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FOSTERING CREATIVITY IN SCIENCE AND MATHEMATICS EDUCATION THROUGH IN-SERVICE TEACHER EDUCATION

By

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Abstract

This paper illustrates various concept and traits of creativity as well as factors contributing to enhancing the divergent thinking skills of in-service teachers with descriptions made on the activities for fostering creativity which were conducted at SEAMEO RECSAM, the center of excellence for training, as well as research and development in Science and Mathematics Education. Some strengths and opportunities for future training programs are explained briefly in this paper. Teachers play important roles in fostering students' creativity. As such , their exposure to the concept of creativity, as well as the training given to enhance their creative or divergent thinking skills are important for their continuing professional development (CPD). In the subsequent sections, this paper reports on hoe SEAMEO RECSAM as regional center in Science and Mathematics Education has provided training grounds for fostering creativity through in-service teacher education including implementing regular and customized courses, as well as other initiatives such as the conduct of research and development, the organization of seminar/workshops/ competitions/congresses and publications. Sample o activities to foster the various traits of creativity are illustrated, extracted from classrooms activities and participants' project to foster creativity in Science and Mathematics Education. Some ideas had been implemented and suggestions for future training in Science and Mathematics Education are also illustrated.

Keywords: Creativity, Science and Mathematics Education, In-service Teacher Education, SEAMEO RECSAM

INTRODUCTION

SEAMEO RECSAM as a center of excellence for training, research and development as well as pedagogical consultancy in Science, Mathematics and Technology Education has the mission to achieve regional, national, and international recognition in the SEAMEO member countries. For this mission, the center is committed to nurture and enhance the quality of Science and Technology Education by developing and delivering flexible, innovative and relevant programs.

One of the management philosophies of SEAMEO RECSAM is to design innovative and challenging programs and activities which address the need of mathematics and science teachers

as well as educators in the SEAMEO MEMBER countries in line with contemporary advances in mathematics, science and technology education. Toward this philosophy, the center has to achieve the goal of developing and implementing quality, innovative and relevant training programs. SEAMEO RECSAM in its Five Year Plan (2003) has put "fostering creativity" as a major part which is incorporated in the training. Curriculum in each of the course offered, including classroom teaching and learning, enrichment as well as other programs action research activities. For the recent and future training programs, SEAMEO RECSAM has targeted to train more teachers with high potential of intellectual capabilities and creative in the teaching and learning of science and mathematics. To achieve this aims, the Center is trying to enhance the scientific, mathematical and technological literacy as well as the innovative capacity of the trainees, also including providing support for the development of new generation of excellent teachers for science, mathematics and technology education in the SEAMEO region. Why has the initiative of "fostering creativity" been given the emphasis in most of the training programs of in-service teacher education at RECSAM? In the sections this paper illustrate various concepts and traits of creativity as well as factors contributing to enhancing the divergent thinking skills of participants with description made on the Center's initiative in fostering creativity through various programs and activities.

CONCEPT OF CREATIVITY AND ITS IMPLICATION IN SCIENCE AND MATHEMATICS EDUCATION

What is Creativity?

Creativity is the ability to bring something new into existence. This may involve doing something original, which could not be achieved solely by following rules or satisfying general criteria, or may also include synthesizing ideas from various aspects to bring out some innovations. Creativity cannot always teach by a teacher, but it can be encouraged and developed to a very high level (Fryer, 1996 in Alindada, 1999). It could also be enhanced in a certain degree as stated,

> *"Creativity (in the value sense) is termed as some sort of inner source of mental energy which can be dram med up, alternatively, set free to flow into different channels of intellectual or aesthetic activity"* (Dearden, et.al, 1972, p.145)

In the nutshell, the concept of creativity encompasses various traits. "The trait of fluency, flexibility, originality and elaboration are generally categorized as divergent thinking" (Guilford and Torrance et.al., 1962 in Stenberg, 1988, p.46). These aptitude factors (divergent –thinking abilities) emphasize searching with freedom in all directions to achieve excellent performance. Normally, creative thinking involves sensing difficulties, problems, gaps in information, missing elements, something asked; making guesses and formulating hypothesis; possibly revising and retesting them (Torrance, 1965 in Fryer, 1996).

Why and How to Foster Creativity Among Students and Teachers?

