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COMPARISON OF SCHOOL BASED-COOPERATIVE PROBLEM BASED LEARNING (SB-CPBL) AND CONVENTIONAL TEACHING ON STUDENTS' ATTITUDES TOWARDS SCIENCE

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Abstract. *This study examined the effect of the SB-CPBL on Jordanian 8th-grade students' attitude towards science. A quantitative quasi-experimental design with a non-equivalent control group was employed in this study. 120 8th-graders, divided into two groups, were involved in this study. Two groups (60 students, 30 males, and 30 females) were designated as the experimental group; they used the SB-CPBL module for six weeks, while two groups (60 students, 30 males, and 30 females) were designated as the control group and taught conventionally. The validity and reliability of the measurements used, comprising four sub-scales with 40-items, were already robust. The statistical comparison between the groups showed a significant improvement in the SB-CPBL students' attitudes towards learning science compared with their conventionally-taught counterparts. The findings also confirmed the insignificant effects of gender vis-à-vis attitudes towards science. The results concluded the effectiveness of SB-CPBL approach in improving students' attitudes towards science in school settings.*

Keywords: *cooperative learning, cooperative problem-based learning, problem-based learning, students' attitudes towards science*

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Introduction

Attitude towards science has been one of the most crucial research topics pursued by scientists for decades since there is a decrease in students majoring in science and technology (Bicer & Lee, 2019; Halim et al., 2018). This decline has negatively affected countries' and societies' endeavors towards economic and societal development in an era based on accelerated knowledge in science, technology, and mathematics (Evans et al., 2020). Thus, the pursuit of developing more positive attitudes towards learning science is seen as a crucial goal of science education systems worldwide to invest in science and pursue its related careers (Toma et al., 2019). Otherwise, the continuous supply of qualified professionals in science and technology disciplines will face a severe threat (Galama & Hosek, 2008). Arab countries have made great efforts to support students' engagement in science. However, it is still falling behind other world regions in the enrollment ratio in the scientific disciplines (UNDP/RBAS, 2014). In addition to the graduates' weakness in terms of competencies and skills, they need to lead, compete, and excel in the age of science and technology (Dagher & BouJaoude 2011). In Jordan, where the country launched ambitious, comprehensive educational reform projects in science education over the past decades, recent studies have been shown a modest level of student enrollment in science and technology courses at higher education (Assaad et al., 2018; Bicer & Lee, 2019). The ratio of students in middle and high school level who do not prefer scientific subjects has increased (UNESCO, 2015). Moreover, the low performance of Jordanian students in the global ranking of science (i.e., TIMMS and PISA) (Martin et al., 2016; OECD, 2014, 2018) has become a concern shared by planners and decision-makers. This is a significant disappointment in Jordan as it has believed that these reformation efforts could produce scientifically innovative and qualified cadres as serve as an investment in its scientific sector in light of the country's lack of natural resources (Al-shboul, 2012; Al Jabery & Zumberg, 2008), which forces it to rely on international aid, particularly from the World Bank.

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Despite the enormous budgets spent on these reforms, it was confined to specific aspects of teaching and learning science, such as supplementary materials, redesigning textbooks, and teachers' guides (Alhabahba et al., 2016), while little attention has been paid to conventional teaching practices that still dominates the minds of science teachers in Jordan (Abu Naba'h et al., 2009; Ahmad et al., 2015; Dagher & BouJaoude, 2011). The importance of the teaching methods used and the classroom climate lies in the fact that exposure to science can positively contribute to shaping students' attitudes towards science, as posited by (Hu et al., 2018). Based on empirical research on pedagogy, the conventional teaching style has been proven to be boring and results in negative attitudes towards learning (Duffany, 2017; Gorghiu et al., 2015). As students' attitudes towards science refer to their' feelings, opinions, and beliefs about learning science as a school subject, teachers in Jordan need to establish an effective learning environment that promotes meaningful participation in the learning process. Otherwise, the setback in students' attitudes towards science poses severe challenges for Jordan's renaissance and progress.

Reformers advocate moving towards constructivist teaching strategies to ensure a conducive and meaningful learning environment that promotes students' attitudes towards learning subjects. Problem-Based Learning (PBL) has been examined and resulted in commendable impacts on improving students' attitudes towards learning subjects (Demirel & Dagyar, 2016; Ferreira & Trudel, 2012; Gok & Sylay, 2010). Contrary to the conventional teaching approach, where students act as passive listeners, PBL as an application of the constructivist learning approach redefines students' roles and learning habits. PBL students are actively engaged in their learning (Syafii & Yasin, 2013). They have rich opportunities to discover knowledge meaningfully (Osman & Kaur, 2014). However, the typical cycle of PBL originating from the medical school of McMaster University, where a group of 10 medical students undergoes the process of PBL guided by a facilitator (Servant-Miklos, 2019), may not be practical in overcrowded class settings (Mohd-Yusof et al., 2011a), as is the case of Jordan and other developing countries (Al-Abdallat & Omari, 2019). In such a case, higher cooperation is required among students within their respective groups (Chen & Kuo, 2019). Moreover, students usually eschew working within groups (Mohd-Yusof et al., 2011a, 2011b), especially those who come from a conventional learning background, as learning via groups differs from their previous experience in learning, contradicting their beliefs (Woods, 1994), leading to what is described as a shock/struggle (Beaumont et al., 2004). Thus, to achieve PBL goals in a conventional classroom setting, where problem-solving strategies are uncommonly used, students must be grouped into collaborative learning teams (Casey & Goodyear, 2015).

In this regard, several works have explored Cooperative Learning (CL) combined with PBL and reported that it affects students' collaboration when undergoing the PBL cycle (Bergin et al., 2018; Sadikin et al., 2019; Siew & Chin, 2018). CL establishes a learning community where learners can support and obtain help from each other. PBL and CL's natural synergy is vital in producing a supportive and cooperative learning environment (Nawi et al., 2019). At the level of students' attitudes, several studies have highlighted how PBL strategies combined with CL can create more positive attitudes towards science amongst students (Adi et al., 2012; Gok & Sylay, 2010).

This study elucidates the effectiveness of a developed School Based-Cooperative Problem-Based Learning (SB-CPBL) component, which takes advantage of the combination of CL and PBL to improve students' attitudes towards science in Jordanian schools. This study has also interested in determining whether independent variables such as gender correlate with attitudes toward learning science. Studies in attitudes towards science among males and females have been frequently carried out and reported contradictory findings; some noted that males have better attitudes towards science relative to females (Wan & Lee, 2017) and are more willing to continue studying science (Reilly et al., 2019), while females are less enthusiastic in engaging in scientific inquiries (Hacieminoglu, 2016), and have less desire to continue with science and technology-related careers (Sadler et al., 2012). Other researchers have been reported similar attitudes towards science among both genders (Akpinar et al., 2009; Zeng et al., 2019). Accordingly, these contradictory findings require more search and clarification. The present research has expected to elucidate the effect of gender on attitude development towards science in middle school students, which could guide pedagogical intervention to prevent negative attitudes towards science during the middle school education stage. This study sought to answer the following research question "how do SB-CPBL improve students' attitudes towards science." This study hypothesized no significant differences in students' attitudes towards science post-test between SB-CPBL and the control group.

