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Author(s) Lucille Lee Kam Wah, Goh Ngoh Khang, Chia Lian Sai, Wan Yoke Kum and
           Lee Chui Eng

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Some Difficulties Encountered in Fostering Creativity in Science Education

Lucille Lee Kam Wah, Goh Ngoh Khang, Chia Lian Sai and Wan Yoke Kum
Nanyang Technological University

Lee Chui Eng
Tanjong Katong Secondary School

Abstract

Science is a method of inquiry, a way to ask intriguing and important questions and a procedure for finding new and novel answers to these questions. Besides disseminating knowledge and imparting skills, science education should also emphasize fostering creativity which is obviously important to science and technology as we move forward in the direction of scientific understanding and invention. In recognition of the importance of creativity, ten years ago Singapore government launched the Thinking Schools and Learning Nation (TSLN) initiative with emphasis on teaching creativity in schools. Since then fostering creativity is an area of concern for the Singapore Education System and needs to be better understood. In view of the need for Singapore students to become better thinkers, problem-solvers and learners, teachers have been sent for training in teaching creativity, encouraged to teach creatively and to find ways to foster students' creativity and thinking skills. Previous studies done indicated that creativity could be nurtured through the use of creative teaching strategies. However, what are the difficulties that can possibly be encountered if the creative teaching strategies were to be implemented? This paper reports on the third part of the findings of the study through interviewing ten school and university science educators to address the issue on some of the difficulties associated with the teaching of creativity through science education.

Keywords: Creativity, Difficulties, Science Educators, Teaching

Teaching / Nurturing Creativity in Science Education

Some previous studies have indicated that creativity could be nurtured through the use of creative teaching strategies (Goh, Lee, Xu, Tan and Chia, 2000; Christensen, 1988; Hill, 1976). In the context of science education, scientific research requires creativity in the sense of going beyond existing knowledge and techniques, to create new understanding. But even at a more common level, solving problems in science already requires a student to explore his repertoire, to imagine a variety of routes to a solution, and frequently to create novel combinations of knowledge or novel techniques for a solution (Hu and Adey, 2002). Thus, it is believed that cultivating of creativity through science education is possible if the following three stages are adhered (Goh, Lee, Xu, Tan and Chia, 2000):

1. Getting to know the fundamental science concepts,
2. Learning to see the insight of science concepts, their relevance and applications, and
3. Making use of the applications of science concepts and process skills to have a deeper coupling with languages and social arts.

The first stage focuses on introducing science concepts which play a fundamental role in the teaching of creativity in science education. This is because having a clear understanding of the concepts, students' knowledge and horizon can then be widened to proceed to investigate on the nature of the concept which opens an avenue for them to associate with other science concepts and apply in-depth of what they have learnt. Having fulfilled the second stage, the last stage exposes students to an unrestricted zone where they can let their imagination run wild, and hence serve to develop their creativity and cultivate their creative mind. It is also at this stage that students get to know the formation and evolution of science concepts through process skills which challenge students' curiosity and stimulate creativity, thus providing students with the opportunity for vast dimension of imagination.

To produce students who are inclined to creativity, there are a few approaches associated with implementation that can be considered. Firstly, there should be a de-emphasis on memorization of scientific facts. Instead, it should be replaced by understanding of concepts through problem

solving (Moravcsik, 1981). More 'open-ended' questions where there are no known complete answers should be included in our teaching, since in reality simple solutions to questions that require simple substitution resulting in an exact and unique answer is a far cry from how science actually works which is often 'fluid' and uncertain. Secondly, teachers should stress more on experimental work and allow students' understanding be demonstrated through this means. It also gives students the opportunity to think and work like a scientist. Experimentation is thus a crucial element in enhancing student creativity in science education. A specific area in science mentioned in the literature concerning creativity in experimentation is the project work (Swain, 1977). Through such activity, students would be able to relate science concepts with as many daily life experiences as possible and couple intensively the learning of concepts in deeper ways with process skills.

