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Exploring the use of computer technology in a Caribbean context: Views of pre-service teachers

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ABSTRACT

This article presents a qualitative study of five pre-service secondary school mathematics (PSSM) teachers in an English-speaking Caribbean context. The major goal of this study was to investigate the experiences and perceptions of the PSSM teachers as they explored the use of computer technology (CT) in their mathematics instructional practices, and to identify factors they consider necessary for successful integration of CT in mathematics instruction. These teachers faced similar challenges of developed and other developing countries in their exploration. They suggested that CT use in secondary schools is needed because of its benefits for both students and teachers and to stimulate interest, motivation and improvement in their students' performance.

Keywords: *Caribbean; preservice teachers; mathematics; computer technology; graphing calculator; computer software*

INTRODUCTION

As part of the mathematics reforms of the National Council of Teachers of Mathematics (NCTM) of North America and the Advisory Task Force of the Caribbean Community (Caricom), it is required that students be able to learn and use CT as an integral part of the learning of mathematics (Carrington, 1993; NCTM, 2000). Some countries or islands in the Caribbean have been providing their teachers with computer literacy skills and integrating CT in various subject areas (Carrington, 1993; Miller, 1996). However, this innovation is not common in mathematics classrooms. Yet, researchers have seen CT as a tool with capabilities to support an exploratory and experimental environment aimed at improving the teaching and learning of mathematics (Barron & Goldman, 1994; Carrington, 1993; Cousins & Ross, 1993; Hazari, 1992; Larson, 1995; Oliveira, 1989).

Norvak & Berger (1991), in their study, concluded that teacher education did not prepare preservice teacher educators to use technology in their teaching and provided little support on hardware, software or inservice training. As a result, preservice teachers could not deal with the demands from school districts, parents and students to use CT in their classrooms. Larson (1995) suggested that preservice teachers needed to understand the potential of these essential tools, have opportunities to apply the tools, be supported in their explorations, and have time to experiment with them. The implications of this approach meant that preservice teachers are not only expected to select and create new instructional materials, but to learn how to use the technologies with a learner-centered approach in their pedagogy (Carrington, 1993; Graham, 1998; Larson, 1995). A learner-centered approach to teaching is demonstrated when students are allowed the opportunity to explore the meaning of new knowledge using prior knowledge on which to build. The teacher using this approach facilitates and does not dominate or prohibit personal discovery of new meaning from the learner's own style or pace for learning (Huerta-Macias, A., 1993). For many pre-service teachers it is challenging to make the change from a teacher-centered approach, which is traditional, to a learner-centered or student-centered approach.

According to Hope (1997) teachers are engaged in a psychological tug-o-war because school leaders and change facilitators pay little or no attention to their perceptions and the challenges they confront while integrating CT in their classrooms. As educators in developing countries move forward with the integration of CT in mathematics classrooms, it is imperative that the stakeholders take into account the challenges that preservice secondary school mathematics teachers face in bringing about positive changes when exploring CT in mathematics instruction. A lack of detail in the literature regarding the integration of CT in mathematics instruction in the Caribbean and the move toward CT integration in mathematics classrooms, were instrumental in the investigation of:

> "*What are preservice secondary school mathematics teachers' experiences within the junior high school classrooms as they explore the use of CT in their instructional practices in an English-speaking Caribbean country?"*

Past Experiences in Developed Countries

The following sections describe the lessons learned in developed countries when preservice and inservice teachers were integrating CT in mathematics instruction: teachers' attitudes, concerns, and motivation in CT integration, role of the teacher, classroom management, support systems, and computer coping strategies.

Teachers' Attitudes

Research has shown that teachers who had a spectrum of attitudes such as fear of possible failure because of a lack of knowledge of the technology, and skepticism toward technology, gradually changed toward an appreciation through classroom experience that convinced them of the positive benefits technology has to offer as a problem-solving tool (Tharp, Fitzsimmons, & Ayers, 1997; Abramovich & Brown, 1996). It is important for teachers to have positive attitudes about an innovation, so they can encourage those attitudes in their students. Their students, in turn, will develop positive attitudes that will reinforce the knowledge gained. The students will then achieve an understanding of the process and benefits of CT (Senge, 1990); at the same time, any negative ideas of CT will disappear or be minimized.

