British Journal of Education, Society & Behavioural Science
3(1): 93-108, 2013

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Exploring Primary Science Teachers' Creativity and Attitudes through Responses to Creative Questions in University Physics Lessons

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Author's contribution

This work was carried out by NMS. She managed the literature searches, designed the study, performed the statistical analysis, wrote the first draft of the manuscript, read and approved the final manuscript.

Research Article

Received 26th November 2012
Accepted 25th January 2013
Published 2nd February 2013

ABSTRACT

Aims: 1. To investigate the levels of primary science teachers' creativity through their responses in creative questions carried out in university physics lessons; 2. To find out the primary science teachers' creative attitudes towards the use of creative questions in learning physics.
Study Design: Case study research design.
Place and Duration of Study: The study took place at the University of Malaysia Sabah for a period of two hours.
Methodology: The sample consisted of 74 in-service primary science teachers (age range 25-40 years) who took Mechanic, Matter and Heat as a core course towards Bachelor of Science Education. Simple creative questions were infused into normal Physics lessons. The tasks were content-oriented, and the goal was to yield a deeper understanding of what was being taught. The appropriate responses given to each creative question were evaluated as to their divergent thinking: fluency, flexibility and originality [32]. Questionnaires with closed and open-ended questions were administered to explore in what ways learners found their learning with creative questions was different from ordinary physics lessons.

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Results: The results showed that a majority of primary science teachers attained different levels of creativity when assessed through creative questions - moderate level (65.8%), low level (31.5%) and only 2.7% were deemed to be at an acceptable level. Results also revealed that creative questions enable primary school teachers to develop an increased level of fluent and flexible thinking. Nevertheless the originality dimension of creative abilities of science teachers was at a low level.
Conclusion: The primary science teachers who participated in the study were mostly moderate creative and only a few of them were deemed to be creative. This study reveals that physics knowledge is a necessary condition for creativity development.The findings of this study could imply that either primary science teachers are not so much impressed by the use of creative questioning as part of their classroom teaching practice, or teachers have not implemented the creativity elements of primary science curriculum effectively, or both. On the whole, primary school teachers have positive creative attitudes towards the use of creative questions in learning and teaching physics.

Keywords: Creativity; creative question; creative attitudes; divergent thinking; physics lesson; primary science teacher.

1. INTRODUCTION

A country's greatest asset in the 21st century no longer depends on tangible assets but on the creative minds of its people to produce innovative and useful solutions to complex problems facing society. As such, the cultivation of creativity in students is essential to prepare the generation to meet the challenges of this ever-changing society. Students need to be able to think creatively in order to apply a variety of approaches to solving problems. Creativity is one of the core skills for success; not just for an individual but also for a society.

Some profound scholars in creativity research, [12,32,34] consider divergent thinking skills as central to one's creative ability. Most of these scholars focus on three of the divergent thinking skills - "fluency", "flexibility", and "novelty". With regards to fluency, [12] states that those people who generate a great quantity of ideas were more likely to have significant ideas. For flexibility, he states that creative people should be able to generate ideas of different categories or approaches. For novelty, he states that creative people would have unusual or rare ideas but appropriate ideas.

In recent literature, these three divergent thinking abilities are widely accepted as a significant measure of one's' scientific creativity [14,23,24]. However, [9] challenges this approach by suggesting that creativity development should be multi-faceted, taken into account the cognitive, affective, motivational, personal, and social factors, and should permeate the whole curriculum. In affective aspects, for example, William's Taxonomy of Creative Thought [35] suggested that curiosity, imagination, challenge-taking and risk-taking attitudes are conducive to creativity development. Meanwhile, Amabile's [1] study emphasizes that playful attitudes facilitate the emergence of creativity.

Sorgo [28] believed that creativity is something that can be learned. Creativity can be nurtured and enhanced through the use of strategies and appropriate methods [15]. To engage students in creative behaviour, a science teacher could think of a variety of approaches to foster their interest in science and get them thinking of how knowledge from science is developed and contributes to the real-world. Classrooms with teachers who value creativity may use creative questions in which students may encounter appropriate stimulation, igniting their sense of wonder and inviting questions [16]. According to Burnett [5], good questions encourage children to think outside the square, to think and solve problems creatively. At the primary school level, questioning lays the basis for later science concepts and essential understandings. A science teacher as a role model for supporting creative performance therefore needs to experience how creative questions would help them to encourage creativity before they can translate this skill into action. Sternberg and Williams [31] also emphasize that role model is one of the most important factors for the development of creativity. They stress that, children develop creativity not when teachers tell them to, but when teachers show them. As Coelho [8] wrote *'What is a teacher? It isn't someone who teaches something, but someone who inspires the student to give of her best in order to discover what she already knows'*. In other words, science teachers have to be creative in order to develop new classroom activities, or to adapt activities in the textbooks to special classroom environment that nurture creativity and innovation among pupils.

