

The Effectiveness of Problem-Based Learning on Qatari Students' Readiness for Self- Directed Learning in Biology

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Abstract

This study aimed to compare the effectiveness of problem-based learning (PBL) and traditional instruction on 12th-grade students' Self-Directed Learning (SDL) in the Biology unit on Genetics and Inheritance. For this purpose, four classes with a total of 76 students were randomly assigned as experimental and control groups. The experimental group students were taught the subject using the PBL approach, while the control group students underwent traditional Biology instruction. Quasi-experimental designs with a non-equivalent control group, and pretest and posttest design were used for this study. The self-Directed Learning Readiness Scale (SDLRS) was used to measure the SDL. Multivariate Analysis of Covariance results showed that the PBL students had higher SDLRS score improvement when compared with their counterparts in the control group. This indicated that the PBL students appeared to be better compared to the conventional students in terms of SDL. The implication of the study suggested that PBL is effective in improving students' SDL in Qatari schools.

Keywords: Problem-based learning, Self-directed learning, Biology learning.

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المخلص

هدفت هذه الدراسة إلى مقارنة فعالية التعلم القائم على المشكلات (PBL) والتعليم التقليدي في التعلم الذاتي (SDL) لطلاب الصف الثاني عشر في وحدة علم الأحياء في علم الجينات والوراثة في المدارس القطرية. لهذا الغرض، تم تخصيص أربعة مجموعات من الطلبة تضم ما مجموعه (76) طالبًا، تم تقسيمهم بشكل عشوائي في أربع مجموعات؛ اثنتان تجريبيتان واثنتان ضابطتان. تم تدريس طلاب المجموعة التجريبية باستخدام منهج التعلم القائم على المشكلات، بينما خضع طلاب المجموعة الضابطة للتدريس بالطريقة التقليدية. تم استخدام تصميم شبه تجريبي مع مجموعة ضابطة غير متكافئة، وتصميم الاختبار القبلي والبعدي لهذه الدراسة. تم استخدام مقياس الجاهزية للتعلم الموجه ذاتيًا (SDLRS) لقياس التعلم الذاتي. أظهر التحليل متعدد المتغيرات لنتائج التباين المشترك أن طلاب المجموعة التجريبية قد تحسّنوا في درجات الجاهزية للتعلم الموجه ذاتيًا مقارنة بنظرائهم في المجموعة الضابطة. يشير هذا إلى أن الطلاب الذين درسوا منهج التعلم القائم على المشكلة كانوا أفضل مقارنة بالطلاب التقليديين من حيث التعلم الذاتي. وتشير النتائج الضمنية للدراسة إلى أن التعلم القائم على المشكلات فعال في تحسين التعلم الذاتي للطلاب في المدارس القطرية.

Introduction

Traditional teaching practices or pedagogies, such as demonstrating the solution to a problem and lecturing, may influence the problem-solving capabilities of students. In such situations, it has been observed that students become capable only of solving textbook problems and are unable to solve real-life problems (Albion & Gibson, 1998). The National Science Education Standards emphasized that students in the natural sciences should develop an understanding of the inherent nature of science and epistemological development of scientific knowledge (National Research Council 1996).

Individuals, through their interaction with the environment, are exposed to many problems that need to be solved. The aim of scientific learning is to solve these problems; therefore, teaching science aims to enhance and improve the ability of students to solve their real-life problems (AAAS 1993). Traditionally, science learning usually progresses from abstract to concrete learning, with concepts being introduced first, followed by problem application.

The leaders of Qatar state have anticipated that education is the key factor behind the social and economic progress of Qatar. It has been established from the reports of the General Secretariat for Development Planning (2008) that the State of Qatar National Vision intends to transform the entire country into an entirely new and advanced country, by the year 2030. Therefore, Qatar needs to prepare its upcoming generations in an integrated manner, so that they can attain their aspirations and fulfill the needs of transformation, which are going to occur in Qatar. In this account, the educational institutions of Qatar need to ensure rapid development in the field of science and technology. This feature may considerably help the country in bridging the knowledge gap of Qatar, with modern countries of the world (Durib 2014). Consequently, this feature will also enable individuals to deal with their real-life issues.

Studies have presented an idea that, in Qatar, a severe decline has been observed in the number of students studying science and mathematics at both tertiary and secondary levels of education. It is significant to notice that the trend has been observed over the past fifteen years (Said 2011). The leadership entities, as well as the concerned authorities of Qatar, perceive education as the key factor behind the social and economic progress of the country. Therefore, it is considered one of the foremost responsibilities of these entities to ensure the integration of a suitable and fruitful education system, to produce high-quality outcomes for the students of Qatar. These outcomes may include the academic achievements of the students, their success in the labor market, college attendance, etc. (Brewer et al. 2007).

Science Education in Qatar

In the year 2001, the International Mathematics and Science Study (TIMSS) for Qatari secondary students and the Program for International Assessment (PISA) showed lower scores (Romanowski & Amatullah, 2014). After considering these facts, Qatari leaders started to work with RAND Corporation to make a governmental approach for investigating the Qatari educational system.

