Concept Mapping and Enhancement of Problem Based Learning Practices Among Nursing Students: A Quasi-Experimental Study

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Abstract

Background*:** Concept mapping (CM) is a complementary strategy to problem-based learning (PBL). Therefore, using concept maps in PBL could improve students' practices in tutorial sessions. ***Aim: The current study aimed to study the effect of a training program on using CM in the enhancement of PBL practices among nursing students at Suez Canal University. ***Methods:*** A quasi-experimental design was conducted at the Faculty of Nursing in Suez Canal University, including a comprehensive sample of first-year students. Data were collected using five tools: a students' knowledge questionnaire about CM, a structured tool for assessing concept maps in PBL, a students' performance in PBL tutorial sessions questionnaire, concept maps developed by students in brainstorming sessions, and a students' opinion about working with CM on PBL scale. ***Results***: The CM training program had a significant positive effect on the knowledge and practice of nursing students. There was a significant correspondence between the preset learning objectives and the learning objectives\issues generated by study groups students compared with control groups at the follow-up phase. Furthermore, there was a significant improvement in nursing students' attitude toward using CM in PBL tutorial sessions. ***Conclusion:*** CM enhances nursing students' practices in PBL tutorial sessions by facilitating the extraction of more learning objectives and issues, improving their performance in these sessions, and increasing their positive attitude towards using CM for enhancing the PBL process and memorizing relevant information. **Recommendations:** Implement necessary measures to adopt and monitor the use of the CM strategy in PBL tutorial sessions as a teaching-learning strategy.

Keywords: Brainstorming session, Concept mapping, Debriefing session, Nursing students, Problem-Based Learning, Training program.

1. Introduction:

The CM implementation in PBL can be considered beneficial to the learning process and practice of PBL in that it helps students' cognitive abilities to be represented and facilitated, deepens their understanding of the basic sciences, improves their retention of knowledge, and helps them apply that knowledge to new and challenging problems **(Bridges, Corbet, & Chan, 2015; Veronese, Richards, Pernar, Sullivan, & Schwartzstein, 2013)**.

Senita (2008) describes concept mapping as a technique for arranging data graphically and illuminating connections between it. According to **Khrais and Saleh (2017)**, it's a strategy that improves cognitive skills like problem-solving, knowledge application, construction, comprehension, and information processing. On the other hand, a concept map is a graphic illustrates the connections between concepts **(Stoica, Moraru, & Miron, 2011)**. PBL is an educational methodology that uses patient cases to teach students about basic and clinical sciences as well as problem-solving techniques **(Ali & Mittal, 2014)**. According to **Adiga and Adiga (2015)**, it encourages active learning, enhances comprehension, and improves knowledge retention. Additionally, it enhances students' autonomy, learning motivation, active search attitude, teamwork abilities, and communication skills **(González Hernando, Carbonero Martín, Lara Ortega, & Martín Villamor, 2014; Santos, Otani, Tonhom, & Marin, 2019)**. In addition, it promotes confidence, plays a vital role in developing and enhancing students' problem-solving and decision-making abilities, and encourages critical thinking **(Alrahlah, 2016)**.

CM is an established technique in PBL. It can be carried out by developing a methodical inventory of problem analysis, wherein learners use concept maps to represent their past knowledge and can differentiate between what they already know and what needs more research to gain a deeper understanding of the problem and its fundamental mechanisms **(Johnstone & Otis, 2006; Zwaal & Otting, 2012)**. Also, the tutorial group's learning needs could be used as a template to create a concept map for each PBL scenario **(Kassab & Hussain, 2010)**. Also, **Soltan et al., (2022)** indicated highly significant positive correlation between students' practice of concept mapping in brainstorming and debriefing sessions.