School Based-Cooperative Problem-Based Learning (SB-CPBL) Conceptual Framework

The PBL model used in this study was adapted from (Mohd-Yusof et al., 2011a), where the CL principles, which are known to promote cooperation among students, have been integrated into the typical cycle of PBL to become

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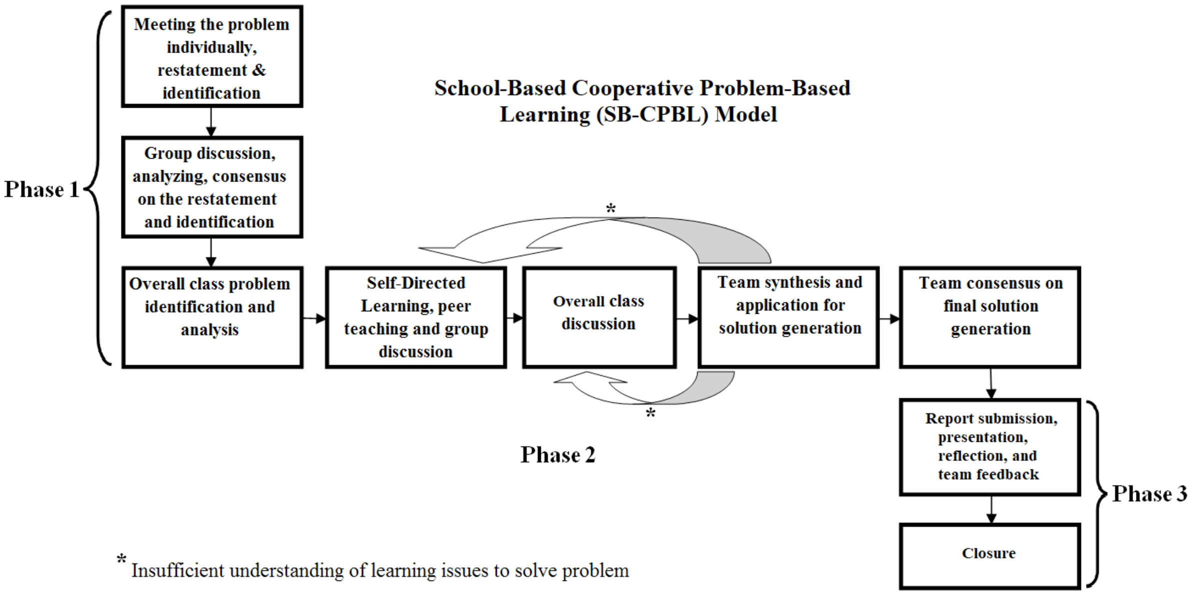
a Cooperative Problem-Based Learning (CPBL) model. CPBL was initially developed for engineering courses and has recently gained popularity with other courses (Adi et al., 2012). CL and PBL were integrated to purposefully to achieve an optimal PBL implementation by having small learning groups guided by a floating facilitator in large classes (Mohd-Yusof et al., 2011). The framework was useful in constructing functional learning groups that are characteristic of the PBL approach (Mohd-Yusof et al., 2011b). In this study, the CPBL approach has been adapted to fit a school environment, which resulted in the School Based-Cooperative Problem-Based Learning (SB-CPBL) Model, detailed in Figure 1.

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



The SB-CPBL framework serves as a systematic model to drive students' learning, with sufficient details, while undergoing the PBL process. It is conducted in 3 phases; Phase 1: problem restatement; phase 2: gathering information, synthesis, and determining the final solution; Phase 3: final report submission, presentation, generalization, and closure. The SB-CPBL model takes place in phases present in the different PBL models, and the five basic principles of CL are promoted and emphasized throughout the teaching and learning activities. It has been argued that learning groups can be classified as CL groups only if all of the essential elements of CL are present in their learning activities (Hallinger & Bridges, 2016). The following elements are regarded as the main principles of CL that must be provided in CL contexts and translated into learning activities; face-to-face interaction, positive interdependence, appropriate interpersonal skills, individual accountability, and regular group function assessment (Aranzabal et al., 2019).

The SB-CPBL cycle begins with an ill-structured problematic scenario given to students a day before the class. The subject matter content is organized around the given problems. At this stage, each student is required individually to write up a problem restatement and identification. The next day, group members will meet to discuss their problem restatement and identification and reach a consensus for group problem restatement and identification. Afterward, an overall class discussion will be conducted to agree on the overall class problem restatement and identification. Phase two is where the SB-CPBL students need to search for other sources to answer the learning issues determined in phase one. As the students search, inquire, and gather missing information, they are expected to summarize what they learned to be shared with their groups, and they can learn from each other. An overall class discussion will then be held, which would improve the students' understanding, leading to possible solutions. During the discussions, the teacher acts as a facilitator that guides students by asking questions, encouraging them to generate new ideas, and evaluate the learning process. The students within their respective SB-CPBL groups need to synthesize the newly gained knowledge and test them to gener-

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ate effective solutions, followed by coming up with the best solution, critically evaluated by group members. The last phase of the SB-CPBL cycle is where each team's final report will be submitted and presented in front of the class. In the last step, closure is where the generalization of the theories or concepts learned takes place.

Besides the social underpinnings of the CL approach and the constructivist theory underpinnings of PBL, the SB-CPBL model was developed within the How People Learn (HPL) framework (Bransford et al., 2004), Understanding these philosophies acts as a compass in planning a significant SB-CPBL climate, and helps facilitators understand their roles. Based on constructivism theory, students construct their own knowledge. In this context, they need to be given the opportunities to discover and explore, rather than forced to be passive listeners that are prevalent in the conventional learning process. PBL strategies emerged from learning by discovery. Also, CL principles adhered throughout the three phases of SB-CPBL, and are all emphasized when planning teaching and learning activities. Emphasizing these principles confirms functional learning groups that are crucial towards the successful implementation of PBL (Siew et al. 2017), particularly among novice students new to PBL. The SB-CPBL module was also aligned with the HPL framework, as presented by (Bransford et al., 2004). HPL is a guide for designing environments that promote high-quality learning (Nawi et al., 2019) by emphasizing four overlapping focus; a) learner-centered, b) knowledge-centered, c) community-centered, and d) assessment-centered used as criteria for planning effective learning environments. For example, using problematic scenarios that are crafted based on the level of learners' prior knowledge is in alignment with the knowledge-centered element.

The learning activities in SB-CPBL were planned as per these principles to ensure influential cooperative groups that are fundamental for achieving a successful PBL implementation. Through these approaches, learning may become an exciting process for students; hence, more positive attitudes towards science may be developed when students engage in meaningful learning.

Research Methodology

General Background

A quasi-experimental approach with a non-equivalent control group pre/post-tests design (Creswell, 2014) was used in this study to explore the SB-CPBL's effectiveness in enhancing 8th-grade students' attitudes towards science. The research design falls under this category due to the lack of random assignment for students in both the control and experimental groups (Cozby, 2007). The students were selected from the existing science sections, due to the Jordanian Ministry of Education (MoE) system and avoid disruption to the students' learning environment. Students' achievement in science was evaluated using their scores on the final test of the previous academic year to ensure that those involved in the study represent a range of abilities.