There are many strategies an individual can be nurtured for spurring creative effort. One of those strategies is problem finding. Identifying a problem to solve rather than solving a preset problem is called problem finding [28], According to Starko [28], problem finding is an important component in adult creativity. Extending these processes into classroom situations can allow creative activities to occur naturally. Meanwhile, [13] recognized the importance of sensitivity to problems in generating and assessing creative ideas. A problem sensitive person, according to Guilford [13] has an ability to recognize problems where they exist, often before others become aware of them. On the other hand, metaphorical thinking can be used as a mechanism for divergent thinking because it can generate as many varied and unusual ideas as possible. According to Starko [28], the ability to think in metaphors allows individuals to find parallels between unlike ideas. The process of seeing or imagining how one thing might be like something else can allow new parallels to unfold, spurring transformation, syntheses, and perspectives. Still in the same vein, De Bono [10] suggested the use of "po" to provoke new patterns of thought. In many ways, "po" is parallel to children's use of "what if" or "suppose" question. "What if" questions could help stimulate creative thinking that engage learners to produce a range of ideas [3].

Infusing creativity elements into regular classroom is an important movement in recent Malaysian educational reforms. The newly-implemented Primary School Standard Curriculum (KSSR) which was introduced to Year One primary students in 2011 focused on a more fun way of learning science. The KSSR was an improvement as one of its purposes is to inculcate the interest and to promote student's creativity via experience and investigation in order to master science knowledge, scientific skills, thinking skills and noble values [21]. Promoting creative thinking abilities is a value-added skill to be achieved in KSSR. As Dato' Sri Mohd Najib, Prime Minister of Malaysia addressed in The Malaysia Education Blueprint 2013 - 2025, Malaysia needs creative and innovative workers to help steer the transformation of the country's economy as anticipated in the New Economic Model, Economic Transformation Plan and Government Transformation Plan (Ministry of Education Malaysia, 2012 [22]).

The Malaysian science curricula seek to develop creative thinking but the current research findings indicates that Malaysian university science student-teachers, including those science teachers who have served in secondary schools were mostly moderately creative and not creative [2,27]. This is in line with research findings (Lam KK, University of Houston; Hussein S, Hashim R, International Islamic University Malaysia, unpublished results) that reported that Malaysian teachers had little knowledge and the skills in the area of critical and creative thinking and the teaching strategies necessary to teach it. Teachers lacked training to prepare them for this aspect of teaching. Meanwhile, according to Han KL (National University of Malaysia, unpublished results), the level of infusion of critical and creative skills in the chemistry laboratory practical was below satisfactory. In another finding, Yong (Kuala Lumpur, unpublished results) discovered that Malaysian pre-service teachers lacked originality. These results could imply that the process of teaching and learning will be affected due to the lack of creativity amongst teachers. Hence, relevant efforts need be taken to help teachers incorporate important aspects of creativity in the classroom.

As mentioned above, the low level of creativity among Malaysian science teachers and university science student-teachers have been highlighted by the result of recent researches. However, there is little information on the creativity of primary science teachers from both the cognitive and affective aspects, though the importance of these aspects is widely accepted by educators nowadays [25]. In an effort to include creativity as an important element in Malaysian primary science education, therefore, it is essential to investigate primary science teacher's level of creativity in terms of these two aspects mentioned.

1.1 Objective of the Study

The objective of this study is attempted to investigate whether the use of creative questions could help primary science teachers to develop their creative abilities and attitudes. This study examined teachers' creativity in the solutions or responses given to three different physics creative questions and its relation to fluency, flexibility and originality. In this study, creative thinking elements were purposely infused into normal Physics lessons to facilitate the creativity skills in teachers. The tasks were content-oriented, and the goal was to yield a deeper understanding of what was being taught. Therefore, the present study would demonstrate how a set of simple creative questions can be infused into normal science classroom teaching in primary school levels. Infusing creativity-enhancing elements into Physics learning was assumed to have an influence on primary science teachers' creative abilities and attitudes.

