Education Research Journal
ISSN 2026-6332
Nathalie & Zalpha, *Volume (11) Issue (9): 194 –204 September - 2021.* *RESEARCH PAPER*

The effect of an inquiry and reflection teaching method on Grade 8 Chemistry students' achievement, attitudes, and motivation

***Nathalie Farah and Zalpha Ayoubi**

Lebanese University, Faculty of Education, Beirut

*Corresponding Author Email: nathaly_farah@hotmail.com

***Corresponding Author**

Nathalie Farah

Lebanese University, Faculty of Education, Beirut

*****Corresponding Author Email: nathaly_farah@hotmail.com

Abstract

Lebanese Chemistry teachers detected lack in middle and high school students' Chemistry grades in the official exams as well as in international tests such as TIMSS. They also noticed that most of the Lebanese students have negative attitudes and are unmotivated and not interested in learning Chemistry. Therefore, instructional approaches were necessary in order to help students improve their learning skills and motivate them. The Inquiry and Reflection teaching method (I&R), a non-computer enhanced method, was developed based on the White and Frederiksen's method (1998) that consists of a conjunction between inquiry and metacognition. This strategy includes four phases: Scaffolded inquiry, Reflective assessment, Argumentation and Generalized Inquiry and Reflection. The purpose of the study was to investigate the effect of using the I & R instructional method on studnts' achievement, attitudes and motivation. Thirty-eight grade 8 students, in one Lebanese private school participated in this study where 19 students were randomly selected to constitute the control group and the remaining 19 students constituted the experimental group. In the first semester, both groups learned via the traditional method; however, in the second semester, the experimental group students learned via the I & R teaching method, while the control group ones continued learning via the traditional method. Students' achievement was measured by three exams: Exam 1 which took place before the implementation of I & R method and was considered as a pre-test, Exam 2 took place three weeks after the I & R implementation, and Exam 3 took place at the end of the I & R implementation and was considered as a post-test. In addition, interviews with the experimental group students were done at the end of the I & R implementation in order to measure their attitudes and motivation toward learning Chemistry. Findings showed that achievement of the experimental group students has improved significantly, while the control group students' achievement did not. Results also showed that the experimental group students had a positive attitude toward the I & R method and were motivated to learn Chemistry.

Keywords: Achievement, Motivation, Attitude, Inquiry based-learning, Metacognition

Introduction

Contrary to traditional science instruction, which encourages students to memorize facts from textbooks and emphasizes lectures to present scientific information, today's scientific instruction rejects science as a body of facts that must be memorized (Burke, 2008; Changwong, 2018; Fennimore, 1990; Kaplan, 2017; Karakoç, 2016; Uribe Enciso, Uribe Enciso, & Vargas Daza, 2017; Zohar, 2005) and emphasizes on the inquiry-based laboratory activities. Through a combination of "hands-on" and "minds-on" learning, inquiry engages students in a process through

which they learn science content best (Garrison, 2002; Smallhorn, 2015) and construct conceptual understanding as the goal of the learning experience. As students engage in the inquiry process they develop the ability to learn how to learn. In other words, they learn to use inquiry to acquire ideas and information on their own (Eslinger, 2008; The National Academy of Sciences, 1998). Research has confirmed the value of an Inquiry approach in fostering students' learning (Bransford, 2000). A variety of inquiry based strategies showed to be successful at helping students consistently perform at a higher academically level (Crawford, 2000; Windschilt, 2001) and also successful at increasing student motivation (Caswell, 2017; Laursen, 2011; Madden, 2011). Inquiry motivates students not only to want to come to classes but also want to learn and enjoy learning. Attitude and motivation factors were found to have positive effects on mathematics and science achievement (Singh 2002), since the most successful students are usually the most highly motivated (Moore 2006).

