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The Effectiveness of the School Based-Cooperative Problem Based Learning (SB-CPBL) Model in Improving Students' Achievement in Science

(Keberkesanan Model Pembelajaran Berasaskan Masalah Berasaskan Sekolah (SB-CPBL) dalam Meningkatkan Pencapaian Pelajar dalam Sains)

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ABSTRACT

School Based-Cooperative Problem-Based Learning (SB-CPBL) model is a model that integrates Problem-Based Learning and Cooperative Learning towards becoming more student-centered. This study elucidates the effectiveness of the SB-CPBL model on 8th-grade students' achievement in science. The study was conducted in King Abdullah II School for Excellence in Jordan using four classes, assigned as experimental and control groups. The quasi-experimental with non-equivalent control group pre-test/post-test design was used, with a sample of 120 students from both genders. Two classes (60 students) were selected randomly as an experimental group learning via the SB-CPBL Module, while the other two classes (60 students) that assigned as the control group followed their teacher's usual approach of teaching. A treatment period of 6 weeks was used in this research. A science achievement test was employed to measure the differences in the dependent variable quantitatively. Data analyses confirmed that the SB-CPBL students had higher scores in the achievement post-test relative to their counterparts in the traditional group. Also, the results showed that the difference between the SB-CPBL module and traditional teaching methods is not dependent on the achievement levels of the students. The analysis showed significant main effects of gender in the context of achievement. The findings implicate that SB-CPBL can help in providing meaningful science education that meets the needs of the students in the 21st century.

Keywords: school based-cooperative problem-based learning; cooperative problem-based learning; problem-based learning; cooperative learning; science education

ABSTRAK

Model Pembelajaran Berasaskan Masalah Kooperatif Berasaskan Sekolah (SB-CPBL) merupakan model yang mengintegrasikan Pembelajaran Berasaskan Masalah dan Pembelajaran Koperatif ke arah menjadi lebih berpusatkan pelajar. Kajian ini menjelaskan keberkesanan model SB-CPBL terhadap pencapaian pelajar gred 8 dalam subjek sains di King Abdullah II School for Excellence di Jordan. Reka bentuk eksperimen kuasi dengan ujian pra dan pasca kumpulan kawalan tidak setara digunakan, dengan sampel 120 pelajar dari kedua-dua jantina. Dua kelas (60 pelajar) dipilih secara rawak sebagai kumpulan eksperimen melalui Modul SB-CPBL, sementara dua kelas lain (60 pelajar) sebagai kumpulan kawalan mengikuti pendekatan pengajaran biasa. Tempoh rawatan selama 6 minggu digunakan dalam penyelidikan ini. Ujian pencapaian sains digunakan untuk mengukur perbezaan pemboleh ubah bersandar secara kuantitatif. Analisis data mengesahkan bahawa pelajar SB-CPBL mempunyai skor yang lebih tinggi dalam pencapaian ujian pasca berbanding dengan rakan mereka dalam kumpulan tradisional. Hasil kajian juga menunjukkan bahawa perbezaan antara modul SB-CPBL dan kaedah pengajaran tradisional tidak bergantung pada tahap pencapaian pelajar. Analisis menunjukkan kesan utama utama jenatina dalam konteks pencapaian. Hasil kajian mengimplikasikan bahawa SB-CPBL dapat membantu dalam memberikan pendidikan sains yang bermakna yang memenuhi keperluan pelajar pada abad ke-21.

Kata kunci: pembelajaran berasaskan masalah koperatif berasaskan Sekolah; pembelajaran berasaskan masalah koperatif; pembelajaran berasaskan masalah; pembelajaran koperatif; pendidikan sains

INTRODUCTION

Science and technology advancement is a critical aim for many countries, as both are seen as crucial to social and economic development. Achieving this aim depends on developing educational policies that value gaining the scientific knowledge required while fostering pedagogical strategies that promote active involvement in science and mathematics. These policies usually include redesigning the educational system, contributing to the development of the written-curriculum and encouraging the acquisition of scientific knowledge. Such efforts often accompanied by professional development programs for teachers, with limited attention to the teaching activities that occur inside classrooms. Over the past years, many Arab countries have experienced waves of educational reform initiatives in one or more of those areas. Over the last two decades, the pace of education reforms in Jordan has grown considerably (Alhabahba et al. 2016; Alkhawaldeh 2017) striving to counteract the acute lack of natural resources and increase the country's capability to provide individuals' needs instead of relying on international loans and aids (Al Jabery & Zumberg 2008). The successive reforms were aimed mainly at improving science education provided and increasing the efficiency of its outputs (Qablan et al. 2010). School science curricula in Jordan are mainly focused on equipping students with enough scientific knowledge and the tools that they will require for lifelong learning (Gu & Belland 2015).

