented; yet others stated that they are still a bit pensive and that the class this term was very encouraging in this regard. EGONE4 stated that they were in some doubt to begin solving problems but needed some more time to grow and gain the confidence required.

… my fear for solving maths problems is almost gone and … I feel much better now. I have change how I think about maths [EGONE2, recorded November 26th 2013]

… I have the skills but still a bit doubtful… I will get there shortly but I need to practice more and think more [EGONE5, recorded November 26th 2013]

… I have it [the skills] and I have worked out more problems this term [EGONE4, recorded November 26th 2013]

Some of the students hinted and suggested that the teacher's probing and questioning also accounted for them to think more about a solution. EGONE3 and EGONE7 commented that their teachers were not apt to just state the answer and go on but allowed them the space and time to think through the problems. They further stated that the real-world questions and projects assisted them to see the need for mathematics and being able to think and solve problems.

Question 7: What did you gain from the classroom interaction during mathematics classes?

The students interviewed said that they welcomed and enjoyed the interactions. They mentioned that their teacher's explanation of the need to acquire communication skills through collaboration were helpful. Despite not being on friendly terms with every member of the class, students suggested and emphasized that the professional nature of the group work was astonishing. EGONE4 admitted questioning whether all this group work would prepare them for CSEC examination and that one of his colleagues explained its usefulness in the 21st Century.

… it was a nice sight to see my friends in the class trying to work out a problem and then share what they think is the answer based on their reasoning [EGONE2, recorded November 26th 2013]

… because there was so much sharing in my group there was hardly [any] need for the teacher at times [EGONE7, recorded November 26th 2013]

… I can communicate with anyone now to solve problems – a really nice experience … I liked it when the group came together and we all put in our little pieces to help [solve the problem] … a really nice experience but I wondered if it will help me in exams [EGONE6, recorded November 26th 2013]

By and large, most students suggested that the mathematics classroom sessions were different and the inclusion of collaboration on the computer on the wiki and via blogging added to the extraordinary nature of this term's mathematics experiences. They also suggested that continuing the discussion online was a great move because classroom time was not sufficient when they started sharing ideas to solve the problems given.

… to have the class extended was really nice and then to use the computer was even better… as the class-time was not enough it was nice to have the internet to continue our discussions to solve the challenging problems… blogging was like Facebook minus the distractions [EGONE1, recorded November 26th 2013]

As the teachers were constantly faced with questions about preparation for CSEC, they expressed that they had to spend time explaining to students about the nature and purpose of mathematics. At times it caused some disagreements but the teachers pointed out that emphatically that they will be ready.

In this study, the exploration of teachers' and students' perceptions of implementing a newly designed instructional model, 2T2C, was deliberated. Despite having to spend more time to prepare lessons which will not only cater for mathematical content and concepts, the teachers of the experiment groups and their students were able to benefit from the new experiences, and the skills which they now possess. Despite the challenges faced by teachers in implementing the model initially, they were able to witness students thinking skills improve; see the desire for them to have responsibility for doing the various tasks assigned to them; use technology to communicate and share with their group members, both in and out of class; to listen attentively and give their peers a chance to answer when they of themselves think they know the answer to a question; and give themselves a chance at solving which before they may not even attempt.

The teachers said that they saw their students making efforts to understand mathematics concepts from the interest reaction and responses from the various techniques and strategies used. The think-share-method was a technique which both teachers corroborate was the highlight of the group work by most students. These results also show that it is possible to teach mathematical content and concepts simultaneously with elements of 21st century skills.

It was clear from the students' responses that although some were concerned with being prepared for CSEC, most enjoyed the challenges and appreciated the real-world problems and the group work. Thus, their thinking skills improved as they could use the new mathematical content and concepts and the old, to solve non-algorithmic problems. Most admitted that their confidence improved to the extent that despite how arduous and tough a problem may seem, they were willing to attempt to solve same. Some concurred that the technology assisted them with their work as the wiki platform kept the, and their classmates connected and sharing. Generally, most students benefitted from the experience positively.