Afterward, the RAND report eventually led the Qatari leaders towards the establishment of a wide reform schools model (the independent school model), which was publically launched as Education For a New Era (EFNE), which was identified as the central point to the development of the economic condition of Qatar (Romanowski & Amatullah 2014).

An independent model is nothing more than a government-funded school that is granted independence to conduct its educational objectives and mission while being held responsible to the terms and conditions of an agreement (Brewer et al. 2007). The independent school model aimed to emphasize different aspects, including professional development, assessments, curriculum, and standards of education. Furthermore, the model also aimed to support four major principles (Brewer et al. 2007). These may include autonomy, accountability, choice, and variety.

It has been established that independent schools encourage the kind of critical thinking and creativity that is needed in the continually evolving trends of the 21st century. It is because independent schools offer new paradigms and concepts, which foster teamwork, learning methods, and curriculum design (Brewer et al. 2007).

International benchmarks are used for English, mathematics, and science of these subjects, but not in Arabic subjects (Zellman et al. 2009). The Qatari Curriculum Standards Office sets standards for Science education curricula for all grades (kindergarten through grade 12). The advanced and foundation standards for a science of tenth to twelfth grades include physics, chemistry, biology, and a scientific inquiry branch (Zellman et al. 2009).

The overall objectives for science education standards are that students should develop and maintain an interest in science and its application (Supreme Education Council, 2013). More so, these standards are aimed at using information communications technology efficiently, in the search and communication of science. In addition to this, these standards also aim to develop a systematic and sound knowledge of important scientific principles, concepts, and facts. Furthermore, these standards are also found to be effective in terms of developing such skills, which help in coping with different situations in a range of environmental, industrial, domestic, and personal contexts. Moreover, it is also essential for the students to identify the significance of the application of scientific knowledge in the contemporary world while having ample knowledge about environmental and ethical implications (Zellman et al. 2009).

Standards of science emphasize students' engagement in inquiry and problem solving (Ikhlef & Knight, 2014). These standards focus on student-centered teaching and curriculum standards (Knight et al. 2014). To meet the Qatari science education standards, there is a need to adopt an active learning method like PBL, which is a student-centered learning strategy. PBL plays an incredible role in developing students' higher thinking skills, improving scientific inquiry skills, and improving students' ability to deal with and solve their real-life

problems. Besides that, PBL also assists the students in terms of developing their intellectual level, to deal with the changing demands of modern life.

Problem-based learning (PBL)

PBL is one of the most integrated and advanced teaching methodologies, in which students are presented with an interesting, relevant problem “upfront” so that they can experience for themselves the process of doing science. They proceed from the unknown to the known, to understand the underlying abstract principles (Albanese & Mitchell, 1993; Boud & Feletti, 1998).

Recently, PBL has been a widely accepted method of instruction and has been integrated and implemented in several disciplines of education. These may include the education setting of kindergarten through grade 12, as well as in higher education (Hung et al. 2008). It has been revealed from the analysis of studies, which were conducted by Shahin and Tork (2013), that PBL plays a commendable role in making the students self-dependent, in the context of solving any problem or issue.

PBL in classrooms has a commonly accepted sequence of delivery (Barrows 1986). This may include (1) present a problem that students working on understanding, and then they working on solving it, (2) students are working in groups, (3) students are encouraged to be self-directed to solve the problem, and (4) tutors have a role of a facilitator, not an instructor.

In addition to this, one of the most prominent and imperative skills, which is promoted in the PBL setting, is referred to as Self-Directed Learning (SDL). Most of the students have a higher estimation of their knowledge and a lower estimation of the gap in their knowledge (Grego & Eisenberg, 1993). Thereby, once students identify or distinguish these gaps, they may easily respond to knowledge gaps by adopting or utilizing one of the following approaches. (1) make frequent inquiries about the areas, in which they have limited knowledge, to fill the knowledge gap, (2) ignore or disregard their knowledge gap and restrict their discussion to what they have already known, (3) become enthusiastic and concerned that their teacher provides them with appropriate and comprehensible answers (Grego & Eisenberg 1993). On the other hand, suitable and high-quality facilitation of the discussion in PBL and providing support to the students as they move to a structure of PBL may assure improve and enhanced outcomes; this feature may also offer a great opportunity to the students to master PBL skills (Sparling 2001) as well as encourage their SDL. This study looks at the effects or impacts of utilizing PBL versus the traditional method on the SDL of the students.

The self-Directed Learning Readiness Scale (SDLRS)

The most frequently used operational definition of SDL was proposed by Guglielmino (2008). Following the views of Guglielmino (2008), SDL consists of a complex of attitudes, values, and abilities that create the likelihood that an individual is capable of SDL. To conduct this study, SDL is examined in the context of the degree of control, which is acquired by the learners. More so, it

has also been investigated in terms of the skills and capabilities, which are necessary for the students, to become effective. This effectiveness can be understood in terms of creativity, the enthusiasm of learning, independence and initiative in learning, self-concept, learning opportunities, and positive orientation to the future. Furthermore, it is also associated with the capability to utilize basic and important problem-solving skills and learning skills. SDL Readiness Scale (SDLRS), which has been adopted from Guglielmino (2008), can be understood as a self-report questionnaire. It is important to notice that it also incorporates Likert-type items. This tool is used to estimate and analyze the SDL within the students.