Educators are pivotal players in the classroom and organisation to consciously fashion the school site into a place for creative education as well as a creative organisation. Craft (2000), Loehle (1994), Meador (2003), Pye and Sherborne (2001), and Schamel (1992) considered engaging students in the active thinking in the open-ended scientific discovery and inquiry process as means to foster student creativity. Instead of asking students to follow a fixed set of directions in doing experiments, educators encourage students to form their own hypotheses and develop their own experimental designs. This open-inquiry approach is considered as a fundamental way to foster creativity in science, and is most widely incorporated into creativity-enhancing course in science education.

Besides this open-inquiry approach, problem-solving activities, which are always included in science learning curricula to elicit creativity, follow two common structured approaches. They are the creative problem-solving (CPS) model (Treffinger, Isaksen, and Dorval, 2000), and the problem-based learning method (Gallagher, 1997). Abell (1990) illustrated how teachers can adopt the six stages of CPS strategies systematically to solve a biology ill-structured problem. Other educators (Gallagher et al., 1995; Krynock and Robb, 1999; Plucker and Nowak, 2001) suggest problem-based learning developed in science-society-technology approach as a most effective way to foster creativity in science. These instructional designs ask students to do projects on real-life ill-structured problems in a rather self-directed and systematic mode.

Besides the widely accepted scientific inquiry and problem-solving learning activities, educators have tried to integrate some common creativity-enhancing methods (most of which were originated from gifted education field) into science learning. McCormack and Yages (1989) proposed a new taxonomy of science education. On top of the common domains of science education (knowing and understanding, exploring and discovering, feeling and valuing, using and applying), they included an "imagining and creating" domain.

Our earlier study (the second part of the overall study) (Lee, Goh, Chia and Wan, 2006; Kwang, Lee and Goh, 2005), using interviewing method, found out from ten school and university science educators that there are 15 teaching methods and activities of promoting creative thinking in Singapore schools. These methods and activities are categorized in two strands of teaching ideas, namely using creative teaching strategies to teach chemistry, and providing students opportunities to exercise their ideas of creativity. For using creative teaching strategies to teach chemistry, the strategies suggested include creative problem solving, project work, asking thought-provoking questions, creative teaching using analogies, demonstrations, discrepant events, different forms of models and telling stories, use of IT, creative use of data-loggers, three levels of hierarchal structures of teaching, and incorporation of the Thinking Skills Programme. For providing the students opportunities to exercise their ideas of creativity, the exercises suggested include students' creative presentation of scientific concepts, students' design of experiments / practical work, students giving alternative solutions, students' involvement in collaborative work within and outside the school, students being given more space to think creatively, and students being encouraged the spirit of constructive criticism.

Purpose of the Study

The present study (the third part of the overall study) was a follow-up of the second part of the study (Kwang, Lee and Goh, 2005) to find out from this same group of science educators their views on the difficulties possibly encountered if their suggested ideas were to be implemented. The research question for this part of the study is stated below:

What are the difficulties that can possibly be encountered if the interviewed teachers' suggested ideas are to be implemented?

Method

The method used to explore science educators' views for this study is interviewing technique. A total of ten science educators were identified for the interview. Among them, six were from six secondary schools; two from two junior colleges and two from a tertiary institution. The schools and the junior colleges chosen for the study were of different school types, namely Government, Government-Aided, and Independent. The tertiary institution was a statutory board organization. Table 3.1 shows the background of the ten science educators in terms of their genders, numbers of years of teaching science, the levels / genders of schools or institutions, types of schools or institutions, remarks on teaching history / additional duties for the senior educators. The science educators were interviewed with the following two questions:

Interview Question 1:   In your view, what difficulty(ies) would you encounter if your ideas were implemented in classroom situation?

Interview Question 2:   Do you think the difficulty(ies) can be overcome? How?

