

Teaching Primary Mathematics Creatively: Some Insights For Educators

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Abstract

Teaching mathematics creatively is essential. Creative teaching that is interesting and challenging can motivate pupils' learning. Teaching creatively means teaching with variations and innovations. There are various components of creative mathematics lessons. Basic pedagogical components include planning, managing, communication and evaluation. Creative expertise comprises the content of a subject, developmental psychology, and creative techniques. Teachers should also be familiar with various modes of assessment. They should self motivate, and be able to motivate their pupils. Educational policies and the school culture constitute two essential components that influence teachers' beliefs in and attitudes towards creative education. A model is presented illustrating these components. This paper highlights the components with some observations of mathematics teaching, and findings of student teachers' perception of stress during teaching practice. Suggestions on how to convince student teachers of the importance of creative mathematics education are discussed.

Basic Challenges

Teaching creatively means teaching with variations and innovations. A creative lesson is interesting, challenging, unconventional, productive, and motivating. There are variations in teaching techniques and materials, instructional activities, and assessment. There are innovations in designing teaching aids, selecting activities, and evaluation. Teachers can employ approaches that facilitate students' participation and active interaction. Creative mathematics teaching allows flexibility in adopting various pedagogical approaches that are suitable for pupils' level of understanding, and that are appropriate for the nature of the content. Flexible teaching shifts between the student-centred approach and the teacher-students interactive approach. The student-centred approach emphasises pupils' abilities to discover and construct

new knowledge. Active participation of every pupil is encouraged. Activities are designed to explore pupils' competencies in various domains. Pupils learn to evaluate their performances, and achievements of their peer. They are given the opportunities to voice opinions and present ideas. The teacher-students approach emphasises guiding pupils to optimal performance and development. There are active interactions between teachers and pupils. The teacher-students interactive approach highlights teachers' assistance, guidance, and hints, whereas the student-centred approach emphasises discovery of knowledge by individual pupils, or with their peer. The two approaches consider learning in various contexts, and recognise interpersonal interactions (Mellou, 1995).

Must student teachers acquire basic pedagogical skills before they qualified for the creative mathematics teaching? Would they be able to conduct creative lessons, while they are acquiring these skills? The answer can be positive, if student teachers perceive teaching creatively as indispensable, and as a necessity. What kinds of supports do they need? This paper intends to discuss components of a creative mathematics lesson. Considering these components, suggestions on ways to support beginning teachers in conducting creative mathematics lessons are discussed.

Components of Creative Mathematics Teaching

Creative teaching is influenced by various components (see Figure 1). There are at least six components. The first component is related to basic pedagogical skills such as lesson planning, classroom management, communication, and evaluation. The second component refers to the domain specific expertise, creative techniques, and knowledge of developmental processes. The third component is related to the competence in selecting appropriate assessment modes. The fourth component refers to teachers' and pupils' motivation. Intrinsic motivation is an indispensable component (Amabile, 1983a, b) as it generates an on-going commitment. The fifth and the sixth components are related to the learning climate and environment: Educational policies and the school culture. Creative mathematics teaching is influenced by educational policies and school cultures. Educational policies influence school learning climates. If creative and critical thinking is one of the educational concerns, teachers and principals may pay more attention to developing pupils' problem solving skills and creative competence. They are likely to adopt an unconventional approach to teaching. If examination results constitute the hallmark of education,

schools are likely to adopt an examination-oriented learning culture. Teachers may concentrate on ensuring good results. Consequently, attempting the past year series is likely to be one of the major learning activities.