Significance of the study:

Numerous research studies **(Addae, Wilson, & Carrington, 2012; Johnstone & Otis, 2006; Kassab et al., 2016; Zwaal & Otting, 2012)** have examined the impact of CM on improving health professions students' practices in PBL, with a few studies conducted on nursing students as well **(Chan, 2017; Tseng et al., 2011)**. **Chan (2017)** investigated students' perspectives on the usage of CM as a learning exercise in PBL classes and found that it increases students' creativity and motivation to learn. Furthermore, **Tseng et**

al. (2011) investigated the effectiveness of incorporating PBL and CM. Their findings indicated that using CM in PBL enhances students' capacity for critical thought as well as their sense of personal responsibility for self-directed learning. Additionally, it would improve individual study, thinking, and group interaction. It is crucial to evaluate how CM affects nursing students' PBL session practices.

Aim of the study:

This study aims to study the effect of a training program on using CM in the enhancement of PBL practices among nursing students.

Objectives:

- Assess nursing students' knowledge and practice regarding CM.
- Assess nursing students' practices in PBL sessions.
- Assess nursing students' attitude regarding using CM in PBL sessions.
- Assess the effect of a training program on using CM in the enhancement of nursing students' practices in PBL sessions.

Hypotheses:

- The CM training program has a positive effect on knowledge and practice of nursing students.
- The CM training program has a positive effect on nursing students' practices in PBL tutorial sessions.
- The CM training program has a positive effect on nursing students' attitude regarding using CM in PBL tutorial sessions.

2. Subjects and methods:

Research Design:

This study employed a quasi-experimental design.

Setting:

The study was conducted at the Faculty of Nursing in Suez Canal University. The Faculty of Nursing in Ismailia had been established in 2006. It adopts new and innovative educational approaches including Community-Oriented, Community-Based Education, and PBL. The faculty has six academic departments: Pediatric Nursing, Maternity, Obstetrics and Gynecological Nursing, Medical-Surgical Nursing, Psychiatric and Mental Health Nursing, Nursing Administration, and

Community and Family Health Nursing. Also, it offers one undergraduate program awarded bachelor's degree in Nursing, and twelve postgraduate programs as master's and doctorate degrees for the six academic departments.

All the academic departments teach nursing courses along with the four years of the undergraduate program. Each nursing course has one brainstorming session and one debriefing session weekly. The brainstorming session lasts for an hour and the debriefing session lasts for two hours distributed according to the academic schedule. The PBL sessions evaluation scores represent 15% of students' semester work related to nursing courses. In addition, the educational bylaw of the Faculty of Nursing in Suez Canal University permits students' absence from the PBL tutorial sessions up to 25% of sessions per nursing course.

The faculty has two buildings; administrative building and educational building. The educational building contains the PBL classrooms where the study phases taken place.

Sample:

A comprehensive sample comprised 77 students from 8 PBL groups, with 43 students in the study groups representing 4 PBL groups and 34 students in the control group also representing 4 PBL groups, all of whom were first-year nursing students at the Faculty of Nursing. Prior to the commencement of this study, the total population was 154 students representing 10 PBL groups. Each group includes 15-16 students. Then the following students were excluded before the implementation of the CM training program: 15 students from 31 excluded represented 2 PBL groups for the pilot study, and 21 chronically absent students from both the study and control groups. Consequently, the total number of students was reduced to 102, divided into two groups: 52 in the study group and 50 in the control group. Also, all students who did not complete the three phases of the CM training program were excluded. Hence, statistical procedures were done on a sample that included 77 students (43 in study groups, and 34 in control groups).

Tools of data collection:

Tool one is a questionnaire designed to assess students' knowledge about CM. The authors developed this tool after reviewing relevant literature and preparing the training program. It was used to assess nursing students' knowledge regarding CM. The questionnaire includes two sections.

Section one consists of five introductory questions about CM. Section two is a test for assessing students' knowledge about CM, and it consists of 30 multiple-choice questions, in addition to eight open-ended questions. The test includes questions that cover 7 elements: definition of concept map and CM, various benefits, components, difference between concept maps and mind maps, characteristics of concept maps, and its uses.

Scoring system:

The correct answer scored (1), and the incorrect answer scored (0). The total scoring of students' knowledge about concept mapping ranged from 0 to 38. The closer the students' scores were to the maximum score, the greater the improvement in their knowledge about CM.