This study embarked on the following objectives:

A. To investigate the levels of primary science teachers' creativity through their responses in creative questions carried out in university physics lessons;
B. To find out the primary science teachers' creative attitudes towards the use of creative questions in learning physics.

More specifically, this study addressed the following questions:

A. Which level of creativity do primary science teachers attain by the end of a physics lesson using creative questions?;
B. What are the primary science teachers' creative attitudes towards the use of creative questions in learning physics?

2. RESEARCH METHODOLOGY

The study took place in University of Malaysia Sabah. In this study the researcher followed the "convenience" sampling procedure defined by McMillan [20], where a group of 74 in-service primary science teachers throughout Sabah and Sarawak, Malaysia, was selected because of its availability. They were 39 (52.7%) females and 35 (47.3%) males. They were pursuing a Bachelor of Science in Education, majoring in Primary Science. The age of the participants ranged from 25-40 years old. They have between 3-16 years of teaching experience in primary schools. 96% of the participants were married. The in-service primary science teachers were required to attend a physics course named Mechanic, Matter and Heat for a semester during the weekend and school holidays.

This study employed a mixed methods approach which involved the use of closed and open questions in a self-evaluation questionnaire and student's responses in creative answer sheets. Items of the questionnaire were modified from the studies by Cheng [7]. The students were required to evaluate the difference between physics learning activities and normal physics lectures using creative questions.

The questionnaire consisted of 20 items, covering creative attitudes on physics learning using creative questions. The creative attitudes favouring creativity development which were targeted at in this questionnaire included the interest and confidence in creative thinking, an appreciation and aspiration of creativity, being curious and imaginative, favouring challenges, and willing to take sensible risks. Items of the questionnaire used 5 Likert scale options i.e. 1 = strongly disagree (SD), 2 = disagree (D), 3 = unsure (U), 4 = agree (A) and 5 = strongly agree (SA). Students were also asked to give some written feedback on the activities for the open questions included:- What is your feeling towards these exercises? What have you learnt in doing these exercises? Two experts comprising one physics lecturer and one Malay language expert reviewed the Malay version of the questionnaire and creative questions in terms of its language and content.

A pilot study was conducted in the form of a one hour workshop to refine the questionnaire and creative questions. A total of 30 Year Three undergraduate physics students took part in the pilot study. Prior to the pilot study, the students involved were briefed by the researchers in two sessions. They had learned the related physics concepts in Year One and Two. Once the session ended, the students were asked to complete a questionnaire asking their perceived creative attitudes towards the conducted activities. Students were also asked to comment and make suggestions regarding the items in questionnaire and creative questions. The students agreed that all items were relevant, thus should remain in the final questionnaire and creative questions. The index of reliability of the questionnaire is 0.88.

2.1 Learning Objectives

Based on the Guilford [12], Torrance [32] and Williams [35], and other literature reviewed in previous section, the following learning objectives were employed for infusing creativity in creative questions. They involved both cognitive and affective learning objectives. The first cognitive objective was to nurture the divergent thinking abilities of teacher which includes fluency, flexibility, and originality. To stimulate fluency, students were required to generate a large number of answers/examples at a time. For encouraging flexibility, students were asked to generate many different categories of ideas, and add or eliminate some well-accepted things. Besides divergent thinking abilities, the tasks employed by this study also aimed at imagination, problem finding and sensitivity, and metaphoric thinking. To encourage imagination, students were asked to answer 'suppose' or 'what if' questions. To encourage problem finding and sensitivity, students were asked to use their intuition to discover problems. To equip with some idea-generating heuristics, activities like comparing metaphors were used.

In affective aspects, the learning activities were aimed at cultivating teachers' motives in creative thinking. It was also meant to arouse their interest and to boost their confidence in creative thinking. Other positive attitudes to favour creativity development that includes appreciation and aspiration of creativity, being curious and imaginative, favouring challenges, willing to take sensible risks, were also targeted at in this study.