Teachers' Concerns

In teacher education programs where training was provided for preservice educators, there were concerns about not having up-to-date equipment or faculty with technological expertise; preservice training was about computers and not learning with computers (Willis, 1997). One earlier study concluded that teacher education did not prepare preservice teacher educators to use technology in their teaching and provided little support on hardware, software or inservice training (Norvak & Berger, 1991). As a result, those preservice teachers realized that they could not deal with the demands from school districts, parents and students to use CT in their classrooms. Teachers' Motivation

Motivation is a key factor that contributes to change in attitudes and at the same time results in effectual continuation of an innovation. Teachers need support in integrating CT in their classrooms. The technology is rapidly escalating in sophistication, and educators and teachers are finding it hard to keep up with the changes. Teachers need to be educated with the appropriate skills so they can function and facilitate learning in the most suitable manner promoting high-quality education. Mentoring has been demonstrated as an effective model for teachers' change (Erickson, 1995). This model has posited factors involved in genuine change, which includes having a goal, addressing conflict, having a vision, being committed, translating knowledge into activities, and reflection on the learning. Erickson (1995) found that it was important to have support and executive control as an integral part of the change process to maintain a constructive direction. Success of mentoring is directly related to support from administration and peers. This approach would definitely add to the development of teachers' professional growth by the use of innovative tools and the constant reflections on classroom events (Guzdial et al., 1996).

Role of the Teacher

According to Dexter, Anderson, and Beck, (1999), teachers' instructional styles are determined by the way they learn. The experiences and knowledge bases developed in that learning process influence their decisions about the best course of action to take in their instructional practices. With the introduction of CT in the education systems, the role of the teacher has been reconsidered. The teacher's past role of being an information giver has changed to one of facilitator and mentor in the classroom. The teacher has the responsibility for (1) planning and providing careful organization of activities, and (2) helping students to access information, process it and communicate their understanding. This role will allow students to become less dependent on their teachers as experts (Dexter et al., 1999; Noss, Hoyles, & Sutherland, 1990). The teacher in adapting this role must perceive a vision of the benefits, be motivated, committed, and an active learner in the process.

Classroom Management

Computers in classrooms not only influenced instruction but also classroom management. Yet unexpected problems were also present; these frustrating experiences were some of the discouraging conditions that were encountered in integrating CT in the classrooms (Sandholtz, Ringstaff, & Dwyer, 1992.). Effective implementation was hindered by teachers' lack of confidence in their computer skills and lack of motivation (Scheffler & Logan, 1999). Students, in turn, recognized these behaviors of their teachers, and could quickly turn the classroom into chaos. In the mathematics classroom, it would be advantageous for the teachers to be prepared to meet the challenges in the learning process.

The flexibility of using various strategies to solve many problems is an advantage in mathematics, and should be used in the classroom to motivate students. Educational change takes time, and it is worth noting that the skill of classroom management in a technological environment cannot simply be mastered once and for all (Sandholtz et al., 1992); the zeal to achieve and maintain this skill must be present. In order to cope with classroom management, teachers with computer skills must be prepared to demonstrate patience, flexibility and persistence with a great passion for teaching and learning in the process of trying different things.

Support Systems

A critical barrier to continuing computer usage has been the lack of support from other members of staff (peer support), heads of departments and heads of schools (Noss et al., 1990). Support from the other preservice mathematics teachers, peer support, could be influential and therefore needs immediate and continued attention while in training and during implementation. The lack of appropriate technical support for equipment has been reported to be discouraging in the educational setting (Cooper & Bull, 1997; Noss et al., 1990).

Computer Coping Strategies

Ropp (1999) reported that research on reducing stress caused by anxiety about computer use (computer anxiety) in ways other than increased experience with and instruction in computers is less common. Several measures of coping with stress have been developed. In using individual characteristics as pedagogical tools for learning to integrate CT into teaching, Ropp (1999) developed the Computer Coping Strategies scale to emphasize adaptive coping strategies. Adaptive coping strategies are the ones students might use when they encounter difficulties in getting the computer to do what they want.

The coping strategies, among other individual characteristics such as attitude toward computers, technology proficiency, computer anxiety, and computer self-efficacy[1] have shaped the computing experiences of all individuals including preservice teachers (Ropp, 1999). The individual characteristics were identified as being associated with learning to use computers. Consideration of these characteristics has been valuable to teacher educators who are charged with helping preservice teachers learn to teach with technology (Ropp, 1999). Educators being aware of the diverse experiences and expertise that students bring to the learning setting will be better able to integrate this diversity into CT tools for positive growth.