Tool two is a structured tool for the assessment of concept maps in PBL. This tool was developed by **Kassab and Hussain (2010)**. It was used to assess nursing students' practice regarding using concept maps in PBL tutorial sessions. Each concept map as an output of the PBL tutorial session was scored based on five skills: valid selection of concepts, hierarchical arrangement of concepts, integration between concepts, relationship to the context of the problem, and degree of students' creativity.

Scoring system:

The tool scored each skill on a five-point Likert scale, ranging from poor (1) to excellent (5). An overall score ranged from 5 to 25. The closer the students' scores were to the maximum score, the more improvement they achieved in their concept map practice during PBL tutorial sessions.

Tool three is a questionnaire that assesses students' performance in PBL sessions. This questionnaire was developed by **Valle et al. (1999)**. It was used to assess nursing students' performance in PBL tutorial sessions as one indicator of PBL practices. It consists of 24 items grouped into four skills: independent study (9 items), group interaction (5 items), reasoning skills (6 items), and active participation (4 items).

Scoring system:

It was scored using a six-point scale ranging from never (1) to always (6). Total scores ranged from 24 to 144, with a higher score indicating a higher level of students' performance in PBL tutorial sessions **(Valle et al., 1999)**.

Tool four consists of concept maps created during brainstorming sessions. Students developed these maps as an outcome of their brainstorming sessions. They were used to assess the correspondence between the preset learning objectives and students' generated learnings/issues as another indicator of PBL practices. The students' generated outline, which represents the core of writing learning objectives, was used as an alternative for learning objectives\issues as the first-year students still were unable to write a complete learning objective.

Scoring system:

The correspondence between the preset learning objectives and students' generated learnings/issues was scored from 0 to 100, with a higher score indicating a higher degree of correspondence. The outline should be complete. If the outline includes subheadings, distribute the total score of 100 across all subheadings.

Tool five is students' opinion about working with the CM scale. This scale was developed by **Zwaal and Otting (2012)**. It was used to assess nursing students' attitude regarding using CM in PBL tutorial sessions. It contains six elements, which are CM supports the construction of learning goals; it stimulates the activation of prior knowledge; it helps in creating a better understanding of the problem; it enhances the PBL process; it enhances my interest in the subject matter; and it will help me memorize relevant information for the test.

Scoring system:

Each element was scored on a scale ranging from strongly disagree (1) to strongly agree (5). An overall score ranged from 1 to 5 **(Zwaal & Otting, 2012)**. The closer the students' scores were to the maximum score, the more improvement in their attitude towards using concept maps in PBL tutorial sessions was achieved.

Tools' Validity:

The predictive validity of the structured tool for assessment of concept maps in the PBL was checked **(Kassab et al., 2016; Kassab & Hussain, 2010)**. The students' performance in the PBL tutorial sessions questionnaire has established content and construct validity **(Valle et al., 1999)**. Two tools, the students' opinion about working with the CM scale and the students' performance in PBL tutorial sessions questionnaire, were translated into the Arabic language, followed by a back-translation process. The translation process was done to meet the intended meaning and be suitable for the level and experience of first-year nursing students. The compatibility between original and back-translated versions was ensured by the researchers.

Tools' reliability:

The students' knowledge questionnaire about CM in the current study had total reliability coefficients (Cronbach's Alpha) of 0.97 (n = 77). Also, the Interclass Correlation Coefficients (ICC) of the structured tool for assessing concept maps in PBL in the original study ranged from 0.58 to 0.78 **(Kassab & Hussain, 2010)**, and its ICC in the current study was 0.78 (n = 77). In addition, the total reliability coefficients of the students' performance in the PBL tutorial sessions questionnaire in the original study were 0.96 **(Valle et al., 1999)**, and in the current study were 0.91 (n = 77). Finally, the total reliability coefficient of the students' opinion about working with the CM scale in the current study was 0.72 (n = 77).

Pilot study:

A pilot study was carried out during January 2018. It was conducted on 15 students to check the suitability, applicability, understanding of tools, and duration of fulfilling it. Necessary modifications were carried out as revealed from the pilot study.

