What does research say on the use of ICT to improve the teaching and learning of mathematics?

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Abstract

This paper reviews the literature related to the use of ICT in teaching and learning mathematics. Particularly this paper will focus on reviewing factors that lead to the typical practices of the ICT use in mathematics teaching. This review shows that the use of ICT in education more specifically in mathematics teaching is ubiquitous and undeniable. While some researches informed the benefits of using ICT in mathematics teaching, yet the evidences were still unclear for claiming that the students' achievements were increased due to the use of ICT. Some characteristic of effective use of ICT were identified in this review of literature. To be able using ICT effectively, teachers must possesses good content and pedagogical knowledge, good attitude towards ICT, and receive adequate supports from the school system. A framework for assisting teacher to use ICT in teaching mathematics is proposed

Introduction

Information and communication Technology (ICT) has become one of the basic building blocks of modern society. Mastering basic skills and concepts of ICT is becoming part of the core of education, together with reading, writing and numeracy. Furthermore, the use of ICT as medium in teaching and learning processes for various subjects gains its momentum nowadays. Many researches have been done in the area of using ICT in mathematics classroom.

The term "*information and communication technologies*" (ICT) refers to forms of technology that are used to transmit, process, store, create, display, share or exchange information by electronic means. This broad definition of ICT includes such technologies as radio, television, video, DVD, telephone (both fixed line and mobile phones), satellite systems, and computer and network hardware and software, as well as the equipment and services associated with these technologies, such as videoconferencing, e-mail and blogs (UNESCO, 2007, p. 4).

One of the main problems related to discussions on ICT in education is that ICT has in far too many contexts been discussed from a technological perspective. It is of course correct to say that ICT is a technology, but the challenge for schools is not whether they use this technology or not but how they use it. ICT does not solely provide a set of technological tools. It must also be linked to educational goals and objectives.

All too often schools and different education authorities have focused exclusively on technology, but not on the questions of why and indeed how ICT should be used. Many governments have launched expensive programmes to introduce ICT, but have

forgotten to focus on how to use ICT in the classroom. There is a need to further develop ICT pedagogy. Schools must be aware, that good pedagogical use of ICT must be part of a whole school development strategy. ICT is only a pedagogical tool, not a goal in itself.

ICT changes the nature of teachers' work, requiring different skills and competences such as facilitating independent work, critical review and analysis. Lacking experience on how to use ICT pedagogically costs extra time in preparing ICT-integrated lessons. The important issue for teachers is to identify what they would like to do and how ICT can help.

Why use ICT in mathematics classroom?

There is a general consensus that the use of ICT in teaching and learning brings about positive benefits in student learning. The findings of the ImpaCT2 survey (Harrison, 2002) provide concrete evidences of ICT having an impact on teaching and learning in the classroom. At the subject level other than mathematics, ICT supports the development of science concepts (Nakleh & Krajcik, 1994). Friedler and McFarlane (1997) found that that pupils' ability to interpret data improves with the use of data loggers. Harlen (1999) in his review of literature suggests that data-loggers and simulation in practical work improve learning when used in appropriate ways. Similarly, Cholmsky (2003) also gives evidence for learning improvements when simulations are used. Barton (1997) argues that data logging could change the nature of children's thinking in experimental work in science. Barton (2004) adds that data logging helps pupils by reducing data collecting and processing times.

More than a decade ago, it was argued using ICT in mathematics classroom provide ample learning opportunities for the students. First, the ICT enable students to learn from feedback. The computer (ICT) often provides fast and reliable feedback which is non-judgmental and impartial. This can encourage students to make their own conjectures and to test out and modify their ideas. Secondly, the ICT (e.g. computers and calculators) enables students to produce many examples when exploring mathematical problems. This supports their observation of patterns and the making and justifying of generalizations. Thirdly, the ICT help students to see pattern and connection. The computer enables formulae, tables of numbers and graphs to be linked readily. Changing one representation and seeing changes in the others helps students to understand connections between them.
Fourth, the use of ICT allows students to work with dynamic images that cannot be done within traditional teaching. Students can use computers to manipulate diagrams dynamically. This encourages them to visualize the geometry as they generate their own mental images. Fifth, using ICT (e.g. computers) enables students to work with real data which can be represented in a variety of ways. This supports interpretation and analysis that lead students to higher order thinking skills.

