Enhancing Creativity of Elementary Science Teachers - a preliminary study

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Contents

Abstract

This study presents a program for developing the creativity of teachers in designing hands-on science activities with the use of everyday resources. The design of this program is based on creativity theories in mainstream psychology. It aims at fostering the creative attitudes (i.e. confidence, interests and values) and the divergent thinking abilities (i.e. fluency, flexibility, unusualness and elaboration) of teachers in self-developing science experiments with simple everyday items. Strategies adopted in the program include --- hands-on inquiry, breaking of perceptual and cognitive sets, generation of multiple answers, suspension of judgment in brainstorming, attribute listing, usage of checklist, morphological synthesis, modeling and providing creative examples, thought-provoking questioning, cultivation of playful environment and self-reflection for meta-cognitive awareness. This program has been conducted to about 80 in-service teachers. The evaluation results are positive, indicating that part of the objectives of the program is achieved. Suggestions are made for improvement and future studies.

Literature Review

Basic concept of creativity

After reviewing a number of important literature on creativity, Mayer (1999) recently concluded that there was a consensus on the how to define creativity in terms of its products. Creative products have two criteria, i.e., novelty and appropriateness. For instant, Sternberg and Lubart (1999) stated, "creativity is the ability to produce work that is both novel (i.e., original, unexpected) and appropriate (i.e., useful, adaptive concerning task constraints)" (p.3).

Amabile (1996) had proposed a theory for the development of creativity. In her framework, creativity is hypothesized as a confluence of three kinds of resources: (i) creativity-relevant skills (across domains), (ii) domain-relevant knowledge and skills (domain-specific), and (iii) task motivation. Domain-relevant resources include factual knowledge, technical skills and special talents in the domain. Creativity-relevant resources include appropriate cognitive style, personality trait, conducive work style and knowledge of strategies for generating novel ideas. In specific, the major features of the appropriate cognitive style are the preference of breaking perceptual set and cognitive sets, keeping response options open, suspending judgment, etc. Furthermore, Amabile (1996) had proposed that "intrinsic motivation was conducive to creativity; whereas extrinsic motivation was detrimental" (p.107). Concerning the nurturing of intrinsic motivation, Hennessey (1995) highlighted the importance of promoting a "playful attitude" in the environment. Persons who are able to maintain playfulness, may continue to focus on the interest and enjoyment they derived from the task. They are more likely to keep their intrinsic motivation, even under external constraints. Humor, fun, and play take the brain from a cognitive, rule-bound state to a more fluid state where the whole body can work on a problem while the "thinking mind" is relaxed (Prouty, 2000).

In line with Amabile's social psychology approach, Nickerson (1999), in his review, suggested that numerous characteristics, competencies, traits, attitudes and other factors were associated with creativity, but most basic determinants to realize one's creative potential were affective (attitudinal, motivational) and not cognitive ones. Desire, internal motivation, and commitment are more important, than either domain-specific knowledge, or knowledge of specific creativity-enhancing techniques (Nickerson, 1999).

In support to their affective approach, Feldman (1988,1999) suggested that creativity was rooted in the desire for creative change, i.e., "the conscious desire to make a positive change in something real" (Feldman, 1988, p.288). People's new creative efforts are inspired by the results of previous creative efforts. He emphasized that seeing the results of other people's creativity illustrated that it was possible to make a difference. He believed that the interaction with the creative efforts and products of others would have significant stimulation on ones' creativity. Other scholars (Sternberg & William, 1997) also emphasized that role model was one of the most important factors for the development of creativity.