Unfortunately, despite the huge budgets being spent, the results were dismal (Dagher & BouJaoude 2011; UNESCO 2014). In terms of students' performance in science, of the TIMSS and PISA reports shown that Jordan always came in low in the global ranking of science (IEA 2016; 2000; Said & Friesen 2013; TIMSS 2007, 2012), and fared poorly compared to all the other countries involved in the studies, as its results were below average (OECD 2009; 2014; 2016). According to several critiques, it is believed that several waves of educational reforms have largely failed in its objectives to provide quality education in Jordan and improve students' performance in science (Khan Al-Daami et al. 2007). The UNESCO (2014) report on teaching and learning quality, stated that despite Jordanian learning outcomes improving earlier, they have deteriorated not only in international assessments but in national assessment scores. Studies on reform the education system towards the knowledge-based economy in Jordan argued that the reform process was superficial, focused on a part of the problem, as the interest was only in school facilities, units building, and quickly finish teaching the content knowledge, while a few investments focused on improving the current pedagogies (Abuhmaid 2011; Qablan et al. 2010).

Specifically addressing teachers' role for educational reform in Jordan, Al-Amoush and Markic (2011) highlighted a high level of teacher-centeredness, a strong focus on the pure learning of the subject matter, and knowledge transmission. This suggests that the Jordanian students are exposed to unsafe educational practices, with growing concerns for low achievement and increased rates of dropouts (Alhabahba et al. 2016). With the emergence of many experimental studies on science curriculum and pedagogies in the last decade, findings stressed that the traditional approach of teaching that still characterized the climate of science classroom in Jordan should be accelerated and schooling practices need to be modernized (Alhabahba et al. 2016; Alkhawaldeh 2017; Dagher & BouJaoude 2011; Qablan 2016), otherwise, the decline will continue (UNESCO 2014).

As empirical research in the constructivism continues to grow in different parts of the world, education reform activists advocate moving towards constructivist learning strategies, which ensure active involvement, cooperation, and engage students in meaningful learning in line with the requirements for success in the 21st century (Aziz & Andin 2018; Aziz & Bustam 2011; Eronen 2019; Shah 2019). As such, it is necessary to free the Jordanian system of education from traditional practices and adopt an effective learning approach that engages students in a constructivist learning environment instead of memorizing concepts and facts.

Problem-Based Learning (PBL) is described as a constructivist pedagogical approach (Gustin et al. 2018) where scenarios drive the learning process (Silver & Barrows 2006; Kazemi & Ghoraishi 2012). PBL has been gaining popularity in recent years (Gustin et al. 2018). It is an efficient modality that offers a healthy learning environment (Ferreira & Trudel 2012; Gorghiu et al. 2015; Kek & Huijser 2011). In the original cycle of PBL developed for medical courses, a group consisting of 8-10 students, guided by one facilitator, are presented with a medical problem that needs to be solved. However, such a style of PBL implementation could be ineffective in traditional classroom settings, which are often overcrowded (Mohd-Yusof et al. 2011b), as is the situation in Jordan and other developing countries. In this case, a high level of cooperation is required on the part of the students within their respective PBL groups (Mohd-Yusof et al. 2011a, 2011b). Also, when conducting PBL for the first time, students usually eschew working in groups, as it is unusual and conflict with their experience in learning (Woods 1994; Beaumont et al. 2004). In order for PBL to be implemented successfully in a traditional classroom where the problem-solving technique is uncommon, it is critically important to enhance team-working skills and cooperation among students (Rahmani et al. 2013). In this context, researchers carried out a wide variety of studies on combining Cooperative Learning (CL) and PBL to support students' collaboration when undergoing PBL (Bahar-Ozvaris et al. 2006; Bergin et al. 2018; Siew & Chin 2018; Thompson & Gregg 2004). Findings revealed that the natural synergy between CL and PBL transforms the class into an active learning community and highly facilitates the facilitators' task in large-sized classes, where support, feedback, and assessments can be obtained from peers, especially other team members.

Although many examples of using PBL combined with CL in teaching and learning occurred in the literature, inspiring examples are relatively sparse (Bergin et al. 2018). Empirical researches on the effectiveness of this combination at the school context appear to be lacking. School Based-Cooperative Problem-Based Learning (SB-CPBL) combines these approaches for teaching and learning science in the school classes, whereby students can develop a deep understanding of the surrounding natural events and practice a spectrum of scientific habits. Combining both CL and PBL, focusing on science, showing that in well-functioning, students share arguments and conceptual and procedural knowledge, as well as seeking justification from one another (Avery et al. 2010; Heller et al. 1992). This work sought to investigate the effectiveness of SB-CPBL on the students' academic performance of science in Jordan middle schools. In addition, the study was also interested in finding out whether some independent variables, such as gender and achievement levels influence students' achievement when PBL is used. These interactions put together to have important implications for the type of instructional procedures that are to be employed for setting up an appropriate learning context for science education that is suitable for both genders (Ajai & Imoko 2015). The choice of achievement level as an independent variable is predicated on the current research emphasis on providing a balanced education that gives lower achiever students the same opportunities and challenges to gain the same scientific knowledge as their high achieving peers.

