THE EFFECTS OF PROBLEM BASED LEARNING IN CHEMISTRY EDUCATION ON MIDDLE SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT AND ATTITUDE

By

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DEDICATION

This project is dedicated to my husband, Fady, whose love and support gave me the strength and perseverance I needed to achieve my goals; and to my sons, Ahmad and Yusuf, whose innocence and happiness taught me the beauty of life and the patience to live it. It is also dedicated to my parents, Faysal and Salam, who made all of this possible with their endless encouragement and patience.

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ABSTRACT

The objective of this study was to determine the effects of problem-based learning (PBL) on students' performance and attitude towards chemistry. In the study, data was obtained through the use of pre-test post-test, research-control group model. The data obtained from both groups was analyzed using t-test cores, mean, and standard deviation. The study was conducted on 7th grade students, in a private school in Lebanon. Two types of instruments were used for measurement: achievement tests, and an attitude questionnaire. The research group was taught chemistry using PBL while conventional teaching methods were applied in the control group. Results indicated that implementing problem based learning approach had improved students' achievement and attitude. This study encouraged teachers to implement problem based learning method in teaching science concepts especially chemistry for middle school students.

Keywords: Problem-based learning, teaching strategy, chemistry, achievement, attitude.

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CHAPTER I

INTRODUCTION

We live in a world where society and technology are changing regularly. That is why every individual should own the skills of analyzing, discussing, explaining, researching, synthesizing, and communicating in order to be able to keep up with these changes. We need people who have the ability to make decisions, and give logical solutions to real life problems.

The instruction process is traditionally based on tests, books and documents. The contents are explained; learners pay attention to what is taught and do the exercises at the end of the chapter. This procedure is not relevant as learners do not have a clear picture of experimentation, thus they grow confused.

Teachers, parents, and administrators are concerned that high school graduates are not capable of making real life decisions. Gallagher, Sher, Stepien, and Workman (1995) stated that most of the questions that teachers ask in conventional teaching are direct questions and do not stimulate higher-order thinking. Educational reform must take place in schools, new strategies are needed especially the ones that teach students to solve problems effectively.

Conventional teaching strategies are teacher centered, where student passively receives information. While in students centered approaches the instructor is a mentor of the learning process and students have the options to make their own judgments about the different problems presented to them.

People face different kind of problems in their lives and they use previously gained knowledge and experiences to find solutions to these problems. Thus, students should learn the way to deal with these challenges by confronting such problems during their learning process (Ali, 2010; Chin & Chia, 2004).

Even though traditional teaching methodologies exist in most educational settings, alternative techniques are also available to educators. Techniques that incorporate higher levels of thinking and problem solving should be considered. PBL is a strategy that helps students to acquire problem solving skills in addition to the skills of communicating, analyzing, researching and accepting others. In this methodology, students are independent learners and teachers are facilitators who guide the learning process.

Rationale

In this study, PBL effect on students' academic performance and perception in chemistry learning will be investigated. This study aims to offer the teachers alternative educational strategies that they can use during the instructional process. The researcher hopes that students' engagement in science learning will increase when using the PBL method. This active learning and engagement will lead to an enhancement in students' performance.

Research Questions:

What effects does adopting PBL approach in a chemistry unit have on student achievement and attitude towards chemistry?

The study aims to accomplish the following goals:

(1) To investigate the extent to which the use of PBL will enhance students' achievement.

(2) To investigate if the use of PBL will enhance students' attitude towards chemistry.

These following two hypotheses are to be investigated:

(1) There is a significant difference in students' achievements after the use of PBL.

(2) There is a significant difference in students' attitude after the use of PBL.

CHAPTER II

LITERATURE REVIEW

Recent reports stressed that using new modern strategies for teaching science improved students' engagement in the learning process (Osborne & Dillon 2008). Rocard et al, (2007) suggested the usage of teaching strategies incorporating real-world type of activities that are student-centered since it is more valuable than traditional teacher-centered lectures in which most of the information is presented by the teacher.

Catalano and Catalano (2004) stated that student-centered teaching takes place in classrooms where pupils are active learners; they are the focus of the learning cycle. Whereas a learning environment where the teacher is lecturing and the student are passive learners, recording and memorizing information, is called teacher-centered teaching.

Halperin (1994) indicated that traditional teaching strategies are still being used in most schools and universities. In such conventional learning student is passive, receiving information from the teacher, and memorizing lessons to be able to pass hi test. But authentic learning takes place when students are the center of the learning process, when they are actively involved in solving real like problems.

Torp and Sage (2002) described PBL as an approach where student is the focus of the learning process. In such model small groups of students cooperate to solve a given problem, they retrieve their prior knowledge and discuss it with each other. Based on the discussion they formulate hypothesis, research and synthesis probable solutions to solve

the given problem. Reflection, self-assessment, and cooperation are main components of the PBL process.

This literature review considers the effect of PBL on students' performance and attitude by addressing the following issues:

(1) Origin and goals of PBL

(2) Characteristics of PBL

(3) The student and teacher role in PBL

(4) Benefits of PBL

(5) Barriers to PBL implementation

(6) Students' perception

Referring to numerous authors, (Hmelo-Silver, 2004; Savery & Duffy, 1994) PBL is an instructional strategy that deviates from traditional strategies by moving from a teacher- centered model to a more active student-centered learning environment where students are active independent learners. Torp and sage (2002) referred to PBL as being an important modern educational approach enabling students to be their own knowledge architects.

Most research carried on the usefulness of PBL took place in medical schools (Hmelo-Silver, 2004; Colliver, 2000; Major & Palmer, 2001; Sahin, 2009). Pecorce (2009) stated that contradictory findings were reached when PBL was investigated in medical schools. Whereas, Vernon and Blake (as cited by Sahin, 2009) revealed that this strategy generated students' interest and motivation. Chin and Chia (2004), Greenwald (2000), Major and Palmer (2001), and Sahin (2009) concluded that PBL approach students conveyed better attitude about their learning than conventional learning students.

However, a study by Beers (as cited by Sahin and York, 2009) showed no advantage in using the PBL approach over more conventional strategies. An experimental study conducted by Alcázar and Fitzgerald (2005) found that pupils taught using PBL had higher grades in the achievement post-test than students in the non-PBL sections. Akınoğlu and Tandoğan (2006) who conducted a study about PBL effects on students' academic achievement in science found that implementing PBL enhanced students' performance.

There have been several researches carried on in the Arab world that assessed the usefulness of the PBL approach.