Fieldwork:

The fieldwork was divided into five phases as the following:

Phase One: Preparation

The training program was prepared based on an extensive literature review. It was composed of theoretical and practical parts. The theoretical part consisted of four sessions titled: introduction to CM (an hour), benefits and uses of CM (an hour), components and types of concept maps (an hour), and characteristics of good concept maps (an hour). The practical part consisted of three sessions titled: CM tasks (an hour), general steps of concept map construction and the construction of concept map during the brainstorming session (90 minutes), and creation of concept map during the debriefing session (90 minutes).

Students' opinion about working with CM scale and performance in the PBL sessions questionnaire were translated into Arabic, followed by a back-translation procedure which was done to meet the intended meaning and be suitable for the level and experience of first-year nursing students. The compatibility between the original and back-translated versions was ensured.

Phase Two: Pre-test

All data collection tools were applied at the commencement of the second semester in February of the academic year 2017/2018, along with the second problem. Each questionnaire took the students 10 to 20 minutes to complete. Additionally, one concept map was developed for the brainstorming session, and another was created for the debriefing session.

Phase Three: Implementation

The training program was provided to the study groups. The four theoretical sessions were conducted along with the fifth and sixth problems. The three practical sessions were conducted between the sixth and the seventh problem.

Each concept map was assessed separately by four evaluators who had been trained in CM from the researchers and had prior experience with PBL. The average of all raters' scores was used to determine the mean concept map score for each map.

Phase Four: Immediately post-test

All data collection tools were used again immediately alongside the seventh problem, in addition to creating one concept map for each PBL session.

Phase Five: Follow-up

All data collection tools were applied again at the end of the term in May 2018 concurrently with the eleventh problem, in addition to constructing one concept map for each PBL session.

Ethical considerations:

Data were collected when the students agreed to participate in the research. Students were informed about the study's purpose and procedures, and they were assured of confidentiality and freedom to participate. The Suez Canal University Faculty of Nursing's Research Ethics Committee approved the study proposal (code 25:11/2017).

Data analysis:

SPSS version 20.0 was utilized to enter and analyze the quantitative data (SPSS, Inc., Chicago, IL, USA). The results were presented as means and standard deviations. Comparisons of mean scores between the study and control groups, as well as across various phases of the training program, were conducted using the independent sample t-test. Additionally, a paired t-test was applied to assess mean score differences within the study groups. Statistical significance was established at a p-value of less than 0.05. Four raters conducted a content analysis of concept maps from brainstorming sessions to assess the alignment between preset learning objectives and student-generated learning objectives\issues. Each rater evaluated the maps independently. The mean value of the raters was then computed. The data was analyzed to determine significant differences between preset learning objectives and student-generated learning objectives\issues using the independent sample t-test.

3. Results:

Table 1 shows significant improvements in total knowledge regarding CM between the pre-test (11.35 ± 3.40) and the immediate post-test (34.95 ± 2.78), in addition to the pre-test and the follow-up (29.30 ± 2.29) phases. Furthermore, the study groups' total knowledge scored the highest mean during the immediate post-test phase, demonstrating a significant difference between the study and control groups along with training program phases.

Table 2 shows a significant improvement in the total using of concept maps during the brainstorming session, comparing the pre-test (13. 42 ± 1. 81) and follow-up (14. 87 ± 2. 56) phases. Furthermore, the study groups exhibited the highest mean score in using concept maps during the brainstorming session at the follow-up phase, showing significant differences between the study and control groups throughout the training program phases. The usage of concept maps in debriefing sessions showed a significant improvement from the pre-test (12. 05 ± 3. 54) to the immediate post-test (16. 78 ± 2. 64) phases, as well as from the pre-test to the follow-up phases (16. 20 ± 1. 07). Furthermore, the study groups' overall utilization of concept maps during the debriefing session achieved the highest mean in the immediate post-test phase, demonstrating a significant difference between the study and control groups throughout the training program phases.

Table 3 shows the total performance in PBL sessions, which scored a lower mean (102.86 ± 19.08) in the immediate post-test phase compared to the pre-test phase

(110.28 ± 16.89), with a significant difference. The follow-up phase showed a significant increase (110.81 ± 19.36) compared to the immediate post-test phase. However, no significant changes were observed in students' performance in PBL sessions between the study and control across all phases of the training program.