Creativity has long been a subject of great interest to mankind, although there is conflict in the findings of the various recent research studies on it, especially with regards to the inter-relationship between IQ and creativity. To test the proposition, Getzels and Jackson tested 292 boys and 241 girls aged between 12 and 17 years in Chicago. The scores obtained by the pupils in the intelligence, creativity, and scholastic achievement tests were examined. As a result, they felt that they had evidence to suggest that at the "high average level of intelligence and above, IQ and creativity are sufficiently independent to warrant differentiation" (Getzels and Jackson, 1962 in Shields, 1968, p.47). Wallach and Kogan also reported in another study that "the measures of general intelligence were highly inter-correlated, and also that the measures of creativity were highly inter-correlated, but the correlation between the intelligence measures and the creativity measures were very low. They concluded that they had located a dimension of intellectual ability which was independent of general intellectual ability, and was indeed appropriately labeled 'creativity' (Wallach and Kogan in Shields, 1968, p.52).

Seeing the evidence of no high significant inter-relationship between IQ and creativity, teachers should be aware that young learners irrespective of whether they are gifted or not, should be guided to enhance the total development of both hemisphere of human brain, i.e. creativity/innovative thinking (right hemisphere talent) and mathematical and critical thinking (left hemisphere talent). Instead of concentrating on the education of one side of the brain at all times (e.g. merely numerical operations), the enrichment activities should be designed to cultivate the right brain talent (creativity and divergent thinking. Students should be encouraged to take part in brainstorming activities to generate innovative ideas in addition to their involvement in solving puzzle as well as scientific or mathematical problem-solving activities. It is believed that given nurturing environment with psychological safety or freedom and insightful learning opportunities provided by the teachers, innovative students will concentrate and immerse themselves in creative actions and innovations. The following concept map (refer Figure 1) summarizes the "concepts/examples of" and "factors contributing to fostering" creativity.

Creativity in Mathematics and Science Education: The Role of the Teacher

Teacher plays a major role in constructing or orchestrating an environment for the teaching and learning of mathematics and science can be characterized as creative (Higginson, 2000). The term 'creative' included conceptions of the nature of disciplines: the social, philosophical, psychological, institutional, and financial constraint inherent in any schooling context, pedagogic strategies, and curriculum decisions. Creative classrooms are unlikely to happen at random, but it is planned. In fact, there are many social and institutional figures in most educational jurisdictions which militate against the sort of features of which might characterize

as ‘creative’ setting. Higginson (2000) identifies four different but overlapping sense of creative approaches, those are:

1. Creativity as ‘novelty’ – in which the teacher attempts to introduce concepts in ways which are different, unusual, or innovative.
2. Creativity as ‘the construction of artifacts – physical’ – in which the teacher attempts to have mathematical ideas emerge from the building of physical objects.
3. Creativity as ‘the construction of artifacts –symbolic’ – in which the teacher attempts to have mathematical ideas emerges from the development of symbolic system.
4. Creativity as ‘personalization/humanization’ – in which the teacher attempts to structure the learning environment so that students have maximal opportunity to follow their own interpretation of basic mathematical ideas.