- The results of one study conducted by Kassab, Abu-Hijleh, Al-Shboul, and Hamdy (2005) to examine the gender differences in learning PBL revealed that group performance in female led tutorials was significantly higher in comparison than the male student led tutorial. Both male and female students conveyed that they have found difficulties in analyzing the problem when they used PBL for the first time.
- A second study carried out by Al Rukban, Khalil, and Al-Zalabani (2010) compared the learning environment found in PBL curriculum with that of conventional curricula. The data collected indicated that the educational strategy was a factor that affected the educational environment. Problem based learning was a better educational environment compared to conventional curriculum.
- A third study conducted by Bin Abdulrahman (2007), assessed the current status of undergraduate curricula, in the medical colleges of Gulf Cooperative Council (GCC) countries. The Results revealed that out of 30 medical colleges 13 were located in KSA.

Twelve colleges were following the traditional curriculum, while the remaining was following hybrid PBL approach.

- In the fourth study Hasna (2004) described how PBL is applied in an engineering course. The researcher concluded that PBL use in engineering courses allows students to be self learners

- In the fifth study Das, Mpofu, Hasan and Stewart (2002) investigated teachers' evaluation by their students when PBL is used and it also checked if this evaluation changed when students have been exposed for a long time to this specific teaching strategy. Data analysis revealed that facilitators were rated by their students as average to outstanding tutor. But students and tutors perceptions were not similar; students wished they had more support from their teachers whereas tutors aimed to provoke independent learning by using PBL.

- These two studies were conducted on high school students: one study conducted by Al-Belushi and Ambo-Saiidi (2005), studying the effect of PBL approach on grade 10 students , found that PBL students had better achievement than the control group students who were taught using the conventional way. Another research conducted by Sawafta (2008), about the effect of PBL approach on grade 11 students, confirmed AL-Belushi and Ambo-Saiidi (2008), results by showing a significance increase in students achievement through the use of PBL.

1- Origin and goals of Problem Based Learning

According to Chegwidden (2006), PBL was first established by Howard Barrows in the 1960's as part of the education of physicians in medical school. PBL is a strategy that Neild (2004) defined as a set of problems provided to small groups of students to try to solve. Students discuss each problem; retrieve their prior knowledge related to the problem and search for new information that helps in solving the problem. PBL strategy aimed to help student in developing rich cognitive models when solving the problem (Norman & Schmidt, 1992). Similarly, Savin-Baden (2006) argues that teachers' aimed when using PBL to develop their students' self independent learning.

According to Barrows PBL is an approach targeting five different goals not addressed by the conventional strategy (Guedri, 2001):

(1) Construction of useful knowledge: problems produce intrinsic interest which sequentially initiates the cognitive processes of retrieving prior knowledge, determining a problem space, seeking out new information, and reconstructing information into knowledge (Norman & Schmidt, 1992). Constructing extensive and flexible knowledge goes beyond having students learn the facts of a domain. To encourage students to develop flexible knowledge and effective problem-solving skills, learning must be embedded in contexts that require the use of these skills (Hmelo-Silver, 2004). Discussing problems in a PBL group (before beginning to research learning issues) activates relevant prior knowledge and facilitates the processing of new information. Students have better ablility to

construct new knowledge when they can relate it to what they already know (Hmelo-Silver, 2004).

(2) Development of reasoning strategies: through constant contact with real life problems, students will develop abilities to perceive a problem and appreciate its features, formulate and analyze critically possible hypotheses and finally make decisions about appropriate actions to solve the problem (Norman & Schmidt, 1992).

(3) Development of effective self-directed learning strategies: self-directed learning makes the student aware of the importance of personal learning needs. Additionally, it allows him to find and to utilize accurately all kinds of information resources (Norman & Schmidt, 1992). According to Torp and Sage (2002) metacognitive strategies are important for developing self-directed, lifelong learning skills. These are the skills that enable autonomous learning. First, learners must have a metacognitive awareness of what they do and do not understand. Second, they must be able to set learning goals, identifying what they need to learn more about for the task they are engaged in. Third, they must be able to plan their learning and select appropriate learning strategies. In other words, they must decide on a course of action to reach these goals. Finally, as they implement their plan, learners must be able to monitor and evaluate whether or not their goals have been attained.

(4) Increased motivation for learning: since students will perceive the problems studied as relevant and given that sessions are structured as open-ended discussions, curiosity is fostered. (Norman & Schmidt, 1992).

(5) Becoming effective collaborators: the PBL process pushes students to work together and to help each other to get an understanding of what they are learning and its relevance to the problem. It is this collaboration that permits the students to build up the abilities necessary to be responsible for their own learning. Collaboration is an indispensable ability that students should have, since they will be regularly working as members of teams *(*Hmelo-Silver & Barrows, 2006*).* Research literature has shown that the success of problem-based learning depends on group work (Gallagher & Stepien 1993).

From the objectives highlighted above, it is clear that the principal goal of the PBL approach is the development of higher order thinking. PBL main objective is to stimulate students to learn at the higher levels, where students analyze, synthesize and evaluate instead of simply know, comprehend and apply (Guedrri, 2001).

2- Characteristics of Problem Based Learning

According to Torp and Sage (2002) PBL is a strategy that is student-centered, in this methodology students research, explain, and cooperate in order to find meaningful solutions to real life problems. The PBL cycle is made of several steps:

- A real like problem is presented to students.
- Students discuss the problem and formulate hypothesis.
- Students first retrieve prior knowledge and experience relative to the problem next they identify knowledge deficiencies and start making their research.

- Following, students apply their knowledge to check the validity of their hypotheses in light of what they have learned.
- At the end of each problem, students make their own reflection on the knowledge acquired (Akinoglu & Tandogan, 2006; Neild, 2004; Wang, Thompson, & Shuler, 1998).

Hmelo-Silver (2004) stated that the most important factor of PBL is the problem itself. Several features are considered essential to develop a good PBL problem:

- It needs to be complex, open-ended, and ill-structured. (Bridges & Hallinger, 1996; Torp & Sage, 2002).An ill structured problem is problem that is incompletely defined and not easily resolved with any degree of certainty. Furthermore, it has multiple solutions with none clearly superior. (Duch, 1996; Torp & Sage, 1998).
- It must be realistic and resonate with the students' experiences and it should support intrinsic motivation. (Torp & Sage, 1998).
- It must lead students to generate hypotheses and defend them to others in their group. Students publicly articulate their current state of understanding, enhancing knowledge construction and setting the stage for future learning. (Duch, 1996)
- It must afford feedback that allows students to evaluate the effectiveness of their knowledge, reasoning, and learning strategies. And it should challenge students to develop higher order thinking skills (Hmelo-Silver, 2004).