SB-CPBL might be able to improve the performance of science in Jordanian schools, thus improving the quality of the programs' outputs. The current study aims to address the following research question:

1. Does SB-CPBL improve students' academic achievement in science compared to the traditional teaching method?
2. Are there any differences in the achievement between control and experimental groups based on their achievement level (high and low)?
3. Are there any differences in the level of achievement post-test between male and female students?

In response to the research questions, null hypotheses were formulated as follows:

H_{01}: There is no significant difference in the level of achievement of the post-test between the SB-CPBL and the control group.

H_{02}: The effectiveness of SB-CPBL on students' achievement does not vary depending on achievement level (high and low).

H_{03}: There is no significant difference in the level of achievement post-test between male and female students.

SCHOOL BASED-COOPERATIVE PROBLEM-BASED LEARNING (SB-CPBL) MODEL

A review carried out by Smith et al. (2005) compiles evidence pointing to the positive impact that both CL and PBL have had on students' performance but highlights the lack of inspiring models for conducting these methodologies in the classroom. CL is commonly used in school classes and is described only briefly. A unique integration between CL principles and PBL suggested by (Mohd-Yusof et al. 2011a, 2012) for typical engineering courses and translated into a detailed model called Cooperative Problem-Based Learning (CPBL) Model, could be adapted and applied in schools context, and might be able to improve students' achievement in science. CPBL is conducted in three phases:

- Phase 1: Problem restatement and identification.
- Phase 2: Peer teaching, synthesis, and solution formulation.
- Phase 3: Generalization, closure, and internalization.

Generally, these phases are primarily included in the different PBL models. However, CL aspects are incorporated into the learning activities of each phase to emphasize problem-solving in dynamic learning small teams (3-5 students) in medium and large classes with one floating facilitator (Alwi et al. 2012). The CL principles promoted throughout the phases of CPBL are (1) positive interdependence, (2) individual accountability, (3) face-to-face interaction, (4) appropriate interpersonal skills, and (5) regular group function assessment. CPBL is seen as suitable to be adapted for this study, which takes place in Jordan, where the classrooms are often overcrowded. This is due to the flexibility of CPBL, as it can be utilized in medium and large classroom settings (~40-60 students for one floating facilitator), where support and sharing knowledge can be gained from peers and other group members (Alias et al. 2015). The model was also shown to be useful for students who are novice problem solvers (Mohd-Yusof et al. 2011a), which is the case of Jordanian students, who have limited experience in teamwork and PBL. This feature is unique to this model, where it systematically drives students, with adequate details, to undergo the CPBL cycle.

The original CPBL model (Mohd-Yusof et al. 2011a; 2012) has been adapted in this research for a school environment in the science curriculum. The resulting School Based-Cooperative Problem-Based Learning (SB-CPBL) model is shown in Figure 1. Mainly, the SB-CPBL model consists of the three phases present in the CPBL. However, more space was provided for overall class discussion, which is crucial for students new to PBL, especially Jordanian students, who have limited experience in teamwork and PBL strategies. The overall class discussions in SB-CPBL could be extended for some classes, as its time is more flexible at schools relative to engineering courses in the CPBL.

Overall class discussion is the core of the SB-CPBL model. It is a critical component that moves students towards a student-centered learning environment (Chang 2016). A facilitator monitors such discussions in what is called problem-centered discussions (Hmelo-Silver & Barrows 2006). The facilitator acts as a guide by asking questions and providing support and assessments (Hung et al. 2008). Assessment is required to drive the learning process and provide students with meaningful feedback. The SB-CPBL model shown in Figure 1 consists of three phases divided into nine steps and arranged in a specific sequence.

In the beginning, realistic problem is given to the students. Based on their current knowledge, they are required to individually write a problem identification and restatement in their own words prior to coming in for discussions with their group members to arrive at a consensus for group problem identification and restatement. Next, an overall class discussion session is conducted. This is where the problem restatement and identification of each group needs to be discussed in order to arrive at a consensus for the overall class problem identification and restatement. Afterward, the students move on to phase two, where they engage in SDL, aiming to answer the listed learning issues. Then, team peer teaching will be held by each group member to explain what they understood, discuss questions, ideas, and unclear concepts, which is then followed by an overall class discussion session monitored by the facilitator.

During the overall class discussion, information and knowledge will be shared and critically reviewed. In the next step, students within their respective groups are required to synthesize newly acquired information and test them to generate possible solutions. The last part of this phase focuses on coming up with the best agreeable solution that has been critically evaluated from each group. In the final phase, the final report of each group will be handed in, and then each group is required to present their respective solution. Finally, closure is where generalization and reflection take place. Contrast to traditional teaching classes, where the learning described as a one-man show with a large audience of listeners (Travis & Lord 2004), SB-CPBL characteristically occurs in small facilitated teams that take advantage of the social side of the learning with peers and solving problems. The facilitator guides the learners, encouraging them to engage in the learning process and model questions the students should ask themselves, leading to deep and profound thinking.

