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DESIGN, DEVELOPMENT AND EVALUATION OF A PROBLEM-BASED WITH COOPERATIVE MODULE ON SCIENTIFIC CREATIVITY OF PRE-SCHOOLERS

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Abstract. *The purpose of this research was to design and develop a teaching and learning module using Problem-Based Learning and Cooperative Learning (PBL-CL) and evaluate its effects on scientific creativity of pre-schoolers. The module was developed using the ADDIE instructional design model which included five phases: Analysis, Design, Development, Implementation, and Evaluation. Formative evaluation was conducted to determine the reliability, content validity, pedagogical usability and pre-schoolers' acceptability of the module, which involved five subject matter experts, 10 pre-school teachers, and 30 six-year-old pre-schoolers. The results of formative evaluation indicated an acceptable reliability, good content validity, high acceptability among the pre-schoolers, and high level of pedagogical usability. Finally, a pre- and post-test non-equivalent control group quasi experiment design was employed to determine the effects of the PBL-CL module. A total of 144 six-year-old pre-schoolers from three pre-schools were randomly assigned to PBL-CL group (n=72) and control group (n=72). The finding of Paired Sample T-test and Independent T-test established the effects of the PBL-CL module and would therefore represent a reliable, credible, and effective teaching and learning module for fostering scientific creativity among pre-schoolers.*
Keywords: *ADDIE model, cooperative learning, teaching and learning module, pre-schoolers, problem-based learning, scientific creativity.*

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Introduction

Creativity plays a vital part in shaping the future of a country. Scientific creativity as domain-specific creativity has been identified as one of the most important contributing factors to the advancement of human civilization (Hu, Shi, Han, Wang & Adey, 2010). Individuals who possess scientific creativity are considered to be more capable of developing scientific ideas that are original, useful and unique (Simonton, 2012). Children are naturally creative and curious, thus fostering scientific creativity in pre-schoolers will help them achieve their maximum potential.

Accordingly, the Malaysian Ministry of Education (MoE) has placed emphasis on fostering pre-school pupils' creativity via the Science and Technology Strand as stated in the National Pre-school Curriculum Standard (NPCS) (Curriculum Development Centre, 2010). Nationwide, different teaching and learning methods are being implemented by pre-school teachers. However, methods to promote scientific creativity have not become widely used in the real pre-school classroom practice. Very few teaching and learning modules exist regarding methods to foster creativity in science and technology in pre-school classrooms. There is hardly any substantive research that emphasizes on the design, development and evaluation of a teaching and learning module to foster scientific creativity at the pre-school level. This calls for the need of a reliable, valid and effective teaching and learning module that can guide teachers to foster scientific creativity by integrating appropriate instructional approaches.

Problem-based learning (PBL) has been identified as a student-centred pedagogy that is helpful in promoting creative thought (Barak, 2006; Kwon, Park & Park, 2006; Semerci, 2006; Shriki, 2013; Tan, 2000; Tan, 2009). PBL embodies the principle that learning begins when students are encouraged to work as a group to find solutions to real-world problems (Barrett & Moore, 2012; Droha, Mauffette & Allard, 2012; Savin-Baden, 2004; Tatar & Oktay, 2011). PBL creates a supportive learning community and sustained interaction that explicitly scaffolds learners to learn within social constructivist paradigms (Cochrane, 2012, p. 125). According to Capobianco and Tyrie (2009), the

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students' experience of learning through problem solving promotes new ways of doing things. Cole, Sugioka, and Yamagata-Lynch (1999) support that group work in the classroom contributes to a supportive learning environment conducive for developing students' creativity. By engaging students' learning via group work, PBL could create a supportive environment for pre-schoolers to develop their scientific creativity.

The increasing interest in PBL has encouraged some researchers to incorporate cooperative learning (CL) in PBL. Numbered Heads Together (NHT) is a cooperative learning strategy that has been proven effective in increasing class participation among all students (Hunter, 2011) and fostering learners' scientific creativity (Maulana, 2014; Steen, 2013). These findings raise the question, "To what extent does CL 'Numbered Heads Together' help problem-based learning in developing a teaching and learning module that increase the ability of pre-schoolers to think creatively about science?" Tackling questions such as this, particularly in pre-school settings often requires an integrated teaching approach which explicitly promotes scientific creativity among pre-schoolers. Accordingly, in this research, a thorough integration was applied where the learning steps of PBL and NHT were performed simultaneously in each of the learning process in the proposed teaching and learning module. In this integrated approach, the students were taught explicitly about team work and then prompted to undergo the PBL process to think creatively for scientific solutions. It is plausible that the integration of PBL and CL in developing a teaching and learning module may help pre-school teachers to foster scientific creativity among pre-schoolers.

Theoretical Foundation

The design and development of the PBL teaching and learning module was based on analysis of various elements including the context of the problem and its implementation, the understanding of the way pre-schoolers learn and its associated learning theories and approaches, and relevant instructional design model. Based on the fact that this teaching and learning module will be applied to a group of six-year-old pre-schoolers, the researcher decided to adopt Piaget's (1952) cognitive development theory and Vygotsky's (1978) concept of the Zone of Proximal Development and scaffolding. Piaget's theory emphases on cognitive constructivism that learners' schemes are built through active interaction with the environment. When a new situation or problem is given, children will be engaged to apply their scheme to a new situation (Qayumi, 2001) and think of many different solutions. In addition, attention has been given to social constructivism to ensure the less capable children to progress further in their zone of proximal development with the help of their teacher or more experienced peers.