Computer Technology Tools Employed in the Mathematics Instruction

Integration of CT in the Caribbean context had to be strategic and practical because of its economical situation. Mathematics computer software programs, the graphing calculator (GC) and the internet are becoming more commonly used among different Caribbean contexts. In some Caribbean contexts, however, these tools are not frequently used or are not always accessible to teachers and students in mathematics classrooms. Based on economical concerns, availability, and recommendation for their positive effects, the choice of mathematics computer software, Math Trek; the graphing calculator, TI-83Plus; and the Internet were chosen as the tools utilized in the study. For purposes of this paper, the CT tools used in the mathematics classrooms will be described in the next sections.

Computer Mathematics Software

Selecting computer mathematics software such as Math Trek was important in that it had to be interactive and motivating towards learning mathematics. Pokay and Tayeh (1997) have suggested that students' positive reports on one computer mathematics software, such as the Geometer's Sketchpad are likely to become negative when they are frustrated by the program. This phenomenon is common for all software programs within learning environments. This tends to happen when learners fail to make progress in communicating with the computer, and when they do not find answers as in their textbooks. For this reason, researchers have recommended that teachers need to communicate to students that exploratory programs are to provide environments for inquiry and reassure them that these environments and interactions are a normal part of learning (Pokay & Tayeh, 1997). The researcher had found Math Trek for grades 7, 8, & 9 (MT789) to be useful in motivating and engaging students in classrooms. Students' interaction has been empowering for each other and the teachers had opportunities to facilitate active learning and inquiry.

Graphing Calculator

The graphing calculator (GC), a commonly used tool in secondary school mathematics, has been found to have potential benefits for students' understanding of functions (Wilson & Krapfl, 1994). It is further stated that the GC has the potential for influencing the way mathematics is taught and learned, which in turn would affect the students' achievement, their mathematical disposition, and the classroom environment. Berger (1998), drawing on the Vygotskian[2] paradigm, described two effects of the GC, i.e., the amplification effects and the cognitive re-organization effects on the learning of mathematics. In the amplification effect of technology, the GC is seen to amplify the zone of proximal development (ZPD) by removing cumbersome and time-consuming tasks from this zone. The learner then has more space in this zone to perform conceptually demanding tasks with greater effectiveness and ease. The effect of using mathematical conceptions meaningfully or differently as a result of using the technology is known as cognitive re-organization.

These effects of the GC have enabled students to simultaneously view several related graphs or change algebraic parameters and note the corresponding graphical changes. This has led many mathematics educators to believe that students' achievement was affected as they could more easily understand conceptual features of functions. Wilson and Krapfl, (1994) claimed that some students were impressed with the utility and power of the GC, and others found it made mathematics more enjoyable. They also reported that feedback from a GC reduced anxiety and increased confidence, which improved the students' mathematical performance and feelings about their mathematical capabilities. The GC has also definitely influenced classroom environment. As Demana, Schoen and Waits (1993) have reported that the use of GC in precalculus classes enabled and induced teachers to use more group problem solving and less lecturing in the classes. This tool has also created a change in the way teachers plan for their classes, and the way in which they view mathematics and their role as a teacher.

CONCEPTUAL FRAMEWORK

According to Barron and Goldman (1994), beginning teachers having learned models of instruction in their subject areas in an invariably lecture-based mode tend to teach the same way they were taught. They replicate that teacher-centered approach. The expectation that such teachers should somehow change to teaching with a learner-centered approach is not very realistic. However, Wetzel (1997) noted that when learning opportunities are provided for teachers to use CT in their instruction, they used the opportunity to effectively implement the technology in their instructional practices. He found that providing a learner–centered approach and a focus on learning rather than teaching had addressed some of the central issues of implementation and effectiveness on teachers' minds during their training. That is, addressing the question of how they could help their students learn mathematics using these technological tools.

In preparing mathematics teachers to use CT, Blume (1991) has specifically recommended a three-phase model. The first phase is to provide mathematics teachers with opportunities to learn with the use of technology. In the second phase, opportunities are provided for mathematics teachers to reflect on their learning in the technological environment. Finally, in the third phase, they have the opportunity to translate their own encounters, which were facilitated by their instructor in a technology-rich environment, into similar encounters for their students.