3- Role of the teacher and student in Problem Based Learning

PBL requires changes in the teacher's lesson planning, instruction delivery, classroom setting, and information assessment (Torp & Sage, 1998). In PBL, teaching is facilitating and mentoring, it is based on the fact that student are self independent learners who can build their own knowledge with the guidance of their tutor. The teacher role in PBL is critical; a good facilitator will guide his/her students through the different phases of the PBL process.

The teacher insures the involvement of all the students in the learning process where they exchange information with their peers by externalizing their own thoughts and commenting on each other's ideas (Torp & Sage, 2002).

In PBL the teacher encourages student to use logical thinking by analyzing the given problem, thus higher order thinking skills are developed. He/she also encourages student to retrieve prior knowledge and discuss it with their group members by asking probing questions. PBL tutor models problem solving skills needed to assess one's reasoning (Akinoglu & Tandogan, 2006)

Unlike conventional strategies where the teacher is the leading figure, Chin and Chia (2004) indicated that in PBL, student assumes a different role than that in the traditional teacher-centered process in which information is presented to them by the teacher. In PBL, student must play a more active role, that of a highly motivated learner, arriving with substantial intellectual capacity and background information. PBL presents the students with the chance of assessing their own understanding, and discovering their own learning needs.

Through PBL students become more skilled at gathering, organizing, and storing information in a useable form for future use, as well as, confronting and resolving complex, realistic problems. Active participation within the small group requires good interpersonal skills. These include: listening, giving and receiving criticism, compromising, negotiating, educating peers, and motivating others. The teacher is a mentor who guides his student during their group work and helps them to find the knowledge needed to find the problem solution (Bayard, 1994; Stepien & Gallagher, 1993; Woods, 2003).

The use of real life problem in the PBL strategy induces students' interest and thinking which leads to a greater student involvement in learning (Torp and Sage, 2002). Students gain the ability to analyze the problem and synthesize an appropriate explanation to it, thus become independent learners (Torp and Sage, 2002).

4- Benefits of PBL

PBL is a very useful pedagogical approach, with many valuable effects for the students. First of all, it promotes problem solving skills like cooperating, communicating, and researching skills. PBL' Students have greater ability then conventional students to retain the knowledge they gain since they are actively engaged in the learning process (Wood, 2003). These PBL characteristics contribute to an increase in student motivation towards learning (Torp & Sage, 2002; Wood, 2003).

5- Barriers to PBL Implementation

Similar to any educational approach problem based learning has its own limitations. To a greater or lesser extent, overcoming these barriers is possible if appropriate strategies are adopted when PBL is introduced into the curriculum.

Some disadvantages of PBL are:

- It could be difficult for teachers to change their teaching styles (Hmelo-Silver, 2004): Tutors enjoy passing on their own knowledge and understanding so they may find PBL tutoring difficult and frustrating. The lack of training programs, curriculum materials, and rigid scheduling in the high school environment will increase demands on any teacher trying to implement PBL in the classroom. (Edwards-Hammer, 2007)
- PBL is more expensive than traditional methods: the PBL curricula necessitate large number of well-equipped rooms for small group meetings. In addition, it requires other important resources to support small group investigations, including instructional materials (both textbooks and multimedia), space, library, equipment, and support personnel. For instance, having several copies of resource material available in the library for large numbers of small groups implies substantial costs, particularly for schools in developing.
- There is a lack of prepared materials for PBL classroom instruction (Torp & Sage, 2002). Present curriculum guides and textbooks do not contain the variety of sample problems needed to support this methodology on a broad scale. Few

teachers have the time or the motivation to prepare all new materials for classes (Gertzman and Kolodner, 1996; Wood, 2003).

- Students who are used to the traditional lecturing are likely to be uncomfortable when using the PBL approach for the first time (Bayard, 1994). It will be up to the teacher to convince students that they are researchers looking for information and solutions to problems that may not have one right answer.

6- Students' Perception of PBL

A number of studies on students' perceptions towards PBL have been conducted. One study done by Chung and Chow (1999) conveyed the motivation of student to learn using active learning strategies, and the application of numerous study skills in PBL. Carlisle (1985) and Cheong (2008) found that there are several aspects that students liked in the PBL strategy, some of these aspects are: self-learning, understanding on their own and applying that understanding, pooling of knowledge after their individual research, developing the habit to read papers and the work of others on topics of interest, self-control of the study schedule, working on realistic problem, and teamwork.

Students said they disliked PBL for the following reasons: it took them a long time to find solution to the problems; they were not sure about their final answers or the information collected since the instructor only guided without lecturing or providing information; they found it hard to understand some notions on their own although they discussed it with their group members.

Chung and Chow (1999) reported that students attitude towards chemistry was enhanced after the use of PBL. Students stated that their PBL experience was challenging and agreeable. Students developed several skills related to group work like respect, mutual support, and sharing of information (Chung and Chow, 1999; Lo, 2004).

Conclusion

According to Gertzman and Kolodner (1992), traditional approaches have been criticized as devoid of sufficient interface with the real world thus students' experience inability to apply theory to practice. This literature review shows that PBL help students develop this important link and it also encourages deep rather than shallow learning. However, tutors need to assist and guide their student when using PBL for the first time; they should guide the learning process by directing probing questions to individuals in groups to ensure their engagement. They should provide their students with time and resources needed, and help them to understand their roles in the group. The benefits of PBL, like integrating all aspects of learning such as questioning, critical thinking, problem solving, cooperative learning, active learning and discovery-based learning , suggests that this approach has a great deal to offer.

Science education in Lebanon should undergo a reform related to the teaching strategies used. Most science teaching is based on lecturing and simple demonstration. Our teaching strategies must be evaluated and new educational strategies that are student-centered must be adopted. PBL should be considered an efficient teaching approach to be used. The Lebanese University had adopted a PBL curriculum in the school of dentistry,

while some private universities had conducted workshops about PBL and used PBL to teach some of its courses. No research studies about PBL have been conducted in Lebanon at the high school level. So the researcher decided to conduct a study by implementing a PBL chemistry unit about “separation techniques”. This study aims to detect if the implementation of PBL strategy in teaching chemistry for middle school students affects students’ academic achievement and their attitudes towards chemistry.

CHAPTER III

METHODOLOGY

Participants

This study was conducted in a high school in Saida on seventh grades students, having an age ranging between 12 and 13 years. The participants were the pupils in two French sections. A total of 53 pupils participated in the study; they were divided into two groups: an experimental group that consisted of (26) students and a control group that consisted of (27) student.

Before starting the study, the school principal, science coordinator, and students were informed about all aspects of the study. An oral informed consent was received from students, while a written consent was provided by the school principal and the science coordinator.

