JOURNAL OF BALTIC SCIENCE EDUCATION
ISSN 1648-3898

THE EFFECTS OF PROBLEM BASED LEARNING WITH COOPERATIVE LEARNING ON PRESCHOOLERS' SCIENTIFIC CREATIVITY

Nyet Moi Siew,
Mui Ken Chin,
Agnis Sombuling

Abstract. *This research aimed to determine the effects of Problem based learning (PBL) with cooperative learning (CL) and 'Numbered Heads Together' (NHT) on preschoolers' five trait dimensions of scientific creativity: Fluency, Originality, Elaboration, Abstractness of title, and Resistance to premature closure. A quasi-experimental pre-test and post-test control group design was employed in the research. The sample consisted of 216 six-year-old preschoolers from three randomly selected preschools and assigned to PBL-CL'NHT' (n=72), PBL (n=72), and hands-on (TG) (n=72) instructional methods. The Figural Scientific Creativity Test was used as the pre-test (Form A) and post-test (Form B). Multivariate Analysis of Covariance (MANCOVA) was conducted on the post-test scores with pre-test scores as the covariates to determine whether a significant difference existed across the three methods. The results indicated that preschoolers taught in the PBL-CL'NHT' method significantly outperformed their peers in the PBL method who, in turn, significantly outperformed their peers in the TG method in Fluency, Originality, Elaboration, Abstractness of title, and Resistance to premature closure. Large effect sizes were obtained for comparing PBL-CL 'NHT' with PBL and TG method. The findings suggest that the PBL-CL 'NHT' method has a significant positive impact on fostering preschoolers' five trait dimensions of scientific creativity.*

Key words: *cooperative learning, preschoolers, problem based learning, scientific creativity, trait dimensions.*

Nyet Moi Siew,
Mui Ken Chin,
Agnis Sombuling
University of Malaysia Sabah, Malaysia

Introduction

Scientific Creativity has been identified as one of the key domains of specific creativity which has contributed to the advancement of human civilization (Hu, Shi, Han, Wang, & Adey, 2010). Individuals who possess scientific creativity are considered to be more capable of producing a certain product that is original and has social or personal value (Hu & Adey, 2002). Children are naturally creative and curious, thus fostering scientific creativity in preschools can help them develop their potential to the maximum.

Despite the increased emphasis on fostering children's creativity in the recently revised National Preschool Curriculum Standard (Curriculum Development Centre, 2010), there is a little evidence to demonstrate research done on scientific creativity among preschoolers in Malaysia. A review carried out by Chew and Madar (in press) (2016) entailing the most recent studies from multiple disciplines and educational levels between the years 1979 to 2015 showed that research about creativity mostly focused on 'general-content-based creativity'. An affiliated research conducted outside Malaysia showed improvement in creativity among 30 preschool boys' fluency, flexibility, originality and elaboration (Mirzaie, Hamidi & Anaraki, 2009). However, no details were given as to which domain specific creativity was evaluated. These findings raised crucial questions: Can scientific creativity be fostered among preschoolers? What is the best learning environment that encourages the development of scientific creativity among preschoolers?

Learning Environment for Developing Creativity

According to Cole, Sugioka, and Yamagata-Lynch, (1999), group work in the classroom contributes to a supportive learning environment conducive for developing students' creativity. When the principles and processes of

Problem Based Learning (PBL) are examined, it becomes apparent that the learning strategy actualizes such elements proposed by Cole, Sugioka, and Yamagata-Lynch. PBL embodies the principle that learning begins when students are encouraged to work as a group to find solutions to real-world problems (Tatar & Oktay, 2011; Droha, Mauffette & Allard, 2012; Barrett & Moore, 2012; Savin-Baden, 2004). PBL enables students to experience the use of their knowledge to solve real-world problems (Yeung *et al*, 2013). In addition, PBL creates a supportive learning community and sustained interaction that explicitly scaffolds learners to learn within social constructivist paradigms (Cochrane, 2012, p. 125). By engaging students' learning via group work, PBL could create a supportive environment for preschoolers to develop their scientific creativity. Indeed, PBL has been identified as helpful in promoting creative thought (Barak, 2006; Kwon, Park & Park, 2006; Semerci, 2006; Tan, 2000; Shriki, 2013; Tan, 2009).

Effects of PBL on Students' Creativity

Despite claims about the positive effect of PBL on students' creativity, empirical evidence of the advantages of PBL in Malaysian preschools is scarce. In a study on Malaysian fifth graders, it was discovered that PBL had a significant impact on creative traits such as being fluent, flexible, and original in their solutions towards a scientific problem, improvising a technical product, and advancing scientific knowledge (Siew, Chong & Lee, 2015). As the study involved only fifth graders, it was conducted over a short period and only measured three creative traits, further research needs to be undertaken with a broader scope: multi-age group over a longer time frame and assess more creative traits. Meta-analysis on PBL was conducted from 2009-2014 (Mustaff & Ismail, 2014), but its primary focus was on research carried out in Malaysian secondary and primary school level. Several other research studies investigated the effects of PBL on learning achievement in subjects, such as chemistry, biology and primary science (Tarhan, & Acar-Sesen, 2013; Osman & Kaur, 2014; Etherington, 2011), whereas others look at the effects of PBL on learning skills and affective properties of students. For example, self-directed learning skills, attitude, and beliefs among high school and university students (Malan, Ndlovu, & Engelbrecht, 2014; Demirel & Dagyar, 2016; Tarhan, & Acar-Sesen, 2013). There is relatively little research done on the effects of PBL on children's creativity at the preschool level.