Senge's (1990) model, which consists of five learning disciplines known as personal mastery[3], mental models[4], shared vision[5], team learning[6], and system thinking[7], is also part of the framework. These compatible theories of Blume's model, Senge (1990) model and the learner-centered approach formed the conceptual framework that guided this study.

CONTEXT OF THE STUDY

The study was conducted in an English-speaking Caribbean country where the use of CT in the subject areas had been initiated. In the English-speaking Caribbean countries, mathematics is a compulsory subject through elementary and the earlier grades 9 and 10 of secondary school education. In the final year(s), students' programs may be more focused in other subject areas. Preservice mathematics teachers were selected for the teacher education program based on their interest in the teaching profession and high scores in mathematics on their first attempt at the Caribbean Examination Council (CXC)[8]. The participants of this study were selected from the third year students of a teacher education program for preservice secondary school mathematics teachers who were screened by this process.

Background of the PSSM Teachers

In this research study, the participants were five PSSM teachers whose ages were in the range of 20-30years. Using their pseudonyms, Abiola, Levoli and Yvon were females who were new to the profession, while Sean and Wayne were males who had one-year previous experience as mathematics teachers. These PSSM teachers had experience working with computers for a period of five years and accumulated skills in using Microsoft Word, Excel, Publisher, and PowerPoint. In the teacher education program, along with their methods courses, they gained additional training in programming, networking, and system analysis, but there were no opportunities for hands-on experiences integrating CT in the teaching and learning of mathematics.

Classroom Contexts

The participants, being in the computer option of the teacher education program, were sent to schools within the urban area since each of these schools had a computer laboratory. At these secondary schools, the participants were given Grade 7, Grade 8 and Grade 9 classes to teach as is customary for new teachers to be assigned to the lower secondary grade levels. The students in these classes were heterogeneously grouped by ability and performance. For three sessions, Abiola conducted her grade 7 activities with the TI-83Plus GC in a classroom that was large but the furniture was uncomfortable and at times students had to share seats because chairs were broken. Levoli conducted two of the three sessions in the classroom and in the third session shared the computer laboratory that had 15 working computers and a multimedia projector. Her grade seven classroom was large and airy where she conducted her TI-83Plus GC activities.

In the large computer laboratory that Levoli used, there were technical problems when downloading Math Trek software. Subsequently, the researcher's laptop was used with the multimedia projector. Sean conducted his teaching practice with MT789 and the TI-83Plus GC in computer laboratory and classroom that were large and had their computers and furniture loosely arranged. Seating arrangements were appropriate and this allowed for interaction between teacher and students and among students to optimize teaching and learning. This was a comfortable and welcoming learning environment.

Wayne and Yvon had access to computer labs that had 20 and 30 working computers for all three sessions with his grade 8 students and her grade 7 students respectively. Math Trek software was downloaded on the computers individually since the network was not working at the time. Computers were tightly arranged in these two computer laboratories. Wayne and his students had limited mobility in the lab while Yvon and her students could move around more comfortably. The attendance rates in the classes of the participants ranged from 95 to 100 percent. However, the classrooms that were observed had a teacher-to-student ratio ranging from 1: 35 to 1: 45, which is normal in this context.

Teachers' Choices in the Use of CT Tools

The tools made available in the classrooms were at the request of the preservice teachers. Despite the desire to have both CT tools, Abiola was unable to have access to the computer lab to use Math Trek software, and Yvon had scheduling difficulties to use the TI-83Plus GCs during the limited loan period. Levoli and Sean wanted to have the experience of exploring both CT tools. While Sean received support from his principal and cooperating teacher in his venture, Levoli had limited opportunity for exploring with MT789 due to the challenge of availability of lab time. Wayne had specifically concentrated on MT789 based on his research interest for his final project in the teacher education program.

METHODOLOGY

Based on the study's context of a natural setting, and its sensitivity to the local needs and conditions of a developing country (Bogdan & Biklen, 1998; Crossley & Vulliamy, 1997), qualitative methodology was employed to gain an in-depth understanding of the PSSM teachers perceptions of the integration of CT in their classrooms. In particular, a case study approach was taken (Yin, 1994), which was identified with the following research question,

> "*What are preservice secondary school mathematics teachers' experiences within the junior high school classrooms as they explore the use of CT in their instructional practices in an English-speaking Caribbean country?"*

Abiola, Levoli, Sean, Wayne and Yvon volunteered to participate in the study. They were among other student teachers who attended a technology application course, taken in their third and final year of their program - a hands-on experience of CT integration in a learner-centered environment. Having a specialization in computers within the program, the participants were purposefully sent to schools with computer laboratories as part of their student teaching placement requirement.