In contrast to the affective approach, some profound scholars in creativity research, Guilford (1950), Torrance (1974), Wallach & Kogan (1965) and others, considered divergent thinking process as central to ones' creative process, and thus divergent thinking skills were crucial to ones' creative ability. Most of these scholars focused on three of the divergent thinking skills --- "fluency", "flexibility", and "novelty". With regards to fluency, Guilford (1950) stated that those people who produced large numbers of ideas were more likely to have significant ideas. For flexibility, he stated that creative people should be able to change set easily, generate ideas from different perspectives. For novelty, he stated that creative people would have unusual but appropriate ideas. In recent literature, divergent thinking abilities were still widely accepted as a significant measure of ones' creative potential (Lubart, 1999; Runco & Nemiro, 1994). Influenced by these theories, many creativity enhancement packages in the past were designed for training mainly the diverging thinking abilities of participants (Ripple, 1999). However, this approach was challenged by some scholars Crophley, 1999), who suggested that creativity development should be multi-faceted, taken into account the cognitive, affective, motivational, personal, and social factors, and should permeate the whole curriculum.

Creativity in teaching

In-depth studies on creativity of teachers are rare, though its importance is widely accepted in educators nowadays (Randi & Corno,1997). Classroom is a dynamic, interactive, complex and ever-changing environment. Every moment in teaching, teachers are facing new challenges. They have to solve a lot of problems, which they have not been taught directly in training courses or experienced before. In an old book "Creativity in Teaching", Miel (1961) suggested that teachers might express their creativity in three areas of tasks: integrity in classroom relationships, development of teaching content, inventiveness in the use of time, space and materials. Rubin (1985) described two types of inventiveness in teaching----- in its simple form, invention involves adapting lessons to particular classrooms and students; and, in its complex form, invention involves devising ways to solve instructional problems. Halliwell (1993) suggested "inventive flexibility" as a common type of creativity in teaching. Teachers need to make creative mediation between the given materials (e.g. that in the textbooks) and a particular group of learners on a particular occasion. It is this mediation for which some degrees of inventiveness or flexibility become essential. In all their descriptions (Halliwell, 1993, Miel,1961, Randi & Corno, 1997, and Rubin, 1985), teaching was considered as a creative process, demanding the flexibility and adaptability of teachers.

With regards to science teaching, few studies have been documented on the creativity of science teachers. Sussman (2000) suggested, "improvisation is a skill that most science teachers quickly master, whether it's searching for inexpensive or free materials for the classroom, substituting everyday materials for expensive lab equipment, or incorporating activities into the curriculum that don't require a lot of materials"(p.20). She encouraged teachers to "remember to be creative, use your imagination, and improvise"(p.20). Melear (1993) had developed a course titled "Creativity and inventiveness in science", and "creative science teaching" is one of its learning areas. In the final chapter of the book "Creativity in Primary Science" (Frost, 1997), its author concluded that "science teaching provides both the opportunity and the necessity to be creative" (p.182).

Context

In Hong Kong, elementary science teachers, like other teachers, need creativity to develop new instructions and activities, to adapt activities in the textbooks to special classroom environment and students' needs, to motivate students, and to cope with classroom management problems. However, besides these general teaching tasks, elementary science teachers in Hong Kong also require creativity to deal with a specific task --- designing experiments using everyday materials. In Hong Kong, most primary schools do not have laboratory and most primary classrooms *lack science apparatus*. Even if, equipments are available, the numbers of them are few and not enough for individual or small group practical work. However, numerous studies in science education have suggested that direct hands-on experience is highly necessary for children to acquire inquiry skills and attitudes. Even worse, most of the experiments suggested in the curriculum guideline (Curriculum Development Council, Hong Kong, 2001) of General Studies (the subject which has integrated most science topics) and in its textbooks are rather conventional ones. They depend heavily on the use of laboratory apparatus.

Besides the lack of apparatus, there is another reason for using everyday materials to do science experiments. As Monk & Dillon (1995) suggested, "much of science education is presented through the use of apparatus which sometimes seems deliberately arcane … reinforcing the notions that science is a specialist activity undertaken only within institutions rather than giving the impression of science as an everyday activity of great personal relevance"(p.140). Studies (Taylor, 1995, 1998; Taylor & et al, 1990) have suggested that it is more "user-friendly" to use everyday materials (e.g. toys) in science investigations. This kind of activities can help students to build up an image ---- science is fun, science is around us, science is a part of everyday life, science is for everyone (Jocelyn, 1994). However, many of the practical exercises offered in textbooks of Hong Kong do not appeal to young children, or simply do not work in a normal classroom context.

