ENHANCING AND ASSESSING STUDENT TEACHERS' CREATIVITY USING BRAINSTORMING ACTIVITIES AND ICT-BASED MORPHOLOGICAL ANALYSIS METHOD

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ABSTRACT

Creativity is often known as a characteristic that a person possesses, a product or outcome that is regarded as original, and a process by which an unusual, novel or suitable outcome or solution is obtained. According to Segal (2001), creativity involves the exercise of imagination to come out with new, unique and original ideas and products. Many researchers strongly argued that creativity could be taught and fostered (Cropley, 2001; Davis, 1999; Houtz, 2003; Treffinger & Isaksen, 2001; Onda, 1994; Torrance & Safter, 1999). This paper explores the use of Information and Communication Technology (ICT) to assess and foster creativity of student teachers' using brainstorming and Morphological Analysis Method (MA Method). A self-developed integrated system consists of multimedia training modules for fostering creativity and measuring creativity was programmed for the experiment. A sample of ninety-seven student teachers taking B. Ed courses of a public university in Sabah, East Malaysia participated in the study aimed at measuring the creativity traits of the subjects and improving their respective creative potentials. The research found that the assessment of creativity traits such as fluency, flexibility, elaboration and originality using computer is successful using definitions and algorithms adapted from Torrance's TTCT and Guilford's Alternative Task (Torrance & Ball, 1984; Guilford, 1977). It was also found that 85 out of the 97 subjects (87.6%) managed to improve their respective fluency, flexibility, elaboration and originality scores in the summative practice. The improvement of their creative potentials was largely attributed to the effective implementation of the MA Method in the brainstorming activities in the practice. The paper concludes by recommending the MA Method to be integrated into teaching and learning activities of academic courses to improve the creative potentials of student teachers in the Faculty of Education of the university.

Keywords: creativity, brainstorming, morphological analysis, multimedia

INTRODUCTION

Creativity and creative teaching have been gaining prominence of late. Thus for instance, in the case of the U.K. government, it is beginning to recognise that young people need to develop the creative skills that will be necessary in the workplace of the future. The advent of fast-moving technology, coupled with the increasing demands for flexibility and imagination means that future student teachers and students at large need to be able to more creative in confronting the challenges they are likely to face. Creative teaching practices will help prepare them for this – promoting the ability to solve problems, think independently and work flexibly. It is common knowledge that creativity is the foundation to the development of technology (Peterson & Harrison, 2005) to solve practical problems,

or result in inventions and new ways of doing things. Creativity provides the impetus to develop new technologies and new products to satisfy the needs and wants of society (Michalko, 1991).

However, studies on developing teachers' creativity have not been widely conducted despite its growing importance, particularly studies on developing student teachers creativity. Thus this study attempts to fill this gap. Taking cognizance of the dearth of literature in this area, and recognizing the dire needs to foster and develop creativity amongst education student teachers, a study was undertaken to investigate the possibility of training and assessing creativity using multimedia and a computer-based assessment system.

Thus, how can teacher trainers assess and improve the climate for creativity in the education classroom? Torrance (1987), Starko (1995), Ekvall (1999), and Miller (1999) have identified several attributes that are important to the development of creativity. Among the more important attributes are *challenge* (where students are inspired and motivated to be creative); *resources* (where sufficient resources such as time, tools, and materials are available); *environment* (where the physical facility is attractive, and examples of creative work are present); *atmosphere* (where the affective environment is supportive, trusting, free, and open), and *technology of creativity* (where tools, processes, and techniques associated with creativity are utilized); and *educational environment* (where the administration, school/university, and community support creativity).

This study examines the last two attributes, the *technology of creativity* and the *educational environment*. To do so, an integrated system was developed and tested on a group of university TESL and Science student teachers for its effectiveness and reliability in evaluating creative potentials of a person. The main objectives of the study were to explore the extent in which multimedia could be used to improve creativity and to measure creativity traits of the participants.

RESEARCH QUESTIONS

The study was designed specifically to examine and answer the following research questions:

1. In what ways can multimedia be used to improve creativity?
2. What components of creativity are used to indicate creativity improvement?
3. How do the creative potentials of a person improve?