During the technology application course, the PSSM teachers worked individually and in groups on mathematics problems using the TI-83Plus graphing calculator and MT789 software. On the database of Web Knowledge Forum (WebKF), the PSSM teachers communicated and reflected on (1) the National Council of Teachers of Mathematics (NCTM) Principles and Standards, (2) the integration of CT in mathematics, and (3) their experiences of the use of TI-83Plus and MT789. This was ongoing through their practicum assignment. At the end of the course, they were given their student teaching assignments to different schools where they had access to a computer laboratory. Each PSSM teacher provided a lesson plan that incorporated the use of CT for each observed session. During student teaching, each PSSM teacher was observed three times. Each observation was for 30 minutes of a full class session range from 40 through 80 minutes. In each of these observations, the researcher examined the PSSM teachers' use of technology, rationale for its use, teaching strategies implemented, interactions among students, teachers, and computer technology tool, the teachers' role in the classroom and their perception of the exploration. As part of the data collection, each teacher kept a journal of activities and reflections of each lesson. Towards the end of student teaching, 90-minutes interviews were scheduled with each participant. Data collected from observations, journals, lesson plans, field notes, and interviews were transcribed, coded and categorized using Microsoft word and NUD*IST, a qualitative data analysis software.

FINDINGS

In the interviews, the PSSM teachers were reflective on the way they were taught in secondary schools. This provided the opportunity to determine their view of any changes in their teaching methods with respect to the learner-centered approach. In the next sections are their views:

PSSM Teachers' View of the Learner-centered Approach

Abiola recalled when she was attending secondary school:

> *Teaching was done in the traditional way, where the teacher gave examples on the chalkboard and the students answered the questions by applying the examples. The questions were chosen from a textbook, and students were asked to answer those questions for homework assignments. The teacher was the one who wrote on the chalkboard and students copied what was on the chalkboard.*

Levoli stated that

> *……….. I would definitely appreciate such [NCTM] standards in the Caribbean because teachers in the past have used only "chalk and talk," which I thought of as torture.*

Here, it is evident that Levoli has relinquished herself from the traditional method of "chalk and talk."

When Sean was an elementary student, he learned mathematics by practicing math exercises and by taking money and giving change in a shop. In secondary school he was taught higher-level skills through rote learning and much practice. The more he practiced, the better he did in mathematics. He claimed that, if he did not know a concept immediately, he would practice it repeatedly until he grasped it. The majority of his teachers in secondary school used the traditional "the chalk and talk" method in which they demonstrated how to do a particular problem on the chalkboard. Sean did not experience much "discovery" in that method; e.g., formulas were given and the students were required to memorize them. He often wondered, "How did teachers come up with these formulas?" He learned the answer to this question in college.

Changing the instructional tools and method of approach in the mathematics classroom was a revelation for Sean in his training; the change affected him in many ways. Moving away from the traditional teaching style, he realized the effectiveness of the discovery method in mathematics. Sean saw mathematics as a practical subject and in using MT789 and the TI-83Plus GC; he was able to utilize the discovery approach having students explored on their own. He did not see any disadvantage to using CT and felt that his teaching improved due to the strategies he used.

At secondary school, Wayne learned mathematics mostly by trial and error and constant practice. He was taught by the lecture method exclusively, also known as the "chalk and talk" method. Wayne claimed that the classroom environment in which he did his teaching practice was quite different from his experience as a student in secondary school. He remembered that teachers put work on the chalkboard, checked, and marked students' notebooks. These activities were expected to be completed by the end of class. Comparing that time to now, Wayne said that the teacher played a more active role in the classroom today.

Yvon learned mathematics in secondary school using a variety of strategies. When a problem was given she was expected to solve it on her own, and guidance was given when the teacher recognized help was needed:

> *If a student did not understand a problem, normally in school a teacher would come over and say "where did I lose you?" and the student would say, "Well, Miss, I started out here*

> *and then I....” And the teacher would guide the student step by step through the problem. The student would then be able to analyze and say, "oh! I made a mistake.” The student would be able to see the mistakes. It is better than telling them the answer. It is a form of the teacher helping the students to see or realize that they have made a mistake and be able to correct it.*

The "chalk and talk" method was used most often and occasionally a manipulative tool such as a protractor, ruler, or geo-board was used. Yvon identified that she needed to learn more to be able to use CT in the mathematics classroom and would take courses in professional development to upgrade her skills.