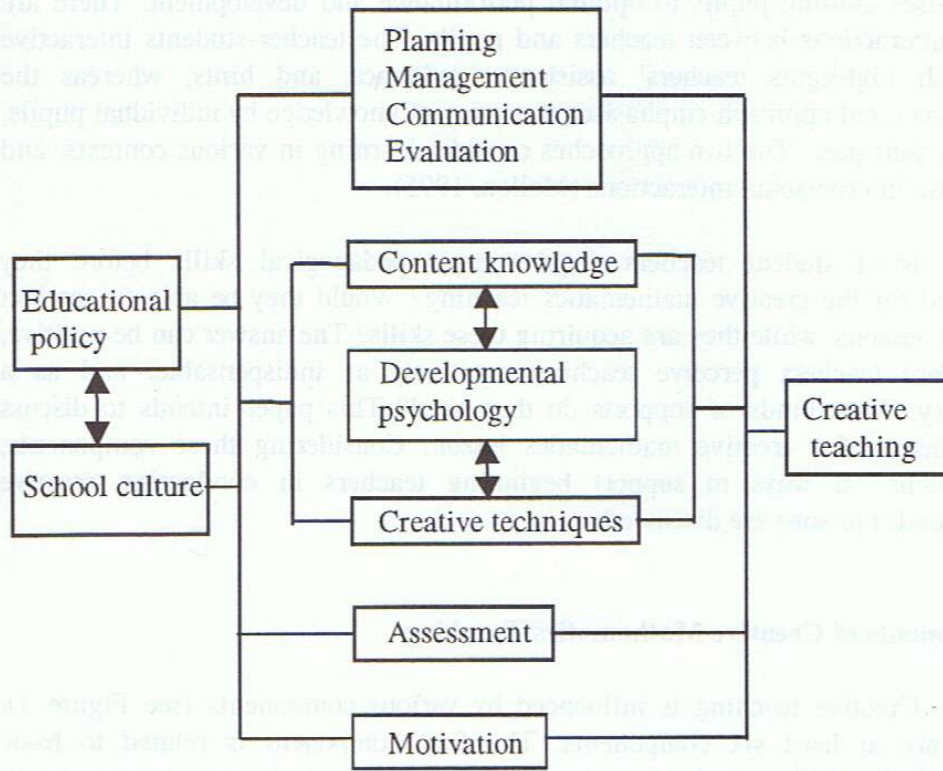


Figure 1: A Componential Model of Creative Teaching

Creative teachers are able to co-ordinate various pedagogical components. Fundamental components are such as teachers' content knowledge, creative techniques, assessment modes, and individual needs. Teachers' understanding of mathematical concepts should be enriched with knowledge of child and adolescence psychology. Teachers should be aware of developmental processes of various age groups. They should investigate how pupils understand mathematical concepts. If teachers understand pupils' cognition and behaviours, they are likely to select appropriate teaching materials, and design suitable teaching aids. Taking teaching geometry of primary two as an example, teachers may find it useful to employ diagrams and objects (see Bohning & Althouse, 1997). When learning

processes involve hands-on experiences, pupils may understand new concepts easily. Cognitive development of primary two pupils is at the pre-operational and concrete operational stages (Piaget's model of cognitive development). Thus, learning with concrete objects can be helpful.

Teachers should acquire various creative techniques. They should know conditions that stimulate creativity. The brainstorming technique, for instance, allows pupils to generate ideas in a non-threatening environment. Problem solving enables pupils to use information available to search for possible solutions. Creative techniques are modified according to pupils' needs and psychological development. In addition to describing in words, lower primary pupils should be allowed to use diagrams or symbols to represent their ideas. A student teacher infused the brainstorming technique and the problem solving technique into her lesson. A group of primary three pupils were asked to discover possible features of an isosceles triangle and an equilateral triangle. First, pupils used six straws with two equal lengths to form as many triangles as possible. Then they were given colour cut-outs of two triangles (one was an isosceles triangle, and the other was an equilateral triangle). Pupils discovered similarities and differences between them. They matched triangles that they formed with the cut-outs, and listed as many similar features as possible. Pupils were allowed to use diagrams to represent their answers.

Teachers should be experts in assessment. Formative and summative assessments are meant to find out pupils' learning progress at the end of a unit or a series of units. Diagnostic assessment can be used to find out weaknesses of individual pupils. Suitable contents and activities can then be designed. In addition to tests, teachers can employ other forms of assessment (see Campbell, 1997) that allow independent and interdependent learning. A one-week project, designing a new school canteen, for instance, allows primary five pupils to apply their knowledge of area and perimeter. Pupils are asked to propose the most suitable location, built-in areas, arrangement of tables, chairs, and food stores.