According to Peterson (1997), the ability of students to work well together in solving problems will to a large extent determine the success of PBL. However, researchers found that teachers and students continue to experience difficulties related to working with and in groups (Murray-Harvey *et al*., 2013; Pfaff & Huddleston, 2003; Holen, 2000). On the other hand, Siew, Chong and Lee (2015) found that fifth graders who worked collaboratively in groups and employed a structured problem solving process as well as a common set of procedures showed improvement in scientific creativity. Numbered Heads Together (NHT) is known as a set of procedures for cooperative structures and is well researched in group work. The use of NHT has been proven to increase students' scientific creativity (Maulana, 2014). Consequently, it is essential to investigate whether NHT can help to address the problem arising from group work in PBL.

Numbered Heads Together (NHT)

Numbered Heads Together (NHT) is a cooperative learning (CL) strategy that combines the components of teacher-directed and peer-mediated instruction while using a distinct teacher questioning strategy that encourages active student participation (Maheady, Michielli-Pendl, Harper, & Mallette, 2006). Kagan (1989) describes four step cooperative structures of NHT in which teachers: (1) assign students to small and heterogeneous learning group consisting of four members and each student has a number in the group, (2) ask question(s), (3) tell the students to "put heads together" to come up with the best answers and everyone in the group knows the answer to the question given, and (4) call a number and students with that number raise their hand to respond the answer. Although NHT has gained interest in research especially in secondary and primary school classrooms, research on preschoolers' creativity is lacking. Kyndt, Raes, Lismont, Timmers, Cascallar, and Dochy (2013) performed a meta-analysis from 1995 onwards on the effects of different methods of cooperative learning on achievement, attitudes and perception yet did not mention NHT. The meta-analysis focused on primary, secondary or tertiary education conducted in real-life classrooms. Evidently, the meta-analysis showed that studying the effects of cooperative learning strategy that is, the NHT, on students' creativity at the preschool level, is worthy of receiving attention. Moreover, NHT has been proven effective in increasing class participation among all students within a classroom (Hunter, 2011), and fostering seventh graders' scientific creativity (Maulana, 2014). These findings raise the question, "To what extent

ISSN 1648–3898

does CL 'Numbered Heads Together' (NHT) help problem-based learning to increase the ability of preschoolers to think creatively about science?" Tackling questions such as this, particularly in preschool settings often requires innovative solutions and supportive curriculum guidelines. There is a need to identify an appropriate or integrated teaching approach which explicitly promotes scientific creativity among preschoolers.

Integration of Numbered Heads Together with Problem Based Learning

This research employed an integrated approach where Numbered Heads Together was meshed together with PBL in a preschool classroom, namely problem-based learning with CL Numbered Heads Together (PBL-CL'NHT'). In this instructional method, the students were taught explicitly about team work and then prompted to undergo the PBL process to think creatively for scientific solutions. 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. Thus, this research attempted to examine the effects of PBL-CL'NHT' on preschoolers' trait dimensions of scientific creativity.

The Theoretical Model of Scientific Creativity

The theoretical model of scientific creativity in this research is based on the Scientific Creativity Structure Model (SCSM) proposed by Hu and Adey (2002), with minor changes to suit to the level of preschoolers. The improved SCSM (Figure 1) was used to guide the development of test items and learning module through three dimensions namely Product, Trait and Process. The validity of SCSM was established through several studies (Aktamıs, Şahin-Pekmez, Can, & Ergin, 2005; Pekmez, Aktamis, & Taskin, 2009).

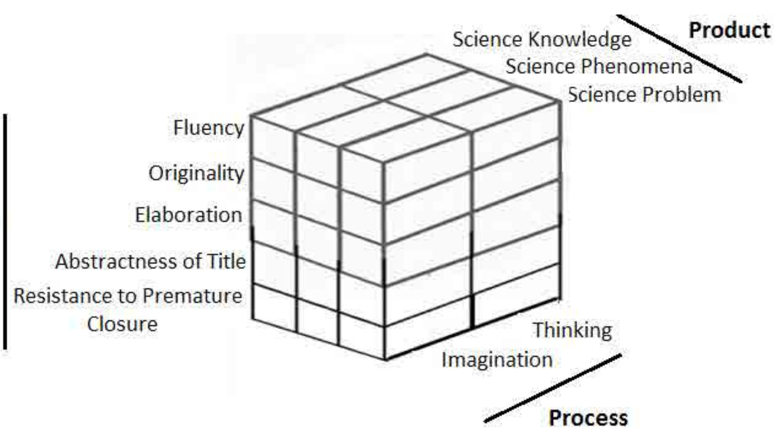

Figure 1: The improved Scientific Creativity Structure Model for scientific creativity.

In regards to this research, an operational definition of trait dimension of scientific creativity refers to Torrance, Ball, and Safter (2008)'s creative abilities of producing i) a variety of different ideas [Fluency (F)]; ii) ideas that are unusual or unique [Originality (O)]; iii) ideas that could be developed or embellished [Elaboration (E)]; iv) abstract title for the drawings [Abstractness of Title (A)]; and v) an open mind and work on available information from a variety of perspectives [Resistance to Premature Closure (R)].

Purpose of Research

Past studies indicated that students may not be able to automatically develop team working skills even though they are assigned to groups in PBL (Wee, 2005). Without proper support, problems may arise during discussions in the small groups resulting in an unpleasant learning experience (Peterson, 2004). The literature shows that students' scientific creativity is cultivated when NHT or PBL is used in the learning activities. It is apparent that an integrated approach which provides explicit guide for preschoolers in the PBL process according to the principles of CL-NHT would positively enhance preschoolers' trait dimension of scientific creativity. As yet, little is known on the positive effects of this integrated approach on the domain-specific creativity at the pre-schooling level. Thus, the overall goal of the present research is to find out the extent to which the PBL-CL instructional method would foster students' scientific creativity compared to the PBL and hands-on method.

