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AN ASSESSMENT OF MATHEMATICS TEACHERS' MOTIVATIONS FOR ATTENDING A HAND-HELD TECHNOLOGY WORKSHOP AT BINDURA UNIVERSITY OF SCIENCE EDUCATION

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Abstract

The study documents reasons given by 35 secondary school and undergraduate pre-service mathematics teachers for attending a graphic calculator workshop at Bindura University of Science Education (BUSE) in January 2004. Participants' motivations, needs and appropriateness of technologies to their instructional practice are documented. The importance of the workshops is examined with a view of making mathematics teachers develop knowledge and an awareness of the role played by technology in mathematics instruction. The discussion challenges mathematics teachers in Zimbabwe to review their belief systems in order to initiate the long awaited technology reform in secondary school mathematics curricula.

Background to the Study

In Zimbabwe, technology is making a slow entrance into the mathematics curriculum because of prohibitive cost that is beyond the reach of most schools and students. Despite the high cost in Zimbabwe, elsewhere in the world, hand-held technologies (e.g. graphic calculators) are affordable and are classroom normality rather than an oddity. Learning how to effectively use graphic calculators during instruction remains a gigantic task, and gaining confidence in their use takes time for mathematics teachers (Brumbaugh and Rock, 2001). Since July 2002, the Centre for Research in Mathematics Education (CRME) at Bindura University of Science Education (BUSE) in collaboration with Teachers Teaching with Technology (T^3) of the United States of America (USA) has been holding annual hand-held technology workshops at BUSE. The main goal of the workshops is to equip mathematics teachers with appropriate knowledge and experiences to appreciate and effectively use graphic calculators in their instruction so that they are not handicapped to perform to the highest potential using the devices when they are eventually available in the classroom.

Mathematics teachers have continuously shown great interest in the technology workshops that the limited numbers of places available make organisers face uncomfortable decisions during registration. The number of registered participants who attend the workshops is determined by the number of devices to be given out. To accelerate the proliferation of the hand-held technology in the country through a cascade model, registered workshop participants receive a device after successfully completing the five-day workshop (thanks to the USA-based facilitators for sourcing them). The interest that mathematics teachers have shown toward the workshops every year compelled us to investigate their motivations for attending. We draw our conclusions from data drawn from the responses of a questionnaire constructed before hand to evaluate the January 2004 workshop. Specifically, the study sought to answer the following three research questions:

1. What are the motivations of mathematics teachers to attend annual hand-held technology workshops held at BUSE?
2. Are the knowledge and skills gained in the workshops to operate the various-hand held technologies (TI-82; TI-83; TI-85 and TI-92) relevant and appropriate to participants' professional practice?
3. Do the workshops provide participants with new knowledge and skills that enrich their professional practice?

Answers to the research questions reveal the motivations of participants (question 1), relevance and appropriateness of the technologies (question 2), and the extent to which the workshops enable participants to achieve personal goals, gain new knowledge and skills that is useful to their professional practice (question 3).

Theoretical Framework

The availability and use of technology in mathematics education has changed what constitutes mathematics problems and the teaching and learning of the subject world wide. During the era of logarithm tables and the scientific calculator, algebraic equations and expansions, straight forward differentiation and integration problems, for instance, formed the core of mathematics education. In the age of hand-held technology, straightforward exercises that require direct use of an algorithm no longer constitute mathematical problems because mathematics is perceived beyond mechanical procedures. In the era of technology, mathematics is perceived in terms of problem-solving, modelling, thinking processes and sustained time (perseverance) on a task. Waits (2000: 187) succinctly emphasised the need for mathematics to go beyond the trivia of computations when he said "we need to communicate clearly and explicitly that paper and pencil procedures are not mathematics and that technology devices provide better methods to do mathematics."

