Chapter #17

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

Mona El Charif[1], Ahmad Oweini[2], & Samar Zeitoun[3]
[1]*Department of Chemistry, Rafic Hariri High School, Lebanon*
[2]*Department of Education, Lebanese American University, Lebanon*
[3]*Department of Education, Lebanese University, Lebanon*

ABSTRACT
The objective of this study was to determine the effects of problem-based learning (PBL) on student performance and attitude toward 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 a sample of 120 7th grade students, in a French-speaking private school in Lebanon. Two types of instruments were used for measurement: achievement tests and an attitude questionnaire. The experimental group was taught chemistry using PBL whereas conventional teaching methods were applied in the control group. Results indicated that implementing the problem-based learning approach had improved students' achievement and attitude. This study recommends that teachers implement problem-based learning in teaching science concepts especially chemistry for middle school students.

Keywords: PBL, science education, Lebanon, achievement, attitude.

1. INTRODUCTION

Too often, science instruction is divorced from students' interests and daily living (Aikenhead, 2006; Koller, Baumert, & Schnabel, 2001). Conventional teaching strategies are teacher-centered, where students passively receive information and gradually become aversive to science and, in turn, exhibit lower performance as they move up grades (Butler & Nesbit, 2008; Roehrig & Luft, 2004).

In the latter approach, the teacher's opinion dominates and the students are only compelled to memorize and reproduce knowledge (Vlassi & Karaliota, 2013), because, according to Perkins (as cited in Lord, 1999), it it is believed that content recitation underscores content comprehension.

According to Angelo (as cited in Lord, 1999), science teachers spend more than 90% of time in a science class lecturing and reviewing the factual content of the lessons.

Believing they have learned the material, the students do not attempt to mold and fashion the new information onto their preconceived mental foundations. For most educators, "student regurgitation of teacher-delivered content has been the standard means of evaluating learning in pupils" (Lord, 1999, p. 23).

The Relevance of Science Education (ROSE, 2003) study, an international comparative and groundbreaking project involving 40 countries, aimed to shed light on affective factors of importance to the learning of science and technology. This study identified key barriers for students in understanding their science classes, namely the curriculum, science classes being too theoretical, some students lacking the confidence to believe that they can succeed in their science classes, not enough room for debate and for addressing current issues and scientific breakthroughs, and so forth (Sjøberg & Schreiner, 2010).

The picture is even gloomier in the Arab World. A negligible percentage (1%) of Arab eigth graders reached the advanced international benchmark (IAEEA, 2011). In 2011, Lebanon ranked at the bottom among all Arab countries (10 out of 11) in science achievement, (IAEEA, 2011). An analysis of the science curricula of Arab countries revealed an overemphasis on the theoretical aspects at the detriment of direct applications of science in novel or everyday situations, and failure to adequately develop students' investigative problem-solving and thinking skills (Nashwan, 1993*)*.

All of the above challenges call for more innovative strategies for teaching science that would help improve students' engagement in the learning process (Osborne & Dillon, 2008). To address this need, problem-based learning (PBL) was advocated as an innovative curricular approach 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 (Akınoglu &Tandogan, 2007; Hmelo-Silver & Barrows, 2006; Savery, 2006;).

Stepien, Gallagher, and Workman (1993) provided the following definition:

> Problem-based learning is apprenticeship for real-life problem solving.…students find a situation with undefined problems, incomplete information, and unasked questions. The scenarios presented to the students demand problem solving the way we find it in life: defining and detailing issues, creating hypotheses, searching for and then scanning data, refining hypotheses with the help of the collected data, conducting empirical experiments or other research, developing solutions that fit the conditions of the problem and evaluating and/or justifying their solutions so there is reason to expect conditions will improve (p. 342).

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. Students taught in PBL have greater ability than conventionally taught students to retain the knowledge they gain since they are actively engaged in the learning process (Wood, 2003). These PBL characteristics contribute to the increase in student motivation towards learning (Torp & Sage, 2002; Wood, 2003). 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. You may be called upon to accept and work with fellow students of differing backgrounds and opinions. The teacher is a mentor that guides his student during their group work and helps them to find the knowledge needed to find the problem solution (Stepien et al, 1993; Wood, 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 & Sage, 2002). Students gain the ability to analyze the problem and synthesize an appropriate explanation to it, which helps students become independent learners (Torp &Sage, 2002).