The SB-CPBL module was developed based on Woods' (2003) PBL Curriculum Modules Design. It acts as a framework to guide learning and teaching designers in constructing optimal PBL curriculum modules. Most importantly, it consists of an interconnected series of phases that use theory to plan to learn. The seven phases of model suggested by Woods' (2003) starts with determining the learning goals of the curriculum unit identified, and ends with the module's evaluation. According to the 8th-grade science curriculum plan of the 2nd semester of the academic year 2017/2018, genetics was selected as a topic and used to develop the SB-CPBL module for this study. The SB-CPBL module aimed at 8th-grade students to provide them with essential knowledge and concepts in genetics and its implications on society.

The SB-CPBL module on genetics consisted of six lessons; 1) an introductory lesson, 2) inherited trait & genetic material, 3) dominant and recessive traits in humans, 4) Mendel's experiments, 5) genetic diseases + pedigree chart, and 6) genotype and phenotype. The introduction lesson involved brainstorming, activation of the students' previous knowledge, and detailing their difficulties in the subject's context. The students were then introduced to the SB-CPBL module and its corresponding phases. One problematic scenario was crafted for each lesson, which resulted in five SB-CPBL cases. Each case was allocated with 4-5 sessions of 45 minutes each, and the module took six weeks to complete.

The SB-CPBL module was evaluated for content, then piloted with other groups of students. The content was sound, and the students accepted it. The teacher acted as a floating facilitator, where they monitored the working groups and only intervened when needed. 8th-grade students were assigned to groups of 4-5, with 2 high achievers (based on the previous year's grades) assigned to each group. The students were assigned roles within their respective groups; chair, scribe, and members, designed to maintain the PBL group dynamic. Ill-

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structured problematic scenarios with no straightforward solutions were given to the students, and they were expected to solve them. These problems were presented to the students via various media, such as video film used to present lesson number four of the module titled "Genetic Diseases." The 5-minutes video showed the suffering of thalassemia patients and the annual costs incurred by Jordan for thalassemia, ending with the question of how we can help Jordan prevent thalassemia and decrease its financial burden. The SB-CPBL groups were guided to propose their best solutions, and feedbacks and comments were provided.

In the control group, the students were seated in columns, and the teachers taught them using conventional approaches, which began by writing the title of the lesson on the chalkboard, specifying the learning objectives and support activities, followed by a lengthy explanation of the main ideas, summarized at the end of the lesson, and ended by assigning homework. Discussions within the class were actively discouraged.

A training workshop on the SB-CPBL module was organized for the experimental group's science teacher before the experiment was conducted. The workshop focused on engaging students in constructivist learning, group monitoring, and scaffoldings. Attitudinal measurement was administered before and immediately after the intervention to measure the dependent variable's difference. Pre-testing on genetics was administrated to define the students' knowledge before the experiment, followed by the post-test at the end of the experiment, which was immediately administrated.

Research Setting and Sampling

King Abdullah II School for Excellence was randomly selected from 283 middle government schools in the Al-Zarqa governorate of Jordan. It made up of a mixture of different elements that share similar characteristics, and this gives the study more authenticity. Four classes of 8th-grade students were randomly assigned as the study sample. Afterward, two classes (one male and one female), with 60 students, were selected randomly as the experimental group using the SB-CPBL module to learn genetics. The other two 8th grade classes (one male and one female), consisting of 60 students, were assigned as the control group. Thus, a total of 120 8th graders, aged 14-15, took part in this research, as tabulated in Table 1.

Table 1
Descriptive Statistics of the Participants (N =120)

Characteristics		*N*	%
Group	SB-CPBL	60	50
	Control	60	50
Gender	Male	53	44.2
	Female	67	55.8

The study followed the guidelines and ethical principles stipulated by The Unit of Scientific Research Ethics-Jordanian Ministry of Higher Education & Scientific Research. Necessary permissions were obtained from the Jordanian Educational Research and Development Department. Permission was also obtained from the school where the study was conducted. Also, respondents were informed that the data obtained will be used for scientific research only, and it will not be shared with the school administration or their teachers.

Research Instrument

A 5-point Likert scale measuring the students' attitudes towards science was administered before and immediately after the experiment. The scale consisted of 40 items, ranging from (strongly disagree = 1) to (strongly agree = 5). The Lesotho Attitude to Science Test (LAST) (Towse, 1983) was found to be suitable for this study. Initially, an overview of the related literature on the measurements of students' attitudes towards science (e.g., Abd-El-Khalick et al., 2015; Juuti et al., 2010; Pell & Jarvis, 2001; Welch, 2010) revealed various measurements that could be used in learning contexts, however, many do not quite match the learning context of Jordanian schools. Moreover, some of these scales contained lengthy questions in addition to deep and complex sentences. Towse's

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(1983) scale, designed to determine the attitudes towards learning school level science, uses transparent and interconnected statements such as "I want to learn more about science" and "I usually do quite well in science." The items included in the instrument were developed from statements taken from the students themselves. The Lesotho test was developed for a country where a questioning attitude towards science is uncommon among students, as is the case in Jordan and other Arab countries, further cementing its suitability in this study. The items were developed to touch upon the essential aspects of science necessary to both students and teachers, as well as reflect the overall attitudes towards learning science, encompassing 1) enjoyment in science, 2) difficulty, 3) the influence of the teacher, and 4) the awareness of the social implications of science (Towse, 1983).

Translate, Re-translate, Validity, and Reliability

The original version of LAST was developed in English; however, due to the respondents' native language being Arabic, the LAST measurement items were translated and validated for Arabic speaking students. Two certified and authorized translation centers were employed for the translation and re-translation of the documents. The English versions of the documents were forwarded to two English professors from the English Literature Department of the University of Jordan to ensure their accuracy. They deemed the translations accurate, and minor issues they pointed out were quickly rectified. The result was a final copy produced for validation purposes. The LAST document was sent to six educational experts, most of them professors in scientific disciplines employed in universities across Jordan. The other experts are professors in Arabic and psychology. The experts were asked to inspect the LAST document and ensure its conciseness in content and alignment with Jordanian culture. Their feedbacks were accepted and incorporated into the documents, which resulted in 40 modified items. The finalized document (instrument) was pilot tested with 60 students (outside the sample classes).

The factor structure of the attitudes towards science was consistent with the theorized conceptual factors via the exploratory factor analysis. The final factor loading identified a four-factor solution, and after executing the attitudes survey items to the principal component analysis, a five-factor solution with eigenvalues exceeding one was obtained. Four items were loaded on more than a single factor, while the other items were loaded less than the recommended value and were therefore dropped. Only four-factor remained, with the first factor accounting for 21.11% of the variance, the second accounting for 63.71%, the third accounting for 40.56%, and the fourth accounting for 52.61%. In terms of the KMO index and Bartlett's sphericity test, the values obtained were 0.770, and Chi-square of 3972.996 ($df = 630$, $p < .001$). The value of Cattell's scree data test supported the four factors solution, and Cronbach's alpha values of the four dimensions were acceptable (from 0.868 to 0.939). Cronbach's alpha internal consistency reliability was (.860).

