Bringing the "Real" Mathematics to Schools through Information and Communication Technology

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ABSTRACT

The purpose of this paper is to discuss the possibilities of using technology to bring the real and authentic application of mathematics into schools. Constructivist learning theory proposes that learning and understanding as an individual process; learning can be facilitated through interaction with the environment, cognitive puzzlement, social collaboration, and self-reflection.

In this paper, three principles are proposed to realise constructivist education: the "real" content, collaborative learning as the learning strategy and the information and communication technology (ICT) as the medium to bring the real mathematics to schools.

A resourceful international project, entitled "*Connecting Math to Our Lives*" is suggested for constructivist learning to explore and discuss about math. It is one of the International Education and Resource Network (IEARN) Projects with the aim of using Internet as the empowering tool to share knowledge, to engage learners and to explore how mathematics is used in local families and communities.

Introduction

The purpose of this paper is to discuss the possibilities of using technologies to bring the real and authentic application or existence of mathematics in real life into schools.

Mathematics is usually perceived as a boring subject. In comparison, subjects like arts and design, sciences, history, geography and other social science studies are more interesting because of the nature of the subjects. They are more realistic, appeal to human senses, applied or story driven.

Conversely, mathematics deals a lot with symbols and notation, abstract concepts, formulas, proofs and also drill and practice to the mathematical problems. The mathematics educators face a lot of challenges to turn mathematics into an interesting and exploratory subject in schools in order to attract more students especially teenagers or young adults to like mathematics.

Theoretical Foundation

This paper proposes constructivism learning theory as the foundation of technology-based learning. It says that the reality of knowledge is constructed by the learner's mind based on his or her experiences, mental structures and beliefs (Jonassen, 1991). Thus, knowledge to a person is something very unique. He or she is the owner of the knowledge, which can be used, manipulated, and related to his or her prior knowledge or can be shared with others through discussion and collaboration. However, the learning process of building up new knowledge ought to be guided by facilitators to avoid any reinforcing misconceptions.

Duffy and Savery (1995, 1996) view constructivism as a philosophical view on how we come to understand and know. They characterize it into the following three important concepts of learning:-

(1) Knowledge is constructed by individual and the construction of knowledge is supported by environment.
(2) Cognitive conflict and puzzlement is the stimulus for learning and it determines the organisation and nature of what is learned.
(3) Knowledge evolves through social negotiation, and self-reflection.

The principle of constructivism is to put the learning contents in the context which is relevant, authentic, integrated or socially supported. Ultimately, the indispensable objective of learning is to achieve "meaningful learning", which Novak (1999) defines it as underlies the constructive integration of thinking, feeling, and acting leading to commitment and responsibility.

Whitehead, A.N. (1861-1947), who is the earliest person to advocate constructivism education. According to him, "even the future workers should receive a 'liberal education'. This would include mathematics, not just as a 'training in concentration', but as part of an interdisciplinary understanding of the world1" (Whitehead, p. 5 in Anglin, 1997).

Dewey (as cited in O'Neil, D.K., 1998) who advocated learning through doing says, "Probably the greatest and commonest mistake that we all make is to forget that learning is a necessary incident of dealing real situations (1915, p. 4)." Dewey (as cited in O'Neil, D.K., 1998) reminded that, "Now, all principles by themselves are abstract. They become concrete only in the consequences which result from their application (1938, p. 20)."

Integrated learning approach is able to generate meaning to learning. Harris and Alexander (1998) believe that there is a need to face the challenges inherent in three forms of integration: intradisciplinary, interdisciplinary, and cross-disciplinary. They believe these integrations are important in constructivist educational reform.

Principles of Implementation

There are many ways of realising the philosophy of constructivism. This paper proposes three principles, which complement each other to bring the real mathematics to schools.

a) The Real Content

The real contents can be brought into schools by emphasising on the real application or usage of mathematics in various subjects and disciplines. The integrated contents have the advantages in creating depth of understanding and meaningful learning. Mathematics can be related to the world outside and its application areas such as everyday life, finance, graphics and visualisation, design and manufacturing, architecture, medicine and biology, robotics, physical sciences and others.

Mathematics is not a content that can be learned merely through memorization. Novak (1998) stated that rote learning, common in most schools and universities today, is shown to be ineffective for achieving the goals of individuals and society in an era when creative production of new knowledge is at a premium.

b) Collaborative Learning as the Strategy

We cannot deny that social involvement is very important in our learning system. It is believed that what the learner can do with assistance today means that he or she can do without any assistance by tomorrow. This is a notion in Vygotsky's concept of Zone of Proximal Development (ZPD) (Bodrova and Leong, 1996). Solving mathematics problem collaboratively among the peers could be a powerful strategy for learning. Learning from peers and teaching the other peers is a useful revision mechanism for learning. Huber (1992, in Slavin, 1995) put it this way, "Very true is the phase, '*he who teachers others educates himself*' ". Besides, collaborative learning has the hidden objective of teaching social skills to young people and to cultivate a better attitude towards group works. In real life, social skills and cooperative value are very important and need to be taught since young age.

c) The Tools

With the advent of Information and Communication Technology (ICT) and its blooming usage in education, there are many researchers believe that ICT can become a promising tool for constructivist education (Kearsley, G., Shneiderman, B, 1998; Jonassen, 1996; Confrey, J., 1996).

