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Problem Based Learning and Students' Views about Science - A Case Study

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Abstract: ***The study was undertaken to find out the effect of Problem Based Learning (PBL) in Biology on the views about science aspects of secondary students in a private school in Beirut. Eighteen students from grade 10 were involved in the learning-teaching process of problem-based learning. The data was collected via the pre-test and post-test administration of VASS survey. The results indicated that Problem Based Learning significantly enhanced the development of the students' core-disciplinary aspects of science including the understanding of nature of science and connecting Biology to different areas. Also, it significantly enhanced the development of the students' metacognitive aspects of science including having meaningful understanding, meaningful learning and more control on one's own learning. Thus, Problem Based Learning fostered the development of all the aspects of the views of science.***

Keywords: Problem-Based Learning; Views about Science; Biology Education

1. Introduction

Research in science education have focused lately on switching science education from the academic scientific education within schools to the application of science in everyday life. This approach promotes the multidimensional aspect of science teaching and learning that enables students to learn about theories and concepts, the scientific method and its related skills representing the nature of science and the interaction between science and society. This multidimensional feature lead to create scientifically literate students and citizens (Chatila, 2016).

Consequently, science educators and policy makers around the word have exerted many effort aiming to promote scientific literacy as a major goal and outcome of science education (Bybee, 2008). Many curricula reforms have been made, to cite only The Next Generation Science Standards NGSS (2013) that aims to improve science education, and empower the educators to design active learning classrooms that enhance students' interests in science and encourage them to undertake science related careers.

NGSS proposed a three dimensions' framework: practices, crosscutting concepts, and disciplinary core ideas, that introduces in addition the body of knowledge aspect, the procedural aspect that leads the students to "doing science" and to connect scientific concepts with other concepts in the same fields and/or in other disciplines to reach the "engineering" level.

Therefore, science teachers are always trying to engage their students, stimulate their interest and promote a positive in active classroom learning environment, by using a variety of innovative and effective approaches. It is well believed that Inquiry based learning approaches are the best to foster students' interest in science and develop their conceptual understanding (Yip, 2001& Rennie, 2010). In other words, it promotes student's view of the multidimensional aspects of science and therefore foster scientific literacy.

2. Problem Based Learning as an Inquiry strategy

Problem Based Learning PBL is an inquiry-based approach where students use an authentic problem as the context to develop their knowledge while finding solutions for the problem (Major &Mulvihill, 2017, Chin & Chia, 2004; Lambros, 2004). It provides active learning environment where the role of teacher is in guidance and facilitating the learning and the students are self-motivated and self-directed learners (Chin & Chia, 2004).

Moreover, PBL enables students develop the critical thinking skills (Ram, Ram& Sprague, 2007), by analyzing and solving real-world problems, working cooperatively with peers, and communicating and sharing in various means their ideas.

Thus, it can be assumed that being an inquiry approach, PBL is successful to address both knowledge and procedural aspects of science and also to connect scientific concepts with other related ones. It fosters knowledge retention (Allen, Donham, & Bernhardt, 2011) and develops inquiry skills including Nature of Science NOS skills such as detecting the problem, formulating research questions and hypothesis, designing and performing a research, processing data and discussing the findings (Abd-El-Khalick et al., 2004 & Lederman, 2007). In addition, PBL may enhance the emotional domain by providing meaningful learning in an authentic problem related to real life, and encouraging students to be self-directed, interdependent and independent learners (Allen, Donham, & Bernhardt, 2011).

However, few research findings indicated that students' responses towards PBL activities were not markedly different from their responses to instruction methods, and some students felt very stressed and overloaded during the PBL process which may hinder their learning and skills' development (Yuan, Kunaviktikul,Klunklin& Williams, 2008).

3. Research Problem

The general objectives of the Lebanese Life and Earth Science Curriculum (1997) states that "teaching should permit students to acquire scientific processes, specifically by developing an experimental approach and problem solving activities".

However, The Lebanese curriculum specific objectives address mainly factual knowledge, and with only few ones addressing scientific process skills. (CRPD, 1997). This study aims to investigate the effect of PBL approach in Biology on the Lebanese Biology students' views about science.