Material:

PBL approach was applied on the experimental groups to teach the unit of separation techniques, while the students in the control group were taught the same content of the unit but using conventional learning strategies. Before starting the lesson information about the problem-based learning model had been presented to the experimental group.

The PBL lessons took place over a period of 3 weeks through 50 minute sessions held twice a week.

To assess the effectiveness of PBL application, two instruments were used: achievement tests and an attitude questionnaire. A pre and post testing control group design was used to compare students' achievement before and after the application of PBL. The pre-test and post-test model aimed to measure students' achievement contained fill in the blanks with the correct expression, open ended questions, and multiple choice questions. Data regarding students' perception was collected using a questionnaire that was administered only to the research group (the 26 students who were taught using the PBL approach). The student questionnaire contained twelve statements linked to a five-point Likert-type scale ranging from (1) strongly disagree to (5) strongly agree.

Procedure:

After collecting the data, the means and t-values were calculated to determining the significance using (SPSS) program. Paired samples t-tests were used to compare the pre-test and post-test scores for each learning style. Independent samples t-tests were used to determine whether relationships existed between each learning-style scores (pre-test and post-test).

Research group pre-test scores and experimental group pre-test scores were compared to find out if any significant difference existed between the achievement of both groups at the beginning of the experiment. Research group pre-test scores and post-test scores were compared to find if any improvement in students' performance appeared after

applying PBL. The post-test for both control and experimental groups were compared to find if there was any significant difference in their achievement.

To analyze the questionnaire concerning the attitude of students towards the PBL approach, the frequency of each response was presented as an indicator. A bar graph was used to show the distribution of student answers for each of the questions presented in the questionnaire.

CHAPTER IV

FINDINGS AND RESULTS

Students' academic achievement:

To find out if the application of PBL had significantly influenced students' achievement, data collected from the pre-test and post-test were analyzed using (SPSS) to calculate student's t-test, at a level of significance $p < 0.05$.

The pre-test objective was to measure students' prior knowledge and to check the equivalence between the research and control group. (Khairiree & Kurusatian, 2009)

Table 1

T test results carried out to examine the difference between the research and the control group pre-test scores.

Group	Df	Mean	SD	t	Sig.
Control (n=27)		82.63	14.4		
	51			0.806	0.424
Experimental (n=26)		79.62g	12.73		
P<.05					

The results obtained in Table 1 demonstrated that no significant difference ($p<0.05$) existed between the mean scores of the two groups pre-test, which means that both research and control groups had homogeneous prior knowledge. (Khairiree & Kurusatian, 2009)

Table 2

T test results carried out to examine the difference between pre-test post-test scores of the research group

Group(n=26)	Df	Mean	SD	t	Sig.
Pre-test		79.62	12.73		
	25			-3.619	0.0011
Post-test		88.27	14.21		
P<.05					

Table 2 data analysis revealed that the t-test results for the difference of means in the research group pre-test and post-test was -3.619, which was considered to be significant at the $p < 0.05$ level. This indicated that students' achievement of the experimental group on the post-test was significantly better than their achievement at the pre-test. Thus the calculated post-test mean of the experimental group at the end of the PBL unit (88.27) was significantly higher than that of the pre-test of the same group (79.62).

Thus, it was assumed that PBL enhanced students' achievement in learning chemistry.

Table 3

T test results carried out to examine the difference between the research and the control group post-test scores.

Group	Df	Mean	SD	t	Sig.
Control (n=27)		79.89	14.74		
	51			-2.107	0.04
Experimental (n=26)		88.27	14.21		
P<.05					

In table 3 a comparison between the means of the post-test scores of the control and experimental groups was carried out. It conveyed the presence of a significant difference

between the mean scores of the experimental and the control group, with the PBL group recording a higher mark. This indicated that PBL approach improved students' achievement.

Students' attitude:

The table below represents the results of the students' responses to the attitude questionnaire:

Table 4

Students' attitude:

Question Num.	Questionnaire Statements	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
1	This PBL lesson allowed me to better understand separation techniques.	2(8%)	0(0%)	1(4%)	3(12%)	20(77%)
2	This PBL lesson was meaningful.	1(4%)	1(4%)	1(4%)	7(27%)	16(62%)
3	This PBL lesson was well-organized.	1(4%)	2(8%)	4(15%)	13(50%)	6(23%)
4	This PBL lesson was engaging.	1(4%)	1(4%)	5(19%)	4(15%)	15(58%)
5	This PBL lesson allowed me to apply my knowledge to solve problems.	2(8%)	0(0%)	2(8%)	8(31%)	14(54%)
6	This PBL lesson encouraged interaction with other students.	1(4%)	1(4%)	3(12%)	6(23%)	15(58%)
7	I enjoy working in a group.	2(8%)	1(4%)	3(12%)	3(12%)	17(65%)
8	I effectively used the material provided in this unit.	1(4%)	1(4%)	2(8%)	8(31%)	14(54%)
9	During this unit, I felt as though my opinions were valued.	2(8%)	0(0%)	4(15%)	6(23%)	14(54%)
10	PBL takes up more time than conventional lecture based approach.	1(4%)	2(8%)	2(8%)	5(19%)	16(62%)
11	I have to take more responsibility for my learning in problem based learning.	0(0%)	2(8%)	4(15%)	8(31%)	12(46%)
12	I would like to learn using PBL again.	1(4%)	1(4%)	7(27%)	7(27%)	10(38%)

Considering that the results with scores of four and five indicated agreement and 1 and 2 two indicated disagreement; the result analysis of the questionnaire listed in Table 4 showed that 89% of pupils found that PBL helped them to better understand separation techniques; 89% found that this lesson was meaningful; 73% found it well organised;73% found it engaging; 85% found that it allowed them to use their knowledge in solving problems; 81% found that it encouraged interaction with other students; 77% enjoyed working in a group; 85% said that they effectively used the material provided in this unit; 77% felt their opinions were valued; 81% found that PBL took more time than conventional lecture based approach; 77% said that they were more responsible for their own learning in PBL; and 65% would like to use PBL again.

CHAPTER V

ANALYSIS AND DISCUSSION

In this study assessing the effects of applying PBL on pupils' performance and attitude, the following results were obtained:

1- Students' academic achievement:

In order to decide whether the experimental treatment of using PBL had significantly influenced students' achievement, data from the pre-test and post-test were analyzed using students' t-test, at $p < 0.05$. (Khairiree & Kurusatian, 2009)

- Both the experimental and control groups were compared on the variable of pre-test achievement scores. The results obtained from the statistical analysis showed that no significant difference existed between the two groups with respect to pre-test in the subject of chemistry "Separation techniques". According to table 1, the difference between the two means was not statistically significant at 0.05 level. Hence, both groups were treated as equal.
- The performance of the experimental group in the post test was found to be significantly better than their performance on the pre-test. The difference between the two means was statistically significant at 0.05 level (Table 2).
- The comparative academic performance analysis was carried out with a comparison between the means of the post-test marks of the LBL and the PBL

approaches. This analysis is shown in Table 3. As can been seen, there was a significant difference between the mean marks of the PBL and LBL, with the PBL approach recording a higher mark.