This research, therefore, tested the 'Integrated Approach' hypothesis against the 'Non-Integrated approach' hypothesis by employing the PBL-CL'NHT' and PBL intervention method to investigate how far these interventions facilitated students' scientific creativity within a PBL-CL'NHT' and PBL environment. In addition, the research explored the extent to which the PBL-CL'NHT' and PBL instructional method affected learning compared to Hands-on (TG) method. Thus, three intervention methods were employed in this research: the PBL-CL'NHT', PBL and TG method. Accordingly, the following hypothesis was postulated:

> Preschoolers taught via PBL-CL'NHT' instructional method will perform significantly higher than preschoolers taught via PBL instructional method who, in turn, will perform significantly higher than preschoolers taught via Hands-on (TG) instructional method on five trait dimensions of scientific creativity namely i) Fluency (F), ii) Originality (O), iii) Elaboration (E), iv) Abstractness of Title (A), and v) Resistance to Premature Closure (R).

Research Methodology

Research Design

The research employed a quasi-experimental pre-test and post-test control group design to examine the effects of three different instructional methods on preschoolers' trait dimension of scientific creativity. The independent variable was the three instructional methods: the PBL-CL 'NHT' (treatment 1), PBL (treatment 2) and Hands-on (control group). The dependent variables were students' five trait dimensions of scientific creativity namely i) Fluency, ii) Originality, iii) Elaboration, iv) Abstractness of Title, and v) Resistance to Premature Closure.

Research Sample

The research population consisted of 1025 six-year-old preschoolers from 19 preschools in Kota Kinabalu, Sabah, Malaysia (Kota Kinabalu District Education Office, 2015). This research was conducted among six-year-old preschoolers in three urban preschools in the Kota Kinabalu district. The three schools were randomly selected from 19 preschools based on the similar pre-test mean score gained by its preschoolers in the FSCT Form A. A total of 216 six-year-old preschoolers were involved: 72 preschoolers were selected from each preschool with the consent of the preschools' principals and the Kota Kinabalu District Education Office. Preschoolers comprised of 113 (52 %) girls and 103 (48 %) boys. The three classes in the selected preschools were randomly assigned to one of the conditions as intact groups: the PBL-CL'NHT' method, PBL method, or the TG method. All 216 students participated in the experimental research within the same week but according to different class schedules over a period of six weeks.

Research Instrument

The Figural Scientific Creativity Test (FSCT) developed by researchers was used to assess the trait dimension of scientific creativity among the preschoolers (Chin & Siew, 2015). Two equivalent and parallel FSCT tests were used as pre-test (Form A) and post-test (Form B). Each parallel FSCT test consisted of six items which were constructed based on Scientific Creativity Structure Model proposed by Hu and Adey (2002) and scored using a scoring criteria adapted from Torrance *et al*. (2008). The items were developed through three dimensions called the product (scientific knowledge, scientific phenomena and scientific problem), the process (imagination and thinking), and the trait (fluency, originality, elaboration, abstractness of title, and resistance to premature closure).

The FSCT items (Form A and B) required responses that were mainly drawings in nature and a small amount of writing was required from the preschoolers when they were directed to label or name the drawing they have drawn. All items showed discrimination coefficient range of 0.22 to 0.40. The Cronbach Alpha internal consistency coefficient was found to be 0.806. The item-total correlations range was within 0.541 to 0.866. The correlations between scorers varied from 0.780 to 0.933. FSCT was found to have a total of six items on one factor as a result of the exploratory factor analysis. Thus, FSCT was found as a reliable and valid instrument in assessing scientific creativity of six-year-old preschoolers.

ISSN 1648–3898

Each FSCT item required ten minutes to complete and the actual drawing time was 60 minutes. The Form A was used as pre-test and Form B as post-test in treatment groups and control group prior to the start of the intervention and after the intervention was completed.

The Implementation of Instructional Methods

The primary goal of this research was to assess preschoolers' five traits dimension of scientific creativity (fluency, originality, elaboration, abstractness of title, and resistance to premature closure) using PBL-CL 'NHT' method as compared to the performance with PBL and TG method. The following discussion was aimed to distinguish the implementation of these three methods.

PBL-CL 'NHT'

The PBL-CL 'NHT' learning module was utilized in the PBL-CL 'NHT' method. The learning module was developed based on the integration of the Seven Steps of Schmidt (1983)'s PBL model, Numbered Heads Together cooperative learning structure, and Directed Creative Process Model. The PBL-CL'NHT' learning module was administered in six separate activities in six weeks, with 60 minutes for each activity. In this research, teachers acted as a facilitator, monitored groups and intervened to provide task assistance if needed. The learning module was found to have an acceptable reliability, good content validity and high acceptability of preschoolers (Chin, Siew & Sombuling, 2016).

The preschoolers were assigned to heterogeneous group comprising four members in each group with no partiality to different backgrounds (e.g. gender, ethnicity, and social variations). The preschoolers' groups were formed by their teacher in such a way that each group inclusive of two high and two low ability children based on the scoring in FSCT Form A. Each preschooler in the PBL-CL 'NHT' group was identified by a number (one to four). Open-ended, ill structured and real-world problems with no straightforward solutions were presented to preschoolers as follows:

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?

All the preschoolers "put heads together" in the group to come up with the best answers. Finally, the teacher randomly called out a number and the preschoolers with the number called would raise up their hand to respond. Thus, the four basic elements of Kagan's CL structures (positive interdependence, individual accountability, equal participation, and simultaneous interaction) were embedded in the PBL-CL 'NHT' method.