Table 3.1 Background of the Ten Science Educators

Educator	Gender of the Educator	No. of Years of Teaching science	Level / Gender of School or Institution	Type of School or Institution	Remarks
1	F	5	Secondary / Boys	Government	
2	M	1	Secondary / Girls	Government-Aided	
3	F	16	Secondary / Co-Ed	Government	Science HOD
4	F	6	Secondary / Co-Ed	Government	2 yrs Science HOD
5	F	10	Secondary / Co-Ed	Government	3 yrs Science HOD
6	M	9	Secondary / Boys	Independent	5 yrs Science HOD
7	M	3	JC / Co-Ed	Government	
8	M	8	JC / Co-Ed	Government	3 yrs in Government Sec Sch., 5 yrs in JC
9	M	28	Tertiary / Co-Ed	Statutory Board	3 yrs in Government Sec. Sch., 4 yrs in JC, 21 yrs in Tertiary Institution, 13 yrs Head, Chemistry Dept
10	M	13	Tertiary / Co-Ed	Statutory Board	11 yrs in Independent Sec. Sch., 2 yrs in Tertiary Institution

The interviews with the ten educators were conducted individually at their convenient time at the first author's office. Each session was tape recorded with the interviewee's permission. The conversations of each interview were transcribed in details. In the analysis of the interview transcripts, as suggested by Creswell (2002, p 190-197) and Gunn, Forrest and Freebody's (1995), the procedure for analyzing the transcripts are shown below:

1.   The entire corpus of interviews was scanned to obtain a sense of the main features of the talk.
2.   Self-contained statements or sections from larger stretches of talk that particularly exemplified

these features were then examined.
3.   After refining the definitions of these features, some tentative themes like those that addressed the difficulties encountered in implementing the suggested teaching ideas, etc., were compiled.
4.   Finally, examples in the form of quotations were selected for the report from the interview transcripts to support the features that addressed the research question.

Results

In the analysis of the ten educators' interview transcripts in responding to Interview Questions 1 and 2, their views on the difficulties encountered if the suggested ideas were to be implemented, how these difficulties to be overcome, are here reported.

Difficulties encountered in implementing the suggested teaching ideas

Based on the ten educators' responses to Interview Question 1, the difficulties encountered in implementing the above suggested ideas in classroom to promote creativity are summarized.

1.   Time constraints
        Eight out of the ten educators (Educators 1, 3, 4, 5, 6, 7, 8 & 10) felt that the limited amount of time available in the curriculum schedule might pose some difficulties in the implementation of creativity-based activities in classroom. As the teachers might be trying to complete the syllabus to prepare students for tests and examinations, they might not have enough time in the curriculum schedule to incorporate activities which promoted creativity. In addition, the teachers in general, might not be given enough time to reflect, prepare and plan for activities which catered for promoting creativity.

2.   Teachers' mentality
        Six out of the ten educators (Educators 2, 3, 4, 5, 6 & 9) felt that teachers' mentality could pose some difficulties in the implementation of creative ideas in classroom situation. Three aspects concerning teachers' mentality, namely responsibility on students' academic performance, open-mindedness and belief in students' capability, were pointed out by the six educators. These three aspects are summarised in the following sections.

(a)   Students' academic performance
        As pointed out by Educators 2, 5 and 4, some teachers were only interested and focused on preparing students to achieve good academic results. These teachers might find activities which promoted creativity too time consuming and did not help in producing good academic results. Hence, some teachers were not willing to sacrifice curriculum time for creativity-based activities.

(b)   Open-mindedness
        Some teachers might not be open-minded enough to accept creative teaching other than the traditional method of teaching. As the teachers might argue that their old ways of teaching has worked well for so many years and they did not see the need to change. On the other hand, some teachers might not be open-minded to accept a variety of solutions suggested by students in solving a problem. Hence, teachers' open-mindedness could pose some difficulties in promoting creativity in class. (Educators 3, 4, 5, 6 and 9)

(c)   Students' capability
        Educator 5 felt that the teachers' belief about their students' capability to achieve more than expected could affect the success of the implementation of creativity-based activities in classroom. If the teachers believed that their students could not even handle the fundamental concepts, it was unlikely that the teachers would assign higher-order tasks to students to challenge them.