2.2 Selecting the Activities

Besides fulfilling the above learning objectives, the creative questions employed by this study need to suit the context of the learners. A set of rationales for selecting the creative questions was employed as below:-

a. First of all, to allow room for creative thinking, the tasks involved were open-ended, with large solution spans. They were of medium level of difficulties to provide acceptable challenges, and able to encourage student to take sensible risks. Playful, personal and daily-life elements were also induced into the tasks to make them interesting and appealing to science teachers, and, at the same time, elicit motivation to create answers.
b. To avoid inducing great changes to the common teaching activities, the creative activities were integrated into the knowledge content of the existing Physics lesson. Participating in these activities would not only enhance creative thinking but also knowledge understanding. At the same time, the activities were simple and flexible. The activities can be completed within 10 to 15 minutes in the classroom by teachers independently with only a simple worksheet. As far as possible, the possible answers were short and easy to understand or express. The tasks had the flexibility of allowing science teachers to express their ideas in written ways.
c. To elicit creative thinking, the tasks involved provided many possible solutions. Even though the creative tasks had to be so open-ended, yet, the solutions had to be specific and concrete so that teachers can have an easy feel to start and quick to finish. Moreover, the activities could give a surprise to teachers. These activities involved questions that teachers had never thought of, but when they began to think, most teachers could actually find a lot of amazing answers that were unexpected to them. An example of the activity was: - Give 5 similarities and 5 differences between force and love.

2.3 The Learning Process

The physics course served 74 science teachers at one time in a large lecture hall. The physics course covered areas in Mechanic, Matter and Heat. This study only focused on Mechanics which included three topics:-Measurement, Kinematics and Force. Each topic lasted for two hours and the process was as follows:-

2.3.1 Part 1 (1 hour and 20 minutes) – whole class lecture

The lectures for each physics topic were being delivered using visual support such as PowerPoint slides and video clips. At the same time, each teacher could refer to a provided learning module. Common teaching activities like questioning, giving examples, and explaining phenomenon were also employed.

2.3.2 Part 2 (25 minutes) – group activities

Firstly, the class was divided into 12 groups and each group consisted of six to seven group members. The group was then asked to answer creative questions related to each topic such as:-

I. "Write down as many examples of friction as you can";
II. "Suggest one measuring device in laboratory which you wish to add or eliminate. Give your reasons"; and
III. "What is the difference between distance and displacement? Illustrate this with your daily route".

For each question, students were given five minutes to list out their answers on a piece of paper. Secondly, the group leader would invite each group member to take turns to share her/his answers that reflect her/his perspective. Each group member could then comment on each other's answers. Thirdly, the groups would have to share their answers with the rest of the class using 'one stay, the rest stray' cooperative learning structure [17]. In this learning structure, one member would stay back to explain the group's answers to the visiting group, while the rest of the group members would go to the table of the next groups. Group members then reported back and discussed the differences among the answers they had gained. This allowed an examination of different answers. Lastly, the lecturer would select randomly several groups to read out aloud to the class the interesting answers found from other groups.

2.3.3 Part 3 (15 minutes) – individual assessment

Primary science teachers' degree of creative thinking was measured using creativity answer sheets. The teachers answered the creative questions individually after each related group activities was being carried out. For the purpose of assessment, the researcher adopted three creative questions based on studies done by Hu and Adey [14] and Cheng [6] as follows:

1. After connecting to a bulb, the pointer of the ammeter does not move. Suggest 10 possible reasons (problem finding and sensitivity).
2. Suppose there is no gravity, describe how the world would be like? Give 10 possible happenings (imagination).
3. Give 5 similarities and 5 differences between force and love (metaphoric comparison).

The characteristics of the chosen creative questions were as follows: science teachers were prompted for being sensitive to the problems, having an ability to wonder, understanding the world around, seeking solutions, imagination and comparing the similarities and differences between two loosely-related concepts. Teachers were encouraged to interpret the questions differently and to use their creativity to solve it from a different perspective.

At the end of the assessment, the science teachers were encouraged to exchange their answer sheets and discussed with their peers. The researcher/lecturer then chose several interesting science teacher responses and read out aloud to all the science teachers. This allowed science teachers to gain ideas on fostering creativity amongst primary school children in their schools. Science teachers' answer sheets were then collected and evaluated to determine the levels of creativity.

The distribution of questionnaires was administered promptly at the end of the intervention for Mechanics, which lasted for 15 minutes.