The problem of the study

The lecture is the traditional instructional method in teaching biology (Barnes 2008). Using this method, students find lessons to be dull and end up as memorization learners. After adopting the EFNE education system, the results of national exams are still showing very low performance of Qatari students. In 2006, PISA science assessment showed that Organization for Economic Cooperation and Development (OECD) countries, i.e., Qatar and Kyrgyzstan, were among the lowest performing adolescents in PISA 2006, and in the results of 2012, Qatar was below the OECD average (Zellman et al. 2009). According to TIMMS 2007, Qatari students were classified at proficiency level 1, (the lowest) (Supreme Education Council 2013). In 2011, the TIMSS achievement test, at the Grade 8 level, showed that Qatar was one of the six lowest-performing countries among the forty-two participating countries (Martin et al. 2012). Given the series of flaws in the present education system in Qatar and its failure to adequately prepare Qataris for the challenges of today's technology-based societies, there is a massive need to carefully and critically examine the factors influencing science achievement and interest in the science of students (Areepattamannil 2012).

According to the previous results of Qatari students in national and international tests, it showed that there was a very low performance for independent school students. This means a lowering in students' achievement (Knowledge and understanding, application, analysis and evaluation of information, and scientific inquiry skills and procedures), reasoning, ability, attitudes, interests and motivation, problem-solving skills, and long-life learning. This is heavily influenced by curriculum goals and their implementation, and individuals' characteristics. Therefore, it can be affirmed that PBL can be one of the solvents. Studies show that an active and constructivist learning environment is found to be most effective and efficient, as compared to traditional instruction (Burrowes 2003). It is because this approach fosters or promotes various beneficial aspects, including conceptual knowledge, academic achievement, higher levels of critical thinking skills, and increasing the interests of the students in biology (Burrowes 2003).

So, this study aimed to investigate the effect of the PBL on 12th graders' performance outcome measures of SDL in the biology, genetics, and inheritance unit. This study will examine the following null hypotheses:

Null Hypotheses 1: There are no significant differences in the level of SDLRS post-test between the experimental group and control group.

Null Hypotheses II: The effect of PBL on student SDLRS for experimental and control groups does not vary depending on achievement level.

EFNE reform engages in an educational discourse using terms such as students as "researchers", "critical thinkers", "critical spirit", "creative expression", or "independent thinkers". It has been observed that all of these aspects are pointing to a particular understanding of critical thinking, which can be improved by PBL.

Based on numerous studies in PBL, it was found that PBL assists learners and students to become self-directed in terms of learning. a study was conducted in Egypt and Saudi Arabia to examine the effect of using PBL on critical thinking and SDL abilities of nursing students in the two countries. The outcome measures in this study were the SDLRS and the critical thinking dispositions inventory. The results showed that teaching with PBL was significantly effective in increasing levels of critical thinking and SDL in both countries, without variation (Shahin & Tork, 2013).

SDL skill can also be understood as one of the key factors behind the development of students' independent problem-solving skills, as well as lifelong learning (Hung et al. 2008). In PBL, learning and development of skills occur through interaction, which often occurs within the group. It is much more beneficial than the conventional method of lecturing, where students are passive learners (Finestone 1985).

Upon the completion of the study, the data will be considered a valuable source for curriculum specialists in Qatar. The main objective is to plan for future curricula and teaching strategies to transform the teaching experience of all science teachers in Qatar. Continually evolving trends of the contemporary world have increased the need to have appropriate and adequate learning techniques. It is a fact that our universe is changing dramatically while producing advanced information technology that has made all information readily accessible. Therefore, our future will not require students to memorize, but to utilize this information in a useful form in their lives, work, and community. PBL is one of the methods that has a strong potential to improve this utilization to a new dimension that suits our modern world and future.

Review of Related Studies about the effectiveness of PBL on SDL

A study by Kim and Jo (2020) aimed to prove the effectiveness of PBL on SDL ability and the learning flow of junior college students. Two hundred and forty-eight students were enrolled in the study from 5 different departments, D University in Busan. The pre-post survey was used. Results showed that 66.2% of all students who learned by PBL were satisfied with their classes overall, and

64% of the respondents said that the PBL method helped them understand the course.

Also, a study conducted on nursing students (Abdelhafezet al., 2020) studied the relation between PBL and SDL. Self-administered scales were used to assess SDL readiness and the PBL approach as perceived by students. Results showed a positive, statistically significant correlation between SDL readiness and the PBL approach.