3.   Students' attitudes
        Five out of 10 educators (Educators 1, 2, 7, 8 & 9) felt that whether the students had the positive learning attitude was an important factor which could affect the implementation of creativity-based activities in classroom. Some students might just want to learn enough to pass the tests and examinations, and they were not interested in learning more. On the other

hand, some students might resent the idea of creative thinking as they could feel that it took up too much of their mental energy and hence found creative thinking a difficult skill to learn.

4. Students' abilities /aptitudes

Four out of 10 educators (Educators 3, 8, 9 and 10) felt that students' ability/aptitude was one of the difficulties encountered in the implementation of creative ideas in class. They felt that teaching creativity to students of a low ability level would be a very difficult task. As these students might find the higher-order critical and creative thinking skills difficult to comprehend and achieve, thus they might tend to reject it. In addition, some students of low ability might create disciplinary problems in classroom and the teachers would have to spend more time managing their behaviour which could hinder the implementation of creativity-based activities.

5. Facilities and resources

Three out of 10 educators (Educators 3, 7, and 8) felt that the lack of facilities and resources could hinder the implementation of creativity-based activities in lessons. The facilities and resources, such as the availability of sufficient computer facilities, apparatus and laboratories, etc., for students to carry out investigative work or involve in creativity-based activities were some of the concerns raised by the educators. In addition, one of the educators (Educator 3) felt that the lack of appropriate teaching resources to illustrate and explain concepts was also a constraint that could affect the implementation of creativity in classroom.

6. Criteria for assessing creativity

Two out of 10 educators (Educators 2 and 5) felt that the lack of standardized way of assessing creativity might make the assessment of creativity a difficult task. Some unfair assessments might arise due to the teachers' different perspectives of creativity. This might create parental objections to students' involvements in activities which promoted creativity, especially if it involved grading.

7. Lack of teaching skills

Two out of 10 educators (Educators 4 and 9) felt that the lack of appropriate teaching skills in teachers can pose some difficulties in the implementation of creativity-based activities in classroom. Two aspects of teaching skills were brought up: fundamental teaching skills and skills for teaching creativity. If a teacher could not even establish his/her fundamental teaching skills, then it was unlikely that the teacher could teach creativity. On the other hand, a teacher could have the fundamental teaching skills but not equipped with the skills to teach creativity, then it was also not possible that they were able to know how to promote and cultivate creativity in students. In all, it is essential that the teachers must already have the fundamental teaching skills so that upon which, further training could be provided to build up the skills required for teaching creativity.

8. School culture

Two out of 10 educators (Educators 4 and 6) felt that school culture could affect the implementation of activities which promoted creativity in classroom. If the school culture was focused only on achieving good academic results and nothing else, then teachers would usually focus on activities which could help students to achieve good academic results. In this case, it is unlikely that the teachers would want to spend time preparing and implementing activities which encouraged creativity and creative thinking.

9. Parental factor

Educator 10 felt that parents who did not see the need and importance to develop their child's creativity might hinder the implementation of activities which encouraged creativity. They might prefer the teachers to focus more on activities which encouraged drills and practices to help their children to acquire the mastery of content knowledge. Hence, it might discourage the teachers from implementing activities which encouraged creativity.

10. Language

Educator 3 felt that students' incompetence in their language could be a barrier to their learning of fundamental concepts. Without a strong foundation of fundamental concepts,

students might find it difficult to accomplish assignments or activities which required creative thinking skills.

11.   Catering to the appropriate cognitive levels of students
        Educator 3 felt that some of the strategies used in teaching creativity might not be catered at students' cognitive levels. This could have confused the students as they are not able to comprehend what the teachers were trying to impart.

12.   Setting of questions for assessment
        Educator 3 felt that setting problems or questions which were open-ended or consisted of more thinking components could be a difficulty as encountered by some teachers. As setting open-ended questions/problems, which allowed a variety of possible solutions, demanded a lot more of effort and creative thinking on the part of the teachers.