The researchers also acknowledge the pedagogical principle underlying teaching and learning in pre-school classroom that support the process of cognitive and social constructivism. Thus, the researcher has integrated the seven steps of PBL model (Schmidt, 1983) with CL 'NHT' (Kagan & Kagan, 2009) to create conducive environments for developing cognitive and team working skills. Children taught in NHT structured groups will go through the steps of PBL as a team adhering to the principles of CL. With this integration, children are exposed to real-world science problems and engaged with peers in searching for many possible creative solutions from different perspectives based on their learned scientific knowledge and relevant practical knowledge.

In addition, specific attention has been given to four phases of Directed Creative Model (Plsek & Associates, 1997) which represent a creative process to engage learners in making observation, generating original ideas, improvising idea, and implementing new ideas. Students are also engaged to display fluency of ideas through drawing. Finally, an improved of Scientific Creativity Structure Model (SCSM) (Hu & Adey, 2002) is used as theoretical model of scientific creativity to guide the development of teaching and learning module and test items through three dimensions namely Product (scientific knowledge, scientific phenomena and scientific problem), Trait (fluency, originality, elaboration, abstractness of title and resistance to premature closure) and Process (imagination, thinking).

On the other hand, in the design and development of PBL-CL teaching and learning module, the researcher has adopted the ADDIE model of Wegener (2006) due to its holistic nature and flexibility. This ADDIE instructional design model provided a structure for thorough planning, developing and adapting instruction to focus on learners' needs and content requirements. The ADDIE instructional design model comprises of five phases: a) analysis, b) design, c) development, d) implementation, and e) evaluation which will be further elaborated in the subsequent Methodology section. Accordingly, the overall theoretical foundation regulating the design and development of the PBL-CL teaching and learning module is illustrated in Figure 1.

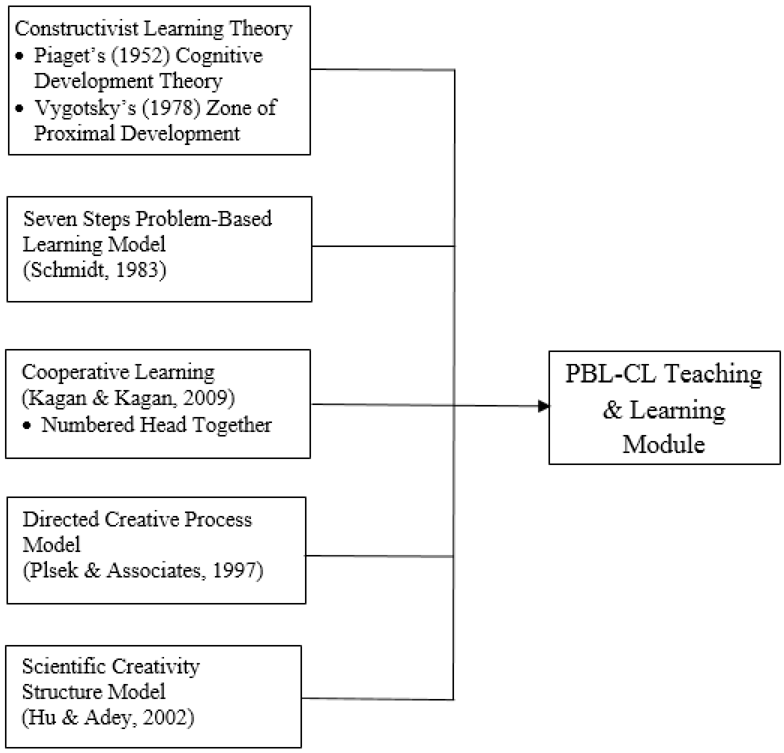

Figure 1: Theoretical foundation regulating the design and development of the PBL-CL teaching and learning module.

Aim of Research

Many research studies have focused on the design and development of teaching and learning modules for science-related fields at elementary level (Dimopoulos, Paraskevopoulos, & Pantis, 2008), However, little attention has been emphasized on the use of PBL and CL in the design and development of modules that foster scientific creativity at the pre-school level. A related research incorporated PBL in a teaching and learning module for fostering the scientific creativity among fifth graders. (Siew, Chong & Lee, 2015). However, the teaching and learning module is improperly modified to be used in a research on pre-school children because its activities required children to produce new and original ideas through writing. It is difficult for pre-school children, especially those who have yet to master the writing. Thus, the design and development of teaching and learning module in other forms needs be undertaken and evaluate its effects on scientific creativity among pre-schoolers. Accordingly, the aim of this research was to design and develop a PBL-CL teaching and learning module and evaluate its effects on scientific creativity among pre-schoolers.

Research Questions

There are three research questions guiding this study:

I. How reliable and valid is the developed PBL-CL teaching and learning module?
II. Is there a significant difference between pre-test mean scores and post-test mean scores in scientific creativity among students who are taught i) using the PBL-CL module, and ii) those without PBL-CL module?
III. Is there a significant difference between students who are taught using the PBL-CL module and those without PBL-CL module in i) pre-test mean scores, and ii) post-test mean scores in scientific creativity?

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Methodology of Research

Research Design and Sample

Descriptive and quasi-experimental research designs were employed in this research. Descriptive research involved formative evaluation that aimed at assessing the validity, reliability, pedagogical usability and the pre-schoolers' acceptability of the module. The targeted respondents in descriptive research involved 30 six-year-old pre-schoolers, 10 pre-school teachers, and 5 subject matter experts. On the other hand, a quasi-experiment was conducted in order to determine the effects of the PBL-CL module on pre-schoolers' scientific creativity. The sample in quasi-experimental research consisted of 144 six-year-old pre-schoolers. The re-schoolers were randomly selected from four government-funded pre-schools in an industrial suburb of Kota Kinabalu district. The pre-schoolers comprised of 99 (57%) girls and 75 (43%) boys. Approximately 62% of the parents were government servants and 38% worked in other occupations (e.g. businessman, teachers, self-employed workers, labourers).