Data Analysis

Data analysis initially involves examining the normality of the data and outliers via observation of its distribution. Outliers can be identified using the Mahalanobis distance between specific cases from the point of meeting of all of the variables' means (Judd et al., 2017; Tabachnick & Fidell, 2007). The Mahalanobis distance is also useful for analyzing the multivariate outliers indicated by the dependent variables. In this study, the analysis confirmed the non-existence of outlier cases. Statistical analysis is acutely sensitive to non-normality. As such, a primary data assumption is the examination of the causal structure among the study variables, where data skewness and kurtosis can be used to confirm the normality of data (Tabachnick & Fidell, 2007). The skewness range of acceptability is ±3.00, while the kurtosis range of acceptability is 7.00. The skewness and kurtosis statistics of the data set in this study with the respondents ($N = 120$) are detailed in Table 2, and it can be seen that the data measurements had normality with all the skewness and kurtosis statistics within ±1.96. Descriptive analysis was carried out to determine the mean values (*M*), standard deviations (*SD*), and the values for pre-and-post attitudes towards science tests. Moreover, the inferential statistics were applied involving; independent sample t-test, paired samples *t*-test, ANOVA and MANOVA to compare the means of the two groups (experimental and control) and gender levels (male and female) based on their scores in pre and post-test of attitudes towards science.

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Table 2
Skewness and Kurtosis for the Variables

Variable	Skewness	*SD*	Kurtosis	*SD*
Pre-test attitudes towards science	-.198	0.221	-.931	0.438
Post-test attitudes towards science	-.654	0.221	0.453	0.438

Research Results

Before testing the hypothesis (i.e., there is no significant difference in the level of attitudes towards science post-test between SB-CPBL and control group), the *t*-test and ANOVA were conducted on the independent samples to determine whether or not the groups are statistically equivalent. The dependent variables included attitude towards science, and the results indicated no significant differences in the variables' homogenous test. In the initial analysis set, the difference between the two groups (experimental and control) was determined in attitude level based on a .05 significance level. The independent sample *t*-test results in Table 3 confirm the lack of significant differences between the two groups in light of the pre-test scores of attitudes towards science ($t = 0.179$, $p = .673$, $t = 0.172$, $p = .864$).

Table 3
Results of the Independent Sample t-test for Variables Pre-test

Variable	*t*	*p*	*t*	*df*	*p*
Attitude towards science	0.179	.673	0.172	118	.864

Table 4 shows the ANOVA results, and it can be seen that there were no significant differences between the groups in the pre-test scores of attitudes towards science ($MS = 0.006$, $F = 0.030$, $p = .864$).

Table 4
Results of ANOVA for between-subjects Effects of the Attitude towards Science Pre-test

Source	Dependent variables total pretest	Sum of Squares	*df*	Mean Square	*F*	*p*
Between Group	Students attitudes towards science	0.006	1	0.006	0.030	.864
Within Group		23.006	118	0.195		
Total		23.012	119			

** p <.05

The independent sample *t*-test results in Table 5 confirmed the significant differences between the two groups in light of post-test scores of attitudes towards science ($t = 2.255$, $p = .136$, $t = 4.036$, $p = .001$).

Table 5
Results of Independent Sample t-test for Variables Post-test

Variable	*t*	*p*	*t*	*df*	*p*
Attitude towards science	2.255	.136	4.036	118	.001

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Table 6 shows the ANOVA results and confirms the significant differences between the groups in the post-test scores of attitudes towards science (*MS* = 2.576, *F* = 16.286, *p* = .001).

Table 6
Results of ANOVA for between-subjects Effects of the Attitude towards Science Post-test

Source	Dependent variables total pretest	Sum of squares	*df*	Mean square	*F*	*p*
Between Group	Students attitudes towards science	2.576	1	2.576	16.286	.001
Within Group		18.668	118	0.158		
Total		21.245	119			

** p <.05

The analytical results of both groups were subjected to further inspection. The mean and standard deviation values in the pre-test and post-test scores of the dependent variables were tabulated in Table 7. For the pre-test, the results showed that the experimental group has a mean score of (*M* = 3.44, *SD* = 0.056), while the control group has a mean score of (*M* = 3.43, *SD* = 0.448). Also, the results show that the experimental group in the post-test has a higher mean score of (*M* = 3.93, *SD* = 0.331) relative to the control group (*M* = 3.63, *SD* = 0.454). The pre-test mean score of the attitude towards science for the entire sample is (*M* =3.44, *SD* = 0.430) relative to the mean post-test score of (*M* = 3.78, *SD* = 0.420).

Table 7
Summary Statistics for Pre-posttests Scores

Characteristics		Experimental group	Control group	Total sample
Pre-test attitude towards science	Mean	3.44	3.43	3.44
	SD	0.056	0.448	0.430
Post-test attitude towards science	Mean	3.93	3.63	3.78
	SD	0.331	0.454	0.420

The results of the paired samples' *t*-test showed that there were statistically significant differences between the mean score of the pre-test and post-test attitudes towards science with a total score of (*t* = -7.230, *p* = .001) in favor of the post-test, which means that the students scored higher in the post-test than pre-test significantly at *p* = <.05, as per Table 8.

Table 8
Results of Paired Sample t-test for Attitude towards Science Pre-post-tests

Variable	Mean	*SD*	*SEM*	*t*	*df*	*p*
Pair 1 pretest-posttest attitude	-.34144	0.517	0.0472	-7.230	119	.001

** p <.05

MANOVA (2x4) was conducted with the subscales of the attitudes towards science (enjoyment in science, the influence of the teacher, difficulty, and awareness of social implications of science), with the independent variables present in both groups (experimental and control groups). The initial set of analyses produced significant main effects for the dependent variables with the homogeneity of variance assumption underpinning MANOVA tested using the M-box test. The results confirmed that the homogeneity of variance was not achieved in the post-test (Box's *M* = 37.473, *F* = 3.610, *p* = .001 <.05). Also, the multivariate test results showed differences between the

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groups in terms of attitudes' subscales mean scores. The study used the Pillai's Trace and Wilks Lambda criteria, which showed statistical significance at (value = .176, F = 6.128, p = .001 <.05; value = .824, F = 6.128, p = .001 <.05). Table 9 shows the comparison of the differences between the groups in the attitudes subscales, and it can be seen that it is significant on the "enjoyment in science" (MS = 10.281, F = 17.800, p = .001 <.05), "influence of the teacher" (MS = 1.556, F = 5.143, p = .025, <.05), and "difficulty" (MS = 2.306, F = 7.614, p = .007 <.05), and insignificant for the "awareness of social implications of science" (MS = .276, F = 1.629, p = .204 >.05).