Similarly to the Inquiry positive impacts on students' learning outcomes and motivation, research showed the important role that metacognition plays in enhancing students' motivation (Al-Baddareen, 2015; Karaali, 2015), in improving students' academic performance (Al shammari, 2015; Gholamshahian, 2016; Kaur, 2018; Mozafari, 2016; Perry, 2019); and in promoting meaningful learning (Davidowitz & Rollnick, 2003; Rickey & Stacey, 2000; Thomas & McRobbie, 2001; White & Mitchell, 1994;) especially in science teaching and learning (Davidowitz & Rollnick, 2001; Thomas & McRobbie, 2001). The way science is taught, both at the high school and college level, plays a major role in shaping students' attitudes toward science. It is in the interest of society and the responsibility of educators to improve students' attitudes toward science, and to prepare students to live in a highly scientific and technological society (Ungar, 2010).

White and Frederiksen (1998) worked on a conjunction between inquiry and metacognition and studied its effectiveness on students' achievement. They developed a computer enhanced middle school science curriculum that develops students' metacognitive knowledge and skills through a process of scaffolded inquiry based on the fact that the combination of Inquiry and Metacognition in a teaching method have a positive impact on students' achievement in Physics, motivation and learning outcomes.

In Lebanon, Chemistry teachers detected lack in students' Chemistry grades in the official exams as well as in international tests. Many countries have been engaging in both national and international assessments and have made use of information to improve the quality of their education system. In 2015, around 540,000 students from seventy-two countries including Lebanon, participated to PISA test which assesses both subject matter content knowledge, and the capacity of individuals to apply that knowledge creatively, including unfamiliar contexts (Schleicher, 2017). Unfortunately, Lebanon ranked 67th (El Hassan, 2019). Moreover, in TIMSS, which is an international assessment that monitor trends in student achievement in mathematics, science, and reading, Lebanese students performed lowest in the Reasoning domain and highest in the Knowing domain in 2015. Their overall science average was lower than international mean (El Hassan, 2019). This indicates that there is a need for instructional strategies that would improve Lebanese Chemistry students' achievement as well as their attitudes and motivation.

Farah and Ayoubi (2020) adapted White and Frederiksen instructional model and elaborated the Inquiry and Reflection (I&R) method to fit the Lebanese schools since the majority of them are not well equipped with computers. The I & R is a non-computer instructional method that consists of four phases: Scaffolded inquiry, reflective assessment, argumentation, and generalization.

- *Scaffolded inquiry*: Students are involved in "open-ended" questions and experience hypothesizing, investigating, planning and conducting experiment, observing, analyzing data and concluding.
- *Reflective assessment:* Students evaluate their own and each other's research, so the habits of thought will be involved in their skills.
- *Argumentation:* students gather the "proofs" to support the claims they seek to defend and then resolve their dispute by agreeing that one conclusion is better supported than another.
- *Generalized Inquiry and Reflection:* the inquiry cycle in conjunction with reflection, is repeated, students refine their inquiry and reflection processes, so they can apply to new learning situations and real-world situations (Farah & Ayoubi, 2020).

This instructional method aims to improve students' academic achievement as well as to enhance their motivation and positive attitudes toward Chemistry. According to Magulod (2019), there are significant relationships between learning styles and academic performance of students in applied science courses, since the nature of motivation and learning strategy use is vital to improving student learning outcomes (Gbollie, 2017). In order to improve students' attitudes toward science, teachers must motivate students, which they can do through their teaching styles and by showing them the relevance of the learning topics to their everyday lives, which helps them see the value of science and in turn motivates them to develop a better attitude toward science and science education. Motivation is a broad concept, which has been described in different theories (Kusurkar, 2012), with accompanying measuring instruments. The most frequently used variables of motivation were educational aspirations/intentions like aspiration to attend college and intention to finish school, and intrinsic motivation like enjoyment of learning and interest in school (Isik, 2018).