Studies of Choi et al. (2014) research the students of the first-year nursing. One of the major objectives of the research is to conduct a comparison between PBL as well as traditional instruction. It is significant to notice that the subjects were taken from two different junior colleges, which were located in two different cities of South Korea. It is significant to notice that the research design that was adopted for the study was a quasi-experiment, a non-equivalent group pretest-posttest. In this regard, uniform self-administered questionnaires of SDL capabilities, problem-solving, as well as critical thinking were assessed after and before providing instruction. It has been established from the final findings of the questionnaire that students, within the PBL, showed noteworthy improvements across all capabilities. In contrast, the students, learning in a traditional environment, had considerably low and diminished SDL scores as well as problem-solving skills.

In South Africa, a study evaluated the nurses' performance in PBL tutorial through self-assessment and instructor's assessment using a computer-based Tutorial Performance Evaluator and SDLRS (Bruce et al. 2013). Also, the performance of this group was compared with the traditionally lectured group. The results showed significant differences between facilitator and student assessment. Significant improvements were found in problem-solving, communication, critical thinking, learning skills, and personal growth. There was a significant difference between the two groups in these areas, but not in SDL.

In Egypt, research was conducted to assess the effect of PBL on undergraduate nursing students who were enrolled in a nursing administration course. They used an experimental comparative design to compare the outcomes of students who were instructed with PBL, and a control group was instructed by traditional methods. The study used four outcome measures in the study including students' spinner questionnaire sheet, students' problem-solving evaluation sheet, five different cases of problem-solving, which are associated with the managerial skills (situations), and SDLRS. In comparison to traditional methods, students who participated in PBL had significantly higher problem-solving grades, better knowledge, and higher SDLRS scores. There was no significant difference in the other measures (Gabr & Mohamed, 2011).

Ali and El Sebai (2010) conducted quasi-experimental design research to examine and assess the effect of PBL approaches on bridging nursing program students' learning in Saudi Arabia. It has been assessed that the sample of the study incorporated all students who were registered in the evidence-based nursing course. In this regard, the SDL instrument, as well as the revised two-factor study process questionnaire, were used to perform the comparison

among the approaches of the students in terms of learning. More so, it also played a significant role in comparing the SDL capabilities before and after the teaching of the course, within the PBL environment. It has been established from the results that PBL is one of the most effective and integrated approaches, which assists the students in establishing and increasing higher levels of intellect and knowledge, among all students of nursing.

SDL readiness of the students of medical and nursing students has also been investigated before and after their exposure to the PBL curriculum, with the help of SDLRS (Tsou et al. 2009). After completing a year of PBL, the students of medical and nursing at Fu Jen Medical School demonstrated or illustrated a considerable increase in the total scores of SDLRS, as well as in the sub-scores for the strategy of learning and self-assessment. It has been assessed that these variations continued till the end of two years of implementing PBL. It has been claimed by the students, during their clinical years, that they were proactive and highly enthusiastic learners during their academic period. In addition to this, they also claimed that they have considerably improved and higher levels of trust and confidence in SDL and knowledge acquisition skills.

Downing et al. (2009) researched two groups of first-year undergraduate students at a university in Hong Kong. Two groups were formed; one was instructed using PBL, the other using the conventional method. There was a significant level of motivation, attitude, meta-cognitive development, and self-regulation in the PBL group in comparison to other groups. The research was carried out in an introductory biology classroom in the biology course (Gabric& Ludovice, 2002). The topics assessed were reproduction and brain function. There were two groups of students in the study, i.e., the PBL group and the lecture-based group. PBL group showed a significant increase in achievement and content retention. The students answered in detail on the contents of these two topics based on the extensive research done to collect and interpret the data.

Results, as seen in the previous section, are promising for higher learning students, and PBL can be used in many educational areas and is not solely restricted to higher education. The approach is simplified compared to its original model to cater to different age groups and subjects. The PBL showed to be effective in improving students' SDL. But, there is a shortage of applications in Arab countries. Studies in the school area still need to be applied to different world areas, topics, grades, and students' levels, and also need to examine the effect of PBL on different variables. Concerning the improvement of science education in the schools, it is important to know how good PBL classroom practices can be enhanced and what the views of students are about effective PBL discussion and working together.

Consequently, the present study aims to investigate the effects of PBL instruction on 12th-grade students' (high achievers and low achievers) learning in the genetics unit in Qatari schools, and three different variables (students' achievement, problem-solving skills, and SDL) will be measured. Quasi-

experiment with a non-equivalent control group and pretest and posttest design with quantitative and qualitative measurements will be used in this study.

Methodology of Research

Subjects of the Study

The research was conducted in Qatar. The population for this study was secondary independent schools. Also, the unit of analysis for this study was Nasser Bin Abdullah Al-Atyyia Independent Secondary School for Boys. The sample of this study was 76 students (38 students were in the experimental group and 38 students were in the control group).

To decrease the students' variability of the past academic achievement test and increase the homogeneity between groups before specific treatment is given, each group was subdivided into two subgroups, which consist of high and low achievement subgroups. Finally, the samples of this study were 19 low-achievement-level students and 19 high-achievement-level students who followed PBL, 19 low-ability students and 19 high-ability students who followed conventional teaching methods.