Table 9

Results of MANOVA for the between-subjects Effects of the Subscales Post-test

Source	Dependent variables posttest	Type III sum of squares	*df*	Mean square	*F*	*p*
Group	Enjoyment in science	10.281	1	10.281	17.800	.001
	Influence of the teacher	1.556	1	1.556	5.143	.025
	Difficulty	2.306	1	2.306	7.614	.007
	Awareness of social implications of science	.276	1	.276	1.629	.204
Total	Enjoyment in science	1861.953	120			
	Influence of the teacher	1816.827	120			
	Difficulty	1441.992	120			
	Awareness of social implications of science	2074.500	120			

p <.05

It was concluded that a significant difference exists in the mean score of the "enjoyment in science," "influence of the teacher," and "difficulty" subscales post-test between the two groups, where the results in Table 10 show that the students in the experimental group reported higher mean scores in "enjoyment in science" (M = 4.14, SD = 0.708) relative to their counterparts in the control group (M = 3.56, SD = 0.808), and the students in the experimental group reported higher "influence of the teacher" mean scores (M = 3.96, SD = 0.462) relative to the control group (M = 3.73, SD = 0.625). The experimental group reported higher "difficulty" mean scores (M = 3.55, SD = 0.596) relative to their counterparts in the control group (M = 3.28, SD = 0.500). Despite the insignificant results for the "awareness of social implications of science" subscales, the mean and standard deviation values shown in Table 10 confirmed that students in the experimental group had higher mean analysis scores (M = 4.18, SD = 0.326) relative to the students in the control group (M = 4.08, SD = 0.481).

Table 10

Summary Statistics for Variables Post-test Scores (N =120)

Variable		Experimental group	Control group
Enjoyment in science	Mean	4.14	3.56
	SD	0.708	0.808
Influence of the teacher	Mean	3.96	3.73
	SD	0.462	0.625
Difficulty	Mean	3.55	3.28
	SD	0.596	0.500
Awareness of social implications of science	Mean	4.18	4.08
	SD	0.326	0.481

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The attitudes towards science subscales results were explored further. The paired samples *t*-test was run to measure the increase of mean scores in the attitudes' subscales. As per Table 11, the results shown that "enjoyment in science" *(t* = -6.499, *df* = 59, *p* = .001), "difficulty" (*t* = -6.141, *df* = 59, *p* = .001), and "awareness of social implication of science" (*t* = -6.429, *df* = 59, *p* = .001) are significant, but "influence of teachers" sub-scale is insignificant (*t* = -1.443, *df* = 59, *p* = .154).

Table 11
Results of Paired Sample t-test for Attitude towards Science Subscales

Variable	Mean	*SD*	*SEM*	*t*	*df*	*p*
Enjoyment in science	-.55000	.655	.08462	-6.499	59	.001
Influence of the teacher	-.17777	.954	.12323	-1.443	59	.154
Difficulty	-.62333	.786	.10150	-6.141	59	.001
Awareness of social implications of science	-.70208	.84594	.10921	-6.429	59	.001

Table 12 shows the comparison between the experimental group students' results in the pre and post-tests in terms of the mean scores of the attitudes' subscales, the mean scores of "enjoyment in science" in the pre-test is (*M* = 3.35, *SD* = 0.770) relative to the post-test results (*M* = 3.90, *SD* = 0.386). The mean score of "influence of teachers" in pre-test is (*M* = 3.92, *SD* = 0.946) relative to the post-test results (*M* = 4.10, *SD* = 0.365). The mean score of "difficulty" in pre-test is (*M* = 3.19, *SD* = 0.894) relative to the post-test results (*M* = 3.81, *SD* = 0.397). Finally, the mean score of the "awareness of social implications in science" in pre-test is (*M* = 3.31, *SD* = 0.714) relative to the post-test results (*M* = 4.01, *SD* = 0.401).

Table 12
Summary Statistics for the Experimental Group

Variable		Pre-test	Post-test
Enjoyment in science	Mean	3.35	3.90
	SD	0.770	0.386
Influence of the teacher	Mean	3.92	4.10
	SD	0.946	0.365
Difficulty	Mean	3.19	3.81
	SD	0.894	0.397
Awareness of social implications of science	Mean	3.31	4.01
	SD	0.714	0.401

Moving on with testing of the gender differences hypothesis (i.e., there is no significant difference in the level of attitudes towards learning science post-test between male and female students), the *t*-test and ANOVA were conducted on the independent samples to identify whether the groups are statistically equivalent. The independent sample *t*-test results are shown in Table 13, and it can be seen that there were insignificant differences between the two groups in light of the post-test scores of attitudes towards science (*t* = -.797, *p* = .427).

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Table 13
Results of Independent Sample t-test for Variables Post-test

Variable	*t*	*df*	*p*	Mean Difference
Attitude towards science	-.797	118	.427	-.06202

Table 14 shows the ANOVA results, and it can be seen that there are insignificant differences between the groups in the post-test scores of attitudes towards science ($MS = .114$, $F = .636$, $p = .427$).

Table 14
Results of ANOVA for between-subjects Effects of the Attitude towards Science Post-test

Source	Dependent variables total pretest	Sum of squares	*df*	Mean square	*F*	*p*
Between Group	Students attitudes towards science	.114	1	0.114	0.636	.427
Within Group		21.131	118	0.179		
Total		21.245	119			

** p <.05

The mean and standard deviation in the post-test scores of the dependent variables is tabulated in Table 15, and it can be seen that male students have a mean score of ($M = 3.75$, $SD = 0.423$), while female students have a mean score of ($M = 3.81$, $SD = 0.423$).

Table 15
Summary Statistics for Attitude towards Science Post-test Scores

Variable		Male	Female
Post-test attitude towards science	Mean	3.75	3.81
	SD	0.423	0.423

Discussion

The results suggest that learning via SB-CPBL is more efficient than conventional teaching approaches to develop more positive attitudes towards science. As previously found by other studies (i.e., Chen & Kuo, 2019; Nawi et al., 2019; Siew et al., 2017), that highlighted the effectiveness of the cooperative problem-based learning approach on students learning, the SB-CPBL students emerged as active learners, engaging in a safe learning environment where they are actively engaged in group discussions, peer dialogues, and are unafraid to ask questions or dissect ideas. Contrary to a conventional classroom, more opportunities for discussions were allocated for the SB-CPBL class, which contributes towards an open climate environment where students can say whatever comes to mind, be they suggestions, comments, or opinions. It has been argued that one unique outcome of combining CL and PBL is a comfortable environment, which encourages students to be more confident asking questions, articulate the difficulties faced, and share what they learned (Ismail et al., 2017). Turan et al. (2012) concluded that combining CL and PBL results in an enjoyable and friendly learning environment with less anxiety and stress.

Contrary to the usual learning environment in Jordanian schools, SB-CPBL framed the learning process elements into an attractive student-centrism context. Instead of providing expert advice within a specific context, the science teachers acted as facilitators to the SB-CPBL groups, tasked with ensuring that they are

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on track with learning. The students were the center of the process, as they are responsible for constructing their respective learning. Performance evaluation was no longer the teacher's task; instead, SB-CPBL students are responsible for self-assessing their contributions. The content of the biology curriculum was formulated as problems contextualizing the real-life situations of Jordan. Students feel that they are part of the problem-solving process, which results in commendable impacts towards improving students' attitudes on the learning process. These results support other researchers' claims that learners can be more motivated if they realize that their work problem is realistic and authentic (Chan, 2014). SB-CPBL activities take place in the class, computer lab, library, and even beyond school boundaries. Several electronic devices were provided for searching on the internet (i.e., laptops and tablets). SB-CPBL allowed students to integrate and apply their information and technological skills to generate knowledge, which seems to be an exciting process for students.