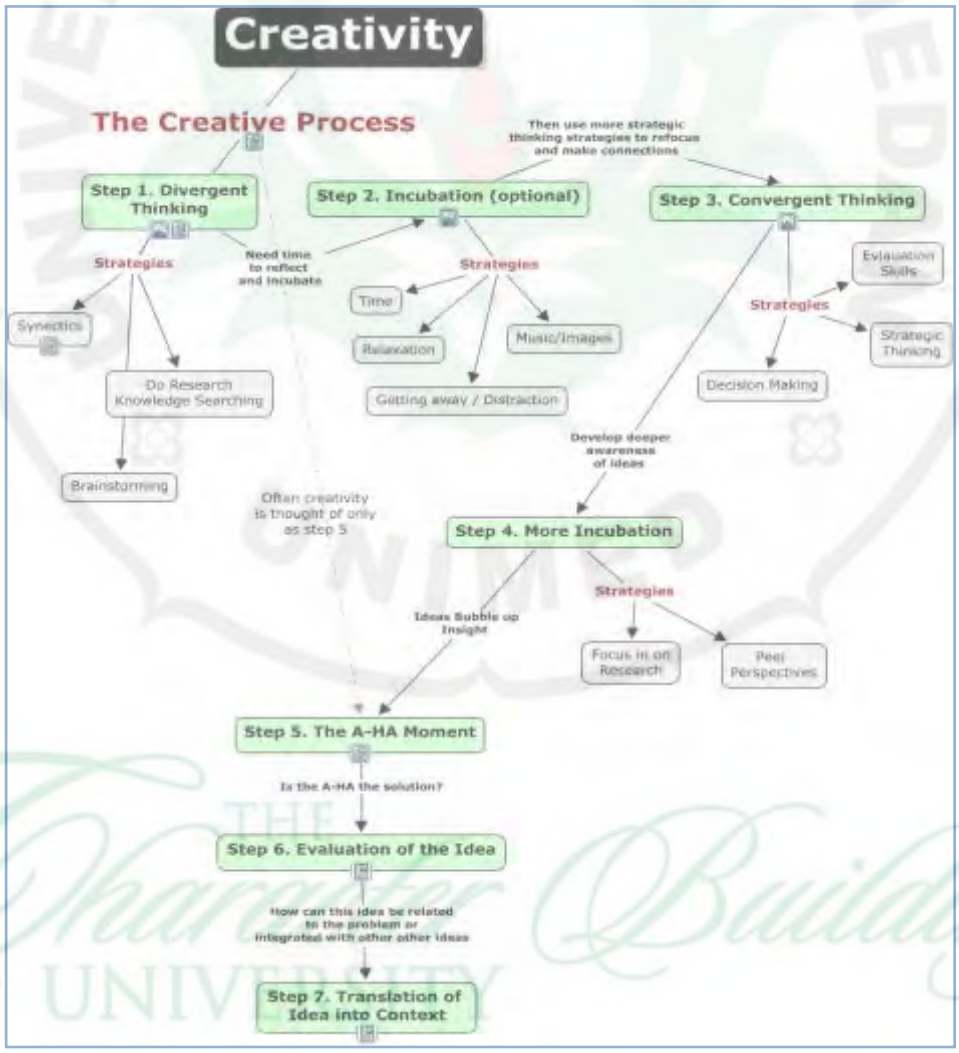

Figure 1.
Creativity process.

Donna Harp Ziegenfuss: https://utah.instructure.com/courses/148453/files/23615270

In practice, creative mathematics and science teachers are likely to mi the aspects of all of these conceptions and many others. This apt to be particularly true when working with gifted learners (Shieffields, 1999 in Higginson, 2000) as well as which others in stimulating environments. As such, in order to enhance the creative potential of mathematics and science teachers during the in-service training programs, participants should be involved actively with the sharing of ideas and experiences so that they could learn from one another how to bring mathematics and science to their students in ways which are creative, productive and satisfying for all students concerned.

The Implications in Science and Mathematics Education

As stated earlier, teachers may not be able to teach creativity but can promote, facilitate and develop this inherent intellectual talent via creating the right environment for the learners. Students should be encouraged to build confidence. Their ideas and contributions should always be valued by the teachers. Some of the factors contributing to fostering the creative potentials that or educators to assist students in developing their creativity such as "building pupils' confidence, encouraging pupils to ask questions, being a creative teacher, some free choice at home, some choice of tasks and learning methods, involved and supportive family, informal teaching, asking provocative, open-ended questions, setting some un-assessed tasks, emphasizing success and setting goals or making expectations clear" (Fryer 1996 in Alindada, 1999). To name a few. Obviously, teachers play important roles in fostering students' creativity. As such, their exposure to the concept of creativity as well as the trainings given to enhance their creative thinking or divergent thinking skills are important for their continuing professional development (CPD).

RECSAM'S INITIATIVES IN FOSTERING AND FACILITATING THE PROMOTION OF CREATIVITY

Since the inception in 1965, SEAMEO RECSAM has been mandated in its mission to enhance the quality of science, mathematics and technology education in the SEAMEO member countries. In addition to in-service training courses designed for science and mathematics teachers, the centre also involved in research and development as well as the organization of various activities e.g. seminar, workshops, conferences, etc. to meet the challenging needs of human resource development especially in the areas of science, mathematics and technology education. Writing workshops or introductory workshops were also conducted, for example to develop curriculum or introduce creative project-based learning activities integrating ICT using curriculum materials of Science Across the World (SAW), an international web-based learning program coordinated by the Centre since 1991. Some of these programs and activities were held during the period of regular and/or customized training courses. As such in-service

teachers were given the opportunities to gain an exposure either from the observation of the event or from the hands-on involvement during their participation and/or assistance given during the organization of the events. Such involvements had given the opportunities for these participants to enhance their creativity as well as divergent thinking skills and enriched knowledge in diversifying various strategies to organize future activities at their respective work place. The following sections will discuss the Centre's roles and activities in fostering creativity through the various abovementioned initiatives.