Ethical Considerations

Permission to do the research was obtained from the pre-school principals and teachers. At the beginning of the research, the parents of pre-schoolers were presented with a letter of consent detailing the nature of their children's involvement in the research and the need to provide their consent on the sheet indicating their full understanding. The purpose of the research was explained in detail and all the parents were assured of the confidentiality of responses given by their children. All parents were informed that their children could withdraw from the research without penalty.

Descriptive Research

Descriptive research involves the five phases of ADDIE instructional design model is described as follows.

Analysis Phase

The main purpose of Analysis phase was to determine the overall instructional goal based on the needs of the target respondents. The instructional goal is expected to be achieved through the evaluation process of teaching and learning to rectify problems faced by pre-school teachers (Kemp, Morrison, & Ross, 1998). The main instructional goal of this research was to foster pre-schoolers' scientific creativity. In order to determine the instructional goal, the researchers performed two steps of analysis: a) needs analysis, and b) learner and context analysis as below.

Needs analysis. During the preliminary stage, the researcher interviewed five pre-school teachers in Kota Kinabalu, Sabah, to gain insight about efforts to foster scientific creativity during the teaching and learning process. The interview questions and responses are shown in Table 1. All of the five teachers responded that they had insufficient knowledge to implement any creative scientific or technology related activities. The interviews also revealed that the teachers were not exposed to scientific creativity lessons as there are no teaching and learning modules or guidelines provided especially on fostering scientific creativity at the pre-school level.

In addition, the pre-school teachers had little knowledge about doing assessments of pupils' scientific creativity as there is no instrument or guideline provided by the MoE. Most teachers also stated that approaches or techniques used in science lessons were teacher-centred. Only one of them had employed the use of inquiry hands-on activities. All the interviewees expressed a need for a teaching and learning module in order to promote creativity in the Science and Technology lesson. Hence, the outcomes of the interview have provided a strong justification for the researchers of this research to design a PBL-CL teaching and learning module as a guideline for teachers to foster pupils' scientific creativity at the pre-school level.

Table 1. Interview questions and responses in needs analysis.

No	Question	Response
1	What approaches/techniques did you use during the teaching and learning of Science?	Pupils carry out activities in accordance with the instructions of the teachers (T1, T2 and T5). Sometimes we carry out a demonstration (T1, T2 and T3); activities within group using worksheets (T1, T5); 'inquiry hands-on' activities (T4).
2	Have you implemented creativity activities via the Science and Technology strand? Do you know how to do it?	Never (T1, T2 T3, T4 and T5), No idea how to do it (T1, T2 T3 and T4). I have heard about creativity but do not know the criteria used for measurement.
3	Have you heard about scientific creativity, and do you know about it?	No. I have never heard about it (T1, T2, T3, T4 and T5). No, I don't know what SC is (T1, T2, T3, T4 and T5),
4	Do you know how to foster pre-schoolers' scientific creativity?	No idea, there is no teaching and learning module (T1 and T4) /guidebook (T2, T3 and T5) provided by MoE. No exposure on SC (T2 and T5)
5	Do you know how to assess scientific creativity?	No idea, there is no instrument or guideline from MoE (T1, T2, T3 and T4). Do not know the criteria for assessing SC (T4)
6	Do you think a teaching and learning module is needed in order to promote creativity in the Science and Technology Strand?	Yes, definitely (T1, T2, T3, T4 and T5).

Learner and context analysis. The criteria used in the analysis of the learner and context were developed from ideas gathered from Carlton, Kicklighter, Jonnalagadda and Shoffner (2000) which focused on topics of interest in Science, prior knowledge based on the topics of interest, drawing and writing skills, comfort level using drawing, and peer interaction (Table 2). The analysis showed pronounced differences among the pre-schoolers in their prior knowledge and writing skills. Therefore, the instruction was adjusted to suit the level and needs of the pre-schoolers as much as possible.

Table 2. Analysis of learner and context.

Topic	Respondents (n=30)
Topics of interest in Science	• Sink and float • Magnet • Shadow • Soluble and insoluble • Absorbent • Senses
Prior knowledge based on topics of interest in Science	• Sink and float (25 respondents knew the topic; 5 respondents misinterpreted). • Magnet (28 respondents knew the topic; 2 respondents misinterpreted). • Shadow (All knew the topic) • Soluble and insoluble (16 respondents knew the topics; 14 respondents misinterpreted). • Absorbent (19 respondents knew the topics; 11 respondents misinterpreted). • Senses (26 respondents knew the topics; 4 misinterpreted).
Drawing and writing skills	• All could draw. • 20 respondents could write more than two words; 10 respondents could not.
Comfort level using drawing	• All felt comfortable.
Peers interaction	• All enjoyed interacting with their peers.

Design Phase

The main focus of the Design phase was to address the outline of learning objectives, planning assessment instruments, and planning instructional strategy in detail before developing the module as discussed below.

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Learning objectives. Six learning objectives were written based on NPCS (Table 3) which included a skill or behaviour identified in the needs analysis. The purpose is to translate the needs and goals into objectives that are sufficiently specific to guide the pre-school teacher in teaching and pre-schoolers in learning. These objectives were used as a guideline during the selection and arrangement of content, teaching material, learning strategies, method of evaluation, and the skills and knowledge to be mastered as proposed by Kemp *et.al,* (1998).

Table 3. Learning objectives.

No	Objectives
1	Grouping objects as sinking or floating objects.
2	Producing shadows using different objects.
3	Identifying the effect of magnets on different objects.
4	Separating materials into those that can and cannot absorb water.
5	Identifying soluble and insoluble materials.
6	Using the senses to explore the environment.