3. DATA ANALYSIS

3.1 Analysis of Questionnaire Data

Data was collected from 74 students about their perceived creative attitudes towards the use of creative questions in learning physics. The questionnaire was analyzed according to Likert's five-point scale ranging from strongly disagree (1) to strongly agree (5), with a 3 representing a neutral response.

The qualitative data consisted of students' responses from open-ended questions that investigated their insights and experiences in learning by using creative questions. All qualitative data was analyzed by an iteractive coding process [11]. The analysis began by reading each of the participant's responses to open-ended questions. Codes were generated during this initial review of the participants' responses. Relationships among the codes were explored in subsequent readings of participants' responses and broad themes emerged. This process continued until consistent themes were achieved. The validity of open-ended response was determined by agreement between a Physics lecturer as independent rater and the researcher.

3.2 Analysis of Students' Level of Creativity

3.2.1 Scoring procedures

The focus of this research was to measure the creativity traits of primary science teachers in terms of fluency, flexibility and originality. Measurement of creativity was based on criterion adapted from Torrance's Test of creative Thinking (TTCT) [32,14]. The Torrance's TTCT has its reliability coefficient ranges from 0.78 to 1.00, at different grade levels [33]. The criterion for the assessment of the creativity of a science teacher is shown in Table 1.

The research team classified the answers for each creative question into categories. Each category consisted of several response items. The response items were then coded by the team, with numbers representing categories and letters of the English Alphabet representing response items under categories. The statistical functions in EXCEL of Microsoft were used as a platform to compute the scoring for creative answer sheets.

The scores of question 1 to 3 are the sums of fluency score, flexibility score, and originality score. The fluency score was obtained simply by counting all of the separate responses or different ideas given by the teachers (excluding the number of repetitive and irrelevant responses). The flexibility score for each question was obtained by counting the number of categories of ideas or areas that one produced. The originality score was obtained simply by counting the uniqueness of the ideas that one produced as compared to the whole sample. The originality score was developed from a tabulation of the frequency of all of the responses obtained. Frequencies and percentages of each response were computed. If the probability of a response was smaller than 5%, 2 points were awarded; if the probability was from 5 to 10%, 1 point was awarded; if the probability of a response was greater than 10%, then 0 point was awarded. For example, in response to question 2, responses like "no tall building can be constructed", "no life", "no daily activities", "objects have no weight" were frequent; however responses which were considered to be original as "injuries caused by collision between living and non-living things", "no water activity", "earth stops at its orbit" had been given each by one student, therefore 2 points were awarded.

Table 1. Scoring criteria for creativity constructs (Adapted and adopted from Torrance [32]; Hu and Adey [14])

Creativity dimensions	Scoring criteria	Score awarded
Fluency (F) (10 marks)	The number of different ideas that one can produce	1 point for each idea
Flexibility (FX) (10 marks)	The number of categories of ideas that one produces	1 point for each category
Originality (O) (20 marks)	The uniqueness of the ideas that one produces as compared to the whole sample	< 5% - 2 points Between 5% and 10% - 1 point >10% - 0 point

3.2.2 Inter-scorer reliability

Since there was an element of subjectivity in interpreting the scoring rules, it was necessary to check that the scoring system could be interpreted reliably by someone who had not been involved in the questions development. Scores for 20 students were obtained independently by two scorers from each question, one was not associated with the research, and the other was the researcher. Pearson product-moment correlation coefficients between the two sets of scores are presented in Table 2. The correlations between scores vary from 0.962 to 0.979.The results suggest that the scoring procedure is adequately objective.

Table 2. Scorer Agreement (n = 20 answer sheets for each question)

Question	Pearson product-moment correlation coefficients
1	0.979
2	0.916
3	0.962

4. RESEARCH FINDINGS

4.1 Participants' Level of Creativity

Table 3 below summarises three levels of creativity attained by the teachers. The weightings from the creativity level scale were assigned by numerical scales graduated from 0 to 40. Scale 0-13 indicates less creative, Scale 14-26 indicates moderate creative, and Scale 27-40 indicates creative. Each creativity level was determined by averaging the values that measure each particular level. As shown in Table 3, 65.8% of the teachers attained moderate level of creativity and 31.5% of them belonged to the "Less creative" level. However, only 2.7% of teachers belonged to "Creative" level.

