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Procedia Social and Behavioral Sciences 2 (2010) 1963–1967

Procedia
Social and Behavioral Sciences

WCES-2010

# Mathematical creativity: usage of technology

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Received October 16, 2009; revised December 25, 2009; accepted January 8, 2010

**Abstract**

Creativity in mathematics helps students make sense of the world. However, in typical classrooms, students are taught as if mathematics is all about rules and procedures. Students need to see how mathematics was developed and realize that creative individuals shaped the body of mathematical knowledge. More emphasis should be placed on creative ways of expressing ideas. In this age of ICT, students need work that stimulates their curiosity and awakens their desire for mathematical creativity. This paper will discuss and describe the essence of mathematical creativity and the impact of technology on creativity in mathematics.


*Keywords:* Statistics: reasoning: SOLO taxonomy: assessment; inference; informal.

## 1. Introduction

In this information and communication technology age, creative and skilled manpower are needed to support the vision of our nation. But the question is, "What kind of work do students find totally engaging to promote creativity?". Students want and need work that stimulates their curiosity and awakens their desire for deep understanding and value towards their mathematical creativity. An emerging technological society and economy makes mathematical knowledge and creativity both essential and advantageous for students as they position to join the workforce.

In Malaysia, the cultivation of a mathematically competent and mathematically creative Malaysian workforce anchors on the concomitant improvement of mathematical achievement in Malaysian students in order to possess the mathematical knowledge to produce, use, and manipulate new technologies. In secondary mathematics, this would mean that the order and treatment of most topics would need to change.

Mathematics relies on logic and creativity, and it is pursued both for a variety of practical purposes and for its intrinsic interest. The essence of mathematics lies in its beauty and its intellectual challenge. Learning to know our creativity ability is one of the most significant aspects of our life, for everything we do, is affected by our thinking abilities.

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1877-0428 
doi:10.1016/j.sbspro.2010.03.264

## 2. Definition of Creativity and Procedure to Assess Mathematical Creativity

Literature shows that there are numerous ways to express and define creativity. Some people refer creativity to a special kind of thinking, while others refer to the generation of products. There is yet to be one definition of creativity that everyone can agree with. However, several experts on creativity generally agree on the five phases a person goes through in the creative process: (1) Preparation phase – acquiring skills, sensing and defining a problem; (2) Concentration phase – focusing intensely on the problem; (3) Incubation phase – withdrawing from the problem; (4) Illumination phase – the stage involving the emergence of an idea; (5) Elaboration phase – testing out the idea (Guildford, 1975).

Torrance (1984) defined creativity as a process of becoming sensitive to problems. Torrance has described four components by which individual creativity can be assessed, such as: (1) fluency as the ability to produce a large number of ideas; (2) flexibility as the ability to produce a variety of ideas; (3) elaboration as the ability to develop an idea; (4) originality as the ability to produce ideas that are unusual. Creativity was defined as the ability to produce new things or new knowledge (Simonton, 2000).

## 3. Fostering Mathematical Creativity in Classroom

Most of the time, there exist many correct approaches that can lead to solve a given mathematical problem. In order to achieve this, mathematically rich thinking skills are required. With the skills, students can understand ideas better, discover relationships between ideas and solve problems that involve the ideas. Laycock (1970) described mathematical creativity as an ability to analyse a given problem in many ways, observe patterns, see likenesses and differences, produce multiple ideas and decide upon a suitable method to tackle unfamiliar mathematical situation.
Balka (1974) outlined six different criteria for describing mathematical creativity. These criteria were selected by a panel of famous and distinguish educators. All the criteria have been identified as checking creative ability in mathematics. These include (i) the ability to formulate hypotheses in a mathematical situation, (ii) the ability to determine mathematical patterns in a mathematical situation, (iii) the ability to break from stereotype established mind sets, (iv) the ability to consider and evaluate unusual mathematical ideas, to think through their consequences for a mathematical situation, sensing what is missing from a mathematical situation and to ask questions that will enable one to fill in the missing mathematical information and (vi) the ability to split general mathematical problems into specific sub-problems.

The concern on mathematical creativity is the ability to generate ideas from given information. Thus it is appropriate that students should at least be given the opportunity to examine a wide variety of enrichment problems in mathematics. By providing divergent responses in unconventional questions and other problem-solving experiences, mathematical creativity can be explored to the fullest.
As a mathematics educator, the author noticed that learning mathematics comes easily for some students, while others struggle every step of the way. However, the main concern of the author was for the group of student who exhibits anger, anxiety, alienation or powerlessness while attending a mathematics class. These will definitely hinder students from being creative.

When students were struggling with motivation they experienced a range of negative feelings including anger, rebellion, anxiety, frustration, and helplessness. Some students who felt unmotivated to do required tasks, demonstrated signs of anger and rebellion because they felt they were denied the opportunity for self- determination. Some become aware of their desire for autonomy. Lack of motivation is also associated with a feeling of being less competent and also anxiety. Anxiety has been recognized as negatively related to intrinsic motivation. Some students who felt anxious and were less competent, also experienced lack of control over outcomes which can lead to a sense of helplessness which then impairs learning and performance and creativity.