Planning assessment instrument. The assessment instrument was the Figural Scientific Creativity Test (FSCT) which was proven as a reliable and valid instrument in assessing scientific creativity of pre-schoolers (Chin & Siew, 2015). The FSCT test was constructed based on three dimensions of Scientific Creativity Structure Model (SCSM). There are six items in the FSCT; two items for each Product dimension: scientific knowledge, scientific problem and scientific phenomena. All the items require responses that are mainly pictorial in nature. A small amount of writing was required from the pre-schoolers when they were instructed to label or name the pictures they had drawn.

Planning an instructional strategy. The final step in the Design phase was planning the instructional strategy which consisted of teaching and learning strategies, writing content for each objective, and planning activities to aid in the transfer of learning. Planning teaching and learning strategies involved identifying strategies that best elicit learning. Three instructional strategies were utilized: (1) Seven Steps of Problem Based Learning by Schmidt (1983), (2) Cooperative Learning Structure - "Numbered Heads Together" (Kagan & Kagan, 2009), and (3) Directed Creative Process (Plsek & Associates, 1997). The next course of action was to write the content needed to perform each of the six learning objectives. Finally, to aid in the transfer of learning, an ill structured problem with no straightforward solution was presented for each objective (Table 4). Real world-related problems were designed to help pupils in the application of their knowledge (Chen & Bradshaw, 2007) and generate hypotheses (Hmelo-Silver, 2004).

Table 4. Ill structured problems.

No	Problems
1	A coin sinks in water. How do you make the coin float?
2	You want to perform "Shadow Play". How do you produce shadows on the screen when a torch light is emitted through a transparent book wrapping?
3	You found a pencil box that is unable to shut tightly. How do you open and close the pencil box tightly?
4	A glass of water spilled on the tray. How do you make the water dry up in a short time?
5	You have mixed sugar with sand. How do you separate the sand from the mixture?
6	You met a blind man on your way back from school. How did the blind man identify the materials or objects around him?

Development Phase

During the Development phase, the PBL-CL teaching and learning module was developed as an instructional material. The content of the module consists of six activities Approximately one hour was needed to complete each activity. The principles of PBL and CL were incorporated into each activity, which was developed through student centred approaches. Pre-schoolers were assigned to small and heterogeneous cooperative learning groups. Each activity underwent the four phases of the Directed Creative Process Model: preparation, imagination, development, and action. The Preparation phase involved identifying and clarifying problems. Themes and concepts were clarified by teachers before the pre-schoolers defined the problems themselves. The Imagination phase emphasised the search for solutions or alternative solutions to the problems presented. In this phase, pre-schoolers 'put their heads together' to search for multiple solutions. Based on the problems given, the pre-schoolers drew systematic solutions on worksheets provided for each group.

The Development phase focused on performing operation and evaluation problem solving. Solutions for the problems were demonstrated through hands-on activities. Improvement was made to the first drawing through the best solution selected by the pre-schoolers. Then, reflections about the solved problems were done in the Action phase. The pre-schoolers presented their work and collected additional information from other groups. A worksheet consisting of reinforcement exercises was given to them for the purpose of synthesising the new information. The integration of learning models in PBL-CL learning activities is shown in Table 5.

Table 5. Integration of learning models in PBL-CL learning activities.

Seven Steps of PBL Model	CL "NHT"	Directed Creative Model	Learning Activities
• Clarify concept • Define problem	• Assign pupils to group • Ask question	Preparation Phase • Identify problem • Clarify problem	• Teacher clarifies themes and concepts with pupils. • Pupils define problem proposed by the teacher.
• Analyse problem • Draw inventory	• "Put heads together"	Imagination Phase • Search for solutions • Search for alternative solutions	• Pupils analyse problem during "put heads together". • Pupils draw a systematic solution in the worksheet.
• Formulate learning objective	• Call number, pupils respond • Ask question • "Put heads together"	Development Phase • Perform operation • Evaluate problem solving	• Pupils in groups demonstrate their solution to the problem through hands-on activities. • Pupils make improvements to the first drawing and select the best solutions to the problem given.
• Collect information outside of the group • Synthesize new information	• Call number, pupils respond	Action Phase • Reflect on the problem solved	• Each group presents their finding and pupils collect additional information from other groups. • Pupils synthesize new information by answering reinforcement exercises in the worksheets given.

Implementation Phase

The Implementation phase involved the delivery of the PBL-CL teaching and learning module in the actual pre-school's classroom. This phase was aimed to assess the efficiency of instruction delivery. It further assesses the students' understanding of the materials, supports the students' acquisition of objectives, and ensures the students' transfer of knowledge from the learning to setting the goals (Muruganantham, 2015).

Prior to implementation, the researchers arranged courtesy visits to the selected school. The researchers explained to the school's headmaster the purposes of the research and requested permission for the respondents' involvement. The researchers also presented a brief procedure of the data collection and obtained verbal consent in carrying out the research in the school. Upon approval from headmaster, the researchers met the pre-school teachers and requested their consents to administer the PBL-CL module for the research's purposes. In order to complete the six activities in the module, the implementation phase lasted for six weeks. During this period, a scheduled of meeting was set up between the researchers and the pre-school teachers to discuss issues related to the implementation of PBL-CL such as close monitoring, discussions, and feedback.

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Evaluation Phase

It is essential to collect data and information during the development of instruction in order to improve the instructional effectiveness (Ellington & Aris, 2000). According to Rusell (1974), the content validity and reliability has to be determined before a module is being used. Hu and Adey (2002) addressed that any new developed tools should have at least some level of acceptance by the pupils. Additionally, Norazah, Effandi. Nik Rahimah and Mohamed (2010) stressed that the pedagogical usability has to be determined in order to illustrate how the module functions in simplifying the learning content delivery. Hence, a formative evaluation was undertaken that included content validity, reliability, acceptance to pupils, and pedagogy usability.