While the effectiveness of PBL has been documented by a number of studies (Colliver, 2000), its implementation may create some barriers, namely teacher's resistance to change their didactic teacher-centered style (Hmelo-Silver & Barrows, 2006), rigid scheduling and heavy curricula (Edwards & Hammer, 2004), cost of special materials and equipment, and space constraints (Torp & Sage, 2002).

2. ATTITUDES TOWARDS SCIENCE AND PBL

Attitudes can be defined as general and enduring positive and negative feelings (Cherry & Mattiuzzi, 2010) and are regarded as outcomes which can be acquired over the process of learning. Research has demonstrated that attitudes toward science change based on exposure to science, but that the direction of change may be related to the quality of that exposure (Gogolin & Swartz, 1992). Accordingly, the best way for students to learn science is to experience challenging problems and the thoughts and actions associated with solving them (Greenwald, 2000). PBL purports to increase motivation for learning by open-ended discussions and effective collaboration (Schmidt, Muijtjens,Van der Vleuten & Norman, 2012), thus leading to improved achievement and attitude.

Studies on the effect of PBL on student attitude toward learning when compared to traditional teaching has generally yielded positive correlations (Demirel & Dağyar, 2016). For example, Üstün (as cited in Demirel & Dağyar, 2016) conducted a meta-analysis study to compare the effects of PBL and traditional teaching in terms of students' attitudes in science classes. Results showed that PBL had a medium effect on students' attitudes toward science classes when compared to traditional teaching (in Demirel & Dağyar, 2016). Ferreira and Trudel (2012) found that PBL use in three regular high school chemistry classes resulted in a significant improvement in student attitudes towards science, problem-solving skills and positive views of the learning environment, coupled with the fostering of a sense of community in the classroom. Yet, as advocated by Demirel and Dağyar (2016) more studies are needed to investigate the effect of PBL on student attitude on young students who use PBL outside of the school and who can solve real life problems.

3. RESEARCH QUESTIONS

The Lebanese educational system is known to be rigorous and demanding and adequately prepares graduates for college studies both in Lebanon and abroad, yet it fails to promote metacognition, application of knowledge in real-life situations, team work, communication skills, self-reflection, and so forth. PBL seems to be a synthesis of the aforementioned skills that is rarely found in other inquiry-based approaches.

The empirical investigation at hand targets the differential effect of PBL on performance on high cognitive level items as well as on students' attitude toward this technique.

It is an unprecedented research effort in Lebanon especially targeting the association between the development of constructivist classrooms and changes in students' attitudes. Specifically, the study addresses the following questions:

- Is there a significant difference in the performance of students trained in the use of PBL in science relative to their peers who are taught using the traditional technique?
- Do students trained in PBL score higher on higher cognitive items than controls?

- Do PBL-trained students have a more positive attitude towards science than the non-PBL group?

Although active and learning and constructivist approaches have long shown their effectiveness in Western educational contexts, their effectiveness on conforming Lebanese teenage students schooled for years in the traditional teacher-centered approach cannot be readily foreseen, thus the need for this study and its potential contribution to the field.

4. METHOD

4.1. Participants

This study was conducted in a private school located 50 km south of Beirut on a group of seventh grade students aged between 12 and 13, attending the French section where science is taught in French, among other subjects. A total of 120 students participated in the study. The students were from similar socioeconomic backgrounds, and were exposed to the same curriculum. They were divided into two equivalent groups: an experimental group that consisted of a convenient sample of 60 students (33 males and 27 females), and a control group of 60 (31 males and 29 females) who comprise four sections of Grade 7. Students were kept in their original sections. The investigator assigned students of the same grade level into homogeneous sections with respect to gender, grade-point average, and highest and lowest grades, to ensure a normal distribution in each class. The same sections were kept for research purposes. Students' grades as well as the achievement test before the treatment were used as covariates to adjust for differences between the experimental and the control group. The experimental group students were not previously exposed to the PBL method.

4.2. Design

This research has experimental design with a control group, pretest and post test design**.** The PBL approach was applied on the experimental group to teach the unit of separation techniques, while the students in the control group were instructed in the same content of the unit using conventional teaching strategies. Before starting the lesson, information on 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.