The SB-CPBL group reported higher mean total scores in all sub-scales (enjoyment in science, difficulty, the teacher's influence, and awareness of social implications of science) relative to their control counterpart, proving that SB-CPBL can integrally improve students' attitudes towards science. SB-CPBL students were better able to express themselves, suggest ideas, and defend them, which seems enjoyable. Moreover, the constructivist underpinnings of SB-CPBL take advantage of the learning process's social aspect by studying with peers, which deepened the students' understanding and decreased the subject's difficulty. To further link SB-CPBL with the constructivist philosophical view of pedagogy, the science teacher acted as a facilitator and a coach of student learning instead of a knowledge-holder. The SB-CPBL facilitator activities included planning, following students' discussion, encouraging critical thinking, guiding students' learning, contributing to their group, scaffolding, and providing feedback. The facilitator-driven classrooms were reported to be more effective in improving students' attitudes towards science relative to a conventional classroom.

What could be argued in this study is that gender has insignificant effects on students' attitudes towards science. The absence of the gender effect in this study contradicts the literature as most published works dealing with this subject posited that male students show better appreciation for science in school (Hasan, 1985; Jarvis & Pell, 2005; Toma et al., 2019). Accordingly, the students' positive attitudes towards science can be attributed to intervention in their learning, and gender variance did not induce significant effects. Problem-solving strategies require male and female students to be afforded the opportunities to search, inquire and share their ideas within an enjoyable learning environment. Both genders can benefit from the social context of PBL towards the development of positive attitudes towards science. These results are consistent with several published works that discussed the development of similar attitudes towards science between males and females (Akpinar et al., 2009; Dhindsa & Chung, 2003).

This study suggests that female students can develop positive attitudes towards science on par with their male counterparts. This comes in line with the view of Zeng et al. (2019), who reported that female students' negative attitude towards science reflects the failure of conventional education in nurturing a positive attitude towards science in female students. SB-CPBL can provide learning in a context of social negotiation in problem-centered discussions, which is highly consistent with the view that female students are more likely to be connected learners who value the social aspects of learning (Reynolds 2003). Consequently, the research results support that SB-CPBL is required in Jordan to provide equal access to study science and technology majors and their related careers, and thus eliminate the gender disparities in access to high-quality science education. Challenges facing equal opportunities between genders are briefly articulated in the United Nations' Sustainable Development Goals (SDGs), where the fourth SDG vows to ensure an inclusive high-quality education for all students (Bruns et al., 2019).

In brief, this study shows a noticeable improvement in students' attitudes towards science due to the adoption of SB-CPBL-based teaching-learning environment, which could help prepare Jordanian students for the 21st-century job market. The cooperative problem-based learning approach that emphasizes CL principles in the PBL cycle is widely used with university students (Adi et al., 2012; Chen & Chang, 2014; Mohd-Yusof et al., 2011), but is rarely used in the school context. The SB-CPBL suggested in this study could contribute to enhancing the knowledge in using this approach in the school. Gender was also included as a construct in this study to provide further insights into the development of female attitudes towards science, which is neglected in the Arab region over the past decades (Profile, 2015; Said et al., 2016). Developing a more positive attitude towards science among females is expected to ingratiate them further into the workforce in science and technology-related careers in Jordan.

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Conclusions and Suggestions

The SB-CPBL model that incorporates the CL principles into the PBL cycle was proven suitable for a school environment and its specific conditions. CL elements contributed effectively towards producing functional working teams that are crucial while undergoing the cycle of PBL with one floating facilitator. The natural synergy between CL aspects and PBL transformed the class into a dynamic learning community enjoying their learning experience. The SB-CPBL module guides the students step-by-step to solve realistic problems in an attractive context and contributed significantly towards enhancing their attitudes towards science, as measured by the LAST. Utilizing the SB-CPBL approach instead of conventional teaching methods, students could be better prepared to face the modern world via their positive attitudes towards science, thus increasing the demand for science and technology-related majors and careers. The findings of the present research provide vital information for teachers and curriculum designers intending to move towards constructivism instead of the conventional approach of teaching. In this work, SB-CPBL was tested using 8th-grade students in their science curriculum. Therefore, more research is needed in other grades and different curriculums. Also, more in-depth studies on the effectiveness of SB-CPBL on other variables are required (e.g., motivation, critical thinking). This study's sample size was also relatively small and would not be extendable to the Jordanian student population's entirety. Finally, it should be indicated that the SB-CPBL requires meticulous pre-planning by teachers, where they are expected to craft realistic problematic scenarios, guide students' learning, follow students' discussions, managing student presentations, and provide feedback to their learning.

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References

Abd-El-Khalick, F., Summers, R., Said, Z., Wang, S., & Culbertson, M. (2015). Development and Large-scale validation of an instrument to assess Arabic-speaking students' attitudes toward science. *International Journal of Science Education, 37*(16), 2637–2663. https://doi.org/10.1080/09500693.2015.1098789

Abu Nabah, A., Al-Omari, H., Ihmeideh, F., & Al-Waily, S. (2009). Teacher education programs in Jordan: A reform plan. *Journal of Early Childhood Teacher Education*, *30*(3), 272–284. https://doi.org/10.1080/10901020903084413

Adi, F. M., Phang, F. A., & Yusof, K. M. (2012). Student perceptions change in a chemical engineering class using cooperative problem based learning (CPBL). *Procedia-Social and Behavioral Sciences*, *56*(2012), 627–635. http://dx.doi.org/10.1016/j.sbspro.2012.09.697

Ahmad, J., Fayez, M., & Al-Zboon, E. K. (2015). The type of curriculum activities implemented in Jordanian preschools. *Early Child Development and Care, 185*(5), 807–823. https://doi.org/10.1080/03004430.2014.958482

Akpinar, E., Yildiz, E., Tatar, N., & Ergin, O. (2009). Students' attitudes toward science and technology: An investigation of gender, grade level, and academic achievement. *Procedia-Social and Behavioral Sciences*, *1*(2009), 2804–2808. https://doi.org/10.1016/j.sbspro.2009.01.498

Al-Abdallat, Z. M., & Omari, H. A. (2019). An investigation on the challenges of teaching oral skills as perceived by upper basic stage English language teachers in Jordan. *International Journal of English and Education*, *8*(2), 174–185.

Al-shboul, M. (2012). Teachers perceptions of the use of EduWave E-learning system in public schools in Jordan. *The Journal of Human Resource and Adult Learning*, *8*(2), 167–181.

Al Jabery, M., & Zumberg, M. (2008). General and special education systems in Jordan: Present and future perspetives. *International Journal of Special Education*, *23*(1), 115–122.