Torrance (1966) defined math anxiety as “the panic, helplessness, paralysis, and mental disorganization that arises among some people when they are required to solve a mathematical problem.” Math anxiety has been called an illness that is an emotional and cognitive dread of mathematics. Motivating students towards learning mathematics is very much related to reducing math anxiety and fostering creativity.

Students’ creativity is also influence by a responsive classroom culture. A deeply responsive classroom culture alleviates motivational struggles and promotes students’ perceptions of self-determination, and thus their ownership of their own learning agenda. Teachers’ responsiveness and empathic understandings of students’ perceptions are

well described by the following phrases: supportive, caring, understanding, accessible, sharing mutual trust and respect, listening to and respecting diverse opinions, explaining things, not telling all the answers, fun, humorous, enthusiastic, sharing interest, holding high expectations, and giving special feedback (Cropley, 1992; Laycock, 1970; Pal & Kathy, 1990).

## 4. Creativity and Technology in the Teaching and Learning of Mathematics

Technology has now become an integral part of our Malaysian educational system. This usage is increasingly rapidly and has also generated new challenges. The purpose of using technology in the teaching and learning of mathematics is for the enrichment and improvement of the conditions in which human beings learn and teach. Pal and Kathy (1990) define creative learning as a natural healthy human process that occurs when people are curious and excited. Creative thinking and learning involve the ability to sense problems, fluency, flexibility, originality, and elaboration.

Technology can empower and provide students all the tools necessary for promoting creativity. The integration of technology into mathematics instruction and creativity has been notably discussed, pointing to the inevitable interest and impact of technology on creativity in mathematics. It has been shown that working with the appropriate computer software can pack a large amount of graphing experience into a relatively short amount of time with the result that students deal with more graphs in class. Learning is an active process; however, a lot of commonly used teaching strategies pace students in passive and receptive roles. Technology has the ability to enrich the content of students' learning experiences, provide greater flexibility, and give students a more self-reliant role in their own education. Students are to be motivated and their enthusiasm enhanced, it is important that instruction be flexible enough to create room for creativity to prosper.

With the help of technology, the teacher can effectively address the challenge of organizing mathematics instruction in such a way that it attracts and develops the abilities of the greatest number of students possible (NCTM, 2000). Students can visualize mathematical concepts which are difficult to comprehend without computers. In a typical classroom, technology would be able to provide easy and clear illustration than those a teacher could make without technology. Let us look at the example given in Figure 1 below. Graphing calculators would be able to help students visualize the given graph better. With the help of graphing calculators, students can creatively draw the graph, and also see different views of the graph, thus saving teachers' precious and limited time.

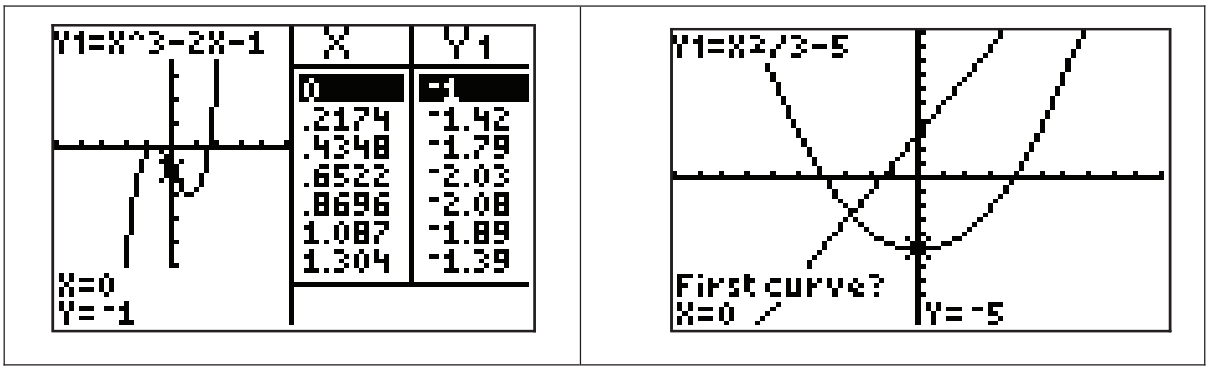


Figure 1. Drawing and plotting graphs using graphing calculator

According to Simonton (2000) creativity comes more from environmental factors than hereditary factors. Research has also shown that creative people do not like to work in a conventional way. In the mathematics classroom, Cangelosi (1996) has reported that mathematics creativity is displayed by students who think divergently. These are students who generate ideas, conjectures, algorithms, or problem solution. With technology capabilities, students can visualize mathematical concepts which are difficult to comprehend without technology as in Figure 2.