REVIEW OF LITERATURE

Since the paper reports on an initiative to explore whether multimedia could be exploited to facilitate creativity assessment while at the same time foster the development of creativity among student teachers, the theoretical overview in this section is premised on the following three fields of study, namely creativity; the use of multimedia for training creativity; and the Morphological Analysis Method for fostering creativity.

Creativity

Creativity is a difficult construct to define. As such one can find a number of definitions that describe it. Thus for instance, Torrance (1967), noted that creativity involves a) connectedness; b) originality; c) non-rationality; d) self-actualisation; and e) openness. Reber (1995), on the other hand, hypothesized that creativity involves mental processes that lead to unique and novel theories, ideas, solutions, or products. Gibson (2005), meanwhile, considered creativity as individuality.

As the definitions indicate thus far, creativity involves mostly two particular areas: skills and personal characteristics. Creativity is often seen as a characteristic that a person possesses, a product or outcome that is regarded as original, and a process by which an unusual, novel or suitable outcome or solution is obtained. Based on survey of the literature, creativity has been studied in a number of forms, including but not limited to product or behaviour (Besemer & Treffinger, 1981); personality (Gardner, 1983); thinking and learning styles (Sternberg, 1985); environmental and social psychological settings such as motivation and work place (Amabile, 1982; 2006) and social-economic factors; creativity processes such as thinking processes (cognition and meta-cognition); and stages of

creativity (Csikszentmihalyi, 1996; Loveless, 2002; Mansfield & Busse, 1981; Shneiderman, 2000; 2002a; 2002b).

Thus for example, Hartley (2006), Torrance and Haensly (2003) studied the importance of creativity in the learning process. Torrance (1987) in his meta-analysis of 142 studies claimed that creativity could be taught. It was submitted that developing creativity should include developing both cognitive skills and personality factors, and importantly too are the motivating conditions and students' activeness.

The use of multimedia for training creativity

Numerous researchers argued that creativity could be taught and fostered (Cropley, 2001; Davis, 1999; Houtz, 2003; Treffinger & Isaksen, 2001; Onda, 1994; Torrance & Safter, 1999). In this study, multimedia coursewares that uphold the principles of multimedia of self-access, self-directed and self-paced were employed in creativity training. According to Schwier and Misanchuk (1993), multimedia courseware must have interactive learning components and practices that come with responses and suitable feedbacks. Carefully designed multimedia coursewares that are consistent with how people learn, can aid learner greatly (Liou, 1994; Mayer, 1997; 1999a; 1999b).

It is submitted that the incorporation of video sequences and animations into multimedia courseware can help teachers to tackle the many misconceptions that students may have and which are difficult to address within the limitations of chalk, textbook and overhead projector. The development of quality computer graphics is also essential to present visual ideas clearly to explain concepts. Voice, which is narrated audio, and music are types of audio that can aid learning in multimedia courseware (Mayer, 2003).

Animation is also a highly effective tool for illustrating a concept (Roblyer, 2003). The deliberately-created motion can also illustrate processes and real-life or virtual environment. According to Mayer (2003), animations are processed in the visual or pictorial channel, but he argued that learners are only able to mentally activate for about ten seconds of the animation at any one time.

The Training and Assessment of Creativity

This study used brainstorming and the Morphological Analysis (MA) Method in fostering creativity. Brainstorming is an activity that encourages lateral thinking and a great contributor to creativity and innovations because it gathers all ideas (without pre-judging any of them) into a solution-bank for the next stages of the creativity process (Muttagi, 1981; Rawlinson, 2004; Vidal *et al.*, 2004). The running of brainstorming is usually based on the following principles:

- Criticism is ruled out (Ruling out criticism altogether);
- Freewheeling is welcomed (Welcoming freewheeling);
- Quantity is wanted (Soliciting as many ideas as possible);
- Combination and improvement are sought (Seeking/Looking out for improvement and improvisation)

The creation of a relaxed and judgement-free atmosphere encourages the flow of ideas which will be severely impeded if participants are allowed to convey their judgement on each idea (Majaro, 1988). To ensure all ideas are accepted, the power of imagination is highly encouraged. In other words, the brainstorming session may produce any idea that can solve the problem, be it wild, insane, practical or even impractical idea.