Technology, in this context, is a device that is taken as media to undertake significant cognitive processing of mathematical procedures on behalf of students and teachers (Jones, 1995). An example of such technology is a graphic calculator. Teachers' effective use of technology during mathematics instruction rests on an appropriate choice of activities that lead students to a voyage of discovering conjectures and insight to model or solve real world problems.

Problem-solving and modelling involve real world problems that often invoke tedious computations and complicated diagrams that provide visualisations of situations. An effective use of technology during mathematical work eliminates the tedious manual work. It is determined by the partnership between a student and a graphic calculator in which technology does not diminish a student's mathematical skills (Harvey, 1991). A partnership characterised by a complementary division of labour between a student and the technology is ideal. For instance, in an ideal partnership, the student has sufficient knowledge and understanding of the mathematical processes that bring out desired outcomes, but passes over the responsibility to technology at appropriate stages to perform the tedious computations and visualizations of facts, objects and processes. The complementary function makes technology act as a catalyst in the learning process in ways that dispel the myths associated with technology use in mathematics curricula (Ralston, 1999; Teachers Teaching with Technology, 1999).

The key to successful use of technology in mathematics instruction rests on appropriate teacher development programmes that equip them with pedagogical knowledge and skills to effectively use the gadgets for instruction.

Workshop Participants

Due to some logistical problems, the July 2003 hand-held workshop was postponed to the beginning of January 2004. Twenty eight graphic calculators were {made} available to registered participants who successfully completed the week-long workshop. To ensure impartiality in the registration of participants, the CRME secretary registered secondary and undergraduate pre-service mathematics teachers at the beginning of December on a first-come-first-served basis. News of registration spread quickly to undergraduate pre-service and mathematics teachers who were marking summative Ordinary and Advanced level examinations at Hermann Gmeiner High School. Within one week of registration, all the 28 available places were filled. Commitment shown through the payment of a token registration fee is a prerequisite in order that participants give total devotion to the activities of the workshop. Participants who failed to register due to the limited places available were allowed to attend the workshop, but were warned in advance that they would not receive graphic calculators after successfully completing the workshop. Seven more participants complied, making the total number of participants 35.

Workshop Arrangements

The workshop was facilitated by Prof James Tarvin of Grossmont College (California) and Prof. Stuart Moskowitz of Humboldt State University, whose coming to Zimbabwe was facilitated by a grant from the US Embassy in Harare.

The workshop times were from 9.00 am to 4.00 pm between 5 and 9 January 2004. The participants formed one class of beginners. Each member of the group had access to a graphic calculator during demonstrations and practice sessions. The graphic calculations that participants practiced in were TI-82, TI-83, TI-85 and TI-92. Various operations on the graphic calculators that had a direct link to mathematics curricula such as explorations with graphs, data capturing and analysis using statistical tests, calculus concepts and Calculator Based Ranger (CBR), among others, were demonstrated. More time was spent on practice with the TI-92 than other calculators because participants were to receive this type of technology.

The afternoon of the fifth day of the workshop was characterised by various activities. Firstly, participants evaluated the workshop by answering structured questions that were designed before the workshop. Secondly, a raffle in which all participants won various items that included pens, pads, stickers, calculator batteries, bags etc.was conducted. A moment of happiness for registered participants arrived when they received TI-92 graphic calculators.

The results presented below come from the evaluation text of the 35 participants who attended the workshop. In an effort to increase participants' frankness in evaluating the workshop, the texts were anonymously written. Due to economy of space, transcripts that elucidate conclusions made are selectively chosen to elaborate them.

Results

An interpretation and description of the findings on each of the research question is presented in this section. Table I shows the overall results on each of the research questions.