Alhabahba, M. M., Pandian, A., Mahfoodh, O. H. A., & Gritter, K. (2016). English language education in Jordan: Some recent trends and challenges. *Cogent Education, 3*(2016), 1–14. https://doi.org/10.1080/2331186X.2016.1156809

Aranzabal, A., Epelde, E., & Artetxe, M. (2019). Monitoring questionnaires to ensure positive interdependence and individual accountability in a chemical process synthesis following collaborative PBL approach. *Education for Chemical Engineers, 26*(2019), 58–66. https://doi.org/10.1016/j.ece.2018.06.006

Assaad, R., Krafft, C., & Salehi-Isfahani, D. (2018). Does the type of higher education affect labor market outcomes? Evidence from Egypt and Jordan. *Higher Education, 75*(6), 945–995. https://doi.org/10.1007/s10734-017-0179-0

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Beaumont, C., Sackville, A., & Cheng, C. S. (2004). Identifying good practice in the use of PBL to teach computing. *Innovation in Teaching and Learning in Information and Computer Sciences*, *3*(1), 1–19. https://doi.org/10.11120/ital.2004.03010003

Bergin, S. D., Murphy, C., & Shuilleabhain, A. N. (2018). Exploring problem-based cooperative learning in undergraduate physics labs: Student perspectives. *European Journal of Physics*, *39*(2), 1–17. https://doi.org/10.1088/1361-6404/aa9585

Bicer, A., & Lee, Y. (2019). Effect of STEM PBL embedded informal learning on student interest in STEM majors and careers. *Journal of Mathematics Education for All*, *12*(1), 57–73. https://doi.org/10.26711/007577152790038

Bransford, J., Vye, N., & Bateman, H. (2004). Creating high-quality learning environments: Guidelines from research on how people learn. In P. A. Graham, & N. G. Stacey (Eds.), *The knowledge economy and postsecondary education: Report of a workshop* (pp. 159–197). National Academies Press. https://doi.org/https://doi.org/10.17226/10239

Bruns, B., Macdonald, I. H., & Schneider, B. R. (2019). The politics of quality reforms and the challenges for SDGs in education. *World Development, 118*(2019), 27–38. https://doi.org/10.1016/j.worlddev.2019.02.008

Casey, A., & Goodyear, V. A. (2015). Can cooperative learning achieve the four learning outcomes of physical education? A review of literature. *Quest*, *67*(1), 56–72. https://doi.org/10.1080/00336297.2014.984733

Chan, C. K. Y. (2014). Facilitators' perspectives of the factors that affect the effectiveness of problem-based learning process. *Innovations in Education and Teaching International*, *53*(1), 25–34. https://doi.org/10.1080/14703297.2014.961501

Chen, C. M., & Chang, C. C. (2014). Mining learning social networks for cooperative learning with appropriate learning partners in a problem-based learning environment. *Interactive Learning Environments, 22*(1), 97–124. https://doi.org/10.1080/10494820.2011.641677

Chen, C. M., & Kuo, C. H. (2019). An optimized group formation scheme to promote collaborative problem-based learning. *Computers and Education, 133*(64), 94–115. https://doi.org/10.1016/j.compedu.2019.01.011

Cozby, P. (2007). *Methods in behavioral research* (9th ed.). McGraw Hill.

Creswell, J. W. (2014). *Research design: Qualitative, quantitative, and mixed methods approaches* (4th Ed.). SAGE Publications.

Dagher, Z. R., & BouJaoude, S. (2011). Science education in Arab states: Bright future or status quo? *Studies in Science Education*, *47*(1), 73–101. https://doi.org/10.1080/03057267.2011.549622

Demirel, M., & Dagyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *EURASIA Journal of Mathematics, Science and Technology Education*, *12*(8), 2115–2137. https://doi.org/10.12973/eurasia.2016.1293a

Dhindsa, H. S., & Chung, G. (2003). Attitudes and achievement of Bruneian science students. *International Journal of Science Education*, *25*, 907–922. https://doi.org/10.1080/09500690305025

Duffany, J. L. (2017). Application of active learning techniques to the teaching of introductory programming. *IEEE Revista Iberoamericana de Tecnologias Del Aprendizaje, 12*(1), 62–69. https://doi.org/10.1109/RITA.2017.2658918

Evans, C. A., Chen, R., & Hudes, R. P. (2020). Understanding Determinants for STEM Major Choice Among Students Beginning Community College. *Community College Review, 48*(3), 227–251. https://doi.org/10.1177/0091552120917214

Ferreira, M. M., & Trudel, A. R. (2012). The impact of problem-based learning (PBL) on student attitudes toward science, problem-solving skills, and sense of community in the classroom. *Journal of Classroom Interaction*, *47*(1), 23–30. https://www.jstor.org/stable/43858871

Galama, T., & Hosek, J. (2008). *U.S. competitiveness in science and technology*. Rand Corporation.

Gok, T., & Sylay, I. (2010). The effects of problem-solving strategies on students' achievement, attitude and motivation. *Latin-American Journal of Physics Education*, *4*(1), 7–21. http://dialnet.unirioja.es/servlet/articulo?codigo=3694877

Gorghiu, G., Draghicescu, L. M., Cristea, S., & Gorghiu, L. M. (2015). Problem-based learning-An efficient learning strategy in the science lessons context. *Procedia-Social and Behavioral Sciences*, *191*(2015), 1865–1870. https://doi.org/http://dx.doi.org/10.1016/j.sbspro.2015.04.570.

Hacieminoglu, E. (2016). Elementary school students' attitude toward science and related variables. *International Journal of Environmental & Science Education*, *11*(2), 35–52. https://eric.ed.gov/?id=EJ1086987

Halim, L., Abd Rahman, N., Zamri, R., & Mohtar, L. (2018). The roles of parents in cultivating children's interest towards science learning and careers. *Kasetsart Journal of Social Sciences*, *39*(2), 190–196. https://doi.org/10.1016/j.kjss.2017.05.001

Hallinger, P., & Bridges, E. (2016). Informal cooperative learning in small groups: The effect of scaffolding on participation. *Issues in Educational Research*, *26*(2), 260–279.

Hasan, O. E. (1985). An investigation into factors affecting attitudes toward science of secondary school students in Jordan. *Science Education*, *69*(1), 3–18. https://doi.org/10.1002/sce.3730690102

Hu, X., Leung, F. K. S., & Chen, G. (2018). School, family, and student factors behind student attitudes towards science: The case of Hong Kong fourth-graders. *International Journal of Educational Research*, *92*(2018), 135–144. https://doi.org/10.1016/j.ijer.2018.09.014

Ismail, S., Maasum, T. N. R. T. M., & Bakar, N. A. (2017). Developing higher order thinking skills (HOTS) via a cooperative problem-based learning [CPBL] pedagogical model in the ESL writing classroom. *Man in India*, *97*(12), 255–265.

Jarvis, T., & Pell, A. (2005). Factors influencing primary school children's attitudes toward science before, during, and after a visit to the UK national space centre. *Journal of Research in Science Teaching*, *42*(1), 53–83. https://doi.org/10.1002/tea.20045

Judd, C. M., McClelland, G. H., & Ryan, C. S. (2017). *A model comparison approach to regression, ANOVA, and beyond* (3rd ed). Abingdon, UK: Routledge.