A panel of five experts was involved to ascertain the content validity. The experts were university and college lecturers as well as educators in the pre-school field. One of the experts was a creativity expert from a public university, two were Master Trainers from Science educational programs, and another two were involved in the Pre-school Curriculum Development and Assessment. An Expert Evaluation Form adapted from Goh (2015) was used which required experts to give candid feedback on the pedagogy content (PBL and NHT), activity overview, relevance of each activities, building ideas, overall flow of the activities and written comments to improve the module. The PBL-CL module was written in the Malay language in order to ensure the understanding of the module content among pre-school teachers. It was proof-read by two language experts, one of them was a master graduate in Malay Studies and another obtained a Bachelor in Malay Studies.

In order to ascertain the internal consistency reliability of the PBL-CL module, a set of questionnaires adapted from Jamaludin (2002) was used. According to Mohd Noah and Ahmad (2005), questionnaires based on stages of the activities showed a higher reliability index as compared to objectives in the module. There were six activities in the PBL-CL module. Each activity in the questionnaire consisted of three items with two-point scales labelled as "agree" and "disagree". The items asked if pre-schoolers could follow the stages of the activities in the module in accordance with performance objectives in the lesson. All 18 items were posed in simple Malay which consisted of short sentences that cater to the pre-schoolers' level. The pre-school teacher read and explained each item and the pre-schoolers were asked to put up their hands while responding to the items. The questionnaire was administered to 30 pre-schoolers in an urban pre-school in Kota Kinabalu, Sabah. Once the module activities were completed, the pre-schoolers' views on 'acceptability' were collected to determine whether each activity was interesting or boring. Responses were recorded to facilitate the revision of the PBL-CL module.

On the other hand, the PBL-CL module was also implemented by 10 pre-school teachers. After completing the teaching of the module, the pre-school teachers were asked for feedbacks by responding to the 11-item pedagogical usability questionnaire. The pedagogical usability questionnaire was adapted from Norazah *et al* (2010) which consisted of nine criteria: 1) learner control, 2) learner activities, 3) objective oriented, 4) application, 5) value added, 6) motivation, 7) knowledge value, 8) flexibility, and 9) response. The instrument used a Likert scale with value of 1 (strongly disagree) to 5 (strongly agree) to each item. Descriptive statistic was used for data analysis and mean was calculated for each item as proposed by Boone and Boone (2012). The formula used to calculate means was:

[(number of respondents who selected response 1(weighting of response 1) + (number of respondents who selected response 2*(weighting of response 2… (number of respondents who selected response n) * (weighting of response n)] / (total number of respondents)*

Quasi-Experimental Research

A pre- and post-test non-equivalent control group quasi-experimental design was employed. A total of 144 six-year-old pre-schoolers were randomly selected from three pre-schools in Kota Kinabalu district and assigned to one of the conditions as intact groups: the treatment group (PBL-CL, n=72), or control group (TG, n=72). The PBL-CL module was administered in six separate activities within six weeks in September - October 2016, with 60 minutes for each activity. While the pre-schoolers in TG group were taught using hand on activities. The Figural Scientific Creativity Test developed by researchers (Chin & Siew, 2015) was used as an instrument to assess the scientific creativity among the pre-schoolers. Two equivalent and parallel FSCT Form A and Form B were used as pre-test and post-test respectively. The scores obtained were analysed using scoring criteria adapted from Torrance, Ball and Safter (2008).

Results of Research

Content Validity

The PBL-CL module was reviewed by subject matter experts in order to ascertain the content validity. In accordance with the experts' suggestions, the necessary corrections were made to the grammar as well as the appropriateness of the activities in the module. Two amendments were made to the activities in the PBL-CL module: 1) materials in each activity were reduced to less than seven items in order to restrain the pre-schoolers from playing with them, and 2) the duration of the lesson was extended to 15 minutes as more time was required for the pre-schoolers to be grouped in the CL "Numbered Heads Together" (Preparation phase of the Directed Creative). Overall, experts established the opinion that the PBL-CL module is a suitable module to foster scientific creativity among pre-schoolers.

Reliability

The Cronbach's Alpha coefficient of internal consistency was computed to determine the degree of measure of the activities with a similar module and construct in order to produce a consistent result (Cohen, Manion, & Morrison, 2007). Soon (2008) stated that a preferable alpha value should be higher than .70 for an academic research exercise. The alpha value of the PBL-CL module was .768 based upon scores gained from the 30 pre-schoolers in an 18-item questionnaire, while the range was within .710 to .764 in each activity (Table 6). Consequently, the alpha values of the PBL-CL module were considered to have an acceptable reliability in the context of measurement.

Table 6. Cronbach's alpha coefficient of the learning activities in PBL-CL module.

Activity	Cronbach's Alpha (Overall alpha = .768)
One	.764
Two	.710
Three	.735
Four	.727
Five	.734
Six	.723

Acceptability of Pre-schoolers

In this research, a total of 30 pre-schoolers were asked about the question, "Which activities did you find interesting or boring in the PBL-CL module?". Results are shown in Table 7, indicating a high degree of acceptability by the pre-schoolers.

Table 7. Pre-schoolers' acceptability of the PBL-CL module.