4. Framework

Halloun (2007) developed Views About Science Survey VASS for Biology students, based on the taxonomy designed by the author Halloun (1996) to survey students' Views About Science in Physics. The taxonomy probes the views of students about core-disciplinary and metacognitive aspects of sciences. The taxonomy aspects and dimensions are presented in table 1.

Table 1: Views about Science Survey Taxonomy (Halloun, 2007)

Core-disciplinary aspects Students need to realize the following aspects of science and to construct their own knowledge accordingly
1. Nature of science and of anticipated student knowledge: **N1** Science is about generic: (a) coherently interrelated conceptions, and (b) patterns of thinking, including problem solving, - rather than about idiosyncratic and isolated, situation-specific terms, statements and procedures. **N2** Scientists rely on multiple ways to (a) represent the situation in any problem and (b) solve it; - rather than concentrating on a single representation or a single problem solving strategy. **N3** Mathematical representations help: (a) relate scientific concepts in meaningful ways, and (b) express such relationships objectively, - rather than being good for mere number crunching and open for subjective interpretation
2. Connections: **I1** Science and mathematics benefit from each other's knowledge, - rather than being each confined to its own domain. **I2** Scientists rely on technology for deploying their knowledge in: (a) meaningful ways and (b) novel areas, - rather than for reproducing paper-and-pencil solutions of traditional textbook problems. **I3** Science is relevant to everyone's life, - and not just to scientists.
Meta-cognitive aspects
3. Learning conditions: Locus of control: **C1** Science is learnable by (a) anyone (b) willing to make the effort, - not just by a few talented people. **C2** Achievement depends more on: (a) personal effort, (b) self-confidence and (c) perseverance - than on the influence of teacher, peers or textbook. **C3** Studying science should be an (a) enjoyable, (b) confidence building and (c) self-satisfying experience, - rather than a frustrating and intimidating undertaking for satisfying curriculum requirement. Meaningful understanding favors: **C4** Students who come to class with a prepared mind, - rather than those who study only after the teacher covers materials in class; **C5** Those who seek information from alternative sources, - rather than those who stick to the textbook; **C6** Those who are (a) tolerant, and (b) open to others' ideas - rather than those who stand blindly and firmly by their own ideas; and **C7** Those who cooperate with others for knowledge development - rather than for mere task achievement
4. Insightful, meaningful learning requires one to: **L1** Construct new subject knowledge: (a) on one's own, and (b) delimit its scope, - instead of assimilating it from an authority and memorizing it as given. **L2** Deploy knowledge following purposeful plans, - rather than by recalling certain routines learned by rote. **L3** Deploy knowledge in a variety of activities (paper-an-pencil exercises, case studies, etc.), - instead of concentrating on traditional end-of-chapter exercises. **L4** Continuously: (a) justify, and (b) evaluate one's own work, - rather than getting satisfied with mere task completion. **L5** Look for the teacher as a mediator of learning - rather than an authoritative source of information. **L6** Contrast and regulate any discrepancy between one's own knowledge and the targetscientific knowledge, - instead of blindly assimilating target knowledge. **L7** Use assessment for self-evaluation and regulation - rather than for ranking oneself relative to peers

The figure below represents the framework model

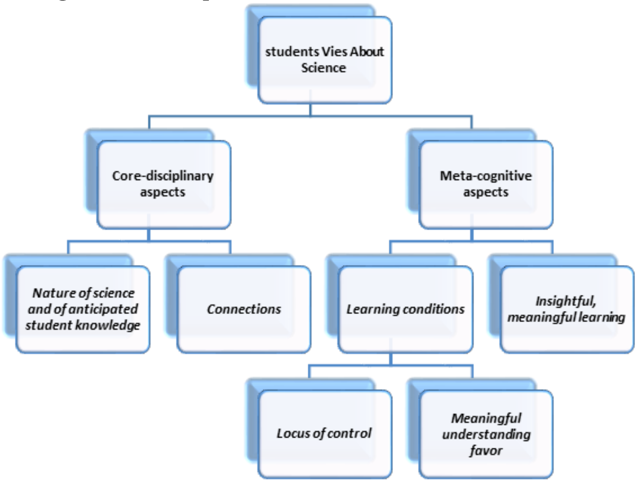

Figure 1: The framework model of the study

Consequently, the study addresses the following general research question:

What is the effect of PBL approach on grade 10 biology student's views about science?