Therefore, there is a great demand for teachers in Hong Kong to self-develop practical work using everyday materials, so as to offer primary students more direct hands-on experience in the classroom.

However, the science teachers in Hong Kong have their formal science education (if they really have) in well-equipped laboratory. They themselves lack the experience in using everyday materials to do science experiments. Therefore, this possibility of arranging experiments is beyond the imagination of most teachers. Besides the lack of relevant experience, the development of teachers in Hong Kong is hindered by another factor. Most local teacher education programs have neglected the training of divergent thinking abilities of teachers. Participants used to generate only one solution to each teaching task. In some cases, the training tasks are even closed-ended with fixed solutions. On the whole, participants have very limited opportunities to develop their divergent thinking abilities in both general teaching areas (e.g. questioning), and specific teaching areas (e.g. the use of everyday resources in designing practical work).

In the context as described, the primary science teachers of Hong Kong are facing several problems. First, the teachers lack the *intrinsic motivation* (e.g., interests) in both doing and designing science investigations. Most of them feel that science is something difficult, remote and unrelated to them. They themselves seldom try to do some simple science investigations in their daily-life. Second, from their past experience, teachers have built up the *misconception* that experiments must need to be done with science apparatus. Alternatives seldom exist in their mind. Third, teachers also have the misconception that the practical work exercises offered in the textbooks are the best. They lack the *confidence* to self-develop or modify the practical work in the textbooks. Fourth, they lack the *sensitivity* to link up everyday materials with science phenomena. Fifth, they lack the *divergent thinking abilities* (mainly flexibility) in finding alternative ways to do practical work, other than the one offered in the textbooks.

Goals

To encounter these problems in Hong Kong, a special program is developed. It aims at enhancing teacher's creativity (including their creative attitudes and abilities) in designing science practical work with the use of everyday materials. The program has both affective and cognitive objectives. The affective objectives are to enable teachers to have higher motivations, confidence, interests, values in self-developing experiments with everyday materials. Besides, this program also attempts to develop teachers' divergent thinking abilities in designing experiments, through practicing some creativity-enhancing strategies.

Strategies

In this program, ten hands-on activities are conducted in an *inquiry learning approach*. Teachers are divided into groups. They are asked to design practical experiments with everyday materials and then try them out on the spot. The activities are arranged with increasing degree of openness and challenges.

The activities are purposely designed *to break the perceptual set and the cognitive set (i.e., the functional fixedness)* of teachers. To perceive creatively, one needs to see things differently from the way most people see them, and able to take advantage of serendipity by recognizing the importance of new information (Amabile, 1996). For example, in breaking the perceptual set, teachers are enabled to see a balloon as an apparatus of science experiments, and not only a simple toy. On the other hand, in breaking cognitive set, an old set of unsuccessful problem-solving strategies is abandoned and the search for solution moves off in a new direction, which may lead to creative solutions in a problem-solving process (Amabile, 1996). For example, when teachers find that they lack the science apparatus for the experimental designs suggested in the textbooks, in the past, they either try to buy them or to avoid doing the experiments. In breaking the cognitive set, teachers are able to solve the problem in a new direction --- search for materials in daily-life to substitute the apparatus, or to redesign the experiments in a simpler way.