With the growth of online services, brainstorming activities have gone online with a new term known as brainlining (combines the words 'brainstorming' and 'online') (Proctor, 1999). In this study, an 'asynchronous' (offline) type of brainstorming activity was created (Binder & Binder, 2007) to be used together with the MA Method (to be explained in the next section) as the main heuristics for investigation.

According to Rawlinson (2004) there are more than 200 techniques used for the fostering of the creative potentials of a person. Some of these techniques are attribute listing, mind-mapping, check

lists, forced relationships, 5 W's (What, Who, Where, When and Why) and H (How), lateral thinking and PO (stands for provocative operation and is commonly used to propose an idea which may not necessarily be a solution or a 'good' idea in itself, but moves thinking forward to a new place where new ideas may be produced), metaphorical thinking and etc. The MA Method was chosen because it encourages the breakdown of a problem into easily approachable components and thereby increases the possibilities of getting more solutions and hence increases the fluency of ideas production (Aleinikov, 2002; Rawlinson, 2004).

The focus of this study was to measure the creativity traits of the subjects in term of fluency, elaboration, flexibility and originality. The criteria for the assessment of the creative potentials of a person used in this study are based on Table 1.

Table 1: Scoring criteria for creativity constructs and Creativity Index
(adapted and adopted for use in this study from Torrance & Ball, 1984; Guilford, 1977)

Creativity components	Scoring criteria	Score awarded
Fluency (F)	The number of different ideas that one can produce	1 point for each idea
Elaboration (E)	Richness of detail in the ideas that one produces	1 point for each creative elaboration
Flexibility (FX)	The number of categories of ideas that one produces	1 point for each category
Originality (O)	The uniqueness of the ideas that one produces as compared to the whole sample	Between 1% and 5% = 1 point If 1% = 2 points

The Morphological Analysis Method for fostering creativity

Morphology Analysis Method (MA Method) is a technique created by Dr Fritz Zwicky, a Swiss astrophysicist based at the California Institute of Technology. It is also known as the morphological box, morphological matrix or even idea box (Michalko, 1991). Morphological Analysis generates a very large number of solution concepts for a problem under investigation (Roy, 2004).

It works through the processes of breakdown and association. The problem is first broken down into component variables and possible values are identified for each. It is also known as the functional decomposition technique which identifies the functions of the independent subsystems that make up the total product (Roy, 2004). The association principle is then brought into play by relating multiple combinations of these values. An example on the use of Morphology Analysis is shown in Table 2.

Table 2: An example of a Morphology Matrix (4 – Dimensions)
(Source: http://www.mycoted.com/Morphological Forced Connections)

Shape / Cylinder	Material	Cap	Ink Source
Faceted	Metal	Attached Cap	No Cartridge
Square	Glass	No Cap	Permanent
Beaded	Wood	Retracts	Paper Cartridge
Sculptured	Paper	Cleaning Cap	Cartridge made of ink

The example shown in Table 2 is on ways to create new products for a pen. The pen is firstly broken into components such as shape, material, cap and ink source. Next, sub-components for each main component are listed. This comes to a 4 x 4 x 4 x 4 Morphological Matrix that can theoretically supply the maximum of 256 ideas. For example, the components in the coloured boxes in Table 2.2 can be combined to create a new product named "*Environmental Cube Pen*" (one corner writes, leaving six faces for advertisements, calendars, photos, etc. using only wood and paper cartridge).

METHODOLOGY

The main research methodology used was the program evaluation approach. Program evaluation is a systematic collection of information about the activities and outcomes of programs to improve effectiveness and make decisions with regard to what those programs are doing and affecting (Patton, 1994; Clarke and Dawson, 1999). The formative – summative evaluation approach has been typically

argued to be suitable for evaluating training programs (Scriven, 1967; Robson, 2000; Morrow et al., 2006; O'Sullivan, 2004).

