EFFECTIVENESS OF PROJECT-BASED LEARNING AND 5E LEARNING CYCLE INSTRUCTIONAL MODELS

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Abstract

This study was aimed at determining and comparing the effectiveness of project-based learning and 5E learning cycle instructional models in improving the acquisition of new biological knowledge related to the human immune system. This quasi experiment study with a pretest-posttest non-equivalent control group design was conducted in SMAN 1 and SMAN 8 Yogyakarta, Indonesia during the academic year 2018/2019. A cluster sampling technique was used to select 3 eleventh grade classes of natural science from each school. The criterion referenced essay test was used to measure the students' learning achievements and the data collected were analyzed using SPSS version 23. The results show that both PjBL and 5E learning instructional models were effective to improve the students' ability to acquire new biological knowledge related to the human immune system. PjBL model was more effective than 5E learning cycle model in improving the students' ability to acquire new biological knowledge related to the human immune system.

Keywords: *project-based learning, 5E learning cycle, human immune system*

INTRODUCTION

Currently in this 21st century, the world is faced with complex challenges in different sectors such as health, education, economic, environmental, geopolitical, societal, and technological. The challenges faced include intense competitions at work places, deadly diseases with no cure, air pollution, water pollution, among others (World Economic Forum, 2019, p. 6; The Ontario Public Service, 2016, p. 5). According to Harvard Advanced Leadership Initiative (2014, p. 2), in order to be able to overcome the current complex and future challenges, it is very essential for the current education system to focus on developing 21st century competencies among the learners. The 21st century competencies include knowledge (i.e. procedural, factual, conceptual, & metacognitive knowledge), skills (e.g. communication, collaboration, critical thinking, creativity skills, among others), and attributes (e.g. integrity, adaptability, among others) (The Ontario Public Service, 2016, p. 5; Bishop, 2015, p. 2). The 21st Century Curriculum and Instruction that integrates the use suitable & innovative teaching and learning models form part of the supporting systems of an education system that supports development of the 21st century competencies (Bishop, 2015, p. 8). The suitable & innovative teaching and learning models are instructional models that enable learners to become constructive, active participants, collaborative, communicative, creative and critical thinkers (Fullan & Langworthy, 2014, p. 7; McLoughlin & Lee, 2007, p. 8). Some of the innovative and ideal models of instructional in this 21st century include project-based learning (Scott, 2015, p. 5) and 5E learning cycle (Bybee *et al.*, 2006).

Project-based learning (PjBL) is defined by Bender (2012, p. 1), as 'using authentic real-world projects based on a highly motivating and engaging question, task or problem, to teach students academic content in the context of working cooperatively to solve the problem. Project-based learning involves an elaborate student-centred inquiry process driven by well-structured challenging question/problem investigated by learners using organised learning tasks to produce a product that answers that question. During PjBL, learners work on their projects in teams, explore different sources of information, critique each other's' work, create authentic and meaningful products, and present the product to the public (Hallermann, Larmer, & Mergendoller, 2011). Generally, PjBL instructional model involves seven stages/phases of instruction with different activities in which the learners are able to experience learning as they work on their projects (Du & Han, 2016; Patton & Robin, 2012, p. 33).

The *first* stage of project-based learning is developing the project idea (Patton & Robin, 2012, p. 34; NYC Department of Education, 2009, p. 12). This involves activities (such as watching/reading news about the current issues, asking some questions to students, assigning some tasks to the students e.g. asking the students to read/watch some textbook) that stimulate and motivate the students to get ready to learn (Hallermann *et al.,* 2011). From the project idea developed, the challenging question/problem is then generated which serves to 'getting students to think about the complexities around issues, scientific principles, and events' (NYC Department of Education, 2009, p. 12).

The challenging question/problem communicates the purpose of the project and give students a foundation and direction for doing the project as well as helping the teacher to maintain consistency, guiding in planning the lessons, resources, and activities that will help students answer it (Hallermann *et al.*, 2011). After identifying the challenging question/problem, the next stage is project designing which aims to clarify student learning goals, project final products, timeline, and instructional activities. It involves activities such as determining the scope of the project, establishing content and skill goals, developing formats for final products, designing instructional activities, developing a balanced assessment plan with rubrics, identifying the technologies to use in the project, planning the activities for launching the project, and finding & arranging resources to use during the project (Patton & Robin, 2012, p. 38; NYC Department of Education, 2009, p. 15).