Based on some existing theories, the program has adopted several *structural strategies for facilitating divergent thinking* in designing its activities. Unlike conventional activities in teacher training, most activities in this program request *multiple answers* to foster divergent thinking and flexibility of teachers. For example, "design 20 experiments using these three sheets". A lot of group and individual brainstorming exercises are implemented. The cardinal rules of Osborn's (1953) brainstorming program are adopted. The steps in sequential order are---- criticism is ruled out, freewheeling is welcomed, quantity is wanted, combination and improvement are sought. Special attention is paid to *suspension of judgment*. Participants are encouraged to keep response options open as long as possible, so as to develop their ability to avoid foreclosure of alternatives. All ideas are accepted in brainstorming. Even crazy or seemingly impossible experimental designs are also taken into account in the first stage of discussion. Besides brainstorming, morphological synthesis, *attribute listing* and checklist method are also implemented in the program. They are introduced in the following paragraphs.

Sometimes, free association of experimental design is difficult because there are too many possible cognitive paths. In attribute listing (Crawford, 1954), a problem is divided into its key attributes, which would be addressed separately. For example, in designing heat expansion experiments, teachers first analyze what the key attributes of such an experiment would have, and then consider how each attribute can be altered or combined to form new experimental designs. In *morphological synthesis* (Starko, 2001), forced combination of two sets of attributes (e.g. everyday items and science topics) in a matrix form (see Table 1) would produce large number of inventions (e.g. new experimental designs). The matrix form allows all possible interactions between the two diverse sets of attributes. The forced association between each pair of attributes (e.g. balloon and sound-emission) helps to narrow down the number of possibilities, focus our attention on fewer things and offer clues to solve the problem at hand. In *checklist method*, a set of idea-spurring queries is used to stimulate people to generate new ideas. Eberle (1977) developed an easy-to-remember checklist, namely SCAMPER. The Table 3 in the next section describes the idea-spurring queries of SCAMPER, and illustrates how it can be used to facilitate divergent thinking in science teaching.

Modeling effects are induced in the program, through the sharing of ideas with peers and lecturers, and that in the books. According to Feldman's theory, seeing creative products of others would induce a desire to be creative and a belief that alternatives exist and creative outcomes are possible. Throughout the program, brainstorming, sharing and hands-on try-out are arranged successively and repeatedly. In most cases, after obtaining stimulation in the sharing and try-out process, participants are encouraged to brainstorm more innovative ideas. At the end of some activities, some books or articles on science hands-on activities (e.g. "100 science experiments with paper") are showed. This arrangement is to reinforce the belief that everyday materials can be extremely useful. In the program, teachers are encouraged to continue their creative thinking after the lessons, and also in real-life teaching. The conductor used to say, "There are infinite possibilities. How exciting your teaching is, depends on how creative you are!".

Besides these structural activities, special attentions are also put on the *questioning techniques*. Through some thought-provoking questioning, two objectives are expected to achieve. First, conductor encourages fluent, flexible, original and elaborative thinking (i.e. divergent thinking) of participants through her comments and questions. Questions like "there exist more than 30 ways (exaggerated), try to think of as many ideas as you can in using this item" are used to encourage fluency. Questions like "what are some different kinds of ideas", "so far, all our ideas involve light, try to think of experiments on other topics" are used to encourage flexibility. Comments such as "try to think of something no one else will think of " are used to elicit originality. Comments such as "how can we build on this idea", "describe your experiments in more details" encourages elaboration. (Starko, 2001)

Another set of questions is used to facilitate teachers to get involve in the inquiry process. The conductor used to ask questions like "He suggests that the water droplet on the transparency can be used as a magnifying glass. How this can be done? … Compare the images created by a small and a big droplet, which gives a bigger image … How to produce a bigger image with the same water-droplet? Try to find the answer with your own water magnifying glass."

Besides questioning, the conductor also put special effort in cultivating a *playful and happy environment*. She uses instructions like "today we play with …". To reduce the pressure of external evaluation and competition, she used to say, "groups which loose the game, would need to sing". The conductor always keeps smiling and adopts a humorous mode of interaction. The learning environment nourishes a feeling --- doing science experiments are just "playing" with some everyday objects.