Harasim et.al (1996), who is one of the pioneers to advocate learning networks believe that learning via networks can promote active learning, facilitate collaboration and learning communities. Thus, they propose "*learning networks*" which means groups of people who use computers and network to learn together, at the time, place, and pace that best suits them. To them, one of the best ways of using learning networks is collaborative learning. They believe "*Learning together can be much more engaging and effective than learning alone*" (Harasim et. al. ,1996).

In fact, learning network in Math has begun as early as 1969. Stanford University began delivering Math education to low-income students in Mississippi, Kentucky, and California using time - sharing computer networks (Hunter, 1992 in Harasim et. al. 1996). Now, there are many resources of learning mathematics can be found in the cyberspace.

Multimedia is another useful tool to bring the real mathematics to schools. Multimedia is the new media that derives from the convergence of print and publishing media, broadcast and motion picture media and computer media (Fidler, 1997). It is a powerful tool for education.

The following is an example of a learning activity that embraces the above three principles:-

An Example of A Constructivist Learning Activity:
"*Connecting math to our lives*"

This is an International collaborative project, participated by various countries in the world, to connect math to our real life by using the Internet. Its parent project is International Education and Resource Network (IEARN, url:- http://www.iearn.org). iEARN is a non-profit that enables young people to use the Internet and other new technologies to engage in collaborative educational projects that both enhance learning and make a difference in the world.

By participating "Connecting math to our lives project", teachers and students are able to get the following benefits:-

- explore how math is used in their families and communities
- use math skills (ranging from simple computation, to averages, percents, graphing, and statistics) to investigate community or social concerns
- to take action to promote greater equity in the world around them.

To get more information about this project, do visit its official web site at: http://www.orillas.org/math/

One of the interesting activities in this project is Data Collection Activities through Internet. The participants from various countries were asked to contribute data such as currency exchange, the price list of some product items, and the wages of a factory worker, teacher and doctor in the respective countries. By having the real data, the participants were asked to analyze the data and use the information to make comparison, suggestion or decision.

As part of the contributions to this project, a group of Malaysian students and teachers have produced some local research contents, i.e. to discover the real mathematics, particularly geometry in their lives. By using digital camera, the real world can be projected via still images. The Internet is used as the medium to share and disseminate the information to other participants.

The following are some interesting findings:-

Figure a: A turtle shell

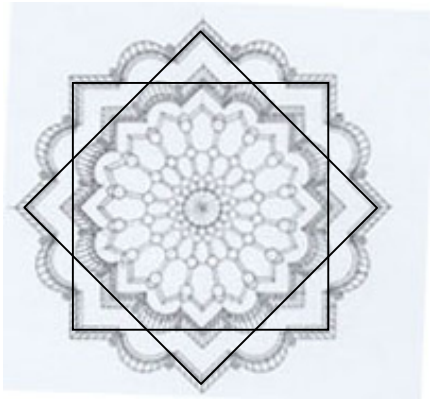

Figure b: Plan for Petronas Twin Tower
Source: Pelli, C. & Crosbie, M.J., 2001

a) They discovered that there is a tessellation of hexagonal shapes on a turtle shell. Derive from the finding, more questions can be asked to generate more mathematical investigation such as: "Why only hexagonal shape is found?", "Are all the sizes of the shapes equivalent?", "Do you think other turtles have hexagonal shapes on their shell?", "What can we learn from this findings?"

b) They found that geometrical concepts such as symmetry and polygonal shapes are used widely in architectural design. For examples, the plan of Petronas Towers (Figure b) is designed based on geometrical concept. It consists of two interlocking squares create an eight-pointed, with eight semi-circles superimposed in the inner angles of the eight-pointed star creating a sixteen-lobed form star shape (Pelli & Crosbie, 2001).

Technologies can be used in many ways such as to publish reports or documentations via the Internet and to analyse real data for decision making or comparative studies. This learning environment is different from the conventional classroom activities. More creative approaches can be conducted by using the technology. Students can create and donate something useful to the world or to their local community. They can gain more power to voice out their opinions and to learn based on their own construction of knowledge. Mathematics is not just the study about figure and formula. It is more than that. Even young people can use it to solve problems or make decision for their own living.

Conclusion

The researcher feels that there is a need to teach and learn mathematics based on the discussed framework. Understanding mathematics is a very personal process, only the learners know how to describe their understanding to themselves or to others. Therefore, meaningful learning in mathematics is important. Three principles are proposed in order to learn mathematics meaningfully. The first principle is to approach the real usage of mathematics in our lives; the second is to use collaborative learning approach to learn mathematics. The third principle is to use ICT as a tool for active learning and creative creation of mathematical contents. Technology itself is a void if we couldn't provide interesting and related contents. Schools should conduct more real lives exploratory activities. The world outside the school is in fact an interesting and resourceful mathematical "text book" which we cannot find in the bookstore.

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