Following project designing, is the launching of the project with an entry event with the aim to spark off again students' interest and curiosity as they begin the inquiry process/investigation to obtain solution for the challenging question/problem. The entry event takes on forms like discussion/debate about an issue of interest or events in the news related to the developed challenging question, an activity like a movie preview, and or a field trip (Hallermann *et al.*, 2011). Project launching is followed bythe implementation of the project which involves activities such asdeveloping of the key knowledge and success skills to facilitate project activities and development of the product. As project implementation progress, the teacher and students revise the developed product at specified intervals. After development and revision of the product, final product is exhibited to the to the audience (e.g. general public, school, or classmates).

Following the product presentation is the reflection stage involvesboth the teacher and the students flashing back and taking note on the effectiveness of the activities done from the pioneer stage up to the presentation of final product. Finally, the evaluation process is carried out to gather feedback from students about the instruction process and the project activities and using the collected data to plan for re-teaching and to improve the in-coming projects.

On the other hand, 5E Learning cycle (5E LC) is a constructivist instructional model in which learners construct knowledge and meaning through asking questions, exploring different sources of information, explaining and generalizing the information obtained to enhance their understanding as well as carrying out self-evaluation (Bybee *et al.*, 2006). The 5E learning cycle instructional model consists of five phases of instruction each with a specific function and contribution towards the teacher's instructional process and the students' understanding of scientific and technologicalknowledge, attitudes, and skills (Bybee*,* 2009, p. 4).

The first phase of engagement comprises of activities that engage learners into learning tasks e.g. asking some challenging questions, defining some problem, or demonstrating a challenging situation. The engagement phase is followed by the exploration phase which consists of activities that help to establish a common base of discussion for the teacher and learners to identify concepts, processes or skills. The third step is explanation in which the learners are required to make connections between the prior knowledge and new discoveries by explaining their observations and findings in their own words. The learners' explanations are followed by direct, explicit, and formal scientific or technological explanations from the teacher. After explanation, the elaboration follows involving discussion and information seeking activities that help learners to extend their concepts, processes, and skills. This enables the learners to get involved in new situations and discover new problems that require them to use similar understandings/knowledge or generalization of concepts, processes, and skills. The final phase of evaluation involvesself, peer and or teacher assessment of the level understanding of the learners. During evaluation the learners showcase their understanding of new concepts and demonstrate their ability to apply them in solving the problem as well as the teacher giving feedback on the adequacy of learners' explanations and whole process of 5E sequence (Bybee *et al.,* 2006).

Biology is one of the important natural science subjects which equips the with essential knowledge to overcome the complex challenges such as deadly diseases (e.g. cancer, HIV/AIDS, diabetes), air pollution, among others that are currently faced by human. Due to its great importance, Biology occupies a high position in the new 2013 senior high school curriculum of the Republic of Indonesia (Ministry of Education and Culture-Republic of Indonesia, 2012). Therefore, it is very essential to ensure an effective teaching and learning process of biology so as to enable the learners obtain important biological knowledge required to find possible solutions to the current complex and future challenges (OECD, 2016; EI & ASCD, 2015, p. 2).

Despite the great importance of biology in our daily life, reports from international assessment bodies such as the Programme for International Student Assessment (PISA) and Trends in International Mathematics and Science Study (TIMSS) show that Science performance is still among the Indonesian students compared to other countries especially those in the same region of South East Asia. The PISA report about the Science results for 2015 ranked Indonesia the 62nd with an average score of 403 out of PISA average score 493. The Indonesian average score is lower than the average score obtained by other South East Asian countries like Singapore (556), China Taipei (532), Vietnam (525) and European countries like Slovenia (513), and United Kingdom (509), among others (OECD, 2016, p. 7). Also, the report on TIMSS science results for 2015 show that Indonesian learners obtained an average score of 397 out of 500 (the scale centre point for TIMSS). The 397 average score is also lower than the average score obtained by Asian countries like Singapore (590), China Taipei (564), and Korean Republic (560) and Western countries like Poland (547), United States of America (546), and Slovenia (543) (TIMSS, 2015). The low performance in science by the Indonesian students is also showed by the reports from the national level examinations results which indicate that average scores obtained in natural sciences were 56,26% in 2016 and 52,19% during 2017 (Ministry of Education and Culture, Republic of Indonesia, 2017). The low average scores in science are further supported by the findings from several research studies (Novaristiana, Rinanto, & Ramli, 2019; Purwani, Sudargo, & Surakusumah, 2019; Murti, Aminah, & Harjana, 2018).