Activity	Pre-schoolers' Response (n)	
	Interesting	Uninteresting
One	30	0
Two	28	2
Three	30	0
Four	30	0
Five	29	1
Six	30	0

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Pedagogical Usability

The results of the pedagogical usability showed items had overall mean of 4.08 (Table 8), which was rated as a high level of pedagogical usability. Overall 57.3% agreed and 25.4% strongly agreed on the usability aspect of the PBL-CL module. Table 8 presented the ranked mean of pedagogical usability criteria from the highest level to the lowest. According to Inas, Harry, Yugo, and Andika (2015), criteria with the mean level equals or more than 3.50 are considered as acceptable, while below 3.50 is considered as unsatisfactory indicating changes should be made in the module. From the results, the mean level ranged from 4.50 to 3.70 indicated the pre-school teachers agreed the module can be used to foster scientific creativity in the pre-school classroom.

Table 8. Ranked mean of pedagogical usability criteria.

Pedagogical Usability Item	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree	Mean
	f (%)					
Learning goals are clearly stated in the module	0 (0)	0(0)	0 (0.0)	5 (50.0)	5 (50.0)	4.50
The use of learners' drawings to assess scientific creativity in science lesson is appropriate	0 (0)	0 (0)	1 (10.0)	4 (40.0)	5 (50.0)	4.40
Module enable teachers to assess learner's scientific creativity	0 (0)	0 (0)	1 (10.0)	5 (50.0)	4 (40.0)	4.30
Module does integrate PBL with CL 'NHT' in the promoting of scientific creativity	0 (0)	0 (0)	1 (10.0)	5 (50.0)	4 (40.0)	4.30
Activities in the module are student centred	0 (0)	0 (0)	2 (20.0)	6 (60.0)	2 (20.0)	4.00
Module motivates learning	0 (0)	0 (0)	1 (10.0)	8 (80.0)	1 (10.0)	4.00
Module is flexible and enhances learners to generate ideas	0 (0)	0 (0)	2 (20.0)	6 (60.0)	2 (20.0)	4.00
Application of the module makes learning more interesting	0 (0)	0 (0)	2 (20.0)	6 (60.0)	2 (20.0)	4.00
Experience as pre-school teacher does have an added value in using this module	0 (0)	0 (0)	3 (30.0)	5 (50.0)	2 (20.0)	3.90
Module could be applied in the fostering of scientific creativity	0 (0)	0 (0)	3 (30.0)	6 (60.0)	1 (10.0)	3.80
Module has added value on learner's knowledge	0 (0)	0 (0)	3 (30.0)	7 (70.0)	0 (0)	3.70
Overall	0 (0)	0 (0)	19 (17.3)	63 (57.3)	28 (25.4)	4.08

Effects of PBL-CL Teaching and Learning Module

A paired sample T-test was performed to determine if there was a significant difference between the pre-and post-test mean scores in the PBL-CL group and TG group in scientific creativity. The result of this analysis (Table 9) indicates that the post-test mean score (M=126.64, SD= 44.27) of pre-schoolers in the PBL-CL group is significantly higher (t (71) = -12.12, $p < .05$) than their pre-test mean score (M=62.15, SD=24.58). Similar result is also found in in the TG group where post-test mean score (M=77.74, SD= 48.21) of pre-schoolers is significantly higher (t (71) = -2.70, $p = .009$) than their pre-test mean score (M=59.75, SD=23.37) in scientific creativity. These results indicated that both groups performed significantly better on the post-test compared to the pre-test in scientific creativity. However, it was found that the average increase in mean scores of 64.49 in the PBL-CL group was higher than the average increase in mean scores of 17.99 in TG group.

Table 9. Mean scores difference between pre-test and post-test of PBL-CL and TG group.

Variables	Group	Pre-test	Post-test	Difference	t	df	p
		Mean (SD)					
Scientific Creativity	PBL-CL	62.15 (24.58)	126.64 (44.27)	-64.49 (-19.69)	-12.12	71	p < .05
	TG	59.75 (23.37)	77.74 (48.21)	-17.99 (24.84)	-2.70	71	.009

Note: Significant level at p =0.05

An independent-samples t-test was conducted to compare the mean scores of pre-test in scientific creativity between PBL-CL group and TG group. The result of this analysis (Table 10) revealed that there was no significant difference in pre-test mean scores between PBL-CL group and TG group (t (142) = .601, *p* = .549) in scientific creativity. According to Gay and Airasian (2003, p. 467), if there is no significant difference between the two pre-test means, then a t-test can be computed on the post-test means. An independent sample T-test was therefore performed to compare the mean scores of post-test in scientific creativity between the PBL-CL group and TG group. The result of this analysis revealed that students in the PBL-CL group scored significantly (*t* (142) = 6.73, *p* < .05) higher (M=128.76, SD= 42.67) than the students in the TG group (M=77.74, SD= 48.21). This result indicated that there was a significant difference in post-test mean scores between students in the PBL-CL group and TG group in scientific creativity.

Table 10. Group difference in pre- and post-test mean scores.

Variables	Test	PBL-CL	TG	Group Difference	t	df	p
		Mean (SD)					
Scientific Creativity	Pre	62.15 (24.58)	59.75 (23.37)	2.40 (1.21)	.601	142	.549
	Post	128.76 (42.67)	77.74 (48.21)	51.02 (-5.54)	6.73	142	< .05

Note: Significant level at p = .05

Discussion

This research was an attempt to design, develop a PBL-CL teaching and learning module and evaluate its reliability, validity and effects. The PBL-CL teaching and learning module was developed based on an integrated instructional design and theoretical model for assessing scientific creativity of six-year-old pre-schoolers. The analysis on internal consistency reliability, content validity, pedagogical usability and the pupils' acceptability of the module were found to be acceptable and suitable. Overall the internal consistency reliability suggested that the PBL-CL module was with an acceptable reliability in fostering scientific creativity. Each appointed expert greatly approved the pedagogy content, relevance and overall flow of each activity, and building ideas of PBL-CL module. Some revisions needed to be made in order to improve the language, the materials used and duration of the activities. The PBL-CL teaching and learning module also received high acceptability from a pool of 30 pre-schoolers indicating that the module has good face validity. As for the pedagogical usability of the module, all the 10 pre-school teachers agreed that the module would greatly help them to foster scientific creativity in the pre-school classroom.