These results were an indication that the PBL approaches yielded to an increase in students' achievement. They verified the first hypothesis stating that "There is a significant difference in students' achievements after the use of PBL." This study results confirmed earlier findings of Loggerenberg and Hattingh (2003) and Liu (2004) that the use of PBL is more efficient in learning science than the traditional method.

Several studies used the pre-test post-test designs to find the effect of PBL on student performance. In such design, students are divided into two groups, one group is taught using the PBL approach (experimental group) while the control group receives no treatment, over the same period of time. In this design, statistical analysis determines if the intervention has a significant effect.

Both groups are pre-tested and post-tested:

1. The researchers compare the scores in the two pre-test groups, to ensure that the randomization process is effective.
2. The researchers see how both groups changed from pre-test to post-test, and whether one, both or neither improved over time.
3. This design allows researchers to compare the final post-test results between the two groups, giving them an idea of the overall effectiveness of the PBL approach.

The results of a study conducted by Shen, Lee, and Tsai (2007) revealed the positive influence of web-based PBL on enhancing students' computing skills. Sahin and York

(2009) study indicated that students' achievement and expectations in physics didn't improve after the use of the PBL approach.

Akınoğlu and Tandoğan (2006) study revealed an improvement in students' science achievement after the implementation of the PBL model. They had also deduced that the PBL model had a positive effect on students' conceptual development. Sawafta (2008) and AL-Belushi and Ambo-Saiidi (2008) studies revealed that PBL ameliorated students' achievement level.

2- Students' attitude:

The results of the questionnaire analysis showed that 65% of students liked to use the PBL approach more frequently. With regards to students' motivation, engagement, and interest; 77% of pupils enjoyed learning chemistry using PBL; moreover, 73% considered this unit engaging, and 89% of them found it meaningful. In fact 89% of the students thought they had clearly understood what they learned, about 77% of pupils said they were involved in learning, 81% of them reported that they had to work more than usual, and 81% of the students reported that PBL enhanced their cooperation skills.

The results of the questionnaires indicated that students' experiences of PBL reflected varying attitudes, some negative and the majority more positive. However, the fact that some of the students had negative attitude towards PBL use does not mean that these students should not be challenged and empowered to develop the necessary skills for functioning responsibly and independently in an ill-structured learning environment. On the contrary, life outside the classroom is complex and often threatening, whether

learners prefer it or not. Real-life demands will neither highlight the essence of a problem nor provide the recipes to be used for solving it. Teachers will not always be there to provide direct instruction, the next steps or a structured, safe environment, even though learners might prefer it that way. The purpose of problem based learning approach is geared towards preparing learners to perform complex real-life roles and to make them flexible life-long learners.

The results of this research are similar to other studies' findings that have used questionnaires as an instrument to assess student attitude and perception towards PBL. Some of these studies are listed below:

- A study conducted by Chin and Chia (2004) indicated that students social development was influenced positively and some positive changes occurred in their social tendencies such as making decisions with other group members or acting in as a team.
- In their study to determine the effectiveness of problem-based learning model, Çakir and Tekkay (1999), found that students' willingness to learn increased and their attitudes improved in a positive manner.
- Loggerenberg & Hattingh (2003) studied the levels of enjoyment experienced by students who were exposed to PBL. The learners' experiences of PBL reflected varying attitudes, some negative and the majority (75.5%) more positive.
- Liu (2005) used both questionnaires and student interviews to check student attitude towards PBL. Interviews provided insights as to why the students liked or disliked using PBL. Almost all the students interviewed said they enjoyed using it. They mentioned different reasons for liking it, which included having fun,

being able to use various hypermedia tools provided in the program, using computers, and working in groups. Very few students were not enthusiastic and said they were frustrated because the problem was difficult to solve and the teachers did not give the answers.

- The aim of a study conducted by Pirrami (2009) was to investigate the impact of PBL on students' learning. Questionnaires were administered to assess students' perceptions after the module was completed. Findings showed that students reported enjoyment of what was done and this appeared to be related to the great engagement with lesson activities and to the high autonomy they had been given.
- A study conducted by Mossuto (2008) through the use of a survey and interviews with students examined whether engagement, questioning, critical thinking and problem-solving skills are enhanced using PBL. The initial findings showed that those participants who had been involved had enjoyed the experience and apparently preferred this mode of study. Most students indicated that PBL had challenged their mode of thinking in relation to problems set in the classroom. Students found that their interactive skills had improved through their close association with other group members. The approach presented them with the opportunity to explore their own skills and to work on their weaknesses such as confidence, presentation skills, working in a team environment and problem-solving skills.

Although not listed as an instrument in the methodology section, classroom discussion was conducted with the research group students to have a qualitative

understanding of the empirical numbers collected in the questionnaire. The findings highlight the students' viewpoints on some of the issues surrounding the PBL unit.

When the PBL unit was first introduced most of the feedback was negative towards PBL, and it was categorized in three ways: Preference for directive or didactic learning, perception of reduced learning efficiency, and feelings of uncertainty. Students stated that they preferred didactic learning possibly because that was the main teaching method they had experienced prior to the present class. Students also contended that PBL took too much time compared to traditional lectures. The students thought that it was much easier and less stressful to be handed prescriptions of the information needed to be able to solve the problem instead of deciding themselves what sources of information to use. Another factor that raised students' concerns was the quantity of knowledge they had learned, they felt that the information they acquired was not adequate although their test scores proved the opposite.

By the end of the PBL unit most students described the PBL strategy as a real challenge; they expressed a feeling of satisfaction and self confidence during the learning cycle. Yet minority of students still had the feeling of frustration. Moreover, pupils enjoyed the interactions among themselves; they mentioned that they liked group work in terms of taking responsibility for themselves and their peers as well as appreciating different points of view. They were pleased for having their opinions accepted by their friends.

Most of the previous researches conducted to study the effect of PBL on students' attitude used questionnaires and interviews as instruments. The researcher found one study that was conducted by Ma, O'Toole, and Keppell (2008) that used classroom

discussion as an additional tool to questionnaires and interviews to assess students' perception about PBL. The results of this investigation suggested that PBL aim is to encourage life long self learning.