According to Scriven (1967), formative evaluation is evaluation done to provide feedback for program improvement. Its primary objective is to support the process of improvement. It is also known as "developmental evaluation" by Patton (1994). In summative evaluation, Scriven (1967) said that the principal aim of the exercise is to determine the overall effectiveness or impact of a program with a view to recommending whether or not it should continue to run. According to Clarke and Dawson (1999), the formative – summative approach is appropriate because formative evaluation is "process-oriented' which focuses on improving program development while summative evaluation is "conclusion-oriented" which usually indicates whether or not the program needs to continue at the end of the training session.

Sampling

The participants involved were the final year student teachers (N = 172) of the education faculty of a public university in the state of Sabah, East Malaysia. Based on the sampling size table provided by Bartlett *et al.*, (2001), the minimum sample size required is estimated to be 94 (n = 94). To solve problem of absentees, the names of 110 participants were selected randomly from the name list supplied by the faculty. Finally, only 97 participants from two academic disciplines (TESL and Science) participated in the creative training program.

Before the training, the 97 subjects were asked to do Practice 1 (formative evaluation of the program) which was a brainstorming activity. They were allowed to access the multimedia training for knowledge on the brainstorming strategy. After completing Practice 1, they were requested to go through the multimedia presentation again to learn another creativity technique known as Morphology Matrix (Morphology Analysis) Method. Once the participants were confident of themselves, they were then asked to carry out Practice 2 (summative evaluation program).

Instrument

The main instrument used for assessment of creativity was the self-developed Creativity Assessment System embedded in the integrated system. The chosen topic for Practices 1 and 2 was the "Future Transportation in Malaysia". The principle of creativity measurement purely lies with divergent thinking and hence 'the number of ideas produced' contributed to the fluency component. Thus, for example, if 10 ideas were contributed, that would have generated 10 points for a person's creativity indicator (fluency). In this exercise, there was no such thing as the right or wrong answers for the topic. The principle of creativity states that there is no such thing as 'wrong idea' because all ideas are valued and accepted.

In ensuring content validity for the instrument, a renowned creativity expert from another public university was engaged to verify the content input. An important consideration pointed out was topic familiarity which might influence idea generation efficacy. To ensure that this did not pose a problem, the topics selected for this study were first piloted to ensure they were not culturally alien to the participants. As for reliability, the Creativity Assessment System was deemed to be reliable because the calculations for the four creativity components (fluency, flexibility, elaboration and originality) were done via the implemented algorithms programmed strictly based on the criteria defined in Table 1. In addition, the results of the pilot run of the integrated system showed that the anticipated results tallied perfectly with manually calculated results.

Besides using the creativity assessment system, follow-up interviews were also conducted to solicit participants' views and perceptions towards the creativity training program. Their responses were used to explicate certain behavioural characteristics or phenomena and to supplement the findings obtained from the quantitative data.

FINDINGS AND DISCUSSION

Improving creative potentials via multimedia

The training modules used in this study contained all the five multimedia components. They are text, graphics, audio, video and animation. The multimedia modules were developed complete with

interactive features such as definitions, explanations, examples (in multimedia format with animations) related to the creativity techniques employed. To further scaffold the participants learning experience, practices with guided solutions were also included in the system. The purpose was to enforce scaffolding or knowledge enhancement that acts as support and guidance to problem solving that could be beyond their current knowledge possession (the MA Method) (Rogoff, 1990).

The training modules were all designed based on a video-format as they are deemed more effective for illustrating concepts (Roblyer, 2003; Brooks *et al.*, 2001). This view is also supported by William and Abraham (1995) (cited in Brooks *et al.*, 2001). However, as Mayer (2003) pointed out learners could only be mentally active for approximately ten seconds of animation at any one time. To tackle this problem, option for replaying video was made available. Participants who encountered such problems were encouraged to replay the animations as many times as they liked. Findings showed that 85 out of 97 subjects (87.6%) managed to improve their respective creativity scores in Practice 2 (summative evaluation) after going through the training modules, indicating to a large extent that the training was successful.