Fostering Creativity through Regular/Customized Courses, Research and other Programs

Science. The concept of creativity and creative thinking skills were introduced to various groups of participants mainly under the topics such as "Enhancing Higher Order Thinking Skills, Critical and Creative Thinking Skills, Fostering creativity among the gifted learners, Creative technology, etc." as one of the science teaching and learning strategies during the RESCAM in-service teacher education programs. The examples are such as in-service science and mathematics regular courses for the cultivation of gifted learners at primary level (Khairiree and Ng, 1996) and secondary level (Valencia, 1996); courses for the development of higher order thinking skills (e.g. Ong and Abdul Rahman, 1998; Ng, 1999; Ramli, 2001; Foo, 2004) as well as courses that foster teachers' creativity to develop investigative project work (e.g. Abdullah, 2003), development of non-digital instructional materials (e.g. Ng and Ong, 1996) and digital instructional materials (e.g. 0\v Yong, 2001; Ramli, 2002; Robert Peter, 2003). Not only the in-service teacher education programs had fostered the divergent thinking skills of the participants to be more creative teachers in diversifying their teaching strategies, various innovative ideas to foster the creativity or divergent thinking skills of young learners were also developed as illustrated in some of the output of the courses, for example the instructional materials developed for challenging the gifted learners (e.g. Sit, et al., 1996; Garcia, et al,, 1996; Mohd. Apong, et al,, 1996). Table 1 and 2 (Refer Appendix A) summarize how the topic on "Fostering divergent thinking skills : Creative abilities involving semantic content" was introduced in course "PB-514 : Science and Mathematics Teaching for Gifted Learners at Primary Level" (Khairiree and Ng, 1996) and course participants were requested to participate in the activities recommended. Sample lesson activities were also extracted from a selected primary science lesson, e.g. "Fun with the Earth and the Solar System" (Ng, el al., 1996) to illustrate how the training course participants had adapted the input on the various traits of creativity to devise step-by-step activities which are practically quite simple to implement in the classroom to enhance creativity among their students.

Mathematics. During the RESCAM in-service teacher education programs for mathematics teachers, some specific courses and activities were introduced in fostering creativity and creative thinking skills such as: "Enrichment Programs for gifted Secondary Mathematics Students with Emphasis on Creative and Critical Thinking" (SM-0211) and "Student-Research in Secondary Mathematics; A Creative Problem Solving Approach" (SM-0117). In other

courses which are not specifically focusing on creativity, the sub-topic of "Creative Problem Solving (CPS)" was also introduced to enhance the creative potentials of primary and secondary mathematics teachers in almost all of the mathematics courses offered in the training programs. CPS offers a powerful set of tools for creative and productive thinking that can be learned and used successfully by students. It is a framework which individual student or groups can use to formulate problems, opportunities or challenges; generate and analyze many varied and novel options; as well as plan for effective implementation of new solutions or courses of action. Students will leam about their individual preference for problem solving. The courses which include CPS as one of the topics introduced in the training curriculum are for example: (1) "Shifting from Direct Instruction to Constructivist Teaching in Primary Mathematics" (PM-0709); (2) "Contextual Learning Approaches in Enhancing Secondary Mathematics" (SM-1400); (3) "Effective Mathematics Teaching Strategies: Student Centered Approach" (PM-0917); (4) "Using 1CT in Developing Primary Students' Mathematical Thinking" (PM-0213); (5) "Understanding and Using Cooperative Learning Models for Primary Mathematics" (PM-0609); (6) "Exploring Secondary Mathematics with Handheld Technology: The Graphing Calculator" (SM-0213); to name a few.

Action Research. Action Research is offered as specific course, i.e: "Action Research: Improving Teaching in Primary and Secondary Mathematics" (AM-1018) and "Action Research: Improving Teaching in Primary and Secondary Science" (AS-1018). In each of the primary and secondary science and mathematics training courses offered, "Action research" is also included as a general component in the training curriculum. This is to address the needs of primary and secondary science and mathematics teachers to improve their teaching practices using action research paradigm. In addition in-service teachers were also exposed with the theoretical background for carrying out classroom-based action research in their respective workplace. The incorporation of "Action research" component in the training programs had indirectly enhanced the participants' creativity to develop their own research problem(s) with collaborative teachers and choose their own method(s) to solve the problem(s) in classroom practices using action research paradigm.