A creative mathematics lesson maintains pupils' learning interests, stimulates pupils' thinking, and encourages pupils to discover new knowledge. Individual needs of pupils are considered. It is indispensable to arouse pupils' interests in mathematics at their young age (Smith, 1996). Motivation is one of the prerequisite conditions for continuous learning and self-education. Mathematics can be an interesting subject, if teachers can associate this subject with pupils' pleasant learning experiences. Learning mathematics does not confine to

memorising formulae. Games and quizzes (see Baer, 1994) that invite pupils' active participation can be infused into mathematical activities. In a survey, primary pupils were asked to list activities of mathematical lessons that brought forth fun. A group of 33 primary two pupils (average age 8.6 years) reported that they enjoyed activities related to learning fractions (60.6%), using abacus (48.5%), and mental sums (9.1%). I cite comments of a primary two girl (8.4 years old): "I like abacus because it is fun and interesting. We have to use the right fingering or else we'll have to start all over again. I like abacus very, very much." Teachers employed the abacus as a pedagogical instrument, allowing pupils to learn new concepts with a concrete object. Reasons of two primary two pupils who liked fractions are cited: "I like fractions because I can cut things into quarters and half" (male, 8.3 years old). "I like fractions because I made a whole, half and quarter" (female, 8.6 years old). Playing brings joy and fun. Quizzes, games, and puzzles with rewards were favourable activities of a group of 63 primary five pupils (average age 11.1 years). These activities provide them the opportunities to share, to discover, and to interact with peer. Learning that brings pleasant experiences is likely to generate satisfaction. When a lesson is interesting and enjoyable, it is likely that pupils develop positive attitudes towards learning.

An activity that is fun but ineffective is an undesirable pedagogical activity. A creative pedagogical activity should observe guidelines for an effective instructional activity. An effective instructional activity facilitates learning and evaluation. It is a foundation for continuous learning and self-improvement (see Kyriacao, 1986). How can a teacher ensure that an enjoyable lesson is effective? Before pupils attend to an activity, teachers should clearly deliver instructions related to the behavioural and time management, as well as to the content. Basic regulations related to effective group work and discussion should be delivered before pupils form into groups. In a group or in pair, pupils should observe regulations that optimise sharing and learning. After pupils completed an activity, immediate feedback related to the content, pupils' behaviours, and time management should be facilitated. Immediate feedback is essential as it can alert pupils of their strengths and weaknesses whilst the experience is still new. Pupils should be able to self evaluate, and evaluate their peers' performances. Evaluation demands systematic judgement and critical thinking. Teachers should attempt to integrate pupils' response into the new content. New knowledge can be drawn on pupils' responses. For instance, when pupils propose a feature of an equilateral triangle, sides with equal length, teachers can further guide them to discover another feature associated with angles.

Before formal teaching and learning, student teachers should establish a good rapport with pupils. Having a good rapport with pupils is essential, as it is a foundation for behavioural management. If teachers deal with a class of thirty to forty, regulations related to behavioural disciplines and noise levels should clearly be described. Teachers are likely to gain respect from their pupils, if they are able to establish pleasant and firm interpersonal relationships with pupils. Having information about pupils' level of understanding and needs, teachers are likely to define appropriate instructional objectives. Table 1 summarises components of a creative mathematics lesson.