4.3. Instruments

To assess the effects of PBL, two instruments were used: an achievement test and an attitude questionnaire. A pre and post testing control group design was used to compare students' achievement and attitude before and after the intervention. A pre-test including questions prepared by the researcher to the 7th graders was given to both research and control groups. A 30-item pilot multiple-choice questions test, developed by the researchers and based on students' book, was administered to both groups. The thinking levels of the test items varied from knowledge to synthesis according to Bloom's taxonomy. Content validity was established by 3 chemistry school teachers (2 for middle and one for secondary classes) and one university instructor. The academic achievement test was prepared in accordance with the aims and acquisitions in the chapter "Mixtures and Separation Techniques" in the chemistry national textbook. Based on the data, reliability constant (KR-20) of the test and discrimination indices of each item were computed. The items which have item discrimination index under 0.30 were eliminated from the test. Based on the analyses, the final test consisted of 25 items and the reliability constant was high at 0.74. After conducting the test, the general difficulty level was computed (0.53). The total number of points was 100; 4 for each correct answer. The grade distribution was 5 for comprehension, 15 for analysis and application and 5 for synthesis questions.

The questionnaire designed to measure perceptions and attitudes towards the PBL method of instruction in chemistry was adapted from the instruments prepared by Siegel and Ramney (2003) and Khoiny (1995). It consisted of 16 items on a 5-point Likert scale. For each of the 16 items, the students were asked to indicate from 1 (strongly disagree) to 5 (strongly agree). The questionnaire consists of three types of statements representing belief (I think), behavior (I use), and affect (I enjoy….). The 16 statements were distributed as 6 belief statements, 5 affect statements and 5 behavior statements. The validity and reliability of the instrument have been justified in Khoiny's work. The Cronbach alpha coefficient for reliability was very high at 0.96. To analyze the questionnaire concerning the attitude of students towards the PBL approach use in chemistry, students' responses frequency 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.

4.4. Data collection

The subject of chemistry is taught to grade 7 students for 2 periods weekly. The traditional teaching lesson for the theme separation techniques of mixtures requires 6 teaching periods. In parallel, two different sections were taught the same content but one with the PBL approach and the second control group with the traditional approach. For the PBL approach, core concepts were selected based on the Lebanese curriculum. The main investigator taught both the control and experimental groups. While aware of the potential threat of the experimenter's bias, the investigator resorted to a professor and research mentor who oversaw the planning and implementation of the study to make sure that objectivity is maintained to the best extent possible.

The PBL cycle was a real like problem presented to students. The unit separation mixtures started with daily life application of mixtures (drinking water: how does it reach our homesand what techniques are used to purify it). This activity was like a brain storm for students to motivate them and put them in the context the study. Students in the PBL class were divided into groups of 4 according to their performance levels and learning styles. Students were assigned tasks to suggest and perform an experimental procedure to purify a given sample of water (200 ml) with the minimum losses. Through group discussions, and during one session, students were encouraged to formulate hypotheses based on the type of pollutants they expect to find. This was followed by an individual reflection at home where students were expected to do a self- directed learning and present in the second session each in his group one possible hypothesis they think it is the most probable for pollutants. After agreeing on the hypothesis, students were asked to activate their prior knowledge and experience relative to the problem and start making their research to write the procedure for the separation technique to be performed and assigning tasks for each member in the group.

In the third session, the only concept that students did not learn on their own was fractional distillation as it was perceived as difficult. The teacher explained it to the students during a half a hour lecture and asked the students if they wanted to change anything in their procedures. Students were asked to perform the separation techniques to check the validity of their hypotheses, then were asked to complete the table they started first for polluted water so as to compare the results and verify the efficiency of their technique; this was perceived as reflection on the knowledge acquired. Afterwards, students were asked to search for information about separation techniques used in purification plants using certain assigned resources then compare it with the separation techniques they used to assess their efficiency and applicability.

At the end, students were asked to write a brief reflection essay about the whole process.

5. RESULTS

5.1. Student achievement

The means and t-values were calculated to determine the significance using SPSS v.13.0. Significance was computed at $p<.05$. Results showed the following:

- Control and experimental groups had similar prior knowledge, thereby confirming the proper choice of the samples and increasing reliability (Table 1).

Table 1.
T-Test Analysis by Subject - Pre-tests results.