The results of paired sample T-test indicated that pre-schoolers taught in both PBL-CL and TG group performed significantly better in their scientific creativity in post-test compared to pre-test. However, pre-schoolers taught in the PBL-CL group were found to have significant greater improvement scores than their peers taught in the TG learning group. That is, the opportunity to learn with PBL-CL teaching and learning module have a profound effect on pre-schoolers' scientific creativity. As for the results of independent sample T-test, it suggested that the use of a reliable and valid PBL-CL teaching and learning module by pre-schoolers in learning science is effective in fostering their scientific creativity. This study confirms earlier research that PBL (Plucker

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& Nowak, 2000; Tan, 2009; Siew *et al.,* 2015) and CL (Steen, 2013) is able to foster learners' scientific creativity. In the PBL-CL learning process, the pre-schoolers were triggered with real world problem in science context and utilized scientific knowledge as well as imagination in order to solve the problem. Pre-schoolers helped each other to learn and generate ideas with different approaches or categories based on their prior and learned scientific knowledge through cooperative learning. They also combine their imagination and knowledge to form the scientific knowledge as posited by Hu and Adey (2002). The finding was supported by Cardarello (2014) that creative processes and scientific discovery are triggered when problematic solutions are perceived and require imagination and logical knowledge to be resolved.

Conclusions

This research has demonstrated that the principles of using ADDIE instructional design model by integrating the Seven Steps of the PBL model, CL "Numbered Heads Together" and the Directed Creative Process Model offer the potential for developing a teaching and learning module that is valid, reliable and effective in fostering scientific creativity among six-year-old pre-schoolers. The PBL-CL teaching and learning module on scientific creativity whose effects have been empirically proven is a contribution to support the goal of Malaysian Education Blueprint 2013 – 2025, that is to produce a generation who can think creatively and innovatively.

The findings of this research have two direct implications. The empirically proven ADDIE design model with an integrated application of Seven Steps of the PBL model, CL "Numbered Heads Together" and the Directed Creative Model can be a reference model for those who are interested in developing a similar teaching and learning module on fostering scientific creativity. The module can be further upgraded or improved to include more PBL-CL activities and focus on four to five-year-old pre-schoolers.

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References

Barak, M. (2006). Teaching methods for systematic inventive problem-solving: Evaluation of a course for teachers. *Research in Science and Technological Education, 24* (2), 237–254.
Barrett, E., & Moore, S. (2012). An introduction to problem-based learning. In Barret, E & Moore, S. (Ed.). *New approaches to problem-based learning: Revitalising your practice in higher education.* New York: Routledge, pp 3-17.
Boone, H. N., & Boone, D. A. (2012). Analyzing Likert data. *Journal of Extension*, *50* (2), 1-5.
Capobianco, B., & Tyrie, N. (2009). Problem solving by design. *Science and Children*, *47* (2), 38-41.
Cardarello, R. (2014). Enhancing scientific thinking in children: Suggestions based on studies about creativity. *Conference Proceedings: New Perspectives in Science Education: 3rd Conference edition*. Florence, Italy, 20-21 March 2014. Padova: Libreriauniversitaria.it.
Carlton, D. J., Kicklighter, J. R., Jonnalagadda, S. S., & Shoffner, M. B. (2000). Design, development, and formative evaluation of "Put nutrition into practice": A multimedia nutrition education program for adults. *Journal of the American Dietetic Association, 100* (5), 555-563.
Chen, C., & Bradshaw, A. C. (2007). The effect of web-based question prompts on scaffolding knowledge integration and ill-structured problem solving. *Journal of Research on Technology in Education*, *39*, 359-375.
Chin, M. K., & Siew, N. M. (2015). The development and validation of a figural scientific creativity test for pre-school pupils. *Creative Education*, *6*, 1391-1402.
Cochrane, T. (2012). Secrets of m-learning failures: Confronting reality. *Research in Learning Technology, ALT-C Conference Proceedings*. http://dx.doi.org/10.3402/rlts 2010.19186.
Cohen, L., Manion, L., & Morrison, K. (2007). *Research methods in education*. London & New York: Routledge, Taylor & Francis Group.
Cole, D. G., Sugioka, H. L., & Yamagata-Lynch, L. C. (1999). Supportive classroom environments for creativity in higher education. *Journal of Creative Behavior*, *33*, 277-292.
Curriculum Development Centre. (2010). *National pre-school curriculum standard*. Kuala Lumpur: Ministry of Education Malaysia.