Sample and Activities

This program is part of the content of the module "Teaching of General Studies" in the Retraining Course of Primary Teachers in Hong Kong Institute of Education. It has been conducted for about 80 in-service teachers in four successive cohorts. All the participants are primary school teachers in Hong Kong. Their teaching experience ranges from five to thirty years.

Altogether, there are ten activities, with one formal assignment. They are described in the following paragraphs:

Activity one - "Science equipments are found everywhere"

This is an introductory activity with less open-ended tasks. Given a number of everyday materials (a cell, a Yakult bottle, a magnifying glass, an elastic band, a coca cola can, a magnet, a needle, a drinking straw, a balloon, and a piece of butter paper, aluminum foil and blue tack), teachers are asked to design certain hands-on activities. They include -- (1) demonstration of heat expansion, (2) exploring the effect of short-circuiting, (3) making a camera model, (4) making a compass model, (5) creating a musical instrument, and (6) any other practical work they can think of. After this hands-on work, several books on science activities using everyday materials are shown to the teachers.

Activity two- Multiple ways to use one object

Teachers are asked to think of ten different ways to play with balloon(s). The tasks given are ----- making (1) a rising balloon, (2) a horizontally-flying balloon, (3) a running balloon, (4) a rotating balloon, (5) a swimming balloon, (6) a sound- conducting balloon, (7) a sound-emitting balloon, (8) a sticky balloon, (9) a balloon thermometer, (10) a balloon balance (measuring weight), and any other possible ways of playing a balloon. Besides different kinds of balloons, some simple items like drinking straw, elastic band, and thread are available. Again after hands-on work, books and articles on balloon experiments (e.g. Cheng, 2001; McGlathery, & Malone, 1991) are shown.

Activity three- Morphological synthesis of materials and science topics

Teachers are given three different sheets -- a small piece of transparency, color filter, shining metallic sheet (all of them are very cheap and can be easily brought in stationery shop). Some science topics in General Studies curriculum is listed together with the three sheets in a matrix form (see Table 1). Adopting the technique of force association, teachers are asked to relate the sheets with each science topic, one by one, and brainstorm all experiments they can think of.

Table 1. Worksheet for Morphological Synthesis Exercises

Science Topics	**Everyday items**			
	A small piece of			Additional object (________)
	Transparency	Shining metallic sheet	Color Filter	
Light				
Heat				
Magnet				
Electricity				
Electrostatic				
Force & motion				
Air & air pressure				
Burning				
Sound				
Machine				
...				
...				

Participants are reminded of several points --- first, according to the criteria of suspension of judgment, teachers are instructed to put down or voice out all possible ideas they think of, and not to worry about their appropriateness and practicability. Second, participants are remained that they can use one or more sheets together (e.g., the transparency can stick with the color filter after rubbing due to electrostatic generated). Third, they are allowed to cut, fold, or do anything on the three sheets (e.g., creasing the shining sheet to demonstrate rough surface cannot form sharp images). Fourth, after this first exercise, each group of teachers would draw a card from a bag. On each card, one word like "water", "body", "coin", or "ruler" is written. Each group is instructed to associate the sheets with the additional object to design more experiments. For example, one group explores what experiments can be done with the transparency and water (e.g., creating a magnifying glass), and other group explores what experiments can be done with the colour filter and our body (e.g., demonstrating heat expansion). After group discussions, teachers present their ideas and try-out the experiments. They then analyze which experiments are useful and can be implemented in primary classroom.

Activity four -- Identification of versatile everyday objects

After preceding exercises, teachers are asked to brainstorm some everyday items, which they think can be as useful as balloons or these three sheets in doing science experiments. They are encouraged to suggest as many objects as they can (i.e. fluency), as many different kinds of objects (i.e. flexibility) and as unusual as they can (i.e. novelty). At the beginning, they are not required to support their answers with possible experimental designs. Therefore, teachers are free to suggest materials, which they "feel" may be useful. (Their usual answers are paper, ruler, bottles, etc). After collecting an abundant amount of ideas, the whole class is asked to suggest a few experiments using these items. The discussion is brief and just for confirming that these everyday items are useful. Finally, conductor displays a number of books (e.g. "100 science experiments with paper", "Soap science: a science book bubbling with 36 experiments", "Home experiments in physics: 25 investigations with a ball pen"). If time is available, the morphological synthesis exercise would be repeated with some of the versatile object suggested.