Table 4 shows a significant improvement in the total objectives' correspondence between predefined learning objectives and students' generated learning objectives during brainstorming sessions among study groups between the immediate post-test phase (7.61 ± 1.05) and the follow-up phase (16.49 ± 10.05). Furthermore, the total learning objectives correspondence of study groups scored the highest mean in the follow-up phase, with a significant difference between the study and control groups across training program phases.

Table 5 shows significant improvements in total attitude about using CM in the PBL sessions between the pre-test (3.21 ± 0.60) and the immediate post-test (4.14 ± 0.33), in addition to the pre-test and the follow-up (4.08 ± 0.46) phases. Also, the study groups' total attitude of using CM in PBL sessions had the highest mean during the immediate post-test phase, with a significant difference between the study and control groups across training program phases.

4. Discussion:

When comparing the pre-test results with those from the follow-up phase, also between the pre-test and the immediate post-test, there were significant improvements in study groups students' total knowledge. These results are in agreement with **Elmeghawri and Sleem (2021)**. Furthermore, the study groups' students scored the highest mean in total knowledge during the immediate post-test phase, demonstrating a notable difference when compared to the control groups across training program phases. This result is in line with **Attia, Hashim, and Soliman (2019)**. The current result could be attributable to the impact of the training program.

Between the pre-test and follow-up phases, study groups students' total practice in using concept maps in brainstorming sessions improved significantly. This improvement is attributed to the training program's influence. **Moon, Hoffman, Novak, and Canas (2011)** emphasized the necessity of training to improve CM practice. Furthermore, the study groups' total practice of using concept maps in brainstorming sessions had the highest mean during the follow-up phase, showing significant variation between the study and control groups throughout training program phases. This result is consistent with **Hsu (2004)**.

There were notable enhancements in learners' total practice of using concept maps in the debriefing session among study groups from the pre-test to the immediate post-test phases and from the pre-test to follow-up phases. This result is consistent with **Kassab and Hussain (2010)**. Also, the current study result could be attributed to the repeated construction of concept maps for different problems along with phases of the training program. Besides, students' acquisition of knowledge during the self-study phase of PBL could broaden their knowledge structure **(Kassab, 2016)**. This is in addition to the numbers and variety of students learning resources that contribute to maximizing the map quality as a product of a group, not individuals **(Bridges et al., 2015)**. Thus, increasing their ability of concept map construction.

The students in study groups achieved the highest mean in their concept maps usage in the debriefing session during the immediate post-test phase, demonstrating a significant difference between the study and control groups across training program phases. This result might be the consequence of the training program's initial impact. **Herring (2011)** emphasized the importance of CM training in developing its skills. In addition, the current study result indicates that the study groups' skills in practicing CM have progressed/improved in PBL over time. This result is supported by **Slieman and Camarata (2019)** who found an improvement in students' CM practice as evidenced by the increase in their concept maps scores throughout the semester. In this regard, **Novak (1990)** reported that the CM skill takes a long time up to two years to be mastered.

Students in the study groups performed significantly worse on PBL sessions during the immediate post-test phase when compared to pre-test phase. Then, it increased significantly in the follow-up phase than the immediate post-test time. These findings could be ascribed to the fact that CM is a novel strategy, and the implementation of anything new is frequently met with opposition **(Marquis & Huston, 2017)**. This interprets why the immediate post-test finding of study groups is lowered than the pre-test one and it was significantly raised again. This is supported by **Daley and Torre (2010)** who considered resistance as one of the CM implementation challenges at the initial stage of practicing CM that takes time to be understood and incorporated as a learning strategy.

There were no significant variations in learners' performance in the PBL sessions between the study and control groups across the training program's phases. This result disagrees with **Tseng et al. (2011)**. The little effect of CM on learners' performance in PBL sessions may be referred to that students are consuming more time in learning how to practice CM which needs a long time for practice to be mastered **(Lennex, 2012; Novak, 1990)**, and hence having its positive effect on PBL. This is supported by **Kassab and Hussain (2010)** who found that learners' progress in PBL curriculum is associated with progress in CM practice. That assures the need for conducting the training program for a long time associated with regular implementation each academic year followed by continuous monitoring and improvement. As **Ornek and Saleh (2012)** assured the students need longer time to be skillful in CM practice hence having a significant effect on their PBL sessions performance.