PBL

The preschoolers in the PBL group were exposed solely to PBL. They were assigned to collaborative learning with an unstructured group. The preschoolers were given the choices to select their group members and determine their group size. Preschoolers formed groups with whoever they wanted or whoever was sitting next to them. Thus, the groups were made up of preschoolers who might have similar or different abilities in scientific creativity. This might have resulted with either all group members having high scientific creativity or groups with mix or low abilities of scientific creativity. Furthermore, the four basic elements of Kagan's cooperative learning structure were not emphasized during the learning process. The preschoolers were assumed to know how to work together and built up teamwork skills. They carried out the PBL activities as a group in an unstructured and loosely monitored way.

TG

Pre-schooners in the TG group were exposed to hands-on activities and group work. They were given freedom to choose members in a group with whom they most preferred or desired to work. However, the teacher did not monitor the functioning of the groups. As the preschoolers faced difficulties during the hands-on activities, they asked for teacher's assistance and the teacher gave the answers. Hence, the preschoolers in TG group lacked identify as well as problem solving and cooperative skills.

The Training of Teachers

In order to procure similar and equal 'teacher quality' in the research, all the teachers involved were trained to use and conduct the PBL-CL'NHT' module, PBL and hand-on activities two weeks before the study. The teachers were provided with detailed lesson plans with the same content outline to conduct the learning activities in PBL-CL, PBL and TG method. The researcher guided the teachers through the lesson plans and the teachers were to apply the same method to guide the preschoolers during the intervention. The teachers were given information about the learning objectives, the instructional process, rules for working in a cooperative group, group members' roles, and the assessment procedure.

Throughout the study, the researcher visited the preschool teachers to ensure fidelity to the intervention based on the schedule of meeting. The researcher met the teachers to discuss several issues related to implementation of PBL-CL'NHT' module, PBL activities, and hands-on activities. At the end of the intervention, the FSCT Form B was administered to the three groups in each preschool. Preschoolers answered the test individually and scores were calculated as an indicator of the change of their scientific creativity.

Data Analysis

Quantitative data were collected through the FSCT Form A and Form B. Descriptive statistics were calculated for standard deviations and means. The equivalence of the research groups at pretests was examined using MANOVA through the scores obtained from Form A (Pre-F, Pre-O, Pre-E, Pre-A, Pre-R, and Pre-SC). In this study, the Pre-F, Pre-O, Pre-E, Pre-A, Pre-R served as covariates for the instructional groups, serving to adjust for possible preexisting differences between the groups.

Preliminary Analysis

Preliminary analysis was conducted to check whether the prerequisite assumptions of MANOVA / MANCOVA were met. Thus, the assumptions to MANOVA / MANCOVA in the statistical analysis were examined for: (a) multivariate normal distribution, (b) equality of group population covariance matrices, (c) linear relationship between covariates and dependent variables, (d) absent of multicollinearity, and (e) homogeneity of dependent variable variance. The assumptions that were used for the MANCOVA/MANOVA and inferential statistics analyses were tested using SPSS for Windows (Version 22). Alpha value was set at 0.05, level of significance.

Pre-Experimental Research

The purpose of pre-experimental research was to test the assumption that the respondents across the three instructional groups were equivalent in their trait dimension of Pre-F, Pre-O, Pre-E, Pre-A, and Pre-R. One-way multivariate analysis of variance (MANOVA) was performed to examine if there were statistical significant differences among the preschoolers' mean score on Pre-F, Pre-O, Pre-E, Pre-A, and Pre-R across the three instructional groups. The univariate F test (ANOVA) was conducted to further examine if there were significant statistical differences between students across the three instructional groups in each of the pretest. If the overall multivariate test (MANOVA) was not significant, univariate F test (ANOVA) was examined to further identify the presence or non-presence of significant statistical differences between students across the three instructional groups in each of the pre-tests.

A multivariate analysis of covariance (MANCOVA) was conducted (with pre-tests as the covariates) to investigate the main effects of the three different instructional methods on students' Post-F, Post-O, Post-E, Post-A, and Post-R, while controlling the five covariates. By employing the MANCOVA, the extraneous differences among groups can

ISSN 1648–3898

≤≥

be controlled after removal of the effects of covariates from the dependent variables (Hair, Anderson, Tatham, & Black, 2010). If the overall multivariate test (MANCOVA) was significant, univariate F test (ANCOVA) was carried out on post-test mean scores with pre-test mean scores as covariates to further examine if there was a significant statistical main effect of instructional groups on each of post-tests.

The effect size index (f) and eta square (η^2) were calculated. According to Cohen's rough characterization (Cohen, 1988, p. 284-288), 0.2≤ f < 0.5 is deemed as a small size effect, 0.5≤ f < 0.8, a medium size effect, and f ≥ 0.8 as the large size effect (for interpreting η^2, 0.010≤ η^2 ≤ 0.039= small, 0.039< η^2 ≤ 0.11= medium, and 0.11 < η^2 ≤ 0.20 = large effect size).

Results of Research

Preliminary Analysis

Preliminary analysis indicated an adequate conformity to all univariate and multivariate assumptions of MANOVA/MANCOVA for: (a) multivariate normal distribution, (b) linear relationship between covariates and dependent variables, (c) absent of multicollinearity, and (d) homogeneity of dependent variable variance. However, the equality of group population covariance matrices assumption in this study was violated in both FSCT Form A (Box's M = 315.928, F (42, 1.347) = 7.220, *p* < .01) and Form B (Box's M = 434.952, F (42, 1.347) = 9.941, *p* < .01). According to Grice and Iwasaki (2007), the violation for equality of group population covariance is common in MANOVA and MANCOVA analyses and easily addressed by using Pillai's trace to assess for model significance. Thus, Pillai's trace was used as the multivariate test statistic to interpret results of the MANOVA and MANCOVA analyses.