Comprehension	GROUP	N	MEAN	SS	T Test (Pre Test Results)
	Experimental Group (Pre)	60	15.87	1.798932515	0.35
	Control Group (Pre)	60	16.14	1.948489202	
Analysis	GROUP	N	MEAN	SS	T Test (Pre Test Results)
	Experimental Group (Pre)	60	49.87	4.196312613	0.47
	Control Group (Pre)	60	49.90	5.382961191	
Synthesis	GROUP	N	MEAN	SS	T Test (Pre Test Results)
	Experimental Group (Pre)	60	11.47	2.801129716	0.35
	Control Group (Pre)	60	11.73	2.972567609	

-Achievement of experimental group on the post-test was significantly better than that of controls. Given no other interfering variables, this finding is in favor of the PBL intervention (Table 2), consistent with earlier findings by Hattingh and Killen (2003) and Hung, Jonassen, & Liu, R (2008) that the use of PBL is more effective in learning science than traditional methods which do not seem to develop higher-order thinking skills (Tarhan, Ayar Kayali, Ozturk Urek, & Acar, 2008; Yu, She & Lee, 2010).

Table 2.
T-Test Analysis by Subject - Post-tests results.

Comprehension	GROUP	N	MEAN	SS	T Test (Post Test Results)
	Experimental Group (Post)	60	19.07	1.706087472	0.00
	Control Group (Post)	60	16.27	2.313312004	
Analysis	GROUP	N	MEAN	SS	T Test (Post Test Results)
	Experimental Group (Post)	60	56.13	3.605394577	0.00
	Control Group (Post)	60	49.42	4.883270183	
Synthesis	GROUP	N	MEAN	SS	T Test (Post Test Results)
	Experimental Group (Post)	60	15.87	2.752297448	0.00
	Control Group (Post)	60	11.80	2.849125151	

-A significant difference was found between pre and post test results for the experimental group before and after applying PBL across all thinking skills (Table 3).

Table 3.
T-Test Analysis by Subject - Pre Vs. Post Test scores.

Comprehension	GROUP	N	MEAN	SS	T Test (Pre –Post Test Results)
	Experimental Group (Pre)	60	15.87	1.798932515	0.00
	Experimental Group (Post)	60	19.07	1.706087472	
Analysis	GROUP	N	MEAN	SS	T Test (Pre –Post Test Results)
	Experimental Group (Pre)	60	49.87	4.196312613	0.00
	Experimental Group (Post)	60	56.13	3.605394577	
Synthesis	GROUP	N	MEAN	SS	T Test (Pre –Post Test Results)
	Experimental Group (Pre)	60	11.47	2.801129716	0.00
	Experimental Group (Post)	60	15.87	2.752297448	

5.2. Students' attitudes

Analysis of the questionnaire concluded that 89% of pupils found that PBL helped them better understand separation techniques; 89% found that the lesson was meaningful; 73% claimed it was well organized;73% found it engaging; 85% reported that it allowed them to use their knowledge in solving problems; 81% believed that it encouraged interaction with other students; 77% enjoyed working in a group; 85% effectively used the material provided in this unit; 77% felt their opinions were valued; 81% observed that PBL took more time than conventional lecture based approach; 77% became more responsible for their learning when using PBL; and 65% would like to use PBL again.

The subjects'generally favorable attitudes are consisent with Sun & Wilson (2008) who reported that students' positive attitude towards science correlates highly with their science achievement, and the quality of exposure (Gogolin & Swartz, 1992).

Cronbach's alpha was determined to measure the intercorrelations among test items or the internal consistency estimate of reliability of test scores (Table 4).

Table 4.
Item-Total Statistics.

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
q1	42.15	97.713	.845	.900	.955
q2	42.15	91.924	.917	.912	.952
q3	42.80	95.221	.809	.908	.956
q4	42.30	97.589	.770	.860	.957
q5	42.55	93.734	.902	.908	.953
q6	42.10	96.200	.809	.918	.956
q7	42.05	103.629	.557	.877	.962
q8	42.80	96.905	.690	.907	.959
q9	42.55	95.208	.750	.751	.958
q10	42.05	92.050	.884	.967	.953
q11	42.35	97.713	.845	.945	.955
q12	42.90	93.568	.823	.845	.951
q 13	41.90	91.824	.786	.912	.952
q 14	41.86	92.134	.793	.908	.948
q 15	42.03	91.935	.568	.837	.947
q 16	41.89	91.886	.690	.845	.945

6. CONCLUSION

This study comparing the PBL approach to the conventional learning revealed that the PBL approach resulted in favorable gains on students' achievement and fostered a positive attitude toward PBL in chemistry. Teachers helped their students acquire skills they need to use in their day-to-day activities like cooperation, analysis, research, synthesis, communication and problem solving skills. Thus, educators are urged to consider integrating the PBL approach in their teaching.