Other Programs/Activities as well as Research and Development. In addition to conducting in-service training regular and customized courses, the organizing secretary of each project normally led by Research and Development Division had also carried out evaluation studies as and when required to evaluate the various programs and activities conducted by the centre in order to improve the quality of training as well as to identify various measures including the enhancement of creativity. Among the various programs organized by the centre including "Search for SEAMEO Young Scientists" (SSYS) Congress, SEAMEO Mathematics Olympiad (SEAMO) competition, as well as workshops, seminars and conferences.

SEAMEO Mathematics Olympiad (SEAMO) has been a programme at SEAMEO RECSAM being conducted since 1996. This competition was organized once in every two years for students from the SEAMEO Member Countries. The purpose of Mathematics Olympiad is to spur the interest in mathematics and to develop talent of secondary students through the excitement of solving challenging problems as well as to foster insight, ingenuity, quick thinking, thereby also enhance their writing skills, creativity and perseverance.

During the organization of the first SSYS regional congress (20-22 October 1997) with the theme "Conserving the Environment Through Youth Science Research", PS-103 course participants were given the opportunities to participate in the poster competition to write slogans on "Conservation of Environment". This side event of SSYS was also participated by local primary and secondary students, as well as teacher trainees from local teacher training colleges (Ng, et al., 1997, p.63). During the organization of the second SSYS congress (5-7 July 1999) with the theme "Technology for Us", the course participants of Customized Course Malaysia (CCM) from two groups, i.e. SS- B1 [Pengajian Sains dan Teknologi Dengan Pendidikan (Sekolah Menengah) Cohort 4] and AS-C1 (both courses were held in the period from 7/6 to 14/8/1999) were involved in organizing science quiz as the side event which was participated by local school students and SSYS delegates (Ng, et al., 1999, pp.25-26).

In response to the evaluation questionnaires during the organization of the third SSYS congress (4-6 March 2002) with 5-point Likert rating scales ranging from 1 = Strongly Disagree to 5 = Strongly Agree, the responses to the item question No. 8 "The SSYS Congress has stimulated me to be more analytical and creative" given by the teacher advisers (N=9) was the average rating of 4.11 and by the student delegates (N=22) was the average rating of 3.81 as reported by Dr. Elvira Arellano. In addition, before the third SSYS congress, the secretariat was also able to interview the delegates from SSYS1 (1997) and SSYS2 (1999). In response to question on "What are your future aspirations/hopes/dreams/career choices", delegate 3 from SSYS2 (S2c) responded as follows,

> *"... As I'm pursuing medicine now, being a doctor would be the choice of my career. Nevertheless, after joining SSYS, I do see a lot to great minds coming up-very creative and innovative ones. So hopefully in the future, SEA will be one of those regions which will prosper and become developed in every aspect. And hopefully along the route to success, we (people of the SEA regions) will always preserve our beautiful and rich culture because this is what made us beautiful from the inside and outside and of course with brains too ...!"* (S2c in Ng, et al., 2002, p.98)

In response to question on "Did SSYS encourage you in your choice of study options/ career path etc...", delegates 1, 2 and 3 from SSYS1 (S1a, S1b and S1c) responded as follows,

"...Yes, we gained experience and confidence which helped us in our choice of study options or our career path. In school, we have minimum chance to express ourselves because there are too many students... We have developed some of the good attitudes such as dedication towards whatever we are doing, especially in pursuing our research findings. We had also improved our communication skills, such as to be able to speak confidently, especially when we presented our projects in the Congress. SSYS is indeed a good training ground..."

(S1a in Ng, et al., 2002, p.98)

"...Perhaps our choice of study options or career path were not directly affected This is quite subjective But we do agree that we gained confidence to pursue curiosity, to try out our stuff or to put up our ideas on paper..." (S1b in Ng, et al., 2002, p.99)

"...Yes, we came out with new ideas or in now five group work. The experience we gained was something we did not get to learn in school, an eye-opener or exposure whereby we were able to see how other people work ... " (S1c in Ng, et al., 2002, p.99)

MORE NEW PROGRAMS AND ACTIVITIES TO FOSTER CREATIVITY

Being a centre of excellence for training in Science and Mathematics education, SEAMEO RECSAM is keenly aware of the challenges and opportunities that lie ahead in all spheres of human activities. It is in this light that the recent 7th and 8th Five-Year Plans were developed to determine the centre's strength and direction during the periods of 1st July 2000 to 30 th June 2005 and 1 th July 2005 to 30 th June 2010 respectively (RECSAM, 1999 and 2003). The following action will highlight some of the centre's current as well as future programs and activities especially related to fostering creativity among the science and mathematics educators.