13.   Incorporating thinking skills into subjects
        Educator 3 felt that students' inability to understand how thinking skills could be incorporated into the relevant subjects was a barrier to teaching creativity in classroom. According to Educator 3, students tended to see thinking skills as a separate subject entirely on its own and they perceived thinking skills as another subject to be learnt, just like any other normal subjects.

How to Overcome the Above Difficulties?
        Based on the ten educators' responses to Interview Question 2, a summary on how to overcome the difficulties in the implementation of teaching creativity in classroom is here described.

1.   Teachers making conscious effort to overcome the difficulties encountered
        Three out of 10 educators (Educators 1, 8 and 9) felt that if the teachers made the conscious effort to look for alternative ways to solve the constraints that they faced and were willing to try out new ideas, then it would be possible for the teachers to overcome the difficulties. Hence, it depended on the teachers' willingness to make the conscious effort to overcome the difficulties that they encountered.

2.   Supports among teachers
        Three out of 10 educators (Educators 3, 4 and 10) felt that the support rendered by teachers was an important factor in overcoming any difficulties encountered in teaching creativity. The teachers who were more confident with teaching creativity should help and encourage those who were fearful or lack of the teaching skills to teach creativity. Basically, if the teachers worked as a team and helped each other, then the teachers' confidence and competency in teaching creativity could be overcome.

3.   Providing sufficient training and guidance for teachers
        Two out of 10 educators (Educators 5 and 8) felt that teachers should be given proper trainings and guidelines on how to go about in teaching creativity or conducting activities in class to promote and cultivate creativity. With proper trainings and guidelines given, teachers would at least have some guidance to help them to conduct lessons which focussed on promoting creativity and creative thinking in students.

4.   Overcoming students' abilities and mindsets through patience
        Two out of 10 educators (Educators 7 & 9) felt that the students' ability and mindset could be overcome if the teachers could be more patient to allow students to get adjusted and adapted to the approaches of teaching creativity and not to rush into it. For example, a teacher should not begin a first lesson by bombarding students with lots of questions to stimulate thinking but gradually incorporating questioning into their teaching. In this way, the students would be less resistant and more confidence with the new approach to promote creativity, and they will begin to see the benefit of learning using questioning approach. However, Educator 10 felt that the difficulty concerning students' ability could not be overcome. For classes of higher ability level, creativity-based activities could be carried out, but for classes of lower ability level, it was not possible to carry out such activities.

5.   Supports and encouragements from principals and HODs

Two out of 10 educators (Educators 4 and 10) felt that the principals' and HODs' supports and encouragements were important factors in overcoming some of the difficulties in the implementation of creativity-based activities. For instance, if the principals and HODs thought that creativity was an important aspect of students development and they encouraged students' creativity to be cultivated, then it would be the driving force to push the teachers to focus on more creativity-based activities in lessons.

6.   Standardizing criteria for assessing creativity

Two out of 10 educators (Educators 2 & 5) felt that the schools and the teachers should be given a common set of criteria for assessing creativity in students' works to prevent any unfairness in grading. In this way, the teachers would have the guidelines to determine whether student's piece of work was considered to be creative. It was also suggested that on-line help from experts who were good at assessing creativity could be provided for teachers when they were in need of some help.

7.   Allowing times for teachers' adaptation

Educator 8 felt that teachers must be given times to adjust and adapt to teaching creativity. As most of the teachers could be so comfortable with didactic instruction and they might need the times to re-learn and adjust to creative teaching which could be relatively new and unknown to some of them.

8.   Establishing good rapport with students through concerns

Educator 9 felt that at the initial stage it was important for the teachers to build good rapport with the students. Educator 9 felt that once the rapport with the students was established, any teaching strategies implemented by the teachers would be accepted quite easily by the students. Educator 9 suggested that to build good rapport with the students, the teachers must show their concerns for the students and the commitments to teaching so as to build the students' confidence in them.