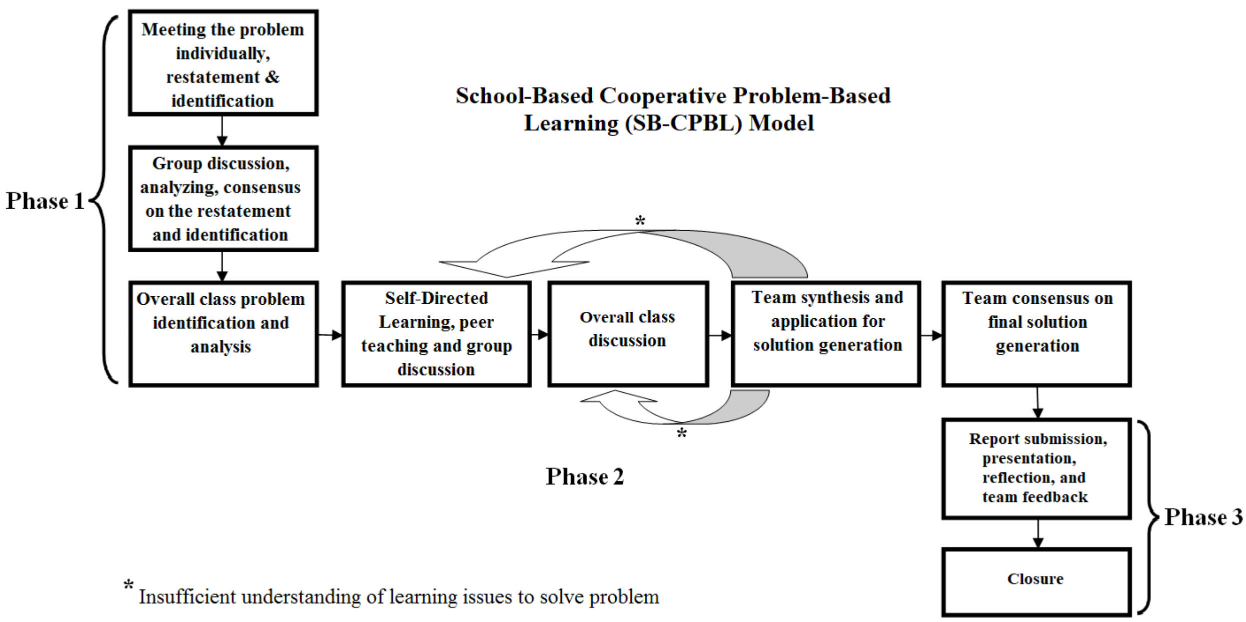

FIGURE 1. The School Based-Cooperative Problem-Based Learning (SB-CPBL) Model adapted from (Mohd-Yusof et al. 2011b)

CONCEPTUAL FRAMEWORK

For systematically designing and implementing an optimal PBL curriculum, the PBL module is a crucial element that shows the process in which learners have to go through. In this research, the SB-CPBL module was designed on the Genetics unit from the eighth-grade science syllabus. The module used as a tool to implement the SB-CPBL strategy on science at school. It was developed in a planned and systematic manner, grounded in constructivism view (Savery & Duffy 1995), cooperative learning principles (Johnson et al. 1984), How People Learn (HPL) framework (Bransford et al. 2004), integrated with the philosophy of problem-based learning. The conceptual framework used in the current research study is shown in Figure 2.

The PBL philosophy was mainly used to develop the conceptual framework in this research. This philosophy is based on the fact that students who engage in PBL often retain experiences and knowledge longer (Gustin et al. 2018), and perform better in real-world problematic situations. It is due to the fact that PBL challenges students to learn via engagement in real-world problems (Kazemi & Ghoraishi 2012). The learning activities in the SB-CPBL module are designed based on the constructivist theory. The SB-CPBL students are responsible for constructing their own knowledge, where they are fostered and expected to think critically to gain a deeper understanding of the problematic scenario at hand. Social negotiation (Tan 2002) is a key factor that leads to SB-CPBL students constructing their respective learning, which is aligned with constructivism.