In PBL students acquire problem solving skills since they practice these skills while solving problems in the PBL approach. When solving problems students are required to formulate hypothesis, to explain and predict, and to exchange information with others. These processes are in fact the skills needed by these students in their daily lives.

This study revealed the necessity to provide guidance and support to student when they use PBL for the first time. Students are used to receive all the information they need from teachers and textbooks but now they have to construct their own knowledge using different available resources. Student must cooperate together, questioning, researching, analyzing and finding solution to problems. All of these skills need time and support to be acquired. This study stresses the need to expose students to numerous opportunities to PBL allowing them to master these life long skills over time.

CHAPTER VI

CONCLUSION

This study comparing the PBL approach to the conventional learning had revealed that PBL approach was more effective in terms of students' achievement and attitude towards chemistry. This implies that using PBL students' performance was enhanced and their perception about chemistry learning was improved. PBL Teachers help their students to acquire skills they need to use in their daily life like cooperation, analysis, research, synthesis, communication and problem solving skills. Thus, educators are urged to consider the PBL approach as one of their teaching strategies.

Limitation

Many important questions were not addressed in this study. A key limitation was the lack of information about teachers behaviors in both classrooms (PBL and conventional). The observation of what teachers were exactly doing in their classes might have been helpful in explaining the effectiveness of the PBL approach.

Recommendations

1. Chemistry teachers should adopt the use of problem-based learning technique at all levels of learning.
2. Classroom and chemistry laboratory should be arranged in such a way to give room for effective interaction among students.
3. PBL strategy should be adopted in schools to allow students interactions and encourage higher order thinking level.

Future Research

This study assessed the influence of PBL on students' learning in one chemistry unit that lasted three weeks. If PBL strategy had to be deeply investigated student would need to undergo several units or even a whole year interdisciplinary curriculum using this approach. Research must compare the PBL approach to the conventional learning when students are first exposed to PBL and do the same comparison when the students become familiar with the PBL strategy.

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Appendix A

The Problem based learning chemistry unit

Classe: EB7 A/B

Les membres du groupe:

1. _____	**2. _____**
3. _____	**4. _____**

Peut-on purifier l'eau polluée?

D'où vient l'eau de notre robinet? Si elle provient d'une rivière locale, pourquoi elle n'est pas troublée? Peut-on éliminer tout ce qui se trouve dans l'eau, ou bien quelques contaminants persistent toujours après le processus de traitement?

Est-ce qu'on est capable de purifier l'eau polluée? Peut-on prédire quelles sont les étapes à suivre pour "purifier" l'eau polluée dont on a besoin pour survivre? (en cas d'urgence par exemple)

Le choix des techniques à suivre sera plus simple en cas ou on sait les substances qui se trouvent dans l'échantillon. Une bonne compréhension de la constitution de la matière peut vous permettre de prendre des décisions logiques pour "purifier" votre eau polluée.

Répondre aux questions suivantes :

1- Quelques mélanges ressemblent à une substance pure. Qu'appelle-t-on un mélange qui apparaît uniforme?

_____

2- Quelques mélanges sont formés de plusieurs phases. Qu'appelle-t-on ces types de mélange?

_____

Objectif :

Chaque équipe va recevoir un échantillon d'eau polluée (un volume de 200 ml). Votre tâche est de purifier cette eau et de conserver autant d'eau que possible durant le processus de traitement. (Il fait chaud et sec et on a très soif! Si on ne conserve pas chaque goutte d'eau on risque la déshydratation!)

Le gagnant de ce défi sera l'équipe qui produit l'eau la plus propre et celle qui conserve la plus grande quantité d'eau. Une seule équipe sera déclarée gagnante!

Quelle équipe va gagner? Ca sera l'équipe qui coopère et utilise le raisonnement scientifique pour atteindre son objectif. Ayez confiance! Cette activité va vous aider à pratiquer la méthode scientifique. Mais n'oubliez pas que vous êtes les scientifiques d'aujourd'hui et votre équipe va prendre les décisions.

Formulation de l'hypothèse:

Observer votre échantillon:

Tableau 1: Observations

Volume de l'échantillon d'eau « polluée"	Présence de liquides de différentes densités?	Présence de larges particules solides?	Présence de petites particules en suspension?	Couleur du liquide? Clarté du liquide?	Autres observations?

La première étape de ce processus scientifique est de commencer à poser des questions concernant votre eau «polluée». Les questions doivent être en relation directe avec vos observations.

Quelles sont les questions de votre équipe ?

1- _____

2- _____

3- _____

L'étape suivante consiste à développer une hypothèse pour répondre à UNE des questions écrites.

Quelle est l'hypothèse de votre équipe?

_____

Pour que votre équipe décide si l'hypothèse est exacte ou non, vous deviez être capable de la tester. On teste une hypothèse avec une expérience.

Est-ce que votre hypothèse est vérifiable?

_____

Si votre hypothèse est vérifiable, votre équipe doit présenter une procédure (de plusieurs étapes). La procédure que vous allez suivre est votre démarche expérimentale et doit être terminée avant de commencer l'expérience.

Protocole expérimental :

De nombreuses expériences sont limitées par la disponibilité de matériel. Réviser cette liste de matériel disponible pour chaque équipe avant de commencer le protocole expérimental.

Liste de matériel :

Entonnoirs
Tamis
Filtres à café
Rocher
Sable (grossier et fin)
Papier filtre
Éprouvettes graduées
Bécher

Procédure :

Planification de la procédure :

En se basant sur la liste de matériel, et en collaboration avec votre équipe, préciser les étapes à suivre pour tester votre hypothèse et remplir le tableau ci-dessous

Table 2: Procédure

Numéro de l'étape	Matériel utilisé	Résultat
Un		
Deux		
Trois		
Quatre		
Cinq		
Six		
Sept		
Huit		

Application de la procédure :

L'étape suivante consiste à réaliser votre expérience. Tous les membres de l'équipe doivent s'entendre sur la procédure avant de commencer l'expérience.
Chacun aura une tâche : une personne sera chargée du matériel, une autre sera chargé de noter les résultats dans le tableau ci-dessous. Les autres membres d'équipe doivent travailler ensemble pour accomplir le travail expérimental. Après avoir complété chaque étape de la procédure, notez vos observations ou les résultats dans le tableau 3 ci-dessous.
* N'oubliez pas qu'on doit faire notre mieux pour garder tout aussi propre que possible.

Résultats:

Tableau3 : Résultats

Numéro de l'étape	Matériel utilisé	Résultat
Un		
Deux		
Trois		
Quatre		
Cinq		
Six		
Sept		
Huit		

Une fois que vous avez terminé votre expérience vous devriez faire les mêmes observations sur votre eau "purifiée".