The following sub-questions are investigated

What is the effect of PBL on:

1) The core disciplinary aspect of sciences at the level of:
- The Nature of science and anticipated student knowledge?
- Connecting Biology to other areas?

2) The meta-cognitive aspects of science at the level of
- Learning conditions including locus of control and meaningful understanding?
- Insightful meaningful learning?

5. Methodology

A quasi-experimental design OXO (observation-intervention- observation) was employed in this study. The researchers used the pre-test/post-test control group design, where a group is observed and measured before and after the treatment (Fraenkel et al. 2012).

The sample consists of 18 grade 10 biology students in a Lebanese private high school in Beirut. They are Arabic native speakers and English is the language of instruction in Biology. Noting that biology is taught three periods per week.

The data was collected by performing VASS, described in table 1. The survey includes 33 multiple choice questions with two viewpoints (a) and (b) on a 5-point scale, and a self-assessment of the student's learning skills. The table below represents item distribution.

Table 2: VASS items distribution

Aspects of science	Categories	Number of items
Core-disciplinary	Nature of science and of anticipated student knowledge	8
	Connections	5
Meta-cognitive	Learning conditions	11
	Insightful, meaningful learning	9

The pre and post-tests descriptive statistics were computed. In order to show any significant progress in the students' pre-tests and post-tests scores inferential statistics were used. T-tests were performed to compare and determine whether the population means differ. Significance was determined at the 0.05 level.

6. Procedure

The study included 4 phases over 10 weeks, where students were taught an average of three periods biology per week. The topic chosen was "Plants" since according to teachers' observations it is considered as "hard" for the students. Only few students would have conceptual understanding and retention of related concepts.

The first phase of the study, first three weeks, aimed students and teachers to master PBL strategy by familiarizing the students with the procedures, and routines, and modeling the inquiry process of PBL. The second phase was the first administration of the VASS questionnaire (pre-test). The following four weeks, phase three, consisted of the period of implementing the study, where students were involved in PBL, in groups under the supervision and guidance of the teacher. The of the study was "plants" in grade 10 National Biology book. Students were given four different problems for investigation in four consecutive weeks. The problems cover various plants related issues from daily life, namely: soil desertification, air pollution, bush fires and sustainable development. The third phase was in week 9, where the students practiced reflection about PBL learning strategy and in the last week, phase four, VASS questionnaire was administrated as post-test.

7. Results

7.1. Core-disciplinary aspects

7.1.1. The nature of science and of anticipated knowledge

Table 3 shows the mean scores and standard deviations for students' understanding of the nature of science and of anticipated knowledge in pre-tests and post-tests.

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.5	0.7	0.0005
post-test	4.1	0.4	
Total	3.8	0.7	

Sig. T.Test=0.0005 < 0.05

With respect to core-disciplinary aspects of science, in the category associated with the nature of science and of anticipated knowledge, the students' mean scorewas 3.5/5 in the pre-test. This value increased to 4.1/5 in the post test. Also, the standard deviation was 0.7 in the pre-test. However, it's value decreased to 0.4 in the post-test.The significance T. Test is 0.0005 which is less than the significance value that is 0.05. The significance of these results is that the students had more understanding for the nature of science and anticipated knowledge, meaning that there is a significant correlation between problem-based learning and nature of science and of anticipated knowledge.

7.1.2. Connections

Table 4 shows the mean scores and standard deviation for students' connections of science to math, technology and real life in pre-tests and post-tests.

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.0	0.8	0.0000
post-test	4.0	0.5	
Total	3.5	0.8	

Sig. T.Test=0.000 < 0.05

In the category associated with connections of science to math, technology and real life, the students' mean scores was 3/5 in the pre-test. This value increased to 4/5 in the post test. Also, the standard deviation was 0.8 in the pre-test. However, it's value decreased to 0.5 in the post-test.The significance T. Test 0.0000 which is less than the significance value that is 0.05. These result show that the students connected science more to math, technology and real life, meaning that there is a significant correlation between problem-based learning and connecting science to math, technology, and real life.

7.2. Metacognitive aspects

7.2.1. Learning conditions

Table 5 shows the mean scores and standard deviation for students' learning conditions in pre-tests and post-tests.