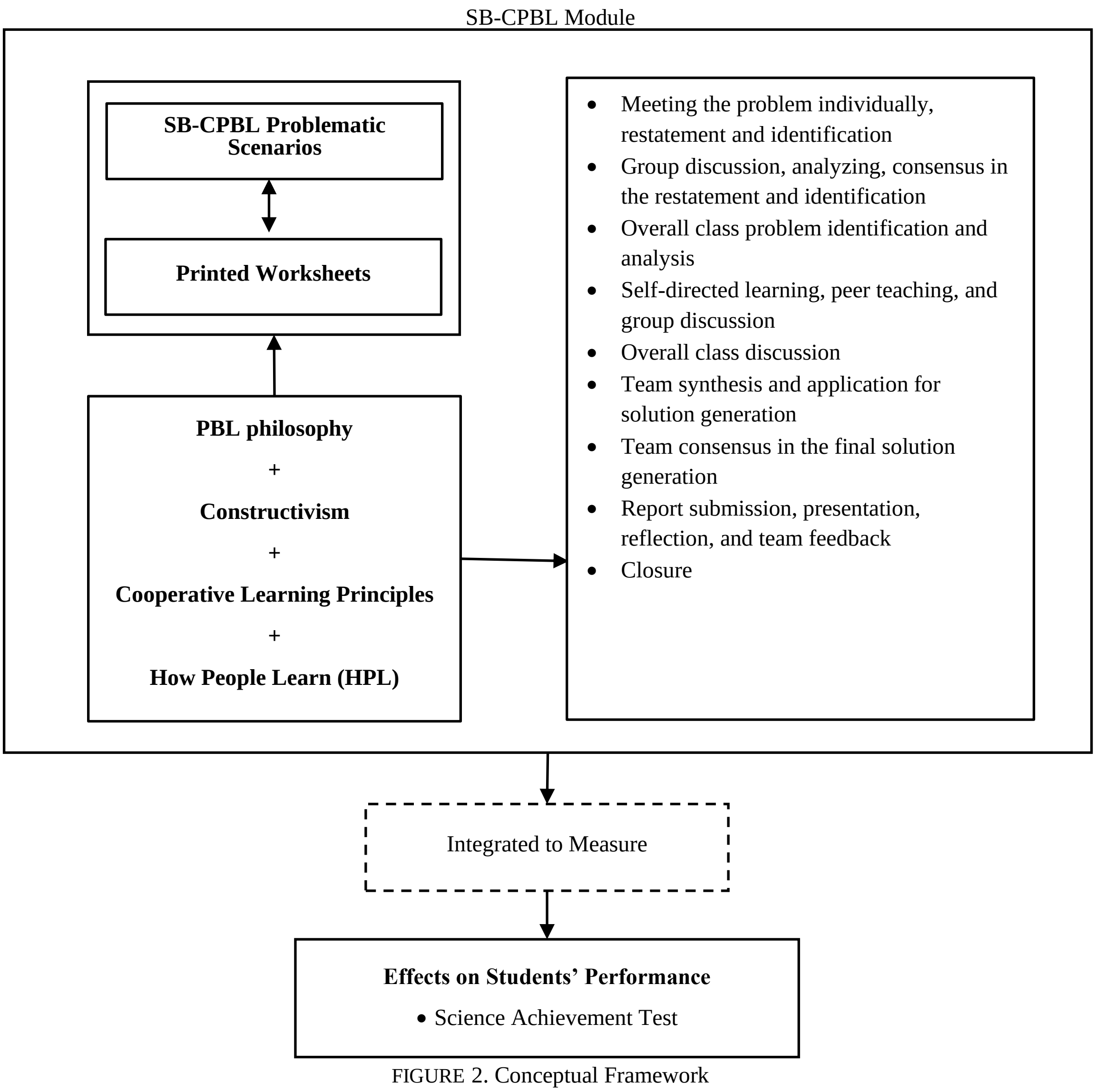

FIGURE 2. Conceptual Framework

Besides that, CL principles are adhered to when planning of SB-CPBL module activities and are all emphasized throughout the three phases. The CL principles are to confirm the collaborative, peer teaching, supporting communications, and team-working skills, all of which are crucial towards the successful implementation of PBL (Casey & Goodyear 2015; Mohd-Yusof et al. 2011b, 2011a), especially within students with traditional learning background, who often needs such skills more than others. The module also aligned with the elements of the HPL framework introduced by (Bransford et al. 2004). It suggests four overlapping lenses (knowledge-centered, learner-centered, assessment-centered, and community-centered) uses as criteria for determining the effectiveness of a learning environment (Duffy & Kirkley. 2003). For example, SB-CPBL uses real-world problems crafted based on the level of prior knowledge of the students, which is in line with the knowledge-centered lens.

Identifying and analyzing the SB-CPBL problem resulted in two lists; “what we know” and “what we need to know”, both of which can help students recall prior knowledge and correlate it to new learning that is closely aligned to student-centered. In the current research, SB-CPBL Model was used as a framework for the implementation of problem-solving strategy in Genetics for eight grade students. The model acts as the backbone of the SB-CPBL Module. It has been adapted to the needs of problem-solving in science. In order to solve problems in Genetics, students must go through the model steps given and monitored by the facilitator. This model will be used by both; students and the facilitator during SB-CPBL in solving Genetics problems. To craft problematic scenarios that are well-aligned to the intended content and students’ knowledge level, an instructional design suggested by Wood (2003) was employed. It serves as a framework that helps educators in designing systematically PBL curriculum modules. One problematic scenario has been crafted for each lesson in Genetics. The scenarios used in the SB-CPBL module are crafted to encompass the desired learning outcomes of Genetics.