Based on these PSSM teachers’ reflections of the teaching and learning styles in their secondary schools as students, it is evident that they were taught mainly with the “chalk and talk” method and became more aware of the learner-centered approach in their teacher education program. In observation sessions, the PSSM teachers were using group activities and facilitating learning in the use of CT in their mathematics instruction. Through these observations, and their reflections, the study provided evidence that the PSSM teachers have the tendency to become teachers who will use the learner-centered approach in their classrooms. Abiola in her interview expressed the learner-centered approach as non-traditional and compared it to the teacher-centered approach as blue versus black and she explained what she meant by “blue and black”:

The blue represents all the colors but the black is dead drag. In my days, it was black but in their days now is blue because you have that different teacher (one who teaches with a non-traditional approach) and technology has gone a far way from when I was in school so the students have what they need to go on further.

PSSM Teachers’ Perceptions of CT Experience

The PSSM teachers did not have attitudes of skepticism or fear toward CT integration in their mathematics classrooms unlike the experiences of Abramovich & Brown (1996) and Noss et al (1990). Being students with a computer option in their development was a positive attitude towards technology. However, they did have concerns about the continued availability of the technology for teachers and students. Abiola stated that if the resources of CT were available, she would use them perhaps 90 percent of the time, because information would be processed easily. Instead of doing manual calculations, the students would do the critical thinking part rather than the knowledgeable part of it. She had the students use the TI-83Plus GC, and instead of constructing graphs, the data were entered and the scales were prepared for the graphic output. The students then analyzed the graphs in groups and proceeded to a class discussion.

The students using the TI-83Plus GC also developed a higher level of understanding of the basics and they constructed ideas to apply knowledge gained from the study of particular models. CT had a positive impact on the students; this technology enabled them to derive the same benefits as Abiola herself (Noss et al, 1990). She felt her students could reap increased benefits because they were introduced to technology [electronic toys] at a younger age. Students were curious about knowing how to use GC’s and were eager to measure accurately.

Levoli was enthusiastic because it was a new task for her as well as her students:

> *I did not know much about MT789 or TI-83Plus GC before the technology application course. They were new to me, so the activities that we explored in the classroom were a learning experience for the students and me. ……..Hopefully, the school at which I will be teaching will have computers for every student. …I would not mind having a copy of the Math Trek software and at least one TI-83Plus GC so I can utilize it in my class because I really enjoy using CT in my mathematics instruction. … It would be good if I had at least one TI-83Plus GC for myself with the view screen panel and I could utilize the overhead*

> *projector with it where students can actually visualize some concepts until I can get a class set.*

The students' positive reaction to the technology had motivated and inspired her. She saw the benefits of the TI-83Plus GC when her students subsequently became aware, explored and analyzed geometric relationships and made conjectures from patterns.

Supporting CT in the Mathematics Classroom

The schools where the practice sessions were conducted had limited resources for the integration of CT. Four of the five principals accepted and showed interest in engaging their practicing teachers with CT integration in mathematics. They gave their verbal support and followed through, giving specific permissions and instructions to guide a smooth process. Levoli's principal granted her permission for the study, but he did not show much interest, which subsequently was responsible for greater challenges in arranging access and availability of computers at that school. The PSSM teachers' supervisors from the teacher education institution verified their lesson plans and teaching strategies used, while the researcher provided the MT789 software and the TI-83Plus GCs.

Generally, in the schools where permission was granted, challenges were often encountered along the chain of administrative command. For example, at the school where Abiola taught, the computer coordinator was a bit cautious about the usage of the computers because of previous students' misuse that damaged a few computers. Therefore, he did not allow her to use the computer laboratory. As a result, Abiola had the only other choice of using the TI-83Plus GC in her teaching practice sessions. At Levoli's teaching practice school it was challenging to gain support in using the computer laboratory. Scheduling was then a problem, and the whole notion of not getting much support from the Principal made it a difficult situation to resolve. The computer coordinators at Sean, Wayne and Yvon's teaching practice schools gave their support in allowing the software to be installed on the working computers, maintained the computers, and were willing to assist with technical issues.