Science education in Lebanon is currently undergoing reform with respect to the teaching strategies. Hence, new instructional approaches that are student-centered must be adopted. PBL should be seriously considered the teaching approach of choice (BouJaoude, 2002; Colliver & Markwell, 2007; Gerber, Lankshear, Larsson, & Svensson 1995). Even the national curriculum could be overhauled to integrate inquiry-based or active learning approaches. For example, Ontario has revamped its science curriculum to integrate similar approaches (The Revised Ontario Science Curriculum, 2008). Lebanon could draw valuable lessons from its innovative educational approaches and tremendously benefit from its success stories. To that end, classroom and labs should be designed spacious enough to make room for effective interaction among students. Further, instructional materials and study guides should contain a variety of sample problems for busy teachers who may lack time or motivation to develop new materials for their classes (Boujaoude, 2002; Wood, 2003).

Given its relatively small size and the non-random and homogeneous nature of the research sample, findings of this study cannot be generalized to the larger population. Future studies are urged to implement PBL in a variety of urban and rural settings, with larger sample sizes and randomly selected students from different socio-economic backgrounds, age and grade levels, and academic subjects and languages of teaching.

REFERENCES

Aikenhead, G. (2006). *Science education for everyday life: Evidence-based practice*. New York, NY: Teachers College Press.

Akınoglu, O., & Tandogan R. (2007).The effects of problem-based active learning in science education on students' academic achievement, attitude and concept learning. *Eurasia Journal of Mathematics, Science and Technology Education 3*(1), 71-81.

BouJaoude, S. (2002). Balance of scientific literacy themes in science curricula: The case of Lebanon. *International Journal of Science Education, 24(2)*, 139-156.

Butler, M. B., & Nesbit, C. (2008).Using Science Notebooks to Improve Writing Skills and Conceptual Understanding. *Science Activities: Classroom Projects and Curriculum Ideas, 44(*4), 137-146.

Cherry, K. & Mattiuzzi, P.G. (2010). *Everything psychology book: An introductory guide to the science of human behavior.* Avon: MA: Adams Media.

Colliver, J. A., & Markwell, S. J. (2007). Research on problem-based learning: the need for critical analysis of methods and findings. *Medical Education*, *41*(6), 533-535. doi:10.1111/j.1365-2923.2007.02762.x

Colliver, J. A. (2000). Effectiveness of problem-based learning curricula: research and theory. *Academic Medicine.* 75(3), 259-266.

Demirel, M. & Dağyar, M. (2016). Effects of problem-based learning on attitude: A meta-analysis study. *Eurasia Journal of Mathematics, Science & Technology Education*, 12(8), 2115-2137.

Edwards, S, & Hammer, M (2004, November). Teacher education and problem-based learning: Exploring the issues and identifying the benefits. *Paper presented at the International Education Research Conference of the Australian Association for Research in Education, Melbourne, Victoria, Australia*.

Ferreira, M.M. & Trudel, A.R. (2012). The impact of problem based learning on student attitude toward science, problem solving skill and sense of community in the classroom. *Journal of classroom interaction, 47(1). 23-30.*

Gerber R, Lankshear C, Larsson S , Svensson L, (1995), Self-directed learning in a work context, Education and Training, *37*(8), 26–32.

Gogolin, L., & Swartz, F. (1992). A quantitative and qualitative inquiry into the attitudes towards science of nonscience college students. *Journal of Research in Science Teaching, 29*(5), 487-504.

Greenwald, N. (2000). Learning from problems. *The Science Teacher*. 67(4), 28-32.

Hattingh, A. & Killen, R. (2003). The promise of problem-based learning for training pre-service technology teachers. *South African Journal of Higher Education*, *17* (1), 39-46.

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and strategies of a problem-based learning facilitator.*Interdisciplinary Journal of Problem-based Learning*, *1*(1), 21-39.

Hung, W., Jonassen, D. H., & Liu, R. (2008). Problem-based learning. In J. M. Spector, J. G. van Merrienboer, M. D., Merrill, & M. Driscoll (Eds.), *Handbook of research on educational communications and technology, 3rd Ed. (pp. 485-506).* New York: Lawrence Erlbaum Associates.

International Association for the Evaluation of Educational Achievement (IAEEA) (2011), Trends in International Mathematics and Science Study (TIMSS).

Khoiny, F.E. (1995). *The effectiveness of problem-based learning in nurse practitioner education.* (Doctoral dissertation), University of Southern California. UMI Number: 9614036.