METHODOLOGY

RESEARCH DESIGN AND SAMPLE

The study employed the quasi-experimental with non-equivalent control group pre-test/post-test design. A quasi-experimental research design found to be suitable for answering the research questions (Creswell 2014). This due to its characteristics, for example, pre- and posttest, and control group and treatment. The current study falls into the quasi-experimental design category because the participants involved in the research are taken from existing science classes in school instead of randomly assigning students to treatments (Johnson & Christensen 2004). Using existing science classes refers to the internal school system and avoid disruption to the students’ learning environment. To ensure that the chosen classes represent varied levels of attainment, students' achievement in science was determined according to their grades obtained in the final science test of the previous semester. A quantitative research method that is known to measure the differences between two groups of students (Maxwell 2005) was selected in this research. Four sample classes of eight-grade aged between, 14-15 years old, have participated in the experiment.

A middle school (King Abdullah II School for Excellence) was firstly selected randomly from 283 middle schools existed in Al-Zarqa, the second-largest governorate after Amman the capital of Jordan. King Abdullah II School for Excellence is one of the mixed (male and female) school affiliated to Al-Zarqa educational directorate. The school possesses six classes of eight grade (three male and three female). Two eighth-grade classes, which consisted of 60 students, were randomly assigned as experimental groups (one male and one female) learned by SB-CPBL Module, which focuses on developing their achievement. Meanwhile, the other two classes (one male and one female) with 60 students were worked as control groups. Table 1 contains the analysis of the demographic variables.

TABLE 1. Descriptive statistics of the participants (N=120)

Characteristics	No. of Students	Percentage
Group		
SB-CPBL	60	50%
Control	60	50%
Gender		
Male	53	44.2%
Female	67	55.8%

This study has obtained ethical approval from the Ministry of Education of Jordan. Permission to conduct the study has also been obtained from the school where this study is conducted and the participants have consented to be involved in the study.

Students’ scores of pretest/posttests will be compared to determine if there is a significant effect of SB-CPBL on student learning. Both groups were subjected to the pre-test in order to identify the level of their ability before the treatment. Students’ scores in the pretest showed that there were no significant differences regarding their ability before the treatment. The treatment was conducted for six weeks then the post-test was immediately re-arranged and re-administrated for both groups.

INSTRUMENT

The eighth-grade students in both experimental and control groups were given a quantitative pretest instrument aligned to the learning objectives of the Genetics. The SB-CPBL module was designed on the Genetics unit according to the teaching plan of the eighth-grade science curriculum set by the department of science education supervision\MoE. The pretest has been given three days prior to the treatment to measure the students' prior knowledge. The pretest set the baseline for students' prior-knowledge in the Genetics unit. The quantitative pretest instrument was constructed by the researcher in cooperation with science teachers involved in the study. It contains 21 four-option multiple-choice items. The items were developed based on the taxonomy levels described by Bloom et al. (1984) and the table of specifications. The achievement test instrument contained items that require learners, for example, to; recalling relevant knowledge from the long-term memory, using knowledge in new ways, making sense of what they have learned, and making judgments based on a set of guidelines. A student gets one mark for each correct answer while each wrong answer gets zero marks. For content validation and to ensure that the items covered the learning outcomes, the test has been sent to a panel of experienced lecturers from the University of Jordan-Faculty of Education /Curriculum and Pedagogy (science pedagogy), and supervisors from Educational Measurement and Evaluation-Jordanians' MoE, finally two Arabic teachers were also involved to revise the test to be free of any printing or grammatical errors. Experts were asked to rate items for each construct based on Blooms' taxonomy. They were also asked to highlight items that are unclear or unsuitable for the subjects' level. Based on their feedback, the achievement test instrument has been modified and arranged.

The instrument was then pilot tested with 60 school students outside the sample classes for reliability. The instrument's reliability was confirmed using Cronbach's alpha coefficient. It appears that the majority of the authors in literature are of the consensus that 0.70 is the acceptable value, although the value may decrease to 0.60 (Hair et al. 2009). Hence, Cronbach's alpha cut-off of 0.60 was used as the criterion. In this research, Cronbach's alpha value was found to be 0.678. Aside from the acceptable value, the discrimination index and difficulty index for the entire items were also obtained and based on the results, the questions ranged from 0.21 to 0.65 which were eventually achieved the value of (0.20). In this regard, Verma et al. (2008) revealed that items with discrimination index values less than 0.15 should be dropped from the test. Therefore, one element was dropped. Moreover, difficult index values of the items ranging from 0.20 to 0.80 are considered acceptable. In this study, the difficulty index value for the achievement test ranged from 0.44 to 0.79 which is in line with the criterion (Kubiszyn & Borich 2000).