In addition, this result could be due to that the students were being trained alone on CM without providing the same training to their tutors. In this regard, **Wilson (2015)** indicated the need for both students and faculty training on the process of CM construction. As the CM is implemented into the PBL sessions, the training of students besides their tutors is necessary as they are the two partners in the PBL system **(Chung, Yeh, & Chen, 2016).**

Furthermore, many factors related to the current PBL system could have an impact on this outcome, as the way PBL is conducted and facilitated affects the students' performance in PBL **(Abdalla, Abdelal, & Soon, 2019)**. To ensure the PBL system is implemented successfully, there should be a regular intensive training program on PBL and its sessions for both first-batch students and newly hired tutors, as well as a refresher program for other academic batches and their staff **(Shamsan & Syed, 2009)**. In this regard, **Wondie, Yigzaw, and Worku (2020)** reported that an adequate orientation on the PBL process should be given to students before their exposure to the first PBL session, and tutors are expected to make clear what is expected from their students in the PBL sessions.

Besides, the problem and its structure which is considered one of the three basic angles of PBL success could be another factor affecting learners' performance in PBL sessions **(Talaat, 2012)**.

During the interval between the immediate post-test phase and the follow-up phase, there was a notable improvement in the overall learning objectives/issues alignment between the predetermined learning objectives and those created by students in study groups. This outcome, which may be ascribed to the training program's impact confirms that the CM skill is an accumulative acquired skill over a long time of practice. Besides, this result was supported by a previous result regarding the significant improvement of study groups students' performance in PBL sessions during the follow-up phase.

In the follow-up phase, the study groups exhibited the highest mean score regarding total learning objectives/issues correspondence, with significant differences across training phases. These findings contradict **Zwaal and Otting (2012)**. However, **Kassab (2016)** supports this, stating that the use of CM in the brainstorming process aids the group in developing meaningful learning objectives. **Bridges et al. (2015)** stated that including CM into PBL sessions can help to improve the PBL process and practice.

There were considerable improvements in study groups' total attitude about using CM in PBL sessions when comparing the pre-test results to both the immediate post-test and follow-up phases. This finding is consistent with **Hamed and Shrief (2015)**. Furthermore, the continuation of good student attitude findings at the follow-up phase, with no significant difference from the immediate post-test phase, may imply that the training program has a long-term favorable influence on students' attitude about adopting CM in PBL sessions. Furthermore, the study groups' total attitude about using concept maps in PBL sessions had the highest mean at the immediate post-test phase showing a significant difference between the study and control groups throughout all training program phases. This result is consistent with **Zwaal and Otting (2012)**.

In general, the findings of CM knowledge and practice, as well as attitude toward its usage in PBL sessions, are strong following the implementation of the training program, particularly students' attitude, which received the highest mean. This implies that students are open to using concept maps in PBL sessions. This finding is corroborated by **Veronese et al. (2013)**, who discovered that learners who participated in the concept maps tutorial group were more inclined to use concept maps later. Additionally, it supported by the results of **Soltan et al. (2022a)**, who reported significant moderate positive correlation between the students' performance in PBL sessions and their attitude toward using concept mapping.

5. Conclusion:

The training program on CM improves students' knowledge and practice. It also has a favorable impact on students' practices in PBL sessions, despite the challenges facing the PBL system, and the students' early resistance to acquiring concept mapping skills. By identifying additional learning objectives, improving overall performance, and increasing their willingness to use CM for process improvement and memory of pertinent data, CM improves nursing students' PBL sessions.

6. Recommendations:

It is advised that necessary steps be taken to incorporate a CM technique into PBL sessions as a valuable teaching and learning strategy. Also, providing students and their tutors with regular intensive training programs on CM and how to use it in PBL sessions combined with training programs on PBL and its sessions. In addition, establishing an effective monitoring system of PBL sessions and CM practices and utilizing its feedback to take the required corrective actions for continuous improvement are recommended.