The current level of ICT use in classroom

While we are aware of ICT impact on learning and the huge investment on hardware, software as well as training in the schools, are teachers using ICT regularly in the

classroom for instructional purposes? Cuban (2000) argues that despite these huge efforts very few teachers are serious users of computers in the classroom. Among his reasons are that teachers face intractable working conditions, external groups making constant demands on the teachers and technology being inherently unreliable. Becker (2001) reports that very few teachers reported students using computers during class hours and provides reasons ranging from block scheduling, too many topics to teach (versus few topics to be covered in depth) to lack of teacher expertise with technology.

Becker and Ravitze (2001) found that teachers with reasonable expertise in using computers, when five to eight computers are available for use in the classroom, and where they believe strongly in a constructivist pedagogy tend to regularly use computers in the classroom. Teachers engaged with peers in collaborative and leadership roles and who thus influence their peers more than most likely to have their students exploit computer resources during class.

What does research say on the benefit of using ICT in mathematics?

Ittigson and Zewe (2003) cited that technology is essential in teaching and learning mathematics. ICT improves the way mathematics should be taught and enhances student understanding of basic concepts. Many researchers have carried out studies to evaluate the benefits of using ICT in mathematics. Becta (2003) summarised the key benefits – firstly ICT promotes greater collaboration among students and encourages communication and the sharing of knowledge. Secondly, ICT gives rapid and accurate feedbacks to students and this contributes towards positive motivation. Finally, the use of ICT in mathematics classroom also allows them to focus on strategies and interpretations of answers rather than spend time on tedious computational calculations.

Furthermore, it is claimed that ICT supports constructivist pedagogy, wherein students use technology to explore and reach an understanding of mathematical concepts. This approach promotes higher order thinking and better problem solving strategies which are in line with the recommendations forwarded by the National Council of Teachers of Mathematics (NCTM); students would then use technology to concentrate on problem-solving processes rather than on calculations related to the problems (Ittigson & Zewe, 2003).

Factors that influence the teachers during ICT integration in mathematics classroom

BECTa (2004) divides barriers/factors leading to the effectiveness of classroom use of ICT into teacher-level and school-level. Most of the barriers referred above falls into the school-level category. Similarly, Crisan (2004) study also categorise those factors into contextual factors and personal factors. The contextual factors include the school context, the availability of and access to ICT facilities and resources, departmental ethos and key persons in promoting the use of ICT and the departmental policy with regard to integrating ICT into the mathematics scheme of work; where as personal factors include teachers' ICT skills and teachers' ICT professional development. Previously, Bramald, Miller and Higgins (2000) found that the degree of teacher's confidence in using ICT appears to be rooted quite firmly in their personal skill levels. Effective teachers who use

ICT are teachers who are confident with ICT and that they are much more comfortable with ICT as an enabling addition to the pedagogical armory.

School-level barriers are generally beyond the purview of trainers. However many of the teacher-level barriers can be addressed at the trainer level. One major teacher-level barrier which has drawn considerable attention is teacher belief (Ertmer, 2006; Goldstein, 1997). For instance, teachers whose beliefs support the view that ICT need to play an integral part in classroom learning are likely to use ICT powerfully in the classroom. Baggott La Velle, McFarlane, A., John, P.D., & Brawn, R. (2005) suggests that beliefs are difficult to change. Any training on ICT integration should take into account the belief factor to ensure the likelihood of the participants to practice what they learned during training.

For a successful integration of ICT into the mathematics curriculum, it is essential to have knowledge of the existing software that is used by mathematics teachers. A survey carried out by Forgasz and Prince (2002) found that 61% of the respondents (teachers) used spreadsheets, 45% used word processing and 30% used Internet browsers. In the same survey, it was found that 19% used Geometer's sketchpads, 19% used CD-ROMs that accompanied mathematics textbooks, 18% used Graphmatica, 14% used Maths Blaster and 8% used other mathematics-specific software. Knowledge of the use of software on the part of the teachers is not the only criterion for integrating ICT into mathematics lessons; a sound pedagogical knowledge on how to integrate it is another critical success factor.

Barriers faced by teachers during integration

In a study, Jones (2004) found that seven barriers existed while integrating ICT into lessons. These barriers were (i) lack of confidence among teachers during integration, (ii) lack of access to resources, (iii) lack of time for the integration (iv) lack of effective training, (v) facing technical problems while the software is in use, (vi) lack of personal access during lesson preparation and (vii) the age of the teachers.

In a study with 111 teachers, Keong, Horani and Daniel (2005) identified six major barriers faced by the tecahers to implement ICT into their mathemtic classroom. Thsese were lack of time in the school schedule for projects involving ICT (54.6%), inadequate teacher training opportunities for ICT projects (40.8%), lack of adequate technical support for ICT projects (39.2%), lack of knowledge about ways to integrate ICT to enhance the curriculum (38.8%), integrating and using different ICT tools in a single lesson (36.8%) and the absence of access to the necessary technology at the homes of students (33.0%).