DATA ANALYSIS METHOD

Statistical Package for the Social Sciences (SPSS) was used to analyse the data collected. Descriptive analysis was carried out on the data to determine the values of the mean (M), standard deviation (SD), and value for pre and post achievement tests. In addition, the inferential statistics were carried out involving; independent sample t-test and Univariate Analysis of Variance (ANOVA) for the comparison of means of the two groups based on their scores in pre and post-test of achievement in science based on .05 significance level. For the first and the third research questions, an independent sample t-test was carried out to find out the difference between experimental and control groups, as well as between males and females in terms of the post-test scores of science achievement. In addition, two-way ANOVA was carried out to determine the influence of the SB-CPBL on the students' achievement based on their achievement level.

FINDINGS AND DISCUSSION

THE EFFECTIVENESS OF SB-CPBL ON STUDENTS' ACHIEVEMENT

An independent sample t-test at the 0.05 alpha level was conducted with the dependent variable (achievement) to test the difference between the two groups' post-test in terms of their achievement. The result showed significant differences for the experimental group (Sig=.084, t=2.465, p=.015<0.05). The experimental group scored higher in the achievement post-test relative to their control counterpart, taking into account the mean and standard deviation shown in Table 2.

The finding of this study has revealed that students who were taught science using SB-CPBL outperformed their counterparts taught using the traditional method. The post-test means scores of the SB-CPBL group (M=16.63, SD=2.37) were found to be significantly higher than those of their counterparts in the traditional group (M=15.41, SD=2.99).

The results showed the efficacy of the use of SB-CPBL in enhancing students' achievement in science. The findings corroborate that of Bergin et al (2018), Gok and Sylay (2010), Alwi et al. (2012), Heller et al. (1992), and Bahar-Ozvaris et al. (2006) who all attested that exposure to PBL combined with CL, resulted in an improvement in students learning. Moreover, the finding of this study confirmed that the implementation of PBL via the SB-CPBL module was effective in science, which are in agreement with Yasin et al. (2012) and Soliman and El-Mouty (2017), confirming that the use of modules can act as a supportive tool for simplifying the process of learning and students mastery of knowledge.

Further, the superiority of the SB-CPBL strategy over the traditional method could be attributed to the philosophy that stands behind the learning context of PBL. Contrary to the traditional teaching that focuses on memorization, SB-CPBL students were required to gather information from several sources to solve a problem at hand. It has been argued that this is the essence of self-directed learning, where students are guided by their need to acquire new knowledge (Quinlan 2016), which encourages active learning and positively impacting their achievement. Also, in an SB-CPBL class, students are no longer passive listeners; instead, they take responsibility for their learning. They collaboratively generate ideas via investigations, which helps them better construct knowledge relative to their counterparts in traditional classes. Constructing new knowledge is consistent with the constructivist underpinnings of PBL (Gurses et al. 2015), which would help students master the content knowledge and improve their achievement (Niwa et al. 2016). SB-CPBL created new demands from the tutors. They were required to act as cognitive coaches and answer students' questions with questions in a form of scaffolding to develop their thinking processes, required knowledge, and skills for problem-solving. The facilitators' role is a critical factor that contributes to the development of students' learning in SB-CPBL. Facilitator activities includes crafting real-world problematic scenarios which helps learners in content acquisition by providing a meaningful learning context.

TABLE 2. Summary statistics for variables post-test scores (N=120)

Variable	Category	Experimental Group	Control Group
Achievement	Mean	16.63	15.41
	SD	2.37	2.99

TABLE 3. Results of ANOVA for the study variables

Source	Category	Sum of Squares	df	Mean Square	F	P
Group	Achievement	16.997	1	16.997	3.761	.055
Achievement level	Achievement	337.844	1	337.844	74.753	.000
Group*Achievement level	Achievement	.654	1	.654	.145	.704

TABLE 4. Summary statistics for variables post-test scores (N=120)

Variable	Group	Achievement Level	Mean	SD
Achievement	SB-CPBL	High	18.09	1.37
		Low	14.85	2.10
	Control	High	17.48	1.87
		Low	13.94	2.78

TABLE 5. Summary statistics for variables post-test scores (N=120)

Variable	Category	Males	Females
Achievement	Mean	15.44	16.75
	SD	2.98	2.26

THE EFFECTIVENESS OF SB-CPBL ON STUDENTS' ACHIEVEMENT DEPENDING ON THEIR ACHIEVEMENT LEVEL

This research took into account the levels of student achievement (high and low). The SB-CPBL effect on the achievement between control and experimental groups based on their achievement level (high and low) was examined. Referring to posttest scores, the consensus among science teachers involved in the study was that high is regarded to be (15-21 of 21), while low is regarded to be (0-14 of 21). The analysis results showed insignificant differences in terms of the interaction between group and achievement level at an alpha level of 0.05. In this context, the main effect and interaction of groups' achievement level, and the dependent variable was carried out with the two-way ANOVA. As for the analysis conducted for the between-subjects effects, shown in Table 3, the main effect for group achievement post-test was insignificant, while the achievement post-test was significant. The interaction effect between group and achievement level for post-test scores was insignificant in terms of achievement.