Activity five--- Exploring creative uses of toys

Toys are well-known to be very useful tools in physical science teaching (Herald, 2001; Taylor, 1998; Taylor & et al, 1990). Each group of teachers is given a simple toy. They are asked to suggest how the toy can be used in science teaching. In a worksheet, teachers would answer questions like --- Which topic is related to this toy? What questions you can ask around the toy? What activities can be done? (For example, in a group given a metal-plate toy piano, participants used to raise questions like "How sound is made? Why after pressing a metal plate with a finger, sound produced becomes very soft? Is there any way to make sound, besides hitting the piano with the stick given?") A discussion is arranged to consider what are the advantages and disadvantages of using toys to do practical work in primary classrooms. Again, literature on teaching science with toys is shown.

Activity six - Identifying other useful groups of objects

Instead of individual items, teachers are asked to brainstorm on groups of objects, which can be as useful as toys. (Suggested answers include supermarket goods, toilet and kitchen items, stationery, things inside needle-box and first-aid box, objects in the classroom, the human body and items on our body, and etc.) It is followed by a brief discussion on what experiments can be done with various groups of objects.

Activity seven - Taking inventory

Teachers are encouraged to take a personal inventory of all useful things, from various kinds of accessible items to simple models they can make. They include items which teachers or student can collect at home, pick up in the classroom, or buy in the supermarket. Teachers are reminded to read over this list when they want to develop new experiments using everyday materials.

Activity eight -- Multiple ways to explore one science phenomenon

Attribute listing method is adopted to explore the possible ways of demonstrating "heat expansion". Teachers first consider what are the key attributes of this experiment, and create Table 2. (The attributes found are --- a material that teachers wish to investigate and the state of it, a suitable container, a heating-up method, a cooling-down method, ways to make the expansion or contraction apparent and their measuring method.) In order to generate multiple experimental designs, teacher would ask himself/herself several questions. For example, in studying air expansion, teachers would ask, "Besides using ping-pong ball, what other containers can also be used to make the expansion or contraction of air apparent?", "What other methods can be used to heat up or cool down the air?", "Besides direct observation, what method can be used to measure the change?". Teachers are instructed to use only everyday tools and materials. Combining the various options of the attributes, many different designs of the experiment are developed.

Table 2

Material under investigation	State of the material	Container of the material	Heating method	Cooling method	Method to make the expansion or contraction apparent	Method of measuring the change in volume
air	Gas	A collapsed ping-pong ball	Warm water	Place in room temperature	A large volume of air, a container which can "expand or contract"	Observed by eyes
air	Gas	a small plastic bottle	Holding the bottle with two warm hands	Ice water	A tiny balloon covering the mouth of the bottle	Direct observation
…	…	…	…	…	…	…

A creative idea should be both new and appropriate. After collecting plenty possible designs, teachers would then evaluate which of them are appropriate by setting up their own criteria. They may need to consider whether the design is convenient and safe, whether the tools are easily accessible, whether the change in volume is obvious and quick, whether the heating and cooling process can be done repeatedly, etc. To check whether their ideas are really useful, some of the experimental designs are tried-out immediately. (Conductor has already prepared some common items, e.g. balloons, small bottles, distilled water bottle, ice, hair dryer, thread. Unprepared items are sought immediately in a nearby laboratory.)