Tableau 1: Observations

Volume de l'échantillon d'eau « polluée"	Présence de liquides de différentes densités?	Présence de larges particules solides?	Présence de petites particules en suspension?	Couleur du liquide? Clarté du liquide?	Autres observations?

En plus de la pureté de votre échantillon, il est important de récupérer le plus d'eau que possible. Calculer le pourcentage d'eau que vous avez purifiée.

$$H2O\% \text{ purifiée} = \frac{\text{volume de l'eau "purifiée"}}{\text{Volume de "polluée" de l'eau}} \times 100$$

H2O% purifiée =

Conclusion:

Une fois que votre équipe a eu les résultats, il est temps de revoir votre hypothèse et de faire votre conclusion.

Oui, mon hypothèse est vérifiée.

Ou

Non, mon hypothèse n'est pas vérifiée.

Ecrivez votre conclusion et expliquer.

_____

_____

_____

Application:

Recherche, à l'aide l'Internet, des livres et/ou du personnel des usines locales de traitement de l'eau dans le but de découvrir le fonctionnement des usines de traitement de l'eau potable.

Que pensez-vous de votre eau « purifier »? Croyez-vous qu'il est assez bon à boire? Est-ce que le processus utilisé dans les usines de traitement de l'eau potable est plus sophistiqué ? Quelles sont les techniques de séparation communes se trouvant dans votre procédure et dans celui de l'usine de traitement de l'eau locale?

_____

_____

_____

Réflexion :

1- Avec les informations que vous savez maintenant et votre capacité de raisonnement scientifique, pensez-vous que votre équipe va gagner? Pourquoi oui ou pourquoi pas?

_____

_____

_____

2- Comment pourriez-vous améliorer la performance de votre équipe, la prochaine fois?

_____

_____

_____

3- En cas où vous avez accès à une liste plus grande de matériel, quel matériel choisissez-vous en plus? Pourquoi?

_____

Appendix B

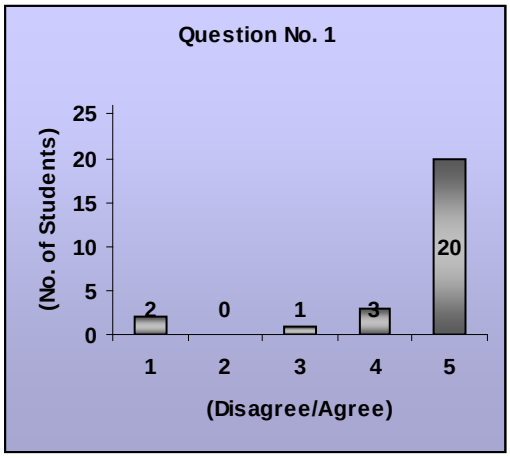
Students' attitude questionnaire:

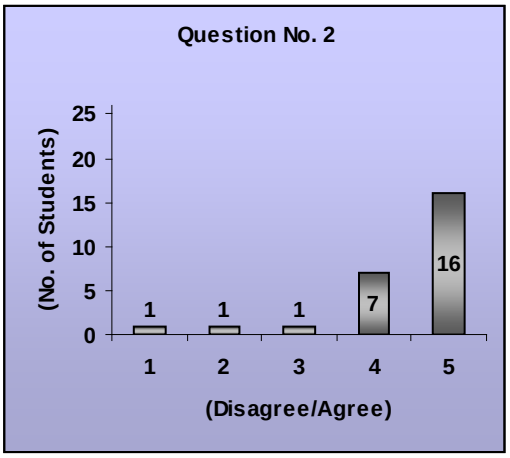
The document below represents the questionnaire used to assess students' attitude when participating in a problem-based learning unit.

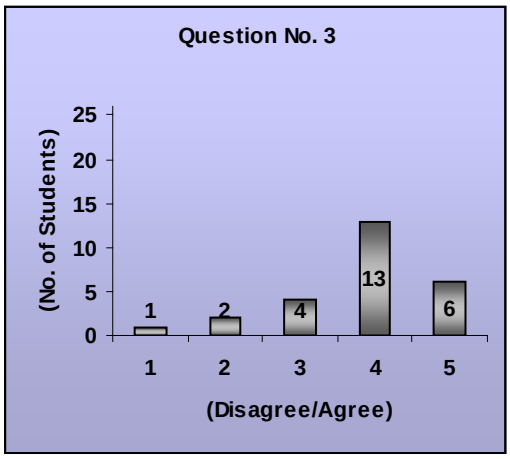
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This PBL lesson allowed me to better understand separation techniques.	1	2	3	4	5
This PBL lesson was meaningful.	1	2	3	4	5
This PBL lesson was well-organized.	1	2	3	4	5
This PBL lesson was engaging.	1	2	3	4	5
This PBL lesson allowed me to apply my knowledge to solve problems.	1	2	3	4	5
This PBL lesson encouraged interaction with other students.	1	2	3	4	5
I enjoy working in a group.	1	2	3	4	5
I effectively used the material provided in this unit.	1	2	3	4	5
During this unit, I felt as though my opinions were valued.	1	2	3	4	5
Problem-based learning takes up more time than conventional lecture based approach.	1	2	3	4	5
I have to take more responsibility for my learning in problem based learning.	1	2	3	4	5
I would like to learn using PBL again.	1	2	3	4	5

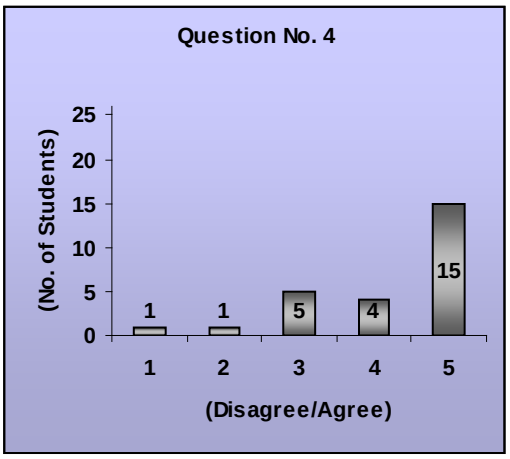
Appendix C

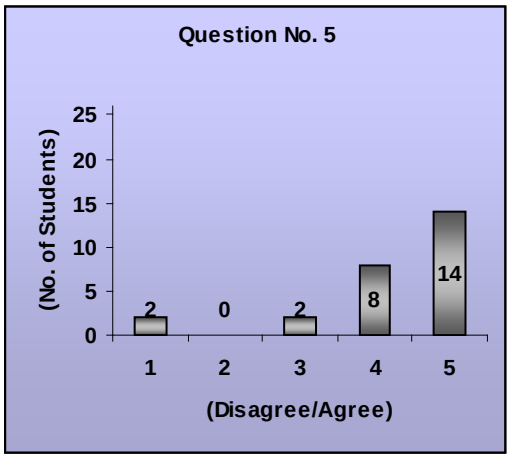
These bar graphs represent the students' responses to the questionnaire:

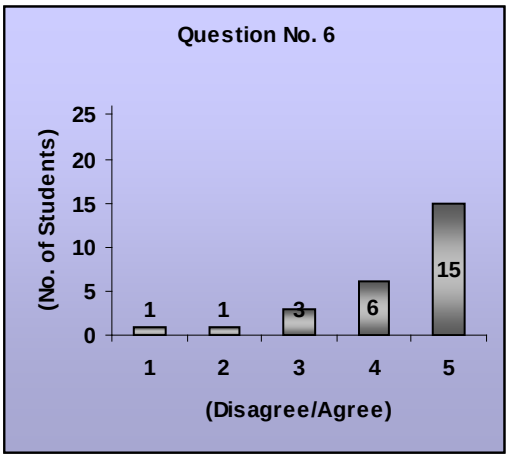


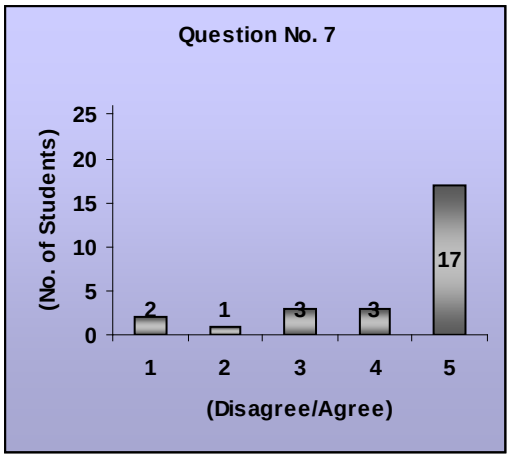











Question No. 7
(No. of Students)
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10
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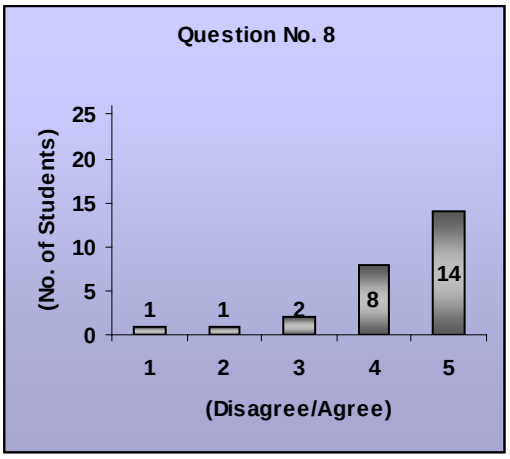
0
2
1
3
3
17
1
2
3
4
5
(Disagree/Agree)


Question No. 8
(No. of Students)
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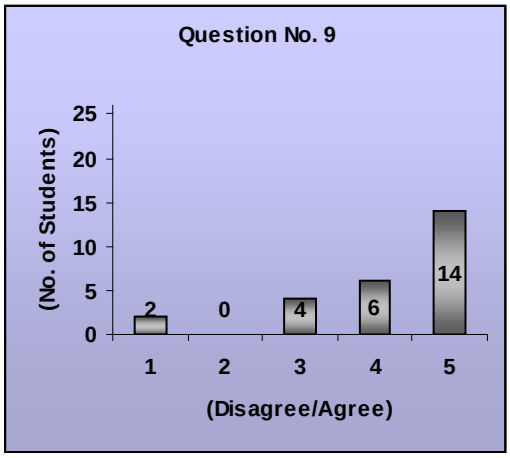
1
2
3
4
5
(Disagree/Agree)


Question No. 9
(No. of Students)
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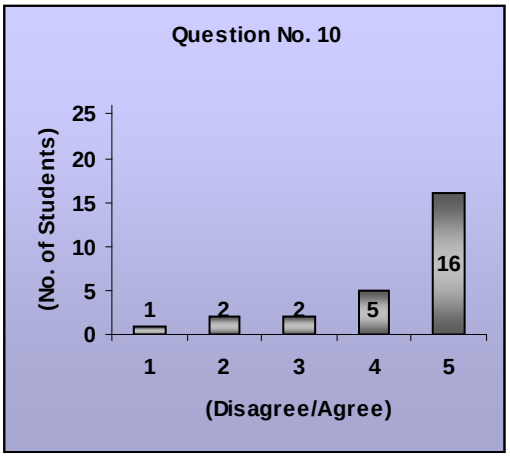
(Disagree/Agree)


Question No. 10
(No. of Students)
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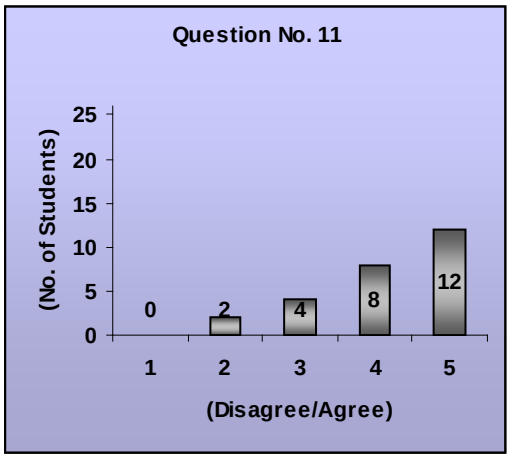
(Disagree/Agree)


Question No. 11
(No. of Students)
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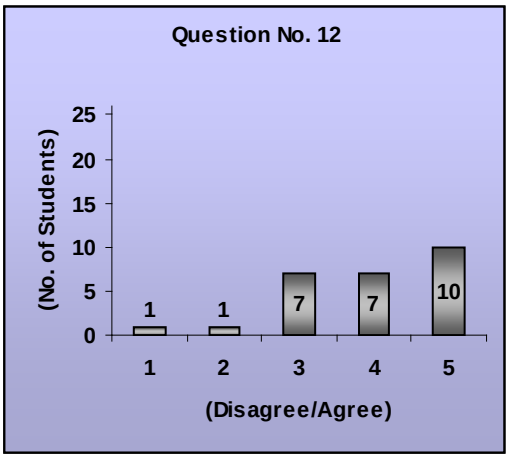
(Disagree/Agree)


Question No. 12
(No. of Students)
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1
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5
(Disagree/Agree)