Table 1: Components of a Creative Mathematics Lesson

| Planning and management | Instructional activity | Creative expertise |
|--|--|---|
| Lesson planning <ul style="list-style-type: none"> Defining objectives Preparing teaching aids Determining teaching procedures | Designing activity <ul style="list-style-type: none"> Preparing activities – group or pair – that can stimulate various levels of understanding | Mathematics <ul style="list-style-type: none"> Fundamental knowledge Possible misconceptions Appropriate contents according to age groups |
| Classroom management <ul style="list-style-type: none"> Behavioural management (e.g. movement, noise) Time management | Conducting activity <ul style="list-style-type: none"> Forming effective groups Delivering effective instructions Facilitating effective sharing | Creative techniques <ul style="list-style-type: none"> The inquiry approach Brainstorming Problem solving |
| Carrying out a lesson <ul style="list-style-type: none"> Explaining new concepts Assigning homework Giving feedback | Giving feedback <ul style="list-style-type: none"> Facilitating immediate feedback Encouraging self and peer evaluation Integrating pupils' responses into new content | Assessment <ul style="list-style-type: none"> Identifying appropriate modes of assessment that capture pupils' strengths and weaknesses |
| | | Identifying individual needs <ul style="list-style-type: none"> Maintaining intrinsic interests Stimulating thinking and discovery |

Being Creative or Discovering Creativity

Will student teachers be able to conduct a creative lesson, while they are acquiring basic pedagogical skills? Let us examine 62 student teachers' perception of stress during teaching practice (see Table 2). We can arrange their stressful life events into three categories according to the descending order: Professional skills, the interpersonal and diagnostic domain, and the intra-personal domain. Life events related to professional skills are such as planning a lesson, carrying out experiments, preparing worksheets for mixed ability groups, designing test papers, and being creative. Life events related to the interpersonal and diagnostic domain are such as managing behaviours, identifying pupils' needs and individual differences, and discovering pupils' creativity. Life events related to the intra-personal domain are such as being humorous, patient, firm and friendly, fair, and rewarding pupils. Student teachers found that it was more stressful to be creative (5.61) than to discover pupils' creativity (3.94). They also found that it was more stressful to integrate the supervisor's comments (5.50) than to integrate those of co-operating teachers (4.65).

What kinds of supports do student teachers need? Teacher educators can provide their supports in two ways: Nurturing student teachers' creative potential, and providing resources and creative techniques. For the former, teacher educators should provide conducive conditions for creativity. For the latter, teacher educators disseminate ways to infuse creative techniques into mathematics lessons. In both cases, student teachers need to convince themselves that creative activities are not exclusive for talented people or experts. Every individual possesses the potential to be creative in one or more than one field (Gardner, 1983, 1993). Creative techniques can be integrated into all kinds of instructional activities, and to pupils of all levels of achievement. Student teachers should be flexible in adopting various roles (Tan 1997). It is also essential to exert a balance between disciplinary and creative teaching styles (Gardner, 1994). Teacher educators should be alert of positive cross-generational effects on creative performances (Simonton, 1983, 1984, 1994, 1996). Teachers are predecessors and experts who can pass on selected cultural and social variations to the young (Mercer, 1995). A multicultural framework is adopted giving attention to individuals' needs regardless of inherited, biological, cultural, and social backgrounds (Tan, 1996a). Lower primary pupils seldom demonstrate gender difference in mathematics achievement. At the higher primary or secondary levels, male pupils tend to outperform female pupils in some topics. Research findings showed teachers' beliefs, social expectations, and learning environments are major causes of gender

differences in mathematics. Teachers tend to give more attention to boys than to girls, especially in relation to negative conducts (Hamilton et al., 1991). Girls learn better in a co-operative setting (Gibbon, Lynn & Stiles, 1997), whereas boys perform well in a competitive environment.

Table 2: Stressful Life Events during Teaching Practice

| Life Event | Mean (SD) |
|--|---------------|
| <i>Professional skills</i> | |
| • Planning a lesson | • 6.02 (2.17) |
| • Carrying out experiments | • 5.93 (2.06) |
| • Preparing worksheets for low and high achievers | • 5.89 (1.82) |
| • Designing test papers | • 5.88 (1.88) |
| • Being creative | • 5.61 (2.40) |
| • Selecting teaching aids | • 5.21 (2.00) |
| <i>The interpersonal and diagnostic domain</i> | |
| • Managing behaviours | • 5.57 (2.33) |
| • Integrating the supervisor's comments into the future lesson | • 5.50 (2.06) |
| • Organising group work | • 5.08 (2.09) |
| • Identifying pupils' needs | • 4.69 (1.95) |
| • Integrating the co-operating teacher's comments into the future lesson | • 4.65 (1.95) |
| • Discovering pupils' creativity | • 3.94 (1.93) |
| <i>The intrapersonal domain</i> | |
| • Being patient | • 4.48 (2.16) |
| • Being friendly and firm | • 4.48 (1.66) |
| • Identifying individual differences | • 4.05 (1.92) |
| • Being fair | • 3.56 (1.79) |
| • Rewarding pupils | • 3.35 (1.67) |
| • Being humorous | • 3.32 (2.05) |