The cooperating teachers did not place any restrictions on the mode of delivery, but cautioned the teachers to ensure the material was valid, and would not lead the students astray. The cooperating teachers were instrumental in the behavior of the students by periodically checking on them in class and cautioning them to be attentive to the teachers. However, Yvon had the support of the cooperating teacher at all times in the classroom because he was curious to learn how to use CT along with the students. Sean's cooperating teacher also provided motivational support.

Technical support was also a concern for Levoli, Sean, Wayne and Yvon. The technician could not get the network connected, and these PSSM teachers had to utilize their expertise in downloading the software on each computer. The constant lack of provision of such expertise to the classroom teachers as Cooper and Bull (1997) and Noss, Hoyles, and Sutherland (1990) reported, could be discouraging in the [general] educational setting. However, these teachers, because of their training and focus in computer studies, had the opportunity to put theory into practice in assisting with such technical issues.

Availability and Accessibility

In many instances, laboratories of 25 computers had to be shared among 35 to 40 students, which meant that at least two students had to share one computer. The multimedia projector was also a limited resource: only two of the five schools had one. Abiola's school had a regular projector that she used with the screen of the TI-83Plus GC.

Yvon realized that the use of one computer with a multimedia projector could accommodate a class of 30 to 40 students. However, having such large schools with arbitrary scheduling made it very difficult to access the facility. Due to unavailability of an adequate number of computers for each school, accessibility to the computers became restrictive, and the personnel in charge of these tools were seen as controllers who perpetuated distance between the CT tools and the students.

The PSSM teachers made changes in their teaching strategies to facilitate the integration of CT in their instruction. For example, they accommodated the students in cooperative groups to use the limited number of computers or GCs available to them. Abiola had a sad feeling of the temporary availability and accessibility of GCs to the students during student teaching. The five teachers had indicated their willingness to use CT tools as students in the mathematics methods workshop and as facilitators in student teaching.

Concept of Time

The PSSM teachers experienced the management of time as a hindrance to complete class activities, so they had to develop strategies to cope with it. Abiola found that time was consumed quickly because of the students' unfamiliarity of the technology and the time she spent imparting instructions verbally. She opted to give instruction sheets in future lessons. Sean found that preparation of the laboratory or classroom ahead of class time was important to save time in the class sessions. He also realized that time limits had to be set and followed.
Levoli's greatest challenge was the time taken away from her sessions because previous classes did not finish on time; thus she was unable to use the entire class period on the computers. The school based assessment (SBA) assignment was also a common preference for students using the computer lab for other academic work. Wayne and Yvon found it quite challenging to set up schedules for their teaching practice sessions because they had to negotiate with other teachers to use their laboratory time. Yvon's challenge of not getting the GCs was due to their inappropriateness for use in class activities at the time when they were available.

Classroom Management

Another challenge that occurred, though not often, was inattention to instructions. Sean found that the students were being inattentive to instructions and exploring on their own, before it was time to do so; this made it difficult for them to draw the graphs on the TI-83Plus GC. He had to spend some time with them discussing the different icons and demonstrating their functions. Sean applied the strategy of "demerit" points for not being attentive, and it worked because students did not want to accumulate such points.
The PSSM teachers formed cooperative groups in their sessions to address the lack of experience with computers, the limited number of computers available, and the varying reading capabilities. Continuing to experience the situation of limited financial support in the school system would be frustrating to teachers in future attempts to implement CT. It would not be motivating to teachers who have a vision for school change, and want to be mediators in such innovations.

PSSM Teachers' Suggestions Based on CT Experience

Based on the PSSM teachers' experience, their common recommendations for effective integration of CT in secondary school mathematics were (1) CT use in secondary schools is needed because of the learning and teaching benefits for both students and teachers; (2) teachers need to know how to choose CT tools that are appropriate, current, interactive and user-friendly in mathematics; (3) teachers need training in the use of these CT tools; (4) teachers need professional development for upgrading their content, technological and pedagogical skills; and (5) teachers need to be motivated first with their use of CT in the classroom, so they would be able to stimulate interest, motivation and improvement in their students' performance.

Wayne's advice to the Minister of Education [rather a leading reformer in the context] about investigating the availability and accessibility of CT tools for secondary school students came from his observations and research project in his teacher education program. From his observations, cooperative learning was a workable application to CT integration in mathematics. He also observed that the students' enthusiasm to learn was increased in the setting with CT use. In his research project, Wayne concluded that his observations were contributors to the increased students' performance in his project. Based on his experience, he recognized the need for CT implementation in secondary school mathematics. Wayne advocated that there is need for an adequate number of computers and other CT tools to be available and accessible in schools for effective implementation to occur in the education system.