The improvement of creative potentials

Many creativity researchers content that the creative potentials of a person can be improved (Cropley, 2001; Davis, 1999; Houtz, 2003; Treffinger & Isaksen, 2001; Onda, 1994; Torrance & Safter, 1999). To find out if this was the case with this study, findings on the creativity achievement for the 97 subjects is presented in Table 3.

Table 3: Summary of creativity achievement: Comparisons of means

Creativity Components	Practice 1 $\bar{x}$ (SD)	Practice 2 $\bar{x}$ (SD)	Difference $\bar{x}$	T-test Result at 95% confidence level
Fluency	3.87 (1.68)	6.46 (2.71)	2.59	Significant (t = -10.94, p < .05)
Elaboration	3.82 (1.70)	6.42 (2.68)	2.60	Significant (t = -10.90, p < .05)
Flexibility	3.22 (1.42)	4.49 (1.28)	1.27	Significant (t = -8.61, p < .05)
Originality	7.00 (3.27)	12.03 (5.23)	5.03	Significant (t = -10.30, p < .05)

Key: $\bar{x}$ is mean; SD is Standard Deviation

Table 3 shows that there is an increase in the mean scores in every creativity component. The differences in the means were all tested with t-test and the results showed significance differences in all components at 95% confidence level. The improvement of creativity scores in Practice 2 can be seen in the increase in the number of ideas the participants contributed to the system, i.e., from 375 ideas in Practice 1 to 627 ideas in Practice 2, an increment of 252 ideas.

It appears then that the MA Method has succeeded to a certain extent in improving the skills of the subjects in enhancing idea generations in Practice 2. Based on the Structure of Intelligence Model (Guilford, 1967; 1977), the more ideas a person generate meant that more innovations can be accomplished. This view is also supported by DeBono (1990) who reiterates that lateral thinking (divergent thinking) is an effective method for enhancing creativity and problem solving.

The MA technique was perceived to be helpful because the brainstorming topic "Future Transportation in Malaysia" helped the participants to view the topic from two perspectives, represented as "type of transport" (y-axis) and "source of power for transport" (x-axis). By combining x and y axis, a 6 by 6 Morphological Matrix was generated, thereby yielding up to 36 ideas in total. Thus, the matrix helped the participants to be more organised when they brainstorm for ideas (see Figure 1).

Besides examining the ideas generated, follow-up interviews were administered after the completion of Practice 2. The following are a summary of the questions posed and the findings obtained:
- Did MA Method help you in generating more ideas? (97.9% subjects said 'Yes')
- Did MA Method help you to organise your thoughts on ideas? (74.2% subjects said 'Yes')

- Was the MA Method systematic and easy to use? (63.9% subjects said 'Yes')
- Did The MA matrix item intersection keep you in focus on ideas? (75.3% subjects said 'Yes')

In examining the opinions of the subjects on whether the MA Method helped them in contributing more ideas, 95 subjects or 97.9% answered affirmatively. As explained earlier, the MA Method is a matrix bordered by the x-axis and y-axis. The intersection of two sub-variables of the matrix was seen to have helped the subjects to think of more ideas creatively.