According to Avikasari, Rukayah, & Indriayu (2018), the students' science performance is influenced by their understanding of science concepts and science literacy abilities. The OECD (2016, p. 50) explains that good science performance in science requires possession of content, procedural, and conceptual dimensions of scientific knowledge. These dimensions of scientific knowledge can be obtained by learners through effective teaching and learning process that uses constructive and innovative instructional models such as project-based learning and 5E learning cycle (Ministry of education and culture, Republic of Indonesia, 2014, p. 84). However, a number of reports indicate that the Indonesian students have continued to maintain a low performance in science due to poor quality teaching and learning process contributed to by the teachers who use conventional instructional models such as personalised instructional models that limit students from acquiring the necessary scientific knowledge (OECD & ADB, 2015, p. 282; Ministry of Education and Culture-Republic of Indonesia, 2015, p. 18; Rasmawan, 2018, p. 2).

Based on the above background this study was conducted with the aim to; determine effectiveness of project-based learning and 5E learning cycle in improving the acquisition of new biological knowledge and compare the effectiveness of project-based learning and 5E learning cycle in improving the acquisition of new biological knowledge, specifically the knowledge related to the human immune system. By comparing the two models with their syntax as described earlier, the researcher wants to know whether project-based learning model is more effective than 5E learning cycle model, consideringthat project-based learning allows the students to carry out stages of the scientific learning method in a more directed manner. In this current study, new biological knowledge refers to the understanding of the specific facts and concepts that cannot be found written in the students' textbook or curriculum but can be obtained by using specific procedures formulated creatively to investigate a specific scientific problems identified about a given subject matter.

METHODS

This was quasi experiment study which involved non-random assignment of participants to the research groups because the researcher could not artificially create the experiment and control classes as this would interfere with the learning activities of the classes (Creswell, 2012, p. 309). The study used the non-equivalent control group design which involved exposure of both experiment and control classes to pretest and posttest before and after the teaching and learning process respectively (Creswell, 2012, p. 309; Abbott & Bordens, 2011, p. 342). This design was used to evaluate the differences in the effect of PjBL and 5E learning cycle instructional models.This study took place in two State Senior High Schools in Yogyakarta City, Indonesia. The study was conducted during the second semester between the month of April and May of the academic year 2018/2019.

The participants in this study consisted of a total of 182 eleventh graders (i.e. 88 students from SMAN 1 and 94 students from SMAN 8), who were selected from 3 classes at each school by using cluster sampling technique. The students who participated in this study were in the age range of 17-18 years. Table 1 shows the classes and number of students in each class selected at SMAN 1 and SMAN 8.

In this study, the students in 3 classes from each school were given pretest so as to measure their initial biological knowledge related to human immune system. After the pre-test, in each school 2 of the3 selected classes became experimental classes and 1 class was made the control class. In each school, one experimental classes were instructed using PjBL model and the other by using 5E learning cycle model, while the control classes were instructed using the scientific approach. All the classes were instructed by the same teacher to avoid differences in the instructional strategies which would occur if the classes were instructed by different teachers, something that would affect the internal validity of results. The teaching process was conducted for 3 weeks which consisted 3 hours meeting every week for each class (1 ½ hours per meeting). After the instruction process a posttest was given to measure the students' new biological knowledge related to the human immune system. Table 2 shows the mode of instruction used in each class in each school.