This study will use a quasi-experimental design, which is specifically known as a non-equivalent control group design. The first group (Two classes) is experimental, which is taught by the PBL method, and their independent variable is the PBL method. In this group, a trained teacher on PBL application will follow the prepared lesson plans (PBL-designed lessons). The second group (Two classes) is the control group, which is taught by the conventional method, that is, the lecture method.

Instruments of the Study

1- Self Directed Learning Readiness Scale

SDLRS or Self-Directed Learning Readiness Scale is a self-reported instrument, which is comprised of 58 items, and is used to measure Student SDL among students. The SDLRS is adopted from Guglielmino, which was originally developed by Guglielmino in the year 1978. The SDLRS had eight subscales to measure different domains of SDL including, openness to learning opportunities, self-concept, initiative, and independence in learning, informed acceptance of responsibility for one's learning, love of learning, creativity, positive orientation to the future, and the ability to use basic study skills and problem-solving skills.

SDLRS are composed of a total of 58 items. Each item has a 5-point Likert format scale including '1=almost never true of me', '2=usually not true of me', '3=sometimes true of me', '4=usually true of me', '5=almost always true of me'. Each point has a score equal to its number. For Example, in positively stated items, selecting 'usually true of me', scores 4 points for that item. This means that if a participant selects 'almost always true of me', 5 points are assigned to that item. The summation of all 58 item scores equals the total score on the SDLRS (Guglielmino & Associates, n.d.). The scale contains 41 positive statement items and 17 negative statement items. Items number 3, 6, 7, 9, 12, 19, 20, 22, 23, 29, 31, 32, 35, 44, 48, 53, and 56 are negative statements items

that should be scored reversely to show support for SDL characteristics, and other items are positive statements items. Negative statement items are used as a means of preventing participants from answering similarly and to avoid an easy response set (Guglielmino 2008). The sum of SDLRS scores will show the SDL total score of that participant. According to Guglielmino (2008), SDLRS scores are classified into five levels, as shown in Table 1.

Table 1: SDLRS Average Scores

	SDLRS Scores	Readiness Level
1	58-176	Low
2	177-201	Below Average
3	202-226	Average
4	227-251	Above Average
5	252-290	High

This instrument is used for several reasons. first, it has high alpha reliability reading above the minimum of 0.70 for all the subscales in the instrument (Boden, 2005). Also, it is divided into eight domains that cover a wide range of subjects to measure the overall SDL. It has been used by more than 500 major organizations around the world and by more than 100 doctoral dissertations (Boden, 2005). The instrument has been translated into more than 19 languages. SDLRS remains the most reliable and valid instrument for measuring the readiness of self-directed learners (Boden, 2005). To summarize, the SDLRS is used more often than any other measure of SDL readiness (Merriam et al. 2007). The major analysis of reliability (internal consistency, test-retest) and validity (content, construct, criterion-related) showed that the instrument could accurately be utilized with confidence to measure SDL (Delahaye & Choy, 2000).

Pilot Study

There are two main translation procedures namely, direct translation and back translation (McKay et al. 1996). The former refers to the source instrument being translated into the target language by one or more people, while the latter involves the translation of the survey instrument from the source language into the target language, and then back again by a separate translator (Heath et al. 2005; McKay et al. 1996). Direct translation has been supported by many researchers and some of them argue that back translation due to its introduction of translation error each time the survey is translated from one language to another language (Heath. et al. 2005; McKay et al. 1996). Furthermore, back translation only provides a literal translation from one language to another; it may not capture the intended sense of the statement (Douglas & Craig, 2007).

This survey is translated into the Arabic language as the study sample comprises Arabic speakers.

The scale was validated in English, but it has not been translated and validated for Arabic language speakers. To translate the SDLRS, official translation by the translation office is used and then it was translated back to English by another office. The translation to the Arabic language was word by word, not clear, and hard to understand by students. Therefore, three English teachers, at Nasser Bin Abdullah Al-Attiya Independent Secondary School for Boys were asked to translate it into the Arabic language that is clear for students. Also, ask the other three English teachers were asked to translate it back to English. After that Arabic coordinator was asked to check grammatical and spelling mistakes of the survey. This time the Arabic translation was clear and translates back to English yielded a similar questionnaire to the original.

After that, the study was piloted on thirty students and they were asked to circle statements that seemed to be confusing and words that were not familiar to them. The inventories were then collected and analyzed. It was found that the students had a problem in understanding the inventory responses range and they preferred the strongly disagree, disagree, neutral, agree, and strongly agree with responses range. So the inventory was modified according to students' feedback.

The SDLRS was assessed by Finestone in 1985 and by Wiley in 1981 for test-retest reliability (Guglielmino & Guglielmino, 2001). The SDLRS received test-retest reliability scores of 0.82 (Finestone, 1985) and 0.79 (Wiley, 1981). Therefore, the scale showed to have high test-retest reliability. Reliability a split-half, odd-even reliability was computed using the scores of the 30 students. The coefficient, corrected by the Spearman-Brown method, was 0.92, which means high reliability for SDLRS Arabic version.