Table 3. Percentage of teachers attaining levels of creativity of each question

Question no.	Creativity level (%)		
	Less creative (0 – 13)	**Moderate creative (14 - 26)**	**Creative (27 - 40)**
1	41.9	58.1	0
2	35.1	62.2	2.7
3	17.6	77	5.4
Average	31.5	65.8	2.7

Table 4 below summarises three levels of creativity dimension attained by the teachers. The results showed that half of the teachers had developed a high level of fluent (52.7%) and flexible (52.3%) thinking. Nevertheless, a majority (93.2%) of the teachers were at the low level of the originality dimension.

Table 4. Percentage of teachers **attaining levels of creativity for each dimension**

Creativity dimension	Level	Creative question no. (%)			Average (%)
		1	**2**	**3**	
	Low (≤ 3)	0	10.8	0	3.6
Fluency	Medium 4 ≤ x ≤ 6	18.9	41.9	70.3	43.7
	High (≥ 7)	81.1	47.3	29.7	**52.7**
	Low (≤ 3)	0	10.8	1.4	4.0
Flexibility	Medium 4 ≤ x ≤ 6	82.4	16.2	32.4	43.7
	High (≥ 7)	17.6	73	66.2	**52.3**
	Low (≤ 6)	100	86.5	93.2	**93.2**
Originality	Medium 7 ≤ x ≤ 13	0	13.5	6.8	6.8
	High (≥ 14)	0	0	0	0

4.2 Participants' Creative Attitudes

The students' response rates of all 20 items in the questionnaire were analyzed. For the purpose of discussion, Strongly Disagree (SD) and Disagree (D) were stated as "disagree", Agree (A) and Strongly Agree (SA) as "agree", while "unsure" was maintained. The items with most and least positive response rate were listed in Table 5.

Among them, most students agreed that they could freely explore new ideas that they were interested in (100%), and exchange ideas with their classmates and stimulate each other's thinking (100%), both of which were rather basic level elements in creativity learning. 98.7% of students agreed that this physics learning have enabled them to think in a broader sense, to learn more from multiple perspectives and challenge difficult questions. Meanwhile, 97.3% of students agreed that they had more opportunities to appreciate creative ideas of their classmates and creative questions. Whereas 96% of students agreed that they had more opportunities to generate creative answers from the given questions, being imaginative in generating new ideas, and participated in novel learning activities.

Table 5. Questionnaire's Items and percentage on each likert type item (n = 74)

Item No.	Compared with previous physics lessons in last semester, in recent ones, I have more opportunities to	Strongly disagreed or disagreed (%)	Unsure (%)	Strongly agreed or agreed (%)
9	Freely explore new idea that I am interested in.			100
8	Exchange ideas with my classmates, stimulating each other's thinking			100
4	Think broader and learn more from multiple perspectives	1.3		98.7
10	Challenge difficult questions.		1.3	98.7
2	Appreciate creative ideas of classmates.		2.7	97.3
3	Appreciate creative questions		2.7	97.3
1	Create creative answer from the given questions		4	96
6	Experience imagination in physics		4	96
7	Participate in novel learning activities		4	96
20	Seeing the world from someone else's perspective		4	96
18	Generate new ideas		4	96
13	Obtain support and encouragement, rebuild confidence in answering questions	1.3	4	94.7
19	Thinking outside the box	1.3	4	94.7
16	Question the viewpoints in the textbooks and those of peers		6.7	93.3
14	Tolerate making mistakes, uncertain answers or ambiguities		10.7	89.3
5	Learn in a relaxed and playful atmosphere		14.7	85.3
12	Express my ideas without being criticized.		20	80
17	Risk doing some tasks which have higher possibility of failure.		21.3	78.7
15	Gain others' praise for my creativity		24	76
11	Tolerate day-dreaming and wild thinking occasionally.	1.3	24	74.7

Meanwhile, 93-93% of the teachers agreed that they have rebuilt their confidence in answering difficult questions, thinking outside the box, and question the viewpoints in the textbooks and those of peers.

On the other hand, less than 90% of students agreed that they have more opportunities to learn in a relax and playful atmosphere (85.3%), tolerate making mistakes, or uncertain answers (89.3%), express ideas without being criticized (80%). Less than 80% of students agreed that the lessons had given them more opportunities to take risks (78.7%), to gain others' praise for his/her creativity (76%), and to tolerate wild thinking occasionally (74.7%), all of which were high-order level elements in creative developments.