The criterion referenced essay test was used to measure the students learning outcomes based on the set criteria. This was because an essay test is suitable for measuring high cognitive process, carries more free validity and allows the learner to think and organize the answer before

Table 1
The Classes and Number of Students that Participated in this Study

School	Classes	Number of students
SMAN 1	Class XI IPA 7	32
	Class XI IPA 8	26
	Class XI IPA 9	30
SMAN 8	Class XI IPA 1	31
	Class XI IPA 2	31
	Class XI IPA 3	32

Table 2
The Model of Instruction Used in each Class

School	Classes	Model of Instruction used
SMAN 1	Class XI IPA 7	Scientific Approach (SA)
	Class XI IPA 8	Project-based learning (PjBL)
	Class XI IPA 9	5E Learning Cycle (5E LC)
SMAN 8	Class XI IPA 1	Scientific Approach (SA)
	Class XI IPA 2	5E Learning Cycle (5E LC)
	Class XI IPA 3	Project-based learning (PjBL)

answering the question (Tuckman, 1993). The constructed test specifically assed the new biological knowledge related to factors that influence: the occurrence of communicable and non-communicable diseases, the risk of occurrence of the HIV/AIDS disease, and the risk of occurrence of the disorders and diseases that affect the human immune system. The test instruments used were assed and passed the construct and content validity through expert judgement by two Biology education specialists whereas the criterion reference validity (empirical validity) was determined by calculating the sensitivity index (S_i) for each test item (Gronlund, 1977). The instruments were also assed for reliability by determining the Kappa coefficient using the approximation method. (Subkoviak, 1988; Landis & Koch, 1997).

The descriptive and inferential statistical data analysis used the Statistical Package for Social Sciences (SPSS) version 23. The descriptive statistical data analysis of normality and homogeneity of the variance of the pretest and posttest was performed as requirement for the inferential statistics. The inferential statistical analysis of one-way ANOVA test on pretest was performed to identify if there was or no significant difference in students' initial new biological knowledge at the beginning of the study whereas the one-way ANOVA test on posttest scores was performed to identify if there is or no significant difference in students' new biological knowledge after instruction. The percentage normalised gain (N-gain) scores was calculated to determine the effectiveness of project-based learning and 5E learning cycle instruction models in improving students' ability to acquire new biological knowledge.

FINDINGS AND DISCUSSION

The following are the findings and their discussion presented based on the stated objectives of the study.

*Step 1. Analysis of the pretest scores of experimental and control groups***.** This involved analysis of the pretest scores of experimental and control groups to identify whether there was or no significant difference in students' initial new biological knowledge related to the human immune system. During analysis, the mean scores and standard deviation of the pretest were determined to compare the pretest performance of the three classes in in each school. Table 3 shows the comparison of mean scores and standard deviations of the pretest scores of the experimental and control classes.

Table 3 shows that the mean scores of the pretest scores of the experimental and control classes at SMAN 1 were

Table 3

The Comparison of Mean Scores and Standard Deviations of The Pretest scores of The Experimental and Control Classes

School	Classes	Mean score ()	Standard deviation (SD)
SMAN 1	Experimental (PjBL)	9.50	3.19
	Experimental (5E LC)	9.40	3.62
	Control (SA)	8.62	2.31
SMAN 8	Experimental (PjBL)	7.06	2.31
	Experimental (5E LC)	6.62	2.72
	Control (SA)	6.00	2.84

PjBL (=9.50, SD=3.19), 5E Learning Cycle (=9.40, SD=3.62), and Scientific approach (=8.62, SD=2.31). At SMAN 8 the mean scores of the pretest scores of the experimental and control classes were PjBL (=7.06, SD=2.31), 5E Learning Cycle (=6.62, SD=2.72), and Scientific approach (=6.00, SD=2.84) (Table 3). The results indicate that the mean scores of the pretest scores students in both experimental and control classes from SMAN 1 and SMAN 8 are very low and not so much different. This implies that students in both experimental and control classes from SMAN 1 and SMAN 8 had the same low initial new biological knowledge related to human immune system before the instruction process was conducted.

Step 2. Analysis of variance of pretest scores of the experimental and control classes. This involved analysis of variance of the pretest scores to compare the initial new biological knowledge related to the human immune system of the experimental and control classes. Table 4 shows the results for the analysis of variance of the pretest scores of the experimental and control classes.