R&D Programme, Publication and Consultancy Services

Future programs. Research and Development Division has targetted to conduct research that is specific on fostering creativity for mathematics and science education. For example. Research on "Creative Problem-Solving and Student-Research in Mathematics Teaching: Curricula and Instruction" (RECSAM, 1999) will be conducted as long term study in building a curricula and its instruction for future. The centre also targeted to publish up-to-date teaching and learning materials including the use of ICT as well as the production of teaching and learning aids based on cutting-edge technology, including also to provide consultancy services with innovative initiatives for fiscal years 2005-2010 in the areas such as "Developing Smart Learning Environments, Integrating ICT in teaching and learning of science and mathematics, Design and

development of instructional materials. Computer network and maintenance, etc." (RECSAM, 2003).

Seminars/Conferences/Workshops/Other Programs and Activities

Family Math Workshop. Workshop on Family Math is one activity that is planned to do at SEAMEO RECSAM for teachers and parents who are interested in helping their students or children at home to do mathematics together. Family Math features learning activities which parents can do with their children to help them understand what they learn in school relating to daily life. This workshop will help parents develop their creativity to work and show an easy way to build mathematics learning into their children's education with an enjoyable and fun environment.

Mathematics Camp. Math Camp programme has been done in the region. Math Camp is an enrichment day camp programme offered for primary and secondary mathematics students participating in different activities in oriented thematics modules. While having lots of fun, campers will be involved in activities which will enhance their understanding of mathematics. This exciting programme invites students to let their imaginations run wild through team work and creative problem-solving and inventive thinking activities.

Lego Robotic Workshop and Techno-Challenge. RECSAM has also recently assisted in conducting workshops for the training of Lego Robotics for in-service teachers, e.g. during ICASE post-conference workshop on 11th April 2003, and for students and teachers, e.g. during the recent workshop on I0 th April 2004 organized by science division. In addition, RECSAM's professional stall' Dr. Azian, Mr. Norjo and Ms. Ng were also involved in the first Malaysian Junior Robotics Competition (MJRC) as panel judges. Among the objectives of MJRC are such as "to stimulate young creative minds to think out of the box and to cultivate a strong desire to solve problems and to be innovative in doing things" (MJRC, 2004). The centre also planned to organize "Techno-challenge" competition for school children as one of the activities for fiscal years 2005-2010 (RECSAM, 2003).

It is believed that by assisting in organizing the above mentioned activities, RECSAM will further strengthen the roles in fostering creativity among teachers and young learners in the region.

CONCLUSIONS

Creativity is analogous to a plant which needs soil, fertilizers and nurturing environment to grow. It has profound meaning and yet an undistinguishable jewel only if it could be discovered by a skillful person (Ng, 1991). The examples given in this article are only some of

the initiative taken by RECSAM to foster creativity among the science and mathematics teachers during their in- service training courses at the centre. Hopefully with the knowledge and skills acquired during the in-service training programs, science and mathematics teachers should have developed higher motivation and interests to enhance the cultivation of creative thinking skills among young learners.

SEAMEO RECSAM as a Center of Excellence for training, research and development in science, mathematics and technollgy education w ill continue to be characterized by a climate of innovation in order to develop participants with capacity for innovation. In a culture of innovation, participants from SEAMEO countries should adopt creative approaches which will be reflected constantly in their teaching as well as on the outcomes of students' science and mathematics learning. It is also of high expectation that through the organization of various workshops, seminars, competitions and congress such as SSYS and SEAMEO which will spearhead more innovations and creative ideas, the potential Nobel laureates and outstanding Scientists or Mathematicians may emerge in the Asia Pacific regions in the near future.