4.3 Findings from the Open-Ended Questions

Individual responses from open questions: “What did you learn from the activity using creative questions?” and “What was your experience?

Almost all participants responded that the questions were challenging, but the relaxing and playful session had made them think and learn more effectively. Some of the related responses were: - “I can learn in a relaxing and playful environment. I do not feel under pressure even though the questions are challenging and difficult”.

Science teachers did perceive changes in their learning experience, and, their remarks about these changes were: - “I now dare to give a variety of answers even though they are different from textbooks and those of peers;”, “It is a way to stimulate me to think logically and imaginatively in physics, and I dare to give uncertain answers;”, “These activities have taught me how to express my views freely and not to be too dependent on the schema and books. I have also learned to accept ideas from a wider perspective;”, “I feel free to give unlimited ideas and explore creative ideas from friends;”, “These activities have motivated me and I now have the courage to point out my point of views which I have not done before especially when dealing with difficult questions;”, and “Sometimes, the ideas from friends shocked me as it can be accepted as a logical idea and that is a new experience for me”.

Science teachers had also changed their perceptions on physics. Some common feedbacks are: "In the past, I thought physics is a scary subject and creates tension in learning it, but now I find physics interesting if we know how to use creative questions in learning;”, “Physics is fun if we use creative questions. Sometimes we feel that the question is something unacceptable but it sounds rational*”.* Responses in answer sheets further indicated that the teachers found new parallels to the mentioned unacceptable question “difference between force and love”. Some of their responses were: -“Force can change the position/shape of an object whereas love can change the appearance of a person”, “Force can be calculated quantitatively using formula F = ma, whereas love can only be measured qualitatively”, and “Force may cause friction, whereas love may cause conflict”.

Most of the science teachers responded that they would modify the questions, and try to make it more interesting or suitable to primary school students. They also pointed out that – “I will encourage students to generate ideas and build up their confidence to defend their answers. At the same time they can learn from the creative ideas contributed by their friends”.

Science teachers also felt that the creative question activities had encouraged them to think in a different way. Their feedbacks were: “The activities have encouraged me to think in a different way after listening to the creative ideas from friends;”, “Many new ideas come into my mind after hearing friend’s answers;”, “I have a chance to build up my confidence to produce answers based on logic, even though I realize that there is a possibility that I have given wrong answers;”, and “I was given chances to produce something that is different from the text books”.

Obviously, most teachers were successful in realizing the strength of creative questions. They mentioned that - “I enjoy learning with the creative questions; it makes me think outside the box. All this while, most lessons had limited my thinking;”, and “the creative questions are medicines to cure stress in learning”. Meanwhile, teachers also expressed that creative questions serve as an opportunity to realise their own personal potential to generate unusual ideas as reflected in their feedback: – "This method has given me the confidence to give new ideas. I am not afraid to be criticized. Without realizing it, I am able to generate new ideas which I have never thought of before". No doubt those teachers had an opportunity to exercise creative thinking and experienced the joy and excitement of generating something genuinely new.

Teachers generally felt that they gained support from group creative activities. Related responses were: "The Ideas given by friends during group activities have opened my mind to generate more creative answers;", "Discussion with friends on creative questions enables me to gain a better understanding of physics concepts;", "Checking peers' answers enable me to realise how imaginative they are. This encourages me to explore my imagination from someone else's perspective;", and "I learn to look at things from multiple perspectives".

More than half of the teachers expressed that the learning experience was interesting, playful, and gave them a lot of fun. Some had this feeling simply because they do not have to worry about the accuracy of their answer. Some others indicated that they especially enjoyed the relaxed atmosphere which gave them less pressure in thinking. On the whole, the findings in the open-ended questions aligned with those close questions in the questionnaire.

5. DISCUSSION

The results from this study found that a majority of the in-service primary science teachers have a moderate level of creative thinking skills and only a handful of them were creative. The results also revealed that the primary teachers were able to generate large numbers of ideas with different categories at one particular time, but their ideas were mostly neither unique nor novel. The creative question activities had provided students a chance, to some extent, to develop their own fluency and flexibility.