Juuti, K., Lavonen, J., Uitto, A., Byman, R., & Meisalo, V. (2010). Science teaching methods preferred by grade 9 students in Finland. *International Journal of Science and Mathematics Education*, *8*(4), 611–632. https://doi.org/10.1007/s10763-009-9177-8

https://doi.org/10.33225/jbse/21.20.261

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Martin, M. O., Mullis, I. V. S., Foy, P., & Hooper, M. (Eds.). (2016). *TIMSS 2015 international results in science*. IEA TIMMS and PIRLS International Study Center.
Mohd-Yusof, K., Hassan, S. A. H. S., Jamaludin, M. Z., & Harun, N. F. (2011a). Cooperative problem-based learning (CPBL): A practical PBL model for engineering courses. *International Journal of Emerging Technologies in Learning (IJET)*, *6*(3), 366–373. https://doi.org/10.1109/EDUCON.2011.5773162
Mohd-Yusof, K., Hassan, S., Jamaludin, M. Z., & Harun, N. F. (2011, June 26-29). Motivation and engagement of learning in the cooperative problem-based learning (CPBL) framework. [Paper Presentation]. *2011 ASEE Annual Conference and Exposition*, Vancouver, Canada. https://peer.asee.org/18387
Nawi, N. D., Phang, F. A., Mohd-Yusof, K., Rahman, N. F. A., Zakaria, Z. Y., Hassan, S. A. H. bin S., & Musa, A. N. (2019). Instilling low carbon awareness through technology-enhanced cooperative problem-based learning. *International Journal of Emerging Technologies in Learning*, *14*(24), 152–166. https://doi.org/10.3991/ijet.v14i24.12135
Organisation for Econo*mic Co-operation and Environment* (OECD). (2014). *PISA 2012 results in focus: What 15-year-olds know and what they can do with what they know*. OECD Publishing. https://doi.org/10.1787/9789264208070-en
Organisation for Economic Co-operation and Environment (OECD). (2018). *PISA 2015 results in focus*. OECD Publishing. https://doi.org/http://dx.doi.org/10.1787/9789264266490-en
Osman, K., & Kaur, S. J. (2014). Evaluating biology achievement scores in an ICT integrated PBL environment. *Eurasia Journal of Mathematics, Science and Technology Education*, *10*(3), 185–194. https://doi.org/10.12973/eurasia.2014.1076a
Pell, T., & Jarvis, T. (2001). Developing attitude to science scales for use with children of ages from five to eleven years. *International Journal of Science Education*, *23*(8), 847–862. https://doi.org/10.1080/09500690010016111
Profile, S. E. E. (2015). Culture's effect on students' attitudes towards science. *Journal of Higher Education Policy and Management*, *7*(1), 27–44.
Reilly, D., Neumann, D. L., & Andrews, G. (2019). Investigating gender differences in mathematics and science: Results from the 2011 trends in mathematics and science survey. *Research in Science Education*, *49*(1), 25–50. https://doi.org/10.1007/s11165-017-9630-6
Reynolds, F. (2003). Initial experiences of interprofessional problem-based learning: A comparison of male and female students' views. *Journal of Interprofessional Care*, *17*(1), 35–44. https://doi.org/10.1080/1356182021000044148
Sadikin, A. N., Mohd-Yusof, K., Aliah Phang, F., & Abdul Aziz, A. (2019). The introduction to engineering course: A case study from universiti teknologi Malaysia. *Education for Chemical Engineers*, *28*, 45–53. https://doi.org/10.1016/j.ece.2019.04.001
Sadler, P. M., Sonnert, G., Hazari, Z., & Tai, R. (2012). Stability and volatility of STEM career interest in high school: A gender study. *Science Education*, *96*(3), 411–427. https://doi.org/10.1002/sce.21007
Said, Z., Summers, R., Abd-el-khalick, F., & Wang, S. (2016). Attitudes toward science among grades 3 through 12 Arab students in Qatar: Findings from a cross sectional national study. *International Journal of Science Education*, *46*(8), 1821–1838. https://doi.org/10.1080/09500693.2016.1156184
Schneegans, S., & Erocal, D. (Eds.). (2015). *UNESCO science report: Towards 2030*. UNESCO Publishing.
Servant-Miklos, V. F. C. (2019). Fifty Years on: A Retrospective on the world's first problem-based learning programme at McMaster university medical school. *Health Professions Education*, *5*(1), 3–12. https://doi.org/10.1016/j.hpe.2018.04.002
Siew, N. M., & Chin, M. K. (2018). Design, development and evaluation of a problem-based with cooperative module on scientific creativity of pre-schoolers. *Journal of Baltic Science Education*, *17*(2), 215-228. http://www.scientiasocialis.lt/jbse/?q=node/653
Siew, N. M., Chin, M. K., & Sombuling, A. (2017). The effects of problem-based learning with cooperative learning on preschoolers' scientific creativity. *Journal of Baltic Science Education*, *16*(1), 100–112. http://www.scientiasocialis.lt/jbse/?q=node/550
Syafii, W., & Yasin, R. M. (2013). Problem solving skills and learning achievements through problem-based module in teaching and learning biology in high school. *Asian Social Science, 9*(12), 220–228. https://doi.org/10.5539/ass.v9n12p220
Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics* (5th ed.). Allyn & Bacon
Toma, R. B., Greca, I. M., & Gómez, M. L. O. (2019). Attitudes towards science and views of nature of science among elementary school students in terms of gender, cultural background and grade level variables. *Research in Science & Technological Education*, *37*(4), 492–515. https://doi.org/10.1080/02635143.2018.1561433
Towse, P. J. (1983). Do new science courses improve attitudes toward science? A study in Lesotho. *Science Education*, *67*(2), 159–169. https://doi.org/10.1002/sce.3730670204
Turan, S., Konan, A., Kl, Y. A., Zvar, Ö. B., & Sayek, I. (2012). The effect of problem-based learning with cooperative-learning strategies in surgery clerkships. *Journal of Surgical Education*, *69*(2), 226–230. https://doi.org/10.1016/j.jsurg.2011.07.010
UNDP/RBAS. (2014). *Arab knowledge report 2014 youth and localisation of knowledge*. Al Ghurair Printing and Publishing. https://www.knowledge4all.com/en/11/Pages/Arab-Knowledge-Report-2014--Youth-and-Localisation-of-Knowledge
Wan, Z. H., & Lee, J. C. K. (2017). Hong Kong secondary school students' attitudes towards science: A study of structural models and gender differences. *International Journal of Science Education*, *39*(5), 507–527. https://doi.org/10.1080/09500693.2017.1292015
Welch, A. G. (2010). Using the TOSRA to assess high school students' attitudes toward science after competing in the first robotics competition: An exploratory study. *Eurasia Journal of Mathematics, Science and Technology Education*, *6*(3), 187–197. https://doi.org/10.12973/ejmste/75239

https://doi.org/10.33225/jbse/21.20.261

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

Wood, D. F. (2003). ABC of learning and teaching in medicine: Problem based learning. *British Medical Journal (BMJ)*, *326*(2003), 328–330. https://doi.org/10.1136/bmj.326.7384.328

Woods, D. R. (1994). *Problem-based learning: How to gain the most from PBL* (2nd ed.). W L Griffin Printing.

Zeng, H., Xu, S., & Chen, L. (2019). Exploring changes in primary students' attitudes towards science, technology, engineering and mathematics (STEM) across genders and grade levels. *Journal of Baltic Science Education*, *18*(3), 466–480. https://doi.org/10.33225/jbse/19.18.466

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