Thus for example, the intersection between the sub-variable on the y-axis "ground' and the sub-variable on the x-axis "soul" resulted in the generation of the idea of "bed transport" (refer Figure 1). Although this idea appears farfetched, illogical or even bizarre, nevertheless in the 'suspend judgement' principle practised in the brainstorming technique, it is permissible and accepted by the system. It is anyone's guesses whether this might become a reality in future, but that is creativity. As Torrance (1967), aptly argued, creativity involves a) connectedness; b) originality; c) non-rationality; d) self-actualisation; and e) openness. Figure 1 shows a sample screen shot of the morphological matrix used by the students in Practice 2.
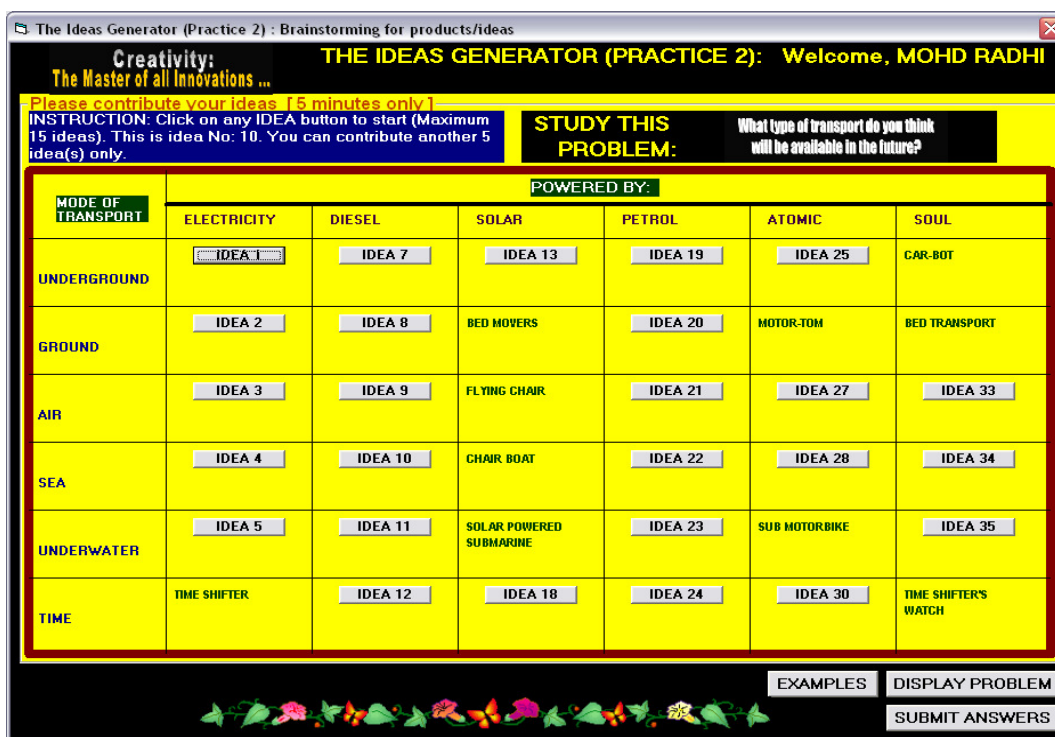

Figure 1: Screen shot of the morphological matrix in Practice 2

The results of the interview showed that 63.9% or 62 of the subjects agreed that the interfaces (shown in Figure 1) were easy to use. When a participant needed to contribute an idea for a particular selected intersection, all that was needed was just a mere click on that particular idea button. 75.3% or 73 participants were of the opinion that MA was not only easy to use but was also helpful in keeping them fully engaged in generating ideas. It was also found that when the participants were focused in thoughts, thinking became more organised. This view was supported by 74.2% of them (72 subjects). In other words, when thoughts were not properly organized (as in Practice 1) participants had to resort to random selection of ideas and that affected their efficacy in generating ideas. MA Method thus proved to be a great help by assisting participants to keep focused and concentrated via the respective intersections of the matrix.

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CONCLUSION AND SUGGESTIONS

On the basis of the findings reviewed in this study, it was felt that the creativity technique, MA Method, is potentially useful to stimulate brainstorming and could be used to generate more ideas than before. Since the MA Method in creative problem solving is positively seen as having fostered and developed creativity in the student teachers, it is therefore felt that this method could be usefully adapted to suit academic activities in schools or universities/colleges that require brainstorming for ideas.

The repeated use of this technique could help improve the creative potentials of student teachers in the long term. Nevertheless, it should be noted that this achievement will only be successful if judgement of ideas is delayed or suspended as recommended by brainstorming experts (DeBono, 1990; Rawlinson, 2004). The multimedia training was also seen as helpful in imparting useful information on the correct use of the MA Method. Thus on the basis of these findings, it could be summarized that the improvement of creativity of the student teachers might be a result of a the combinations of right learning attitude of the student teachers towards learning the MA Method, the effective roles of the MA matrix and the successful completion of both Practice 1 and Practice 2 by the student teachers.

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