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Appendix A

Table 1 : Creative abilities involving semantic content

Ability	Intellectual process	Product	Type of task used to measure ability
Fluency (number of responses)			
word	Divergent production	Vocabulary	To produce words each containing a specified letter or their combination (e.g. Form the words from "abconr". Answer: carbon)
associa-tional	Divergent production	Relations	Write synonyms for each of several words, e.g. for the word "stoma/pores", "lamina/blade", etc.
expres-siona!	Divergent production	Systems	Constnict a variety of four-word sentences, given four initial letters, no words to be used more than once, e.g. "P A S T L" (Possible answer: "Plants are sensitive to
Ideatio nal	Divergent production	Units	Write names of things fitting broad classes, e.g. things that are white and edible, e.g. bread, rice, etc.

(Adapted from Klausmeier. 1971, p.450).

Table 2 : Creative abilities involving semantic content *(continued)*

Ability	Intellectual process	Product	Type of task used to measure ability
Flexibility (number of ways circles or lines were used)			
spontan-eous	Divergent production	Classes	1. List the different uses for a wooden lead pencil. E.g. writing, drawing lines, making a hole, winding thread, etc. 2. Fill in the blanks in the following passage. Find the missing words in the puzzle. P _ _ _ _ _ _ _ _ _ _ _ _ _ is the process by which plants make their f _ _ _ using s _ _ I _ _ _ _ , w _ _ _ _ _ and C _ _ (carbon dioxide) ....
adaptive	Divergent production	Transform-ation	Playing the game involving such things as matchstick. E.g. _ _ _@ one match or math-stick _ _ _@ _ _ _@ _ _ _@ (a) Take away four matches @ @ @ @ figure beside, leaving | | | | three squares and _ _ _@ _ _ _@ _ _ _@ nothing more. @ @ @ @ (b) Remove 5 matches and | | | | leave only 3 squares _ _ _@ _ _ _@ _ _ _@ [use the same diagram as (a)].

Elaboration (number of details contribute to the "story" told)			
Figural	Divergent production	Various implications	Add detailed operations needed to make a briefly outlined succeed to construct picture from a line. E.g. Without lifting your pencil from the paper, connect all nine dots by drawing four straight lines. - - - - - - - - -
Meaning	Divergent production	Various implications	Add detailed operations needed to make a briefly outlined succeed to make meaningful or interesting sentences. E.g. in making mnemonics to remember the name of 9 planets, starting from the nearest to Sun. My Very Efficient Mother Just Send Us Nice Present (Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune, Pluto)

The following are examples of science lesson activities extracted from PB-514 and mathematics lesson activities introduced by ex-Mathematics Specialist (Alindada, 1999) which could be implemented easily in a classroom setting to foster various traits of creativity :

(1) Fluency

Fluency is defined as the ability to produce a large number of ideas, possibilities and alternatives relevant to the problem. Fluency in language also means a good background knowledge in the vocabularies used in the topic. The activities to enhance 'fluency' could be done in the following ways: (a) To form words from unscrambled terms.

(b) To associate words by linking or grouping one thing with another.

(c) To enhance divergent thinking through solving word meanings.

(d) To produce a number of responses from a given group of alphabets.

Below is an example of science activity developed by PB-514 course participants for (1) (a) : "Solar System Scrambled Terms". Students were asked to unscramble the letters and write the word which will form the term related to solar system in the blank space provided. For example,

Loveriutno - once around something (Ans.) revolution
vinueers - we are exploring it (Ans.) universe
heart - where we live (Ans.) earth

Below is the activity for (1) (b) : "Reviewing the spheres". Students were asked to read each statement and then select the proper 'sphere' word that fits the definition.

1. Name given to water portion of the Earth. _____ (Ans.) hydrosphere
2. The areas on Earth where all living things exist. _____ (Ans.) biosphere
3. A name for all of the air that surrounds the Earth._____ (Ans.) atmosphere

(Ng, et al., 1996)

(II) Flexibility and Elaboration

Flexibility includes the characteristics of viewing on idea in different ways and questions that could be used to stimulate creative thinking are such as "What different approach ..., How else might you ..., What other ways ...", Whereas, elaboration includes the characteristics of expanding an idea with details and questions that could be used to stimulate creative thinking are such as "What can you add to ... Give all the details ... What would give it more...".

So what can teachers do in their mathematics classroom? The following are some simple questions to start with to foster the creative traits of "flexibility and elaboration".

- In how many ways can you measure the surface area of your dining table. Describe how you did it.
- Investigate shapes made from squares joined by common sides.
- What different shapes can be made from a particular number of squares?
- How can shapes using four squares be made from shapes using three squares?
- How can you convince yourself that a new shape is 'really different' from those already obtained?

(Alindada, 1999, pp. 9, 10 and 13).