Table 4 shows that in SMAN 1 the variances of the pretest scores of the experimental and control classes were

Table 4

The Levene's Test P-value, F-ratio, ANOVA P-value, and Post-hoc Comparisons of the Pretest scores of the Experimental and Control Classes

School	Levene's Test P-value	F-ratio	ANOVA P-value	I (Classes)	J (Classes)	Post-hoc P-value
SMAN 1	0.038	0.914	0.407	PjBL	5E LC	0.993
					SA	0..475
				5E LC	SA	0.583
SMAN 8	0.679	1.279	0.283	PjBL	5E LC	0.786
					SA	0.255
				5E LC	SA	0.616

Computed at significance level $p<0.05$

found to be significantly different upon the Levene's test p-value (0.038). With equal variances not assumed, the Welch test was considered and the results (F (2, 52.046) =0.914, p=0.407), indicated that there was no significant difference in the initial new biological knowledge between the experimental and control classes. The post-hoc comparisons using the Games-Howell test also indicated that there was no significant difference in the students' initial new biological knowledge related to the human immune system among the three classes in SMAN 1 based upon the results of PjBL compared to 5E learning cycle (p=0.993), PjBL compared to scientific approach (0.475), and 5E learning cycle compared to scientific approach (p=0.583) (Table 4). The results show that in SMAN 8 the variances of the pretest scores of the experimental and control classes were found to be significantly equal based on the Levene's test p-value (0.679). With equal variances assumed, the results (F (2, 91) =1.279, p=0.283), implied that there was no significant difference in the students' initial new knowledge related to the human immune system between the experimental and control classes (Table 4). The results of the post-hoc test using the Turkey HSD test of PjBL compared to 5E learning cycle (p=0.786), PjBL compared to scientific approach (p= 0.255), and 5E learning cycle compared to scientific approach (p=0.616), indicated that there was no significant difference in the students' initial new biological knowledge related to the human immune system among the three classes in SMAN 8 (Table 4).

Step 3. Analysis of the posttest scores of experimental and control groups. This involved analysis of posttest scores of experimental and control groups to identify if there was or no significant difference in students' new knowledge related to the human immune system. During analysis, the mean scores and standard deviations of the posttest scores were determined to compare the posttest performance of the three classes in SMAN 1 and SMAN 8. Table 5 shows the comparison of mean scores and standard deviation of the posttest of the experimental and control classes.

Table 5 shows that the mean scores of the posttest scores of the experimental and control classes at SMAN 1 were PjBL (=53.23, SD=2.40), 5E Learning Cycle (=46.23, SD=2.66), and Scientific approach (=32.25, SD=2.14) (Table 5).The mean scores of the posttest scores experimental and control classes in SMAN 8 were PjBL

Table 5
The Comparison of Mean Scores and Standard Deviations of The Posttest Scores of The Experimental and Control Classes

School	Classes	Mean score ()	Standard deviation (SD)
SMAN 1	Experimental (PjBL)	53.23	2.40
	Experimental (5E LC)	46.23	2.66
	Control (SA)	32.25	2.14
SMAN 8	Experimental (PjBL)	48.64	2.91
	Experimental (5E LC)	40.81	2.96
	Control (SA)	25.19	2.19

(=48.64, SD=2.91), 5E Learning Cycle (=40.81, SD=2.96), and Scientific approach (=25.19, SD=2.19) (Table 5). The results from each school show a greater difference in the mean scores obtained by students in the posttest scores of both experimental and control classes. The results also show a significant difference in the mean scores of the posttest scores of the experimental classes in favour of the experimental class instructed by using project-based learning model. The results imply that after the instruction process in SMAN 1 and SMAN 8, the students taught using PjBL and 5E learning cycle (experimental classes) acquired more new knowledge related to human immune system compared to the students instructed using the scientific approach (control class). The results also imply that the students instructed using PjBL acquired more new knowledge related to the human immune system compared to the students instructed using the 5E learning cycle.

Step 4. Analysis of variance of posttest scores of the experimental and control classes. The analysis involved determining the variance of the posttest scores was performed to compare the final new biological knowledge related to the human immune system of the experimental and control classes. Table 6 shows the results for the analysis of variance of the posttest scores of the experimental and control classes.