Table I: Mathematics Teachers'Evaluations of the Hand-Held Technology Workshop

Theme	Responses	Freq N=35
Motivation for attending workshop	• Exposure to advanced technology	1
	• To acquire skills to operate various technologies	16
	• Learn more mathematics using the technologies	1
	• Master operations and use the technologies for instruction	10
	• Help me verify Advanced level solutions	5
	• Nil responses	2
Relevance & appropriateness of the technologies	• Good for instruction	14
	• Facilitates understanding	1
	• Useful for my studies	3
	• Useful for storing and retrieving data in statistics	6
	• Useful in problem-solving	2
	• Enhances fast and accurate calculations and visualisations of graphs	5
	• Relevant for familiarising teachers with the ever changing technology	4
New knowledge & skills gained	• Can operate the various technologies	15
	• Limitations of time could not allow the explorations of some operations	3
	• Illustration of a bouncing ball on a graph (CBR)	5
	• Transfer of data from one technology to another	2
	• Sophistication of the technology to solve mathematical problems	6
	• Patience and persistence of the facilitators	1
	• Down loading of information from the internet	3

Motivations

The majority of the participants (74.3%) were motivated to attend the technology workshop for utility reasons. They wanted to acquire skills to operate the various technologies to solve mathematical problems and use the devices for instruction. The following quote summarises a mathematics teacher's motivations for attending the workshop.

My goal for attending the workshop was to acquire basic skills to operate the graphing calculators. I am now able to create models, perform statistical tests; transfer programmes from one calculator to another ... it is even more than what I ever expected. I can now do geometry and many other things using the technologies I practised in [sic].

Although personal goals ruled supreme on the motivations for attending the technology workshop, professional motivations were quite high. Ten of the participants (28.6%) were motivated to attend the workshop because they wanted to master the operations and use the technologies for instruction. Some participants were enthusiastic to get a TI-92 graphic calculator and teach other teachers at their respective schools to operate it as well.

Advanced level teachers attended the workshop in order to gain skills of using the graphic calculators for teaching and learning purposes. The devices were useful to solve puzzles on abstract mathematical concepts at this level.

Another motivation expressed by participants (14.3%) for attending the technology workshop was to gain skills to operate the devices when verifying results during mathematics teaching and learning.

Relevance and Appropriateness

The skills that mathematics teachers developed in the hand-held technology workshop were hailed as relevant to their instructional practices. Fourteen of the mathematics teachers (40%) said that the devices were good for instructional purposes.

A sizeable proportion of participants (17.1%) found the devices relevant and appropriate for storing and retrieving statistical data, enhancing fast and accurate calculations and visualisations of graphs (14.3%), and familiarising them with changing technology in the subject (11.4%).

New Knowledge and Skills Gained by Participants

The limitation of time prohibited the full explorations of the operations of the hand-held technologies. This limitation did not, however, stop participants from achieving some fundamental goals. Some workshop participants (42.9%) were happy that they can now operate the technologies that they were exposed to. They did not dream of achieving this skill before the workshop. The sophistication of the technologies to solve tedious mathematical problems and the drawing of complicated graphs, polar roses and cardioids, among other functions, was applauded as the new skills that six participants (17.1%) developed from attending the workshop. The capability of the ranger to come up with a graph of a bouncing ball (CBR) was a surprise to some participants (14.3%). The CBR provided insights into how technology can be used to introduce the concept of a geometric series with a common ratio less than one through problem-solving.

Patience of the facilitators to guide participants through persistent and repetitious exercises that enabled the participants to master the skills of using the technologies was a very important lesson that some participants learnt. One participant applauded the patience of the facilitators to listen to participants' errors resulting from punching wrong buttons as important in mastering the functions of different operations on the hand-held technology. The appreciation was explicitly expressed in the statement by one of the participants, who said:

> It was my first time to handle a programmable calculator, and everything was new. The facilitators listened patiently to my otherwise numerous silly questions each time I went astray. This has convinced me that teaching mathematics requires patience in the way that the facilitators were to the participants. Their patience to listen and understand my misconceptions made me learn a lot of aspects about the functions of the graphing calculators.