CONCLUDING REMARKS

This study being one of few that explored a Caribbean perspective has provided evidence that a Caribbean setting has faced many similar challenges of developed and developing countries when new qualified teachers attempted to apply new technologies. The motivation developed in teacher education programs, and the risks new teachers are willing to take in exploring new ideas, teaching and learning strategies, and new technologies are expressed as in the cases of Abiola, Levoli, Sean, Wayne and Yvon. However, the lack of resources, principal, other faculty and technical support, and environments that are conducive for teaching and learning during teacher preparation are seen to be prohibitive to the appropriate integration of CT. To encourage our new teachers to continue the path to an effective teaching career in the reform of mathematics education in the Caribbean, policy makers need to review the availability, accessibility and pedagogy of computer technology in the mathematics curriculum.
Students' academic acquisition in the world of advanced technologies is not only shown by excellent academic record and aptitude, but it is also indicative of the knowledge they gained about the use and efficiency of computer technology. It is therefore evident that the teachers' conscious effort to move away from the traditional "chalk and talk" approach to a learner-centered approach did lend itself to genuine positive progress in using computer technology. Hence this new approach made the teachers aware that reading and group skills along with computer literacy are factors to be considered in their planning when introducing CT use.

The current mathematics reform of the NCTM-Principles and Standards (2000) and the Advisory Task Force of Caricom (Carrington, 1993) advocated the restructuring of the mathematics classroom and an increased focus on teachers' accountability. There should also be an increased recognition that teachers do play important roles in structural reform in order to respond to students' needs in the classroom. Integrating CT tools in the classroom structure was strongly recommended in the reform because these tools when used appropriately have the power to foster understandings and intuitions in mathematics. In this study, the PSSM teachers had the opportunity to learn with CT tools; they were motivated to continue in this learning mode and gained zeal to remain committed to their personal growth.

According to the PSSM teachers, when they assumed alternative roles like facilitators in the classroom, the nature of interactions significantly changed from what they remembered in their secondary schools. Reflecting on their experiences in the classroom, they provided their perceptions of the challenges encountered and demonstrated their motivation to continue using CT in mathematics instruction. Recognizing the roles that the teachers undertook in the change process, it is vital to provide opportunities in which continuous growth and development can transpire. Furthermore, providing necessary CT resources and support for both teachers and students will be key factors in any reform efforts.

FUTURE ADJUSTMENTS FOR CHANGE

Based on the findings of this study, the following suggestions are made to the stakeholders in the Caribbean and countries of similar economic status:

- PSSM teachers' professional development must increase focus on having teachers' practice teaching strategies to enhance the implementation process of CT integration.
- Class size must be lowered to allow PSSM teachers to conduct meaningful exploration and assessment of students' achievement.
- Technical and human supports are necessary to successfully implement CT integration in mathematics.

For most education systems in the Caribbean, the big question is: Where can we get the financial support for these resources? Community education development programs, such as fund-raising and donations, and foreign agency funding for education are some viable ways to get support. To gain access to these supports entail getting to know the agencies and their requirements, and writing winning proposals that will provide the support needed. However, using CT tools, such as the graphing calculators, which are becoming more affordable, are provisions of a portable mathematics laboratory, which can also be a realistic implementation in developing countries. There are also current developments of computer software for local use. There is a need to get more advocates at the administrative level of the education system who would champion the integration of CT. Teacher educators, teachers, principals, and heads of departments in the Caribbean and countries of similar economic status need to consider the pertinent factors and CT tools that are necessary for implementation to improve their curriculum for a global community.

Endnotes

1 Individuals' judgments of their capabilities to organize and execute courses of action applied to computer learning.
2 Vygotskian paradigm indicates that education is both a theory of development and a process of enculturation in which mediated action links the external social world to internal mental processes.
3 Developing competence with CT use.
4 Managing deeply held internal images that affect change process.
5 Sharing their goals and expectations to develop a common vision for CT use.
6 Builds on developing shared vision and personal mastery through dialogue and discussion.
7 A loop process where there is an interrelatedness of forces when learners reflect and reinforce changes in the overall process of integration.
8 CXC provides examinations and certification at the secondary and post-secondary levels.

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