Descriptive statistics

The descriptive statistics of preschoolers' pre-test and post-test scores on their five trait dimensions of scientific creativity are summarized in Table 1.

Table 1. Descriptive statistics of the dependent variables.

Dependent Variables	Intervention Group	N	Pre-test		Post-test	
			Mean	SD	Mean	SD
Fluency (F)	PBL-CL'NHT'	72	15.03	5.716	29.75	9.631
	PBL	72	14.94	5.686	23.54	8.387
	TG	72	14.72	5.700	18.78	10.628
	Total	216	14.90	5.676	24.02	10.556
Originality (O)	PBL-CL'NHT'	72	10.22	5.554	22.97	10.706
	PBL	72	10.06	5.723	16.69	9.852
	TG	72	9.39	4.975	13.12	10.489
	Total	216	9.89	5.414	17.60	11.085
Elaboration (E)	PBL-CL'NHT'	72	15.64	5.805	30.57	9.757
	PBL	72	15.44	6.250	24.42	9.151
	TG	72	15.04	5.968	19.06	10.706
	Total	216	15.38	5.988	24.68	10.917
Abstractness of title (A)	PBL-CL'NHT'	72	12.24	6.236	25.26	12.418
	PBL	72	11.94	6.093	21.10	8.309
	TG	72	12.08	5.816	14.42	11.577
	Total	216	12.09	6.024	20.26	11.749

Resistance to premature closure (R)	PBL-CL'NHT'	72	9.06	4.182	17.96	6.094
	PBL	72	8.89	4.208	14.85	6.175
	TG	72	8.62	4.109	11.72	6.789
	Total	216	8.86	4.151	14.84	6.826

The Pre-experimental Research Results

MANOVA analysis

The results of MANOVA and ANOVA indicated that there were no significant statistical differences across the three groups in Pre-F, Pre-O, Pre-E, Pre-A, and Pre-R (Table 2).

Table 2. Summary of multivariate analysis of variance (MANOVA) results and followed-up ANOVA results on pre-test mean scores.

MANOVA effect and dependent variables	Multivariate F	Univariate F
Group Effect	df = 12, 418 Pillai's Trace F = .389, P = .967	df = 2, 213
Pre-F		F = .055, p = .946
Pre-O		F = .475, p = .622
Pre-E		F = .185, p = .831
Pre-A		F = .042, p = .959
Pre-R		F = .195, p = .823

The Experimental Research Results

The results of MANCOVA indicated significant main effects for instructional methods on dependent variables [Pilai's Trace =.485, F (6, 202) = 29.698, p < 0.05]. Follow-up ANCOVA showed that there were significant main effects of instructional methods on fluency [F(2, 212) = 23.530, p < .05, η^2 =.182], originality [F(2, 212) = 16.229, p < .05, η^2 = .133], elaboration [F (2, 212) = 24.130, p < .05, η^2 =.185,], abstractness of title [F(2, 212) = 18.084, p < .05, η^2 =.146], resistance to premature closure [F (2, 212) = 17.005, p < .05, η^2 =.138]. A high relationship between the instructional method and dependent variables was obtained, indicating that 18.2% (fluency), 13.3% (originality), 18.5% (elaboration), 14.6% (abstractness of title) and 13.8% (resistance to premature closure) of the variance obtained was accounted by the instructional methods.

Further testing using the Post hoc Pair-wise test revealed that preschoolers in the PBL-CL 'NHT' method significantly outperformed their peers in the PBL group (P_F <. 05, P_O <. 05, P_E <. 05, P_A =.024, and P_R=.004, respectively), who in turn, significantly outperformed their peers in the TG group (P_F =.062, P_O <. 05, P_E =.001, P_A <. 05, and P_R=.004, respectively) in Fluency, Originality, Elaboration, Abstractness of title, and Resistance to premature closure (Table 3). Therefore, the research hypothesis was supported.

Table 3 shows a large effect size in the comparison between the PBL-CL'NHT' and TG methods in Fluency (1.1), Originality (0.9), Elaboration (1.1), Abstractness of title (0.9), and Resistance to premature closure (1.0). Meanwhile, the analysis showed a moderate to small effect size for the comparison between PBL-CL'NHT' and PBL in Fluency (0.7), Originality (0.6), Elaboration (0.7), Abstractness of title (0.4), and Resistance to premature closure (0.5). On the other hand, a medium to small effect size was observed for comparing the PBL and TG methods in Fluency (0.5), Originality (0.4), Elaboration (0.5), Abstractness of title (0.7), and Resistance to premature closure (0.5).

ISSN 1648–3898

Table 3. Summary of post hoc pairwise comparison.

Comparison Group	Mean Difference	Sig.	Effect size	Interpretation
Fluency				
PBL-CL 'NHT' vs PBL	6.198	<. 05	0.7	Medium
PBL- CL'NHT' vs TG	10.936	<. 05	1.1	Large
PBL vs TG	4.737	.062	0.5	Medium
Originality				
PBL- CL'NHT' vs PBL	6.247	<. 05	0.6	Medium
PBL- CL'NHT' vs TG	9.691	<. 05	0.9	Large
PBL vs TG	3.445	<. 05	0.4	Small
Elaboration				
PBL- CL'NHT' vs PBL	6.138	<. 05	0.7	Medium
PBL- CL'NHT' vs TG	11.468	<. 05	1.1	Large
PBL vs TG	5.330	.001	0.5	Medium
Abstractness of Title				
PBL- CL'NHT' vs PBL	4.123	. 024	0.4	Small
PBL- CL'NHT' vs TG	10.824	<. 05	0.9	Large
PBL vs TG	6.701	<. 05	0.7	Medium
Resistance to premature closure				
PBL- CL'NHT' vs PBL	3.088	. 004	0.5	Medium
PBL- CL'NHT' vs TG	6.177	<. 05	1.0	Large
PBL vs TG	3.089	.004	0.5	Medium