Koller, O., Baumert, J., & Schnabel, K. (2001). Does interest matter? The relationship between academic interest and achievement in mathematics.*Journal for Research in Mathematics Education*, *32*(5), 448-470.

Lord, T.R. (1999). A comparison between traditional and constructivist teaching in environmental science. *The Journal of Environmental Education*, *30*(3), 22-27.

Nashwan, Y. (1993). Evaluation of secondary school Science teaching objectives in the Arab world. In M. Debs (Ed.), *Proceedings of the first scientific conference on the future of science and math teaching and the needs of Arab society* (pp. 122 – 141). Beirut, Lebanon: Arab Development Institute. (In Arabic).

The Ontario Revised Science Curriculum (2008). Retrieved in December 2017 from www.edu.gov.on.ca

Osborne, J.F., & Dillon, J. (2008) *Science Education in Europe*: Critical Reflections. *A report to the Nuffield Foundation.* London: King's College.

Roehrig, G. H., &Luft, J. A. (2004). Inquiry teaching in high school chemistry classrooms: The role of knowledge and beliefs. *Journal of Chemical Education, 81(10)*,1510-1516.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning*, *1*(1), 9-20.

Schmidt, H. G., Muijtjens, A. M., Van der Vleuten, C.P & Norman, G. R. (2012). Differential student attrition and differential exposure mask effects of problem-based learning in curriculum comparison studies. *Academic Medicine: Journal of the Association of American Medical Colleges, 87(*4), 463-475.

Siegel, M.A., & Ranney, M.A. (2003). Developing the Changes in Attitude about the Relevance of Science (CARS) questionnaire and assessing two high school science classes. *Journal of Research in Science Teaching*, *40* (8), 757-775.

Sjøberg, S. & Schreiner, C. (2010). The ROSE project: An overview and key findings. Retrieved in December 2017 from https://roseproject.no/

Stepien, W., Gallagher, S., & Workman, D. (1993). Problem-based learning for traditional and interdisciplinary classrooms. *Journal for the Education of the Gifted*, *16*(4), 338-357.

Sun, J., & Willson, V. L. (2008). Assessing General and Specific Attitudes in Human Learning Behavior: An Activity Perspective and a Multilevel Modeling Approach. *Educational and Psychological Measurement, 68, (*2), 245-261

Tarhan, L., Ayar Kayali, H., Ozturk Urek R., & Acar, B. (2008). Problem-Based Learning in 9th Grade Chemistry Class: Intermoleculer Forces. *Science Education*, *38*(3), 285–300.

Torp, L., & Sage, S. (2002). *Problems as Possibilities: Problem-Based Learning for K–12 Education*, (2nd ed.), ASCD, Alexandria, VA.

Vlassi, M. & Karaliota, A. (2013). The comparison between guided inquiry and traditional teaching method. A case study for the teaching of the structure of matter to 8th grade Greek students. *Procedia - Social and Behavioral Sciences*, 93, 494 – 497.

Wood, D.F. (2003). Problem-Based Learning. *BMJ*. Retrieved in September 2017 from https://doi.org/10.1136/bmj.326.7384.328

Yu, W.F., She, H.C. & Lee.Y.M. (2010). The effects of a web-based/non web-based problem solving instruction and high/low achievement on students' problem solving ability and biology achievement. *Innovations in Education and Teaching International* (IETI), *47*(2), 187–199.

AUTHORS INFORMATION

Full name: Mona El Charif
Institutional affiliation: Rafic Hariri High School (Lebanon)
Institutional address: Department of Chemistry, Sidon, Lebanon
Short biographical sketch: MA graduate in science educaiton and teacher of chemistry from the Lebanese American University, is interested in innovation in teaching techniques to maximize student learning, engagement and critical thinking.

Full name: Ahmad Oweini
Institutional affiliation: Lebanese American University
Institutional address: Department of Education, 13-5053 Beirut, Lebanon
Short biographical sketch: Associate professor of education with background in special education and counseling, graduate of Teachers College, Columbia University, New York. Combines teaching, research and clinical work, is interested in training teachers on language development, learning disabilities, classroom management, study skills, and differentiataed instruction.

Full name: Samar Zeitoun
Institutional affiliation: Lebanese University
Institutional address: Department of Education, Beirut, Lebanon
Short biographical sketch: Has received her PhD from Nottingham University, UK in adult and continuing education and teaching, is currently a lecturer of education at the Lebanese University.