Conflict of interest:

None

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Table 1: Students' knowledge regarding CM (N = 77).

Variable	Study groups N = 43			Control groups N = 34			p-value for Paired t-test			p-value for independent t-test		
	Pre-test	Immediate post-test	Follow-up	Pre-test	Immediate post-test	Follow-up						
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Pre/ Immediate post-test	Immediate post-test/ Follow-up	Pre/ Follow-up	Pre-test	Immediate post-test	Follow-up
Total knowledge of CM	11.35 ± 3.40	34.95 ± 2.78	29.30 ± 2.29	10.15 ± 3.81	11.15 ± 4.30	10.21 ± 3.19	**0.000***	**0.000***	**0.000***	0.185	**0.000***	**0.000***

Table 2: Students' practice of using concept maps during PBL sessions (N = 77).

Variable	Study groups N = 43			Control groups N = 34			p-value for Paired t-test			p-value for independent t-test		
	Pre-test	Immediate post-test	Follow-up	Pre-test	Immediate post-test	Follow-up						
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Pre/ Immediate post-test	Immediate post-test/ Follow-up	Pre/ Follow-up	Pre-test	Immediate post-test	Follow-up
Total practice in using concept maps in a brainstorming session.	13.42 ± 1.81	13.63 ± 1.77	14.87 ± 2.56	11.31± 2.94	11.42 ± 0.83	10.52 ± 2.42	0.630	0.061	**0.008***	**0.000***	**0.000***	**0.000***
Total practice in using concept maps in a debriefing session.	12.05 ± 3.54	16.78 ± 2.64	16.20 ± 1.07	12.26 ± 2.48	11.53 ± 2.18	11.52 ± 1.59	**0.000***	0.183	**0.000***	0.769	**0.000***	**0.000***

Table 3: Students' performance in PBL sessions (N = 77).

Variable	Study groups N = 43			Control groups N = 34			p-value for Paired t-test			p-value for independent t-test		
	Pre-test	Immediate post-test	Follow-up	Pre-test	Immediate post-test	Follow-up						
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Pre/ Immediate post-test	Immediate post-test/ Follow-up	Pre/ Follow-up	Pre-test	Immediate post-test	Follow-up

Total students' performance in PBL sessions.	110.28 ± 16.89	102.86 ± 19.08	110.81 ± 19.36	112.50 ± 14.12	110.79 ± 19.41	112.79 ± 15.53	**0.006***	**0.012***	0.838	0.540	0.076	0.629

Table 4: Correspondence between predefined learning objectives and those generated by students (N = 77).

Variable	**Study groups N = 43**			**Control groups N = 34**			**p-value for Paired t-test**			**p-value for independent t-test**		
	Pre-test	Immediate post-test	Follow-up	Pre-test	Immediate post-test	Follow-up						
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	Pre/ Immediate post-test	Immediate post-test/ Follow-up	Pre/ Follow-up	Pre-test	Immediate post-test	Follow-up
Total learning objectives correspondence	15.27 ± 32.32	7.61 ± 1.05	16.49 ± 10.05	13.70 ± 17.68	7.32 ±7.27	7.29 ± 9.27	0.137	**0.000***	0.745	0.800	0.795	**0.000***

Table 5: Students' attitude regarding using CM in PBL sessions (N = 77).

Variable	**Study groups N = 43**			**Control groups N = 34**			**p-value for Paired t-test**			**p-value for independent t-test**		
	Pre-test	**Immediate post-test**	**Follow-up**	**Pre-test**	**Immediate post-test**	**Follow-up**						
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Mean ± SD**	**Pre/ Immediate post-test**	**Immediate post-test/ Follow-up**	**Pre/ Follow-up**	**Pre-test**	**Immediate post-test**	**Follow-up**
Total attitude regarding using CM in PBL sessions.	3.21 ± 0.60	4.14 ± 0.33	4.08 ± 0.46	3.34 ± 0.33	2.51 ± 0.63	2.51 ± 0.46	**0.000***	0.316	**0.000***	0.237	**0.000***	**0.000***

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