Discussion

Overall, this research finding showed that preschoolers taught via the PBL-CL'NHT' method performed significantly better than preschoolers taught via the PBL method. It was also noted that preschoolers taught via the PBL method performed significantly better than preschoolers taught via the TG method in these trait dimensions of scientific creativity of i) Fluency, ii) Originality, iii) Elaboration, iv) Abstractness of Title, and v) Resistance to Premature Closure. A large effect size of more than 0.8, and moderate to small effect size for comparing the PBL-CL'NHT' and TG method, and the PBL-CL'NHT' and PBL method respectively indicates that the PBL-CL'NHT' method is the most effective instructional method amongst the three in promoting the trait dimensions of i) Fluency, ii) Originality, iii) Elaboration, iv) Abstractness of title, and v) Resistance to premature closure among preschoolers. Overall, preschoolers taught via PBL method outperformed those taught via the TG method with a relatively medium to small effect size.

PBL-CL'NHT'

Cooperative learning 'NHT' created conducive environments for developing team working skills as the preschoolers underwent the PBL process. While solving an ill-structured and real-world science problem as a group, preschoolers were engaged in searching for many ideas from different categories or approaches based on their learned scientific knowledge and relevant practical knowledge. As ill-structured problems did not provide all the information necessary to develop a solution (Chin & Chia, 2006), preschoolers were occupied with thinking of different ideas and combining them in new ways to generate solutions. This is supported by Chen and Bradshaw (2007) who posit that ill structured problems demand learners to consider alternative solutions as well as handle competing solutions. Through this learning process, there was an increased likelihood that a larger number of responses would be given by the preschoolers. Consequently, this contributed to an increase in the fluency mean scores with the application of PBL-CL'NHT' method.

Similarly, in the stage of "putting heads together", all the group members were engaged to brainstorm and come up with many new ideas. Each member of the group was involved in the thinking and talking processes as they worked collectively to respond to the question. This supportive atmosphere is conducive for the development of many uncommon or original responses. As Sawyer (2003) stated "two or more people do something together pursuing a novel and appropriate outcome". As a consequence, preschoolers learning with PBL-TM methods were able to gain significantly higher mean scores in Originality compared to their peers in the PBL and TG methods.

In addition, the preschoolers taught with the PBL-CL'NHT' method were assigned to heterogeneous learning groups. The learning activities cultivated productive interaction among preschoolers of different knowledge and backgrounds. Some preschoolers acted as experts by elaborating ideas by incorporating details to amplify the simple idea suggested by the group members. They scaffolded their peers by offering hints and feedback to add more information in the existing idea. The group members then resolved their differing perspective by adding details to the idea to create a more complex outcome. Hence, the preschoolers became more proficient at elaborating ideas during the PBL-CL'NHT' learning process compared to their peers in the PBL and TG methods. This form of novice-expert cooperative learning represents Vygotsky (1978)'s theory, whereby the preschoolers were assisted by their more capable peers to develop and acquire elaboration skills for the group task. As Vygotsky (1978) argued, children can progress further in their zone of proximal development when they are given a cognitive task with the presence of a more competent peer or adult as compared to a child who does not have these influences.

While solving real life problems cooperatively in PBL-CL'NHT' learning environment, the preschoolers were challenged to select the best materials and solutions for the problems, and drew ideas on the worksheet to justify the group's suggestions. In this way, preschoolers found new ways to represent and generalize their experiences. They learned to make mental pictures in their minds and represented it through the title in the drawing. According to Kim (2012), the various real experiences of learners helped them to think abstractly and beyond the obvious solutions. Thus, preschoolers in PBL-CL'NHT' groups were more capable to think of more abstract title rather than the generic title such as "boy", "nail", "towel", as produced by their peers in the PBL and TG methods.

The role of the teacher has also had positive effects in supporting the preschoolers' performance in the trait dimension of resistance to premature closure. In the context of PBL-CL'NHT' activities, the preschool teachers acted as facilitators. They guided the preschoolers and encouraged open minded thinking during the problem-solving process. The teachers scaffolded preschoolers' comprehension and encouraged them to think of different alternatives rather than a specific closed-ended solution to the problem. With teacher's assistance and well-functioning cooperative 'NHT' method, the preschoolers were trained to search for additional details or information for their ideas to prevent the premature solutions of a problem. This is supported by Tan (2009) who states that teacher who acts as a facilitator helps learners to refrain from making general solutions or unwarranted narrow perceptions. This type of learning environment, according to Gillies (2003) and Lazlo (2013) is conducive for the development of available information from a variety of perspectives (Resistance to premature closure).

As a result, preschoolers who worked in PBL-CL 'NHT' method significantly outperformed the preschoolers taught via the PBL and the TG methods concerning the traits dimension of fluency, originality, elaboration, resistance to premature closure, and abstractness of title. This finding is supported by Relter-Palmon *et al* (2012) who posit that information sharing and communication have been identified as key factors that can improve learners' creative outcomes.

PBL

On the other hand, the teachers who taught the PBL method did not expose their preschoolers to CL 'NHT' structures and team working skills. Such a situation did not provide a comfortable environment for preschoolers to work and share ideas with group mates. Pease (2009) states that learner takes time to adapt to a collaborative context and develop teamwork skills. As a result, the preschoolers taught via PBL method had less opportunities to participate in providing ideas, discussion, and explanation on solutions. Thus, they were unable to generate as many ideas as their peers working in PBL-CL group that are unique, novel, and uncommon ideas to solve a problem.