Table 6 shows that in SMAN 1 the variances of the posttest scores of the experimental and control classes were found to be significantly the same upon the Levene's test p-value (0.709). With equal variances assumed, the results (F (2, 85) =581.279, p=0.001), indicated that there was a significant difference in the final new biological knowledge between the experimental and control classes (Table 6). The post-hoc comparisons using the Turkey HSD test also indicated that there was a significant difference in the students' final new biological knowledge related to the human immune system among the three classes in SMAN 1 based upon the results of PjBL compared to 5E learning cycle (p=0.001), PjBL compared to scientific approach (0.001), and 5E learning cycle compared to scientific approach (p=0.001) (Table 6). The results in table 6 show that in SMAN 8 the variances of the posttest scores for the experimental and control classes

Table 6
The Levene's Test P-value, F-ratio, and ANOVA P-value of The Posttest Scores of The Experimental and Control Classes

School	Levene's test P-value	F-ratio	ANOVA P-value	I (Classes)	J (Classes)	Post-hoc P-value
SMAN 1	0.709	581.279	0.001	PjBL	5E LC	0.001
					SA	0.001
				5E LC	SA	0.001
SMAN 8	0.236	598.129	0.001	PjBL	5E LC	0.001
					SA	0.001
				5E LC	SA	0.001

Computed at significance level p<0.05

were found to be significantly the same based on the Levene's test p-value (0.236). With equal variances assumed, the results (F (2, 91) =598.129, p=0.001), indicated that there was a significant difference in the students' final new knowledge related to the human immune system between the experimental and control classes. The post-hoc test using the Turkey HSD test showed that was a significant difference in the students' final new biological knowledge related to the human immune system among the three classes in SMAN 8 based upon the results of PjBL compared to 5E learning cycle (p=0.786), PjBL compared to scientific approach (p= 0.255), and 5E learning cycle compared to scientific approach (p=0.616) (Table 6).

Step 5. Analysis of the percentage normalised gain (N-gain) scores of the experimental and control classes. This involved determining the percentage N-gain scores of the experimental and control classes to identify and compare the effectiveness of PjBL, 5E learning cycle instruction models, and scientific approach in improving the students' ability to acquire new biological knowledge related to the human immune system. The analysis of the percentage normalised gain score of the experimental and the control classes was presented in Table 7.

Table 7 shows that at SMAN 1 the PjBL class obtained the N-gain mean score (75.40%) with N-gain maximum score (93.10%) and N-gain minimum score (63.79%), 5E learning cycle obtained the N-gain score (63.50%) with N-gain maximum score (78.31%) and N-gain minimum score (66.23%), and scientific approach class obtained N-gain mean score (40.73%) with N-gain maximum score (51.72%) and N-gain minimum score (42.60%). The results also indicate that at SMAN 8 the PjBL class obtained the N-gain mean score (71.69) with N-gain maximum score (82.76%) and N-gain minimum score (55.17%), 5E learning cycle obtained N-gain mean score (58.62%) with N-gain maximum score (70.69%) and N-gain minimum score (44.83%) (Table 7), while the scientific approach class acquired N-gain mean score (31.40) with N-gain maximum score (41.38%) and N-gain minimum score (22.41%) (Table 7). The N-gain mean scores obtained from each school indicated that both PjBL and 5E learning cycle instructional models can be categorised

Table 7
The Percentage N-gain Mean Score, Maximum Score, and Minimum Score of The Experimental and Control Classes

School	Classes	N-gain Mean Score (%)	N-gain Maximum Score (%)	N-gain Minimum Score (%)
SMAN 1	Experimental (PjBL)	75.40	93.10	63.79
	Experimental (5E LC)	63.50	78.31	66.23
	Control (SA)	40.73	51.72	42.60
SMAN 8	Experiment (PjBL)	71.69	82.76	55.17
	Experimental (5E LC)	58.62	70.69	44.83
	Control (SA)	31.40	41.38	22.41

being effective enough while the scientific approach was categorised not effective (Hake, 1999), to improve the students' ability to acquire new knowledge related to the human immune system. Therefore, both the first and second stated hypotheses were accepted. The results obtained for the effectiveness of PjBL relate with the findings from other studies (Widiana, Suarjana, & Dewi, 2019; Kızkapan & Bektas, 2017; Bilgin, Karakuyu, & Ay, 2014) while those obtained for 5E learning cycle correspond with the findings (Sam, Owusu, & Krueger, 2018; Crider, 2013; Siddiqui, 2016; Akar, 2005) which indicate that Project-based learning as well as 5E learning cycle instructional models are effective to improve the students' cognitive achievement in science.