In other words, the analysis shows insignificant differences for the achievement post-test scores when the two groups were compared. The results also showed significant differences in the achievement of post-test scores when high achievement was compared with low achievement. Finally, insignificant differences were found in the achievement post-test scores when the experimental group was compared to the control group based on the high and low achievement levels. The mean and standard deviations scores are tabulated in Table 4.

The findings revealed that SB-CPBL demonstrated an ability to improve students' performance in science at both levels of achievement. Low and high performing students showed improvements in their learning achievement when they were engaged in SB-CPBL. The positive effects on students' achievement can be attributed to the collaborative problem-solving small groups that characterize the SB-CPBL process. One of PBL's assumptions is that the small teams' structure promotes shared knowledge construction among students (Mustaffa et al. 2016), which helps low achievers benefit from high achieving peers. The "face-to-face interaction" component is a verbal interchange among group members that helped create a vibrant climate of productive conversations and interaction patterns that encourage sharing and understanding with one another. In SB-CPBL, where learning issues are divided among team members, each member is responsible for sharing new knowledge and the information acquired with other group members and the hall class, which enables low achievers to gain an increased understanding of the subject matter. Another essential point is that learning via problem-solving in small groups increases the students' confidence when asking questions and arguing their points, which overall, enhances their learning experiences, and over time, their achievement levels. This finding contradicts (Han et al. 2015), who found that the low performing students achieved significantly higher than the middle and high performing students under a PBL learning environment. The findings however supported by Fodah (2012) and Tandililing (2015) who reported insignificant effects of the achievement levels on students learning using PBL instruction. Students who are exposed to this type of strategy are more likely to possess in-depth knowledge of the content area. They will be able to organize their learning and acquisition of basic skills in science.

THE EFFECTIVENESS OF SB-CPBL BETWEEN MALES AND FEMALES

An independent sample t-test at the 0.05 alpha level was conducted with the dependent variable "achievement" and the independent variable gender (males and females) for both groups. The independent sample t-test was carried out to determine the differences between males and females, specifically in terms of the post-test scores of science achievement. Significant differences were found for the female group (Sig=.095, t=-2.639, p=.009<0.05). As illustrated in Table 5, the results reported higher scores for female students relative to their male counterparts.

The study findings can elucidate the effect of gender on students' learning in PBL classes. The study yielded significant effects of gender, in favor of female students. The findings of the present study are consistent with Boaler (2002), who concluded that females prefer PBL type activities and outperform their male counterparts. This result is also in agreement with earlier studies of Ajai and Imoko (2015), Kassab et al. (2005), and State (2017) which showed gender differences in achievement within the PBL context., in favor of the females. These findings can be explained from the point of view that male and female students behave differently in PBL (Kassab et al. 2005), and females are more likely to be "connected students" who value the social aspects of learning (Reynolds 2003), which are a key feature of the SB-CPBL learning climate. For example, several researchers have revealed that peers influence attitudes and the academic achievement of fellow students (George 2006; Zhou et al. 2013). In phase two of the SB-CPBL model, ample time is allocated for peer teaching and learning activities. In this phase, team peer teaching was held by each group member to explain what they have understood. Peer teaching has been shown to enhance learning by helping learners be more confident in expressing difficulties, asking questions, and sharing debates (Rahmani et al. 2013). Female students were more active in peer teaching and learning activities during the SB-CPBL experiment relative to their male counterparts. They conducted peer teaching and learning sessions out of the class (in the library, computer lab, and even beyond school boundaries), which explains the higher mean scores reported by female students relative to their male counterparts.

CONCLUSION

The current study investigated the effectiveness of the SB-CPBL model on students' achievement in science. Analysis of the research findings confirmed that the SB-CPBL resulted in higher achievement relative to the traditional teaching method. The results also showed that the SB-CPBL had a significant effect on both higher and lower achiever students. The analysis reported significant main effects for gender in achievement, where females scored higher relative to their male counterparts. The findings implicate that SB-CPBL can be used to systematically implement PBL process with students who are novice problem solvers. This study could provide teachers, educators, and curriculum designers with insights on how constructivist-learning strategies affect students' performance. These insights will help them make decisions on their pedagogical practices needed to prepare future generations to succeed in the 21st century. This study involved 8th-grade students; therefore, the results cannot be generalized to the entire school system. Future researchers are expected to expand the scope of the research to include high school students. Also, the effects of the SB-CPBL module can be examined on other subjects, such as Mathematics, Chemistry, and Physics. Teachers of other subjects may find the study useful for designing and implementing SB-CPBL modules for their respective subjects. Future researchers, especially those involved in the usage of problem-solving in teaching and learning, are recommended to investigate the effectiveness of the SB-CPBL on other variables, including self-directed learning, critical thinking, and team-working skills.

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