2-Problem Based Learning Module

Maastricht's "Seven-Step" PBL module which was adapted from Wood (2003) used for learning students in the experimental group. Judge (2011) used this PBL module in his study that aimed to examine the effect of PBL with ICT on university students' academic achievement, problem-solving skills, attitude and, communication skills in Biology.

The PBL module is used exclusively for the PBL group. It consists of six phases, which include read and understand the problem, identifying the problem and put learning goals, collect and sort information, generate possible solutions, present solutions, and assessing with reflecting. The module was adapted from Wood (2003).

Research Design

The population of this study refers to students in secondary independent schools in Qatar. Besides, the unit of analysis for this study is male secondary school students as subjects from one school in Qatar, which is Nasser Bin Abdullah Al-Attiya Independent Secondary School for Boys. The research was

conducted on 12th-grade students in the 2013-2014 academic year. After training on PBL, a biology teacher from the same school instruct two classes by using the PBL approach and the other two classes by traditional Biology instruction for five weeks (15 lessons). The quasi-experimental research using the quantitative analysis method was conducted in this study. And pre-test / post-test control group design was used in this study.

Statistical analysis

Descriptive and inferential analysis was conducted to analyze data. To analyze the data MANOVA is conducted for each independent variable with the dependent variable. For tests having significance, ANOVA is conducted to find the source of the differences and significance. Differences were considered statistically significant at $p < 0.05$.

Study Limitations

Following limitations were encountered for this study:

- i. Create an effective PBL environment to handle all responsibilities of PBL which develops students' abilities.
- ii. Sample size was 76 students were relatively small, which means that the ability to detect effects that are not large or moderate in size is low. These non-significant effects should be treated with caution.
- iii. The length of the study which was 13 lessons. A longer application period would have been more advantageous to allow more time for evaluating the effects of the PBL.
- iv. The accuracy of the study results depends on the accuracy of the psychometric properties of the study tool and the seriousness of the respondents.

Results of Research

Data normality

For Skewness and Kurtosis statistics, the range of acceptability is between +1.96, -1.96 respectively. This particular characteristic is considered to be abnormal of high or low value on a variable because it stands out from the others on general observation. SDLRS variable in the data exhibited normality with acceptable values.

Levene's Test and MANOVA with dependent variables of SDLRS in pretest are analyzed. The result showed there are no significant differences at the (0.05) level between the experimental group and control groups on the SDLRS pretest. For this reason, MANOVA with the dependent variables post-test only was conducted to determine if those study groups have significant differences.

Descriptive Analysis

In terms of SDLRS, both groups (experimental and control) score differently in the SDLRS pre-test than post-test as described in Table 2. The experimental group obtained a mean pretest score of (M=202.94, SD=24.63), (means above average) and a mean posttest score of (M=255.71, SD=9.82)., (means high). Similarly, the control group has a mean pretest score of (M=204.15, SD=24.32), (means above average) and a mean post-test score of (M=249.47, SD=16.38), (means above average).

Table 2: Summary Statistics for SDLRS Scores

Variable		Experimental Group	Control Group	Total Sample
SDLRS	Pretest Mean	202.94	204.15	203.55
	SD	24.63	24.32	24.32
	Posttest Mean	255.71	249.47	231.33
	SD	9.82	16.38	24.14

Inferential Analysis

Null Hypotheses 1: There are no significant differences in the level of SDLRS post-test between the experimental group and control group.

Homogeneity of variance-covariance assumption underlying MANOVA is tested using the box M test, and the result indicates that homogeneity of variance-covariance is not met.

A multivariate test revealed differences between groups on SDLRS mean scores using the Pillai's Trace criteria are statistically significant [F= 35.468, p=.000, <.0.05). The results of the investigation comparing the dependent variable of SDRLS on the influence of the independent variable of the group indicated a significant difference between the two groups for the experimental group on SDRLS (F=57.40, p=.000, $\eta = .437$) as shown in Table 3. However, it is concluded that there is a significant difference in the average total score in the dependent variable posttest between an experimental group and the control group. Also, the average total score in the dependent variable in the posttest for the experimental group is significantly greater than that of the control group.

Table 3: Results of MANOVA for between-subjects Effect of the Research Variables

Source	Dependent Variables Posttest	Type III Sum of Squares	df	Mean Square	F	P	η
Group	SDLRS	24444.329	1	18089.59	57.398	.000	.437
Total	SDLRS	413035	76				

P<.05

An inspection of the mean and standard deviation scores indicated that the experimental group reported higher SDLRS mean scores ($M = 255.71$, $SD=9.82$) than the control group ($M=249.47$, $SD=16.38$), as shown in Table 4. When the results for the dependent variables are considered separately, analysis of variance ANOVA is conducted, and the results for the variable suggested that statistical significance are SDLRS $F (57.398, p=.000, < 0.05)$, as shown in Table 4.