Dimopoulos, D., Paraskevopoulos, S., & Pantis, J. D. (2008). The cognitive and attitudinal effects of a conservation educational module on elementary school students. *The Journal of Environmental Education, 39* (3), 47-61.
Droha, S., Mauffette, Y., & Allard, J. L. (2012). Employers' perspectives on problem-based learning initiatives. In Barret, E & Moore, S. (Ed.), *New approaches to problem-based learning: Revitalising your practice in higher education* (pp. 89-99). London: Routledge,
Ellington, H., & Aris, B. (2000). *A practical guide to instructional design*. Skudai: University of Technology Malaysia.
Gay, L. R., & Airasian, P. W. (2003). *Educational research: Competencies or analysis and applications*. Merrill: Prentice Hall
Goh, H. (2015). *Scientific skills embodiment through integration of educational robotics in physics.* Unpublished PhD Thesis. University of Technology Malaysia.
Hmelo-Silver, C. (2004). Problem-based learning: What and how do students learn? *Educational Psychology Review, 16* (3), 235.
Hu, W., & Adey, P. (2002). A scientific creativity test for secondary school students. *International Journal of Science Education*, *24* (4), 389-403.
Hu, W., Shi, Q. Z., Han, Q., Wang, X., & Adey, P. (2010). Creative scientific problem finding and its developmental trend. *Creativity Research Journal*, *22* (1), 1-7.
Hunter, W.C. (2011). *Examining the effects of NHT on quiz results and on-task behavior with students identified with emotional behavioral disabilities* (Order No.3469647). Available from ProQuest Dissertations & Theses Global.
Inas, S. J., Harry, B. S., Yugo, K. I., & Andika, Y. U. (2015). Usability evaluation of the student centered e-learning environment. *International Review of Research in Open and Distributed Learning, 16* (4), 62-82.
Jamaluddin, A. (2002). Validity, reliability and effectiveness of self-advancement program module on achievement motivation among high school students in Selangor. Unpublished doctoral dissertation. Serdang: University of Putra Malaysia.
Kagan. S., & Kagan, M. (2009). *Kagan cooperative learning*. California: Kagan Publising.
Kallio, K. A. (2008). *Instructional design.* EBSCO Research Starters Education: Instructional design, pp 1-10.
Kemp, J., Morrison, G., & Ross, S. (1998). *Designing effective instruction* (2nd ed). New Jersey: Merrill.
Kwon, O. N., Park, J. S., & Park, J. H. (2006). Cultivating divergent thinking in mathematics through an open-ended approach. *Asia Pacific Education Review, 7* (1), 51–61.
Maulana, R. T. (2014). *Numbered heads together (NHT): An endeavour to improve student's scientific creativity and mastery concept in learning global warming.* Universitas Pendidikan Indonesia Repository. Upi.Edu Perpustakaan. Upi.Edu.
Mohd Noah, S., & Ahmad, J. (2005). *Module development: How to develop practice module and academic module*. Serdang: University of Putra Malaysia.
Muruganantham, G. (2015). Developing of e-content package by using ADDIE model. *International Journal of Applied Research*, *1* (3), 52-54.
Norazah, N., Effandi, Z., Nik Rahimah, N. M., & Mohamed, A. E. (2010). Pedagogical usability of the Geometer's Sketchpad (GSP) digital module in the mathematics teaching. *The Turkish Online Journal of Educational Technology*, *9* (4), 113-117.
Piaget, J. (1952). *The origins of intelligence in children*. New York: International Universities Press.
Plsek, P. E., & Associates. (1997). *Working paper: Models for the creative process*. Retrieved from: http://www.directedcreativity.com/pages/WPModels.html.
Plucker, J. A., & Nowak, J. (2000). Creativity in science for K-8 practitioners: Problem based approaches to discovery and invention. In M. D. Lynch & C. R. Harris (Eds.), *Fostering creativity in children, K-8* (pp. 145–158). Boston: Allyn & Bacon.
Qayumi, S. (2001). Piaget and his role in problem-based learning. *Journal of Investigative Surgery, 14*, 63-65.
Reiser, R. A., & Dempsey, J. V. (2007). *Trends and issues in instructional design and technology* (4th Ed.). Columbus, OH: Pearson.
Rusell, J. D. (1974). *Modular instruction: A guide to the design, selection, utilization and evaluation of modular materials*. New York: Publishing Company.
Savin-Baden, M. (2004). *Facilitating problem-based learning*. Philadelphia, USA: Open University Press.
Schmidt, H. G. (1983). Problem based learning: Rationale and description. *Medical Education*, *17*, 11-16.
Semerci, N. (2006). *The effect of problem-based learning on the critical thinking of students in the intellectual and ethical development unit.* Social Behaviour and Personality. Retrieved from http://findarticles.com/p/articles/mi_qa3852/is_200601/ai_n17187271/print.
Shriki, A. (2013). A model for assessing the development of students' creativity in the context of problem posing. *Creative Education, 4* (7), 430-439.
Siew, N. M., Chong, C. L., & Lee, B. N. (2015). Fostering fifth graders' scientific creativity through problem-based learning. *Journal of Baltic Science Education, 14* (5), 655-669.
Simonton, D. K. (2012). *Assessing scientific creativity: Conceptual analyses of assessment complexities*. Commissioned paper, The Science of Science and Innovation Policy Conference, National Academy of Sciences. Retrieved from: https://simonton.faculty.ucdavis.edu/wp-content/uploads/sites/243/2015/08/SimontonSciSIPFinalDraft.pdf.
Soon, S.T. (2008). *Data analysis and interpretation using SPSS.* Education Planning & Research Division, Kuala Lumpur: Ministry of Education.
Steen, M. (2013). Virtues in participatory design: Cooperation, curiosity, creativity, empowerment, and reflexivity. *Science and Engineering Ethics, 19* (3), 945-62.
Tan, O. S. (2009). *Problem based learning and creativity*. Singapore: Cengage Learning Asia Pte Ltd.
Tan, O. S. (2000). Thinking skills, creativity and problem-based learning. In O. S. Tan, P. Little, S. Y. Hee & J. Conway (Eds.), *Prob-*

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

lem-based Learning: Educational innovation across disciplines. Singapore: Temasek Centre for Problem-based Learning.
Tatar, E., & Oktay, M. (2011). The effectiveness of problem-based learning on teaching the first law thermodynamics. *Research in Science & Technology Education*, *29* (3), 315-332.
Torrance, E. P., Ball, O. E., & Safter, H. T. (2008). *Torrance test of creative thinking: Streamlined scoring guide for figural Forms A and B*. Bensenville, IL: Scholastic Testing Service, Inc.
Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA.: Harvard University Press.
Wegener, D. (2006). *Training library patrons the ADDIE way*. Elsevier.

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