If time is available, the attributing listing exercise would be repeated with "lever experiments". Participants consider the many different ways to demonstrate the lever principle with everyday items by varying the attributes in the experimental design. The guiding questions are --- What can be used as the rotating object and the pivot? How many different ways can we create a load or an effort on the rotating object? In nearly all cases, participants find that there are more than one possible applicable methods to do the heat expansion and the lever experiments. Finally, the conductor guides the participants to make generalization on these experiences. The conclusion is -- similarly, most science practical work in primary curriculum have many possible designs, with the use of everyday materials.

Activity nine --- Alternative approaches to textbook practical work

Some problematic experimental designs are extracted from some popular textbooks. Participants discuss the drawbacks and limitations of these designs. Based on the experience in preceding activities, participants first identify the problematic attributes in the experimental designs, and then try to generate a number of alternative designs to these attributes. Finally, they evaluate the designs according to the criteria set.

Activity ten - Summarizing and debriefing

An in-depth and systematic reflection is done. First, participants would discuss what are the advantages and disadvantages of using everyday resources in practical works, in comparison with the conventional apparatus. Second, they are asked to imagine why many everyday materials are so useful in science hands-on activities, and why science experiments have so many possible alternatives. Third, participants try to compare their image of science and self-efficacy in science teaching, before and after the program.

After these discussions, all the ten activities are revised once, and participants look back at all the worksheets they have done. A checklist method, SCAMPER, is adopted to summarize the strategies used in the program. Teachers are asked, in doing the exercises, when they have used the following strategies --- substitute, combine, adapt, magnify, put to use, eliminate, rearrange and reverse. Some examples of their answers are listed in Table 3. After the SCAMPER exercise, participants try to summarize the whole learning process they have gone through, and what they have learnt. They evaluate how their creative attitudes and abilities in science teaching are enhanced in the program. Furthermore, teachers are asked in what ways they can continue to develop their creativity in science teaching. This debriefing process (including the SCAMPER exercise) aims at increasing the meta-cognitive awareness of teachers in their creative thinking, and, at the same time, strengthening their development in creative attitudes and abilities.

Table 3. Strategies and applications of SCAMPER

Abbreviation	Strategy	Idea-spurring questions
S	Substitute	What material could I use instead? e.g. In an experiment with alcohol lamp, what other everyday tools can be used instead?(in Activity 9)
C	Combine	How can I combine parts or ideas? e.g. Can the two objects be combined to do experiments?(in Activity 3)
A	Adapt	How to change something existing to adapt to this new problem? e.g. Now the balloon rise up, how to make it fly horizontally ?(in Activity 2)
M	Magnify	How could I make it bigger, stronger, more exaggerated, or more frequent? e.g. How to make the liquid expansion more apparent?(in Activity 8)
P	Put to uses	How can I use this in a new way ? e.g. How to use this toy to teach science ?(in Activity 5)

Evaluation

For the assignment, each participant has to develop a creative learning activity with the use of everyday materials. They are reminded not to copy directly from textbooks or other references, but to self-develop learning activities (modifying some existing ones are allowed). The assignments are graded according to the creativity criteria, i.e. their designs are required to be appropriate and to show some degree of novelty.

Besides the assignment, teachers are required to evaluate the program on a questionnaire, which taps their feelings towards the program. It seeks to find out whether they think the program has changed their attitudes and abilities in science teaching, and in developing hands-on activities using everyday materials.

Results

During the lessons, nearly all teachers participated enthusiastically in the activities. In every cohort, new ideas were collected in various activities. For example, after repeating four times, more than 20 useful experiments were developed with the three sheets in Activity 3, and more than 10 useful designs were created to demonstrate heat expansion. In the last self-reflection activity, most teachers could identify the strategies they had used before, with reference to SCAMPER. And they were aware that the request for multiple answers in most activities had stimulated their divergent thinking. When asked why so many everyday items could be used to do a lot of science experiments, they used to say something like "science is everywhere" and "science is around us". Some teachers showed a deeper understanding by making these kinds of elaboration--- "everyday object is either transparent, or opaque, or partially so, therefore, nearly everything can be used to do light experiment", or "all materials are either conductors, or insulators, or partially so, therefore, they can be used to do electricity experiments".