Table 4: Results of ANOVA for between-subjects Effect of the Research Variables

Source	Dependent Variables Posttest	Type III Sum of Squares	df	Mean Square	F	P
Group	SDLRS	24444.32	1	24444.32	57.398	.000
Total	SDLRS	4130359	76			

P<.05

Null Hypotheses II: The effect of PBL on student SDLRS for experimental and control groups does not vary depending on achievement level.

An analysis was carried out for between-subjects effects. The main effect for group for SDLRS posttest was significant at $F=42.916$, $p=000$, partial eta squared = .373; partial eta squared = .024. The main effect for achievement level for SDLRS posttest was not significant at $F= .419$, $p=0.520$, partial eta squared = .006. The interaction effect between group and achievement level for SDLRS was not significant at $F= 1.795$, $p=.185$, partial eta squared = .024. Table 5 shows the results.

Table 5: Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	3037514.04	1	3037514.046	7204.021	0.000	.990
Post-SDLRS						
Group	18092.850	1	18092.850	42.916	.000	.373
Post-SDLRS						
Achievement - Level	176.637	1	176.637	.419	.520	.006
Post-SDLRS						
Group* Achievement Level	756.786	1	756.786	1.795	.185	.024
Post-SDLRS						
Error	30354.40	72	421.589			
Post-SDLRS						

Upon analysis, the results indicate that there were partially significant differences in SDRLS posttest scores when the experimental group was compared with those in the control group. Furthermore, the results indicated that there were no significant differences in SDRLS posttest scores when the high achievement group compared with those in the low-level group. Lastly, the results indicated that there were no significant differences in SDRLS posttest when compared, experimental and control groups from the high and low achievement level with small effect size for group mean differences (Partial Eta Squared= 0.006). Furthermore, the mean and standard deviations for the SDRLS variables are presented in the following tables.

Table 6: Mean and Standard Deviations for SDRLS Posttest Scores

Variable	Group	Mean	SD
SDLRS			
	Experimental	250.67	4.29
	Control	214.75	3.40

Table 7: Mean and Standard Deviations for SDRLS Posttest Scores

Variable	Achievement Level	Mean	SD
SDLRS			
	High	234.487	3.22
	Low	230.938	4.43

Table 8: Mean and Standard Deviations for SDLRS Posttest Scores

Variable	Group	Achievement Level	Mean	SD
SDLRS	Experimental Group	High	248.77	3.68
		Low	252.57	7.76
	Control Group	High	220.20	5.30
		Low	209.30	4.28

When the result for the dependent variables considered separately, an analysis of univariate is conducted, and the results of the variable that suggested statistical significance are summarized in Table 4.20 below. The univariate results for the SDLRS revealed significant differences among groups ($F=42.916$, $P=.000$), but not significant for achievement level ($F=.419$, $P=.520$), and not significant for the interaction between group and achievement level ($F=1.795$, $P=.185$).

Table 9: Results of Univariate for between-subjects Effect of the Achievement, SPS and SDLRS Variables

Source	Type III Sum of Squares	df	Mean Square	F	P
SDLRS					
Group	18092.850	1	18092.850	42.916	.000
Achievement Level	176.637	1	176.637	.419	.520
Group * Achievement Level	756.786	1	756.786	1.795	.185
P<.05					

Discussion

PBL showed to have higher SDL than the lecturing methods in this study. Also, the difference between the PBL and conventional instruction methods was not dependent on the students' levels of achievement. A comparison of posttest means was made between two groups for the posttest SDLRS total score. It was found that the PBL group had a higher mean than the control group. Furthermore, noteworthy differences were present between the control group and the PBL group. Thereby, it can be affirmed that PBL was efficient enough to improve and increase the SDL of the students. This shows that the students, who belonged to PBL groups, were responsible for their learning. It has also been established that such students perceive problems as challenges, the whole having a strong desire to acquire new knowledge, to resolve the problem.

Such students are also found to be goal-oriented, as compared to the students, learning in conventional groups.

In the traditional instruction method of this study, students learn directly from the teacher and there is only so little chance for improving their SDL skill. But in the PBL group, students after presenting the problem by tutor they start to work collaboratively in groups, in which every student know his role, to read the problem again and understand it, identify the problem by using their prior knowledge in the discussion, identify the gaps in their knowledge then they identify their learning objectives. Then, every student search individually, to found answers for his objective from different resources (books and the internet). Next, students regroup to discuss their searching results without direct help from the tutor. After students agreed on their favorable answer, they started to make their group presentation and present it in the class. Finally, students start to reflect on their SDL skills through their learning in PBL.

In all the steps of students' learning, students were responsible for their learning, even in groups or individuals without any direct help from the tutor in any step. This gave the students an excellent experience to develop their SDL skills comparing to students in the conventional group. All students could be responsible for their learning, but the conventional instruction methods did not give them this chance. In the entire process of PBL, which is found to be student-centered in nature, students are more likely to start working on the given problem, before identifying their knowledge receiving gaps, receiving other curriculum inputs, learning in groups and individually, generating their learning problems, critically evaluating their literature resources, searching the available literature, applying new knowledge to the identified problem, and critically reflecting on their SDL skills (Hmelo & Lin, 2000).