Discussion

Two major motivations for mathematics teachers to attend the annual technology workshops at BUSE emerge from the results. These can be categorised as personal and professional motivations. Gaining knowledge to operate graphic calculators was a personal motivation of the participants. Participants who were motivated to attend the workshop for the sake of gaining new knowledge were keen to keep abreast with new developments in mathematics instruction. A desire to keep abreast with developments in mathematics is paramount for teachers' professional growth as it enables them to keep on learning new knowledge and skills in the subject.

Knowledge of using graphic calculators in Advanced level teaching was a professional motivation that attracts mathematics teachers to attend the workshops. Use of hand-held technology at this level enhances teaching of the subject. With the aid of technology, teachers can reduce the endless hours they used to spend preparing for lessons through manual means because that can be replaced by quick and accurate computations that are possible at a push of a button on a technology device. The long hours previously spent finding manual solutions to problems may be diverted to designing problem-solving tasks. In the same vein, the time spent on mechanical computations during instruction may be put to better use by engaging students in proble- solving activities with the assistance of technology that carry out algorithms fast and accurately.

Teacher competence in using technology in mathematics classrooms at secondary school changes the focus of instruction. Where teachers used to spend a lot of time on drill and practice, for instance, drawing asymptotic graphs, they could meaningfully spend the time on problem-solving or modelling problems from real world situations that apply the concepts. Teacher effective use of technology influences the examples and content of mathematics to be covered in a lesson. Some mathematical content that involve direct use of algorithms will not feature and the places of obsolete topics taken by mathematical problems that involve persistent thinking in modelling and problem-solving.

Teacher use of the knowledge gained in hand-held technology workshops will limit the abstract teaching of mathematical concepts because technology will provide media in the form of visual pictures in ways that will improve students' conceptual learning of mathematics. Pictorial presentation of three dimensional shapes, for instance, enhances students' understanding of these concepts. The ability of teachers to provide visual pictures of relationships in problems through the use of technology at a push of a button provides students with opportunities to explore and make conjectures during lessons.

Sharing pedagogical knowledge among teachers is a world wide phenomenon (Sanders, 2000). Teachers who attended the January 2004 workshop expressed a willingness to share the new knowledge they had gained with colleagues when they returned back to their respective schools. The idea of sharing knowledge gained from workshops through social means in the department or local staff development initiatives of schools promote the proliferation and implementation of new knowledge by teachers in a cascade form.

The cascading of the new knowledge and skills those mathematics teachers who attended the workshops found appropriate and relevant to their professional practice is an effective way of marketing technology in mathematics instruction. Teachers value and implement the knowledge and skills that their colleagues gain from workshops which are illuminated as enriching to their practice and student learning. An appreciation of the relevance and appropriateness of technology for instruction by mathematics teachers is fundamental for influencing their belief systems. Educational reform that is not initiated by teachers is as simple or complex as dictated by teachers' beliefs (Fullan, 1991). Teachers hold a complex web of beliefs about the nature of mathematical knowledge and goals of mathematics instruction. An appreciation of the effectiveness of technology in mathematics instruction (from personal experience gained in the workshops) enables teachers to dispel the beliefs they might hold. Beliefs that militate against reform on technology use in mathematics instruction, such as a fear that students using technology may not master basic computational skills or those students may use technology as crutches, may cease to exist.

Conclusion

Though the cost of graphing calculators is beyond the reach of most schools, due largely to the prohibitive cost, mathematics teachers have shown keen interest to attend the annual hand-held technology workshops at BUSE because of the personal and professional benefits to be derived. The interest they show towards the workshops is a sign of a healthy preparation for implementation of technology in the classroom in future. Advance planning and equipping mathematics teachers with knowledge and skills on technology use during instruction is important. Simply providing teachers with hand-held technology when there is reform in the mathematics curriculum might not produce instruction that is consistent with expected outcomes. Continued short in-service courses on technology use in the mathematics classroom are important for equipping mathematics teachers with the knowledge and skills to effectively use technology in their instruction.

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