Note: The number of student teachers = 62, average age = 22.7, kurtosis and skewness of all life events < 1.69, 9 = extremely stressful, and 1 = extremely not stressful.

Mathematics is a practical subject for every individual. Mathematics teaching and learning should draw upon pupils' experiences, and should resemble real life. Teachers should relate mathematical intelligence to other types of competencies such as common sense (Sternberg et al., 1995), and practical intelligence (Sternberg & Wagner, 1989). Taking teaching estimation as an example, teachers can relate it to a real life situation, asking pupils to round off to the nearest 10 the number of pupils in a hall. The interrelation of mathematics and other subjects should also be revealed.

Creative mathematics lessons need a conducive and pleasant learning environment. Integrating playing into mathematics lessons makes learning an interesting endeavour. To create a conducive learning environment, teachers should often invite pupils to feedback and question. Teachers adopt the inquiry approach to teaching. Open-ended questions are employed to attract pupils' opinions and possible answers. In an open-ended learning structure, teachers are likely to attract multiple solutions because pupils are allowed to express freely. Even if there is only one answer to a closed question, pupils are encouraged to present it in more than one way.

Group discussion or pair work is essential as pupils are able to visualise and verbalise mathematical problems with their peers. Verbal expressions stimulate cognitive development and organisation of thoughts. Explaining to others will deepen pupils' understanding of a concept. Working together with others provides pupils the opportunities to understand a concept from their contemporaries' viewpoints. Interactions among pupils are essential because classmates are contemporaries, partners, or rivals who usually possess a similar repertoire of mental elements (e.g. methods, questions, etc.) (Simonton, 1988a, b). Among pupils there should be a consensus on linguistic, logical, and mathematical codes. To ensure a smooth transfer of information, pupils should acquire communicative skills. They should be able to disseminate new ideas to their contemporaries. Their contemporaries should also possess the similar communicative skill, and be able to convey the same ideas to others.

Integrated Curriculum

What kinds of assistance can teacher educators provide in guiding student teachers to creative mathematics education? Supervisors and co-operating teachers are teacher educators who guide and assist student teachers during teaching

practice. Two levels of assistance can be helpful. First, teacher educators should design an integrated curriculum that emphasises creative teaching. Creative techniques should be taught as integrated components of core and elective modules, but not as separate components. An infusing approach to creative teaching should be adopted. Student teachers who attend modules related to educational studies, academic studies, and curriculum studies should be exposed to various creative techniques, and ways to integrate them into teaching and learning. Student teachers should be convinced that teaching mathematics creatively can generate eustress or pleasant stress, if they adapt a problem-oriented approach to teaching (see Tan, 1996b). Second, teacher educators should help relate theoretical models to practical situations. Suggestions for improvement should be relevant and convincing. D' Rozario and Wong (1996) identified six major factors of stress during teaching practice of which three were related to communicating with new colleagues, co-operating teachers, and the supervisor. Whilst support and assistance were needed for professional development, student teachers perceived the presence of their supervisor and the co-operating teachers as stressful. Teacher educators should ensure that their guidance is not a potential stressor. They can provide appropriate supports for creative development. Mathematics is one of the core teaching subjects for student teachers who attach to the primary schools. To be able to teach mathematics creatively, student teachers need to be granted conducive conditions for creativity (see Csikszentmihalyi, 1988, 1996) that can motivate them continuously.

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