Both project-based learning and 5E learning cycle are student-cantered instructional models (Bender, 2012; Bybee *et al.*, 2006), which enable the students to experience learning through active participation by presenting their personal opinions about the subject under study, asking questions, identifying and solving problems in real life context with the help of the teacher as a facilitator. In this study, the students taught using project-based learning were able to actively participate in the different activities involved in implementation of PjBL such as development of project idea, developing the challenging question, project designing, launching of the project, developing and revising the product, project presentation, reflection and evaluation while the students in 5E learning cycle were involved in engagement, exploration, explanation, elaboration, and evaluation. Through the various activities carried out at each phase during the instruction, the students were able to acquire new biological knowledge. This is because they were able to identify and investigate on their own specific problems related to the human immune system.

Like project based learning, also 5E learning cycle instructional model encourages cooperative learning (Hallermann *et al.*, 2011, p. 93; Bybee *et al.*, 2006), through which the students are able to teach and learn from one another as they work on their projects together in small groups and give critiques to each other's work. During this study, the students in classes instructed using PjBL and those instructed using 5E learning cycle were assigned into small groups of 6 people and then each group was given some forms to fill including the contract form, presentation preparation forms and other self-assessment instructions to guide them in building collaboration skills. During study, it was observed that unlike the students in control class who were taught using the scientific approach, the students in the experimental classes (PjBL and 5E learning cycle classes) exhibited higher collaboration skills whereby they were often seen listening to each other, shared information, helped and respected each other at every step during the learning process. The collaboration atmosphere among the students helped them to sustain their inquiry process during which they were able to read a variety of texts (sources of information) to build their knowledge and find answers to their challenging question under investigation.

The percentage N-gain mean score results in Table 7 also indicated that PjBL instructional model is more effective than 5E learning cycle to improve the students' ability to acquire new biological knowledge related to the human immune system. The difference in the effectiveness of PjBL and 5E learning cycle can be explained from the fact that, unlike 5E learning cycle, project-based learning instructional model includes morestages/phases which enable the learners to experience deeper learning of the specific subject matter. The more phases involved in project-based learning include launching of the project with an entry event, developing and revising the product, and reflection.

Not like 5E learning cycle, in project-based learning the process of exploration is launched with an entry event which serve the purpose of attracting the students' attention, interest and make them become more curious about project to be done (Hallermann *et al.*, 2011, p. 59). In this study, the entry event was in form of a talk show which involved students into discussion about the different factors that contribute to the different kinds of diseases and disorders of the human immune system. The talk show discussion helped to spike the curiosity of the students into asking more questions which helped to guide them into deeper investigation as they searched for the solutions to answer the challenging questions.

Also, unlike in 5E learning cycle where the explanation/presentation step is directly followed by the evaluation phased, in project-based learning there is a provision for both the teacher and the students to reflect back on whole process of learning or investigation took place. In this current study, the reflection process helped the students to retain what they had learnt, sink in deeper of the key concepts in the project (Hallermann *et al.*, 2011, p. 114), and as a result, the students were able to experience more learning and understanding of the subject matter and real-word issues.

According to the NYC Department of Education (2009, p. 14), students experience learning if they see the connection of their own world with the subject matter or through the product expected to be developed. In this study, students taught using project-based learning model got involved in developing artefacts such as scientific reports to demonstrate what has been learnt. In the process of developing the artefacts, the students were involved into thinking and learning because product developed could not be simply copied from anywhere (authentic). Also, the authentic products developed during project-based learning were presented to the audience (e.g. teacher, researcher and classmates, and general public). The presentation of the product to the audience helped to create an atmosphere of collaboration among the students as they taught and learnt from each other and the other members from the audience (NYC Department of Education, 2009, p. 14).

CONCLUSIONS

From this study, it was concluded that both project-based learning and 5E learning cycle instructional models are effective enough to improve the students' ability to acquire new biological knowledge, and also that project-based learning instructional model is more effective than 5E learning cycle instructional model in improving the students' ability to acquire new biological knowledge. This is based upon the results obtained in SMAN 1 showing the N-gain mean scores of PjBL (75.40%), 5E learning cycle (63.50%), and scientific approach (40.73%), and the results in SMAN 8 showing N-gain mean scores of PjBL (71.69%), 5E learning cycle (58.62%), and scientific approach (31.40%).

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