9.   Making learning enjoyable and fun for students

Educator 9 felt that when teachers made the learning process enjoyable and interesting for the students, it would encourage and motivate the students to take up challenging tasks which required higher-order creative thinking skills.

10.   Overcoming the time constraint through content reduction

Educator 7 felt that by reducing the amount of content to be taught to students, more time in the curriculum schedule could be allocated for activities which promoted students' creative thinking. However, Educator 10 did not agree that content reduction could help in allowing more time in the curriculum schedule to be used for activities which promoted creativity.

11.   Flexible usage of the time

Educator 10 felt that the difficulty on time constraint could not be solved easily. However, if the teachers could be flexible and work around the schedule, then creativity-based activities might still be able to be implemented. For instance, Educator 10 suggested that the students in the lower secondary level should be given more emphasis on creativity-based activities as these students did not have to sit for national examination. But the students in the upper secondary level should not be given the emphasis on creativity-based activities as they had to prepare well for the national examinations.

12.   Ingenuity of teachers

Educator 8 felt that the shortage of resources could be overcome through the ingenuity of the teachers. Teachers should try to improvise the required resources for teaching creativity from whatever materials they could get hold on. By doing so, the shortage of resources could be solved quite easily.

Discussion

The results of this part of the study have shown that there will be difficulties encountered if the creative teaching strategies are to be implemented. Many interviewed educators have unanimously expressed their concerns in this aspect. Four major external factors affecting the development and

nurturing of students' creativity in class were identified: (1) school environment, (2) teachers' role and mindsets, (3) students' attitudes and abilities, and (4) family supports.

The issues of school environment being highlighted by the interviewed educators in this study include the national policies (e.g. class size and text books), school curricula, supports from school authority, more varieties for the mode of assessment, more training courses on creativity, time constraints, facilities and resources, school culture in promoting teaching and nurturing creativity. The major concern of the above all is the time constraints. Eight out of the ten educators interviewed highlighted that "time" was a severe constraint for them to implement the creative teaching ideas in schools. The lack of time could be attributed to either the need to finish the syllabus within a certain time frame or teachers are so burden laden with other administrative duties that leave them with no time to try novel teaching ideas that will stimulate thinking amongst students. The fact that teachers have to "rush" in their teaching already deters them from trying new pedagogies in class.

The issues of teachers' role and mindsets being highlighted by the interviewed educators in this study include the teachers' mentality and responsibility on academic performance, teachers' flexibility to be incorporated in carrying out curriculum schedule, and professional sharing among teachers on developing creative thinking in class, etc. The major concern on teachers' role and mindsets is the teachers' mentality and responsibility on their students' academic performance. Six out of the ten educators interviewed have indicated that many teachers are only interested and focused on preparing students to achieve good academic results. The teachers find the activities which promote creativity are too time consuming and are not willing to sacrifice curriculum time for nurturing creativity in their students.

Regarding the students' attitudes and abilities, five out of the ten educators interviewed highlighted their concerns about their students' open-mindedness towards creativity. Some students are very goal-oriented and pragmatic that these attitudes might be against the ideas of teachers' using creative teaching strategies to teach. Some students might perceive that their time is wasted and hence they are not willing to learn beyond the syllabus. On the other hand, four out of the ten educators interviewed highlighted their concerns on their students' capabilities to handle creativity-based activities in class. The implementation of the creative teaching ideas might be hindered by the students' aptitude in this style of teaching. Their level of ability in language, spatial thinking, visual skills and general knowledge might not be adequate. Teachers might have to adjust themselves to the students' abilities.

Regarding the family supports, some parents do not appreciate the creative teaching approach. They are more concerned with their children's results and perceive that the new teaching methods are a waste of time. They rather want the teachers spend more time on drill and practice, and want their child do more exercises, homework or school work.

Conclusion

In view of the need for Singapore students to become better thinkers, problem-solvers and learners, teachers have to try to overcome these difficulties by being flexible, creative and reflective in their teaching performance. It is hoped that the findings of this study could help school administrators and teachers better understand the issues involved in the implementation of teaching or nurturing creativity in science.

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