ISSN 1648–3898

Additionally, preschoolers in the PBL group tended to give a few details on their ideas without considering other possible essential elements from their peers. Indirectly, the preschoolers were more inclined to produce simple and generic titles in their less elaborated drawing. Some group members might be the passive learner in a group work. Consequently, they did not become individually accountable to their peers in discussion, sharing of ideas, and suggestion of new ways to solve a problem. Without peer support, some preschoolers would tend to leap their ideas prematurely without considering the available information suggested by their peers. Subsequently, preschoolers who were involved in the PBL method did not significantly outperformed their peers taught via the PBL-CL 'NHT' in Elaboration, Abstractness of title, and Resistance to premature closure mean scores.

TG

In contrast, the teachers in the TG group did not expose their preschoolers to ill-structured problems and team working skills. No specific attention was given to creating a general feeling of cooperation within the groups in solving real life problems. Thus, there were limited opportunities for preschoolers to discuss, share, contribute, add more details, keep open and delay closure on their ideas with one another. A supportive learning community as suggested by Cochrane (2012) was lacking within the TG groups for the development of trait dimension of scientific creativity. Therefore, preschoolers in the TG group did not foster as much fluency, originality, elaboration of ideas, imaginative and abstract title, and resistance to premature closure as preschoolers who had participated in the PBL-CL 'NHT' and PBL group.

Conclusions

The present research does indicate that preschoolers' domain-specific creativity in science lessons can be enhanced through PBL-CL'NHT' instructional methods. Conclusively, preschoolers taught using PBL-CL'NHT' methods could benefit from the NHT cooperative learning structure to foster their trait dimensions of scientific creativity more effectively, as compared to being taught with only the PBL and TG methods. In other words, creating a learning environment using PBL alone is not a sufficient condition to effectively promote scientific creativity within a preschool classroom. An NHT method that has a clear cooperative structure is necessary to increase the PBL's effectiveness. This research exhibits that emphasis on carefully structured cooperative learning in the teaching and learning of preschool science lessons using PBL would foster preschoolers' fluency, originality, elaboration of ideas, imaginative and abstract title, and resistance to premature closure.

This research has contributed substantive proof that preschool teachers need to integrate NHT and PBL in their science lessons to inculcate scientific creativity among preschoolers. Interim, this research also supports new research examining the potential effects of an integrated approach using different CL learning structures and instructional methods in fostering domain-specific creativity among preschoolers.

Nevertheless, the research findings do have some limitations. The 72 preschoolers that were involved per instructional method may not be representative of the whole population of Malaysian preschoolers. The quantitative research data were collected after 10 hours of preschoolers' learning experiences. A mixed methods approach with a larger sample size, detailed comparison between rural and urban preschools, and a longer period of extra learning activities is required for future research.

Acknowledgements

The research was supported by the University of Malaysia Sabah (UMS), Malaysia under Grant No. FRG0394-SSI-2/2014. Any opinions, viewpoints, findings, conclusions, suggestions, or recommendations expressed are the authors and do not necessarily reflect the views of the University of Malaysia Sabah, Malaysia.

References

Aktamış, H., Şahin-Pekmez, E., Can, B.T., & Ergin, O. (2005). *Developing scientific creativity test*. University of Dokuz Eylul. Retrieved October 02, 2016, from http://www.clab.edc.uoc.gr/2nd/pdf/58.pdf

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.

Bilgin, I., Senocak, E., & Sozbilir, M. (2009). The effects of problem-based learning instruction on university students' performance of conceptual and quantitative problems in gas concepts. *Eurasia Journal of Mathematics, Science & Technology Education*, *5* (2), 153-164.

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.

Chew, E. S., & Madar, A. R. (in press). Patterns and trends of research related to creativity or creative thinking on post-graduate level in Malaysia. *Journal of Education Thinkers.*

Chin, C., & Chia, L. G. (2006). Problem-based learning: Using ill-structured problems in biology project work. *Science Education*, *90*, 44-67.

Chin, M.K. & Siew, N.M. (2015). The development and validation of a figural scientific creativity test for preschool pupils. *Creative Education*, *6*, 1391-1402.

Chin, M.K. & Siew, N.M., Sombuling, A. (2016). Development and evaluation of a problem based learning with cooperative learning module on preschoolers' scientific creativity. *Proceedings of the international conference on education and higher order thinking skills (ICE-HOTS)* 2016, ISBN 978-967-0194-72-1, pp. 285-296, Faculty of Education, UTM.

Cochrane, T. (2012). Secrets of M-learning failures: Confronting reality. *Research in Learning Technology, ALT-C Conference Proceedings*. Retrieved September 12, 2016, from http://dx.doi.org/10.3402/rlts 2010.19186.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences.* Hillsdale, NJ: Lawrence Erlbaum Associates.

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). *Handbook of creativity development and practice in teaching and learning*. Malaysia Ministry of Education: Kuala Lumpur.

Demirel, M., & Dagyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science & Technology Education*, *12* (8), 2115-2137.

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.* London: Routledge, pp. 89-99.

Etherington, M. B. (2011). Investigative primary science: A problem-based learning approach. *Australian Journal of Teacher Education*, *36* (9), 53.

French, A., Macedo, M., Poulsen, J., Waterson, T. & Yu, A. (2002). *Multivariate analysis of variance.* Retrieved 19 October, 2016, from online.sfsu.edu/efc/classes/biol710/manova/MANOVAnewest.pdf

Gillies, R. M.2003. Structuring cooperative group work in classrooms. *International Journal of Educational Research*, *39* (1), 35–49.

Grice, J., & Iwasaki, M. (2007). A truly multivariate approach to Manova. *Applied Multivariate Research, 3,* 199-226.