In the questionnaire, nearly all participants responded that the lessons were very interesting, enlightening and innovative. On the whole, the program had successfully increased their interest and confidence in science investigation and in conducting experiments in primary classrooms. Some common feedbacks are--- "These lessons are very practical and useful to my teaching", "In the past, I cannot imagine that science experiments can be so simple and interesting", "I have never thought that everyday materials can be so useful", "Before, I do not know that there are so many possible designs for one experiment", "I would try to think more when I teach science topics". Obviously, some participants were successful in breaking their perceptual and cognitive sets. Meanwhile, some participants had significant changes in their conceptions of science and science teaching.

However, some of them gave the feedback that it was still difficult for them to develop novel ideas. They used to say something like "Even if I see it (the everyday item), I do not know how to relate it with science", "The problem is we do not have the scientific knowledge, and we do not know what it is, as you do". Moreover, many teachers commented that there was insufficient time, and they hoped that the conductor could explain more thoroughly the scientific phenomena behind each hands-on-activity (though this is only a module on teaching method). In their assignments, most of them had presented something different from the textbooks. However, only a few of them really presented original ideas. Most of them modified the activities they found in library books, and tried to make it more interesting to children or more suitable for school teaching.

Discussion

On the whole, this program is successful in arousing the interest of teachers in teaching science and doing science practical work in classrooms. It enables teachers to become aware that science is around us, nearly everything in our daily-life is related with science and can be used to do science experiments. Through the activities, most teachers have changed their image in science, from something very difficult and remote, to something interesting, simple and daily-life. They seem to have higher motivations, confidence, interests and value in self-developing experiments with daily materials than before. The affective objectives of the program are, to certain extent, achieved. However, there is no obvious evidence that the creative abilities of the teachers are really enhanced, though teachers have developed some innovative ideas during lessons.

In evaluation, the effect of the present program is found to be hindered by two factors. First, the science background of most teachers is very weak. The majority of them have only secondary three level of science education, and many recieved this education more than ten years ago. As suggested by many scholars (Amabile, 1996; Sternberg & Lubart, 1996), domain-specific knowledge is a very significant factor in creativity development. Therefore, the lack of science knowledge hinders the creativity development of these science teachers. The second limitation is the lack of time. The contact time of this program is only five hours and is not enough for achieving such a challenging goal. The program has been conducted for four cohorts of teachers. However, on the average, only around 6 to 8 activities could be finished in each cohort (though all of the activities were tried-out).

This study is only a preliminary attempt in exploring ways to enhance the creativity of science teachers. The program presented is still in a developing stage, and its evaluation is incomplete. In future, more rigorous attempts should be conducted on evaluating the effects of the program. Pre-test and pro-test can be done to examine more accurately the changes in the attitudes and beliefs of the teachers. Follow-up study is necessary to understand teachers' classroom practice, i.e., whether the teachers have really self-developed science practical activities in their school context, and what real-life problems they have encountered in doing so. Based on these evaluations, the program can be revised and improved.

As suggested by recent creativity studies (Amabile, 1996; Nickerson, 1999), affective factors are crucial to creativity development. Therefore, this kind of creativity program should go *beyond skill-based training*. Its ultimate goal is to nourish an affect --- designing experiments with simple tools (like all other creative act) is not a skill nor a job, but it itself is an interesting game, which can bring the participants challenges and the joy of self-actualization (Maslow, 1968). This kind of program should aim at cultivating several beliefs --- teaching has infinite possibilities; science is around us; not only experts or textbooks can have good ideas; teacher themselves can also create new and useful experiments if they try to do so. In conclusion, we should encourage an appreciation of science, a more flexible attitude, a higher self-confidence, a love in teaching and a stronger aspiration in improving our science education. In order to let our children to have more meaningful science education in future, it is highly necessary for us to continue our effort in developing programs for enhancing science teachers' creativity.

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