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.2	0.6	0.0000
post-test	4.0	0.4	
Total	3.6	0.6	

Sig. T.Test=0.0000 < 0.05

As for metacognitive aspects of science, in the category associated with the learning conditions, the students' mean scores is 3.2/5 in the pre-test. It increased to 4/5 in the post test. Moreover, the standard deviation decreased from 0.6 in the pre-test to 0.4 in the post-test.The significance T. Test is 0.0000 which is less than the significance value that is 0.05. The significance of these results indicate that the students' learning conditions has improved among the students, indicating that there is a significant correlation between problem-based learning and learning conditions.

7.2.1 (a) Locus of control

Table 6 shows the mean scores and standard deviation for locus of control in pre-tests and post-tests

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.1	0.7	0.0000
post-test	3.8	0.5	
Total	3.4	0.7	

Sig. T.Test=0.0000 < 0.05

At the level of learning conditions, in the locus of control subcategory, the students' mean scores increased from 3.1/5 in the pre-test to 3.8/5 in the post test. Also, the standard deviation decreased from 0.7 in the pre-test to 0.5 in the post-test.The significance T. Test is 0.0000 which is less than the significance value that is 0.05. These results indicate that the students' locus of control has improved among the students, meaning that there is a significant correlation between problem -based learning and locus of control.

7.2.1 (b) Meaningful understanding

Table 7 shows the mean scores and standard deviations for meaningful understanding in pre-tests and post-tests

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.4	0.8	0.0001
post-test	4.1	0.5	
Total	3.8	0.8	

Sig. T.Test=0.0001 < 0.05

At the level of learning conditions, in the meaningful understanding subcategory, the students' mean scores increased from 3.4/5 in the pre-test to 4.1/5 in the post test. Also, the standard deviation decreased from 0.8 in the pre-test to 0.5 in the post-test. The significance T. Test is 0.0001 which is less than the significance value that is 0.05. These results indicate that the students' meaningful understanding has improved among the students, meaning that there is a significant correlation between problem -based learning and meaningful understanding.

Therefore, there is a significant correlation between problem-based learning and learning conditions.

7.2.2. Insightful meaningful learning

Table 8 shows the mean scores and standard deviation for insightful meaningful learning in pre- and post-tests.

Test	Mean	S.D.	Sig. (T.Test)
pre-test	3.2	0.8	0.0000
post-test	4.1	0.6	
Total	3.6	0.9	

Sig. T.Test=0.0000 < 0.05

In this category, he students' mean scores increased from 3.2/5 in the pre-test to 4.1/5 in the post test. Also, the standard deviation decreased from 0.8 in the pre-test to 0.6 in the post-test.The significance T. Test is 0.0000 which is less than the significance value that is 0.05.These results indicate that the students showed more insightful meaningful leaning, meaning that there is a significant correlation between problem-based learning and insightful meaningful learning.

8. Discussion and Conclusion

In the light of the results and the analysis, it can be concluded that Problem Based Learning (PBL) has a significant effect on the views of science aspects of students of grade 10 while learning Biology.

The students' core-disciplinary aspects and metacognitive aspects were fostered. This means that Problem Based Learning enhanced students understanding of the nature of science aspects; they developed their reasoning skills, improved their comparison and interpretation skills, increased their understanding of things and communication. Moreover, problem Based Learning allowed the students to develop many skills like formulating hypothesis for problems, researching, drawing out conclusions. The students' connected Biology to other areas, learned by themselves, and had meaningful learning. All of the pre-mentioned skills allow the students to solve real problems related to their life and thus be scientifically literate.

The indicated high development of the aspects of the views of science are linked to the fact that the students practiced solving problems gradually from a low level of PBL to a higher level of PBL along with increasing level of complexity in inquiry.

The findings are in parallel with the literature, with the studies reporting significant effect of PBL on the developments of critical thinking skills, NOS skills and other interpersonal skills (Abd-El-Khalick et al., 2004;Allen, Donham, & Bernhardt, 2011; Ram & Sprague, 2005).

9. Limitations

The results of our study present evidence that Problem Based Learning enhances the views of science of secondary students in Biology. The results can't be generalized because the used sample was small. It is recommended to apply PBL on larger samples and at different levels. If learning is associated with real life problems into the classroom situation, students' understanding of the views of science aspects can be enhanced, and literate long-life learning citizens would be raised.

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