It has been claimed by Guglielmino (2008) that the SDLRS incorporates eight subscales, to measure and evaluate different domains of SDL. These may include problem-solving skills, level to utilize basic study skills, positive attitude and orientation to the future, creativity, love of learning, informed acceptance of responsibility for one's learning, independence, and initiative in learning, self-concept, as well as openness to the opportunities of learning. It has been established from the studies of Wetzel (2008) that subscores, which have been derived from SDLRS factors, are not reliable; hence it is not recommended to utilize such sub scores.

Similar to the findings of the current study, a study was conducted in Egypt and Saudi Arabia, to examine the effect of using PBL on critical thinking and SDL abilities of nursing students in the two countries. The outcome measures in this study were the SDLRS and critical thinking dispositions inventory. The results showed that teaching with PBL was significantly effective in increasing levels of critical thinking and SDL in both countries, without variation (Shahin & Tork, 2013). In addition to this, Gabr and Mohamed (2011) have also researched to examine the impacts of PBL in undergraduate nursing students, who have been enrolled in the administration course of nursing. It is significant to bring into notice that the study utilized four outcome measures in the research study.

Those outcome measures may include students' opinion questionnaire sheet, students' problem-solving evaluation sheet, five cases of problem-solving related to managerial skills (scenarios), and SDLRS.

In comparison to traditional methods, students who participated in PBL had significantly higher problem-solving grades, better knowledge, and higher SDLRS scores. There was no significant difference in the other measures. Also, Tsou et al. (2009) has investigated the SDL readiness of the students, studying in medical college, after and before they entered the PBL curriculum, by using SDLRS. It has been observed that after one of the PBL, considerable enhancements in SDLRS scores were noticed in the students of Fu Jen medical school. More so, noteworthy improvements have also been observed in the students, in terms of self-assessment and learning strategies. These changes were continually observed until the end of two years of PBL. It has been claimed by the medical students, during their clinical years that they had proactive learning capabilities and had commendable learning capabilities and they had considerable confidence in SDL, in contrast with the students, learning in traditional environments.

All these studies, which were applied to university learning areas in nursing and medical science, shared the results of the current study that was applied in 12th grade in the biology unit and showed that PBL helped in contributing towards the SDLRS scores, compared to the conventional group. Also, these studies shared this study in using SDLRS as a measurement for students' SDL.

On the other hand, there were several types of research, which used different measurements for SDL and reported the effectiveness of the PBL approach in enhancing the SDL. A study was conducted on first-year nursing students to compare PBL and traditional instruction (Choi et al. 2014). The findings showed that PBL helped the students in improving their capabilities and competencies, in terms of problem-solving. It has also been established that critical thinking is mainly associated with SDLK and problem-solving. Other than that, a study conducted quasi-experimental design research to investigate the effect of PBL approaches on bridging nursing program students learning in Saudi Arabia (Ali & El Sebai, 2010). Results indicated that PBL is highly integrated and efficient, in terms of developing an in-depth and profound approach to learning and enhancing SDL capabilities among nursing students (Choi et al. 2014). A research study was carried out on first-year nursing students, to compare traditional instruction and PBL. It has been established from the findings of the research that the PBL group had commendable and highly appreciable problem-solving skills and SDL, as compared to traditional learning groups.

When students' achievement levels of the present study were taken into consideration, it was found that interaction between the achievement level and total SDLRS score was not significant. This means that both PBL had the same effect on higher and lower achiever students. High achiever students are very academically resourceful (Zimmerman & Martinez-Pons, 1988). In PBL, high achiever students are more structured and able to gain SDL than the low achievers. In this study, students learned collaboratively in heterogeneous

groups that helped all students to establish common ground, decrease the differences between them, discuss and agree on all learning steps through exchanging the opinions openly and group members' engagement.

In these environments, low achievement students took maximum benefits from high achievement level students to learn how to determine their knowledge gap and fill it by exchanging information with them, set their learning objective, identify what they need to learn more about for the task they are engaged in, they should be capable enough to plan their knowledge acquisition and decide on different resources, which are needed for the attainment of the goal, and examine whether or not their objectives and goals have been achieved (Hmelo-Silver, 2004). This helped low achievement level students to develop their SDL skills and lifelong learning skills.

Conclusion and Recommendations

Overall, PBL was effective in enhancing students' SDL. And PBL improved SDL for both high and low students' levels. Therefore, PBL is necessary for all students' levels to improve their SDL. Future research is recommended to compare the effect of PBL on both genders, involve samples from other lower learning grades as primary and preparatory grades or in higher programs, investigate the effect of PBL on School students on long period time, integrated ICT with PBL group, assess the effectiveness of PBL on other variables, and examine the effect of PBL on other unites and topics of Biology, Chemistry, and Physics. Also, Supreme Education Council decision-makers and academicians in designing course planning are recommended to integrate PBL in Qatari schools curriculums.

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