In evaluation, the effect of the present creative questions activities was found to be hindered by two factors. First, the science background of most teachers was very weak. The majority of them had only a Diploma level in science, and many of them received this education more than 3-16 years ago. As suggested by many scholars [1,30], domain-specific knowledge and skills are a very significant factor in creativity development. Therefore, the lack of physics knowledge and skills hinder the creativity development of these science teachers. The second limitation was due to a lack of time. The learning time for the related topics was only limited to two hours and this was insufficient to enable the science teachers to attain a higher level of creativity. According to Starko [29], students have to be provided with the necessary knowledge, skills and surroundings to enhance their creativity. Through this activity, a foundation has been laid for teachers to enable them to develop creative questions for their school context.

Science teachers categorized this creative learning as a kind of relax and playful learning which can encourage them to think in a broader and wider multiple perspectives, to explore and exchange new ideas, to appreciate creative ideas, and to develop their curiosity, interest and confidence in learning. This is supported by Bowkett [4] in his book, 100+ ideas for teaching creativity, who advocates 'keeping the stress low'. Though this classroom reform originally aimed at creativity development, teachers considered freedom of expression such as exploration and exchanging new ideas and stimulation of each thinking as their major gains. The creative activity shows that this highly abstract subject (physics) as perceived by science teachers is in fact interesting and fun. As Mayer [19] notes that students tend to engage more deeply and persist on challenging problems if they find them interesting. As such, a relaxed and playful learning environment can be effective in promoting creativity.

Teachers' high-order creative developments, such as attempting tasks which have higher possibility of failure, and the tolerance level of wild thinking, were found to be weak. These outcomes can be related to their low scores in their originality dimension and some typical characteristics of existing educational system. These two aspects have trained them to believe that questions have only either a right or a wrong answer. Nevertheless, on the whole, primary science teachers have positive creative attitudes towards learning physics using creative questions.

6. CONCLUSION AND RECOMMENDATION

Introducing creative questions to learning and teaching physics allowed for development of creativity in primary science teachers. Though teachers had developed an increased level of fluent and flexible thinking during lessons, the level of originality dimension of creative abilities of science teachers was still low. This study reveals that physics knowledge is a necessary condition for creativity development of science teachers.

In addition, these findings can imply that primary science teachers are either not impressed by the use of creative questioning as part of their classroom teaching practice, or teachers have not implemented the creativity elements of primary science curriculum effectively, or both. This can also suggest that primary science teachers need to be encouraged to get into the habit of posing creative questions and framing answers during their in-service training. In addition, it should be the normal practice for science teachers to raise creative questions as part of their classroom teaching practice.

On the whole, primary science teachers have positive creative attitudes towards the use of creative questions in learning and teaching of physics. This activity was able to arouse the interest of teachers in exploring new ideas in physics. Through the activities, most teachers have changed their image in physics, from something very difficult, to something interesting and simple. They were found to have higher confidence and interests in generating unusual ideas. The affective objectives of the activities were, to a certain extent, achieved.

This study provides primary science teachers a framework to encourage creativity within the science classroom by asking thought-provoking questions. Teachers need to truly believe that there is 'no such thing as a 'silly question'. Primary science teachers should be encouraged to have creative thinking, a more flexible attitude, a higher self-confidence, a love in teaching creativity and a stronger aspiration in improving the science education. Science teachers should not look for answers for answers' sake, but should look for questions for the sake of extending their students' understanding and creativity. In order for the children to have a more meaningful science education in future, it is highly necessary for science educators in higher education to continue their effort in developing programs for enhancing science teachers' creativity.

This study was only a preliminary attempt exemplified by the researcher to the primary science teachers showing that one way of fostering creativity amongst primary school children is through the use of creative questions.There was no followed-up assessment on the creative pedagogical skills of the primary science teachers. In future, a session can be conducted to help primary science teachers in crafting out creative questions. The teacher can choose a topic that he/she is comfortable with and observe a lesson in a classroom. A teacher would probably gain best on how his/her students would react to the type of creative questions she/he constructs. Follow-up study is also necessary to understand teachers' classroom practice, i.e., whether the teachers have really self-developed creative questions in their school context. The capacity to ask creative questions is neither a natural talent nor an in-born trait. It is a learned competency based on motivation, know-how and experience. Based on these evaluations, creative questions employed in this study can be revised and improved.

COMPETING INTERESTS

The author has declared that no competing interests exist.

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