Helping mathematics teachers to incorporate ICT into their classroom practices

Crisan (2004) proposed a framework to help teachers incorporating ICT in their teaching and learning practices. The framework was simplified into pictorial figure as dispalyed in Figure 1 below.

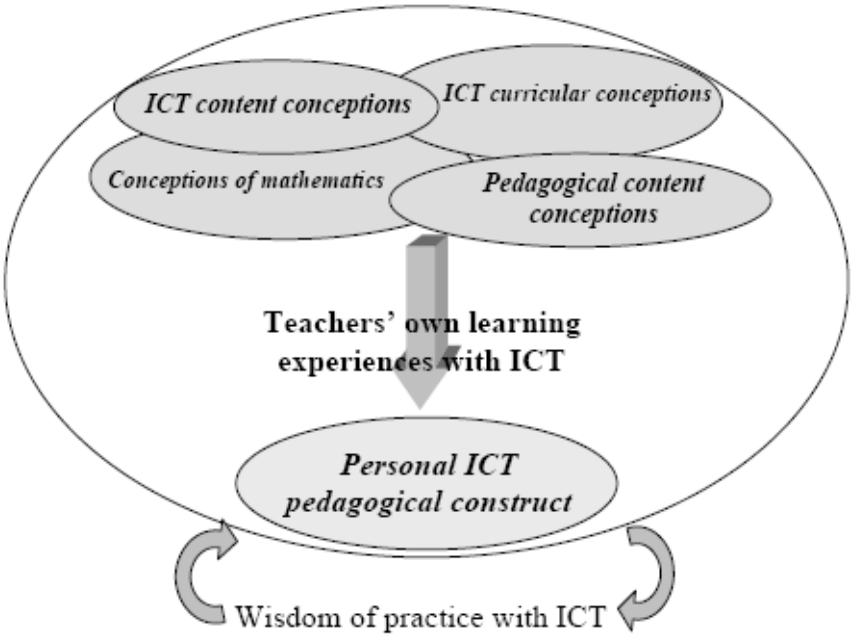

Figure 1. A framework for conceptualising teachers' learning about and incorporation of ICT into their classroom practices (Crisan, 2004. p. 19)

Crisan's (2004) proposed framework of teachers' learning about and incorporation of ICT in their teaching of mathematics can be seen and used as (1) a tool by teachers for categorising their personal understanding of ICT use; (2) The framework could also be seen and used as a useful tool for planning in-service development for teachers. As it could provide a useful starting point for discussing teachers' learning about and incorporation of ICT, the trainers could therefore draw out a training plan customised to each participating teacher's needs. In addition, the framework could guide educators on how to address student-teachers' conceptions of teaching and learning mathematics with ICT and to focus on what student-teachers ought to know and how they might improve their personal construct of the pedagogical conceptions of using ICT in teaching mathematics.

The pedagogical trojan horse: A framework for affordable and effective use handled technology

To wrap up this paper, it is noteworthy to note and review White's (2004) idea of the pedagogical trojan horse. Using metaphor or analogie of the Trojan Horse legend, White (2004) elaborate the stage of ICT integration into mathematics clasrooms. The Trojan horse refers to the legend of the huge wooden horse left behind by the Greeks who had lain siege to the city of Troy for over ten years. Once inside the defensive walls, the Greeks hidden inside the horse were able to open the gates and the city fell. In educational arena, there are a sizeable number of teachers at the Demon or Servant stage of integration in many countries. These teachers use mainly teacher centred teaching strategies. They have been holding out for a lot longer than ten years against the forces of constructivism and the proponents of student centred learning. These analog to the defense wall of Troy city. What is needed is a pedagogical Trojan horse.

Handheld technologies have the potential to be that Trojan horse and to help educational authorities gain entry inside the defensive walls of these teachers. Once inside the walls, the process of integration of ICT and the change to student centred methods can begin.

White (2004) suggested ways of improving the teachers' level of use ICT from demon or servant position toward as partner or liberator. First, teachers are need to be convinced and persuaded that using a GC (or ICT) is not a great imposition. Teachers need to be shown ways that GCs can support their usual ways of teaching mathematics. Secondly, teachers confidence on the ICT use must be bosted. The final stages are about providing teachers with new ways of teaching mathematics using the GC or ICT in general. The speed of a teacher's development will depend upon a number of factors but we need to remember the tale of the Trojan horse before trying to hurry the process. The Greeks tried to speed things up by attacking with great force only to be stopped for ten years. The other approach is more appealing and effective.

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