The students of the experiment group also stated that their collaborative skills improved from the sharing in the group work activities. The strategies used were said to be different as the questioning and the 'think-pair-share' method being highlighted. They were forced to work with peers who otherwise they will not communicate. The two approaches used to choose group members were that the teacher placed students in groups and the other when students decide who they wanted to work with. There were some confusion and discontent, but these behaviours were short-lived, as the students quickly and collaboratively communicated to complete the tasks assigned to them. At times the groups were noisy but working together interactively was achieved. These results also demonstrated that it is possible to teach mathematical content and concepts simultaneously with elements of 21st century skills.

Based on the many responses of the teachers and students in their implementation of 2T2C, 2T2C can be used not only by mathematics teachers but teachers of any other teaching discipline. What is also important is that teachers must be trained to implement 2T2C and that it requires more time planning creative lessons to facilitate using 2T2C. However, the results will be an active classroom environment with learners having 21st century skills and competencies which are necessary for future studies and the present dynamic workforce (Friedman, 2007; Wagner, 2008).

Recommendations

Based on the feedback from teachers, the following are recommendations on how the 2T2C Model can be further improved. Both teachers agreed that 21st Century skills and competencies are necessary and should be included in the curriculum. The first suggestion which both teachers advocated was structured and continuous training of teachers to be able to infuse 21st Century skills and instructional strategies and techniques to ensure that learning takes place. The teachers were concerned about how to get other teachers to subscribe easily and acquiesce with the 2T2C Model.

In an education system that emphasizes and accentuates success at external examinations and where traditionally the teaching is geared primarily towards assessment, the change must be highlighted in terms of school leadership and reform. The teachers also suggested that schools must be furnished with several resources to engage all the different types of learning styles. The teachers further endorsed that to facilitate mathematical concepts, teachers must be prepared and committed and need support from the community of stakeholders. The preparation of lessons and having several learning resources was useful and necessary. The teachers' recommendations support current research on active learning and the reform measures needed to accommodate the workers in the 21st century (Friedman, 2007; Hyslop, 2011; Gordon, 2011; Phillips & Wong, 2010; Trybus, 2013). Generally, the teachers suggest that teaching 21st century skills can be infused simultaneously with the teaching of other subject disciplines and recommended that this should be experimented in the future. It will be useful to determine how the students of both groups performed at the CSEC examinations and can be the source of further studies of the impact of the 2T2C model.

Schools are tasked with major responsibilities of harnessing their learners with the necessary skills to be successful practitioners in the future. The framework of The Partnership for 21stCentury Skills (2009) addresses the needs of this changing world and developed its structure based on presumed future economic needs. Secondary schools need to be efficacious and revolutionary in preparing their learners for the world that awaits them (post-secondary school) in the 21st century. Some schools and education practitioners have responded by embracing globalization; however, to date there is limited research on these programs and practices.

This 2T2C Model as conceptualized is an avenue where mathematics classrooms when facilitated using the model and underlying principles, can ensure the creation of vibrant, effective and efficient classrooms to attain 21st Century goals. To determine the implications of 2T2C, teachers were trained and their views recorded and analyzed. The findings revealed from the teachers'

and students' perceptions of using the 2T2C Model that teachers require continuous training, re-training and professional development sessions to keep them abreast with innovative and creative methods to assist them with their facilitation. Collaboration with peers was vital to the success of the model as the teachers uncovered that it was a tremendous help to them. It was quite clear that teachers need to be aware that to combat the many learning styles of students that they must be armed with accompanying teaching methods and strategies.

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Notes on contributors

Steeve Warner is a Guest Lecturer at the School of Education and Humanities, University of the Southern Caribbean

Abtar Kaur is Dean, School of e-Education, Hamdan Bin Mohammed Smart University

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