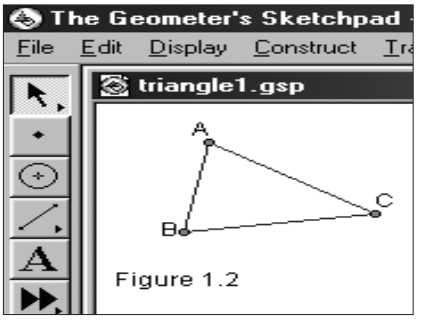


Figure 2. A geometrical sketch using The Geometers' Sketchpad

With the help of computers, the teacher can effectively address the challenge of organizing mathematics instruction for promoting creativity. As shown in Figure 2, student can creatively animate the right-angle triangle. Visual representation on a computer screen is more beneficial to the students understanding compared to diagrams in books. There is no doubt that using a variety of technological tools, such as calculators, computers, and hands-on materials, under the guidance of a skillful teacher creates a rich mathematical learning environment. Such an environment helps in exposing and preparing students for diversified experiences. This is the exposure that is required and necessary to nurture creativity.

With the help of technology such as computers and graphing calculators, students themselves would be able to creatively draw three dimension objects, and also see different view of the object, thus saving teachers' precious and limited time as well as building a concrete image of the object in students' mind. It has been shown that technology can stimulate projects that teach students teamwork, problem solving, and critical thinking, as well as increasing their enthusiasm for learning. In particular, there is a necessity to facilitate the education of smart learners capable of working competently and independently with others in teams in a technology-enabled environment who are aware of their own creativity. The Malaysian Smart School reform seeks to transform the traditionally directive univocal environment to a more flexible multivocal interactive atmosphere where mathematical knowledge and creativity are thoughtfully explored.

## 5. Discussion and Conclusions

The essence of mathematics is thinking creatively, not simply arriving at the one right answer. However, several typical schools, mathematics courses often focus on what the student does rather than what the student thinks. Traditional assessment to identify the mathematically gifted do not identify or measure creativity but often reward accuracy and speed. These tests only identify students who do well in school mathematics and are computational fluent, but neglected the creatively talented in mathematics.

Simonton (2000) has pointed that, the acquisition of creative potential requires the simultaneous contribution of both nature and nurture. As teachers we have very little or no control over the nature, but much can be done in the mathematics classrooms that can nurture the creativity potential of our students. To enhance creativity, it is crucial therefore that qualities such thinking, relevant motivation, engagement, imagination, relative freedom, and independence thinking. As we know that students' growth in mathematics involves more than just mastering computational skills. Mathematics talent requires creative applications of mathematics in the exploration of problems, not replication of the works of others. The challenge is to provide an environment of practice and problem solving that stimulates creativity.

With the aid of technology, especially computers, instruction can be flexible and adaptable to individual needs. Student-teacher interaction and learning are significantly more student-centered, thus creating room for students' optimal creativity. Today's students will live and work in an era dominated by computers, by worldwide communication, and by a global economy. It has been established that good use of computers can empower students to be creative and critical thinkers and better problem solvers (Kaput, 1992)

All students, especially those with potential talent in mathematics, need academic challenge as well as creative opportunities to explore the nature of mathematics and to employ the skills they have developed. While the literature supports the development of mathematical creativity, it also reports that little is being done to identify or develop mathematical creativity in schools today. More research is necessary to develop identification tools so that effectiveness of interventions to encourage creativity can be measured especially in Malaysia.

## References

Balka, D. S. (1974). Creative ability in mathematics. *The Arithmetic Teacher* 21, 633 -636.
Cangelosi, J. S. (1996). *Teaching mathematics in secondary and middle school: An Interactive approach.* New Jersey:Prentice Hall.
Cropley, A. J. (1992). *More ways than one, fostering creativity.* Norwood, New Jersey:
Ablex Publishing Corporation
Guildford, J. P. (1975). Varieties of creative giftedness, their measurement and development. *Gifted Child Quarterly* 19, 107 -121.
Kaput, J. J. (1992). Technology and Mathematics Education. In Grows, DA (Ed). 1992. *Handbook for Research in Mathematics Education.* New York: McMillan.
Laycock, M. (1970). Creative mathematics at Nueva. *The Arithmetic Teacher,* 17, 325 – 328.
National Council of Teachers of Mathematics (2000). *Standards and principles in School Mathematics.* Reston, VA: NCTM.
Oxford English Dictionary (1995). *Concise Oxford Dictionary,* Oxford University Press.
Pal, E. T. & Kathy, G. (1990). *Fostering Academic Creativity in Gifted Students. ED* 321489.
Quigley, P. (1998). *Creativity and Computers. http://erica.net/edo/ED315063.htm* (Retrieved: 12/4/2005, 9.00 A.M.)
Simonton, D. K. (2000). Creativity: Cognitive, Personal, Development, and Social Asects. *American Psychologist,* 55, 1, 151-158.
Torrance, E. P. (1984). *Torrance Test of Creative Thinking.* Bensenville, IN: Scholastic Testing Service.
Torrance, E. P. (1982). Hemisphericity and Creative Functioning. *Journal of Research and Development in Education,* 15, 29 -37.
Torrance, E. P. & Goff, K. (1990). *Fostering Academic Creativity in Gifted Students.* ERIC Digest E484.