Hair, F. J., Anderson, E., Tatham, L. & Black, C. (1998). *Multivariate data analysis.* 5th ed. New Jersey: Prentice Hall.

Holen, A. (2000). The PBL group: Self-reflections and feedback for improved learning and growth. *Medical Teacher, 22* (5), 485-488.

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., and 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.

Kagan, S. (1989). The structural approach to cooperative learning. *Educational leadership*, *47* (4), 12-15.

Kim, K.H. (2012). *The 2012 Torrance Lecture: The creativity crisis*. The Creativity Post. 10 July 2012.

Kota Kinabalu District Education Office. (2015). *Preschool student statistics*. Kota Kinabalu: Malaysian Ministry of Education.

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.

Kyndt, E., Raes, E., Lismont, B., Timmers, F., Cascallar, E., & Dochy, F. (2013). A meta-analysis of the effects of face-to-face cooperative learning. Do recent studies falsify or verify earlier findings? *Educational Research Review*, *10*, 133-149.

Lazlo, I. 2013. Cooperative learning in the kindergarten. *Preschool Inspector*, *4* (3), 98-104.

Maheady, L., Michielli-Pendl, J., Harper, G., & Mallette, B. (2006). The effects of numbered heads together with and without an incentive package on the science test performance of a diverse group of sixth graders. *Journal of Behavioral Education, 15* (1), 25-39.

Malan, S. B., Ndlovu, M., & Engelbrecht, P. (2014). Introducing problem-based learning (PBL) into a foundation programme to develop self-directed learning skills. *South African Journal of Education*, *34* (1), 1-16.

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.

Mirzaie, R. A., Hamidil, F., & Anaraki, A. (2009). A study on the effect of science activities on fostering creativity in preschool children. *Journal of Turkish Science Education, 6* (3), 81-90.

Murray-Harvey, R., Pourshafie, T., Santos Reyes, W. (2013). What teacher education students learn about collaboration from problem-based learning. *Journal of Problem Based Learning in Higher Education*, *1* (1), 114-134.

Mustaff, N., & Ismail, Z. (2014). *Problem-based learning (PBL) in Schools: A meta-analysis*. Retrieved March 27, 2016 from http://directorymathsed.net/montenegro/Mustaffa.pdf.

ISSN 1648–3898

Osman, K., & Kaur, S. J. (2014). Evaluating biology achievement scores in an ICT integrated PBL environment. *Eurasia Journal of Mathematics, Science & Technology Education*, *10* (3), 185-194.

Pease, M. A. (2009). *Experimental investigation of the effectiveness of problem-based learning* (Order No. 3373546). Available from Education Collection. (304864773). Retrieved April 16, 2016, from http://search.proquest.com/docview/304864773?accountid=44242

Pekmez, E. Ş., Aktamis, H., & Taskin, B. C. (2009). Exploring scientific creativity of 7th grade students. *Journal of Qafqaz University*, *26*, 204-214.

Perterson, M. (1997). Skills to enhance problem-based learning. *Medical Education Online*, *2* (3). Retrieved February 12, 2016 from med-ed-online.net/index.php/meo/article/ download/4289/4480.

Peterson, T.O. (2004). So you're thinking of trying problem based learning? Three critical success factors for implementation. *Journal of Management Education*, *28* (5), 630-646.

Pfaff, E., & Huddleston, P. (2003). Does it matter if I hate teamwork? What impacts student attitudes toward teamwork? *Journal of Marketing Education*, *25* (1), 37-45.

Reiter-Palmon R, Wigert B, de Vreede T. (2012). Team creativity: The effect of group composition, social processes and cognition. In: M.D. Mumford (Ed.), *Handbook of organizational creativity* (pp. 295–326). London: Elsevier.

Sawyer, K. (2003). Emergence in creativity and development. In K. Sawyer (ed.), *Creativity and Development.* (pp. 12–60). Oxford: Oxford University Press.

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 July 23, 2016, 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.

Tan, O. S. (2000). Thinking skills, creativity and problem-based learning. In O. S. Tan, P. Little, S. Y. Hee & J. Conway (eds.), *Problem-based learning: Educational innovation across disciplines*. Singapore: Temasek Centre for Problem-based Learning.

Tan, O. S. (2009). *Problem based learning and creativity*. Singapore: Cengage Learning Asia Pte Ltd.

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.

Tarhan, L., & Acar-Sesen, B. (2013). Problem based learning in acids and bases: Learning achievements and students' beliefs. *Journal of Baltic Science Education*, *12* (5), 565-578.

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.

Wee, M.L. (2005). An account of students' learning experience in an engineering PBL subject: Implications for implementation, In K. Tan, M. Lee, J. Mok and R. Ravindran (eds), *Problem-based learning: New directions & approaches.* pp 69-83. Singapore: Learning Academy, Temasek Polytechnic.

Vygotsky, L. S. 1978. *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Yeung, E., Au-Yeung, S., Chiu, T., Mok, N. & Lai, P. (2003). Problem design in problem-based learning: evaluating students' learning and self-directed learning practice. *Innovations in Education and Teaching International*, *40*, 237-244.

Received: *October 05, 2016*   Accepted: *January 25, 2017*

Nyet Moi Siew PhD, Senior Lecturer, Faculty of Psychology and Education, University of Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.
E-mail: snyetmoi@yahoo.com

Mui Ken Chin MSc, PhD Student, Faculty of Psychology and Education, University of Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.
Email: lilycmk2007@yahoo.com

Agnis Sombuling MA, Senior Lecturer, Faculty of Psychology and Education, University of Malaysia Sabah, Kota Kinabalu, Sabah, Malaysia.
E-mail: agness@ums.edu.my