Purpose of the study

The intent of this study is to investigate the effect of the Inquiry and Reflection (I&R) instructional method on

students' achievement. However, in order to perform their academic level, students must have positive attitudes toward Chemistry learning and must be highly motivated. So, the aim is also to study the I & R method's effect on students' attitudes and motivation toward learning Chemistry.

Research Questions

This research tries to answer the following questions:

Q_1: Does the I & R method of teaching affect grade 8 students' achievement?
Q_2: Does the I & R method of teaching affect grade 8 students' attitudes and motivation toward learning Chemistry?

Research Hypotheses

The research hypotheses corresponding to the above research questions are:

H_1: The I & R method of teaching has no effect on students' achievement.
H_2: The I & R method of teaching has no effect on students' attitude and motivation toward learning Chemistry

Method

A mixed research was conducted in order to answer the research questions. The quantitative part consisted of students' scores on three exams, as well as their improvement scores from Exam 1 (pre-test) to Exam 3 (post-test). It should be noted that the three exams were similar, as one third of their content was based on the Knowledge domain, and the two remaining thirds were based on the Reasoning domain. The qualitative part consisted of data collected from the interviews done with the experimental group students at the end of the I & R implementation.

Participants

Thirty-eight grade 8 students, from one private school in Mount Lebanon participated in this study. They were randomly assigned to two sections of 19 students each. At the beginning of the second semester, section A was chosen, randomly through draw lot, as the control group and section B as the experimental group. Both sections were homogenous in terms of number, gender, age, and socio-economic background since they live in the same geographical area and belong to the same economic status.

At the beginning of the year both groups were taught via the traditional method where at the end of the first semester, Exam 1 was administered to both sections as the pre-test. Results showed that there were no significant differences between the two sections in terms of achievement which means that students in both groups had similar academic background.

Procedure

Throughout the academic year, the control group students were taught via the traditional method whereas the experimental group students were taught via the traditional method in the first semester and via the I & R method in the second semester. All students learned the same chemistry material. In the first semester they learned three chapters: "Solutions", "Atoms", and "Compounds" and in the second semester they learned four chapters: "Chemical Reactions", "Types of Chemical Reactions", "Rates of Chemical Reactions" and "Acidic and Basic Solutions".

The I & R method was implemented three hours per week for twelve weeks. The steps of the I & R method were repeated in each of four lab sessions, corresponding to the four units taught, where some of the scaffolding was removed each time. In the first lab session "Chemical Reactions", the experiments were designed and all materials were prepared by the teacher; in the second session "Types of Chemical Reactions" the students collected all the necessary materials in order to perform the experiments designed by their teacher; in the third session "Rates of Chemical Reactions", the students took part in the design of the experiments, while in the fourth one "Acidic and Basic solutions" they carried out all the tasks. In each lab session, teacher asked students to make predictions about what they thought might happen in some simple real-world situations that are related to the research question in order to engage them in "thought experiment". The teacher got the class to generate a set of alternative hypotheses about what might happen, to investigate, to design experiments, to analyze data and to draw conclusions. Then all students were engaged in a debate to reach a consensus about which hypothesis best accounts for their results and considered to be the most accurate and useful. As part of this process, each group of students had to criticize each other's hypotheses and conclusions and attempt to prove them wrong. An example of one of the lab sessions "Rates of Chemical Reactions" appears in Table 1 below.

The control group students learned the same Chemistry content with the same teacher mainly using lectures without any explicit attempt to engage students in metaconceptual processes. In other words, the teacher gives the scientific explanations as a lecture and then passes to laboratory experiments. Students discuss their observations after performing experiments without any attempt to predict or analyze the experiments' results.

Table 1: Example of one lab session: Rates of Chemical Reactions

Duration: 40min Title: Rates of Chemical Re actions Objectives: Knowing that the temperature, the catalyst and the surplus of reactant increase the rate of chemical reactions. Keyword: catalyst Question and researches: Students conducted a library research about factors that influence the rates of chemical reactions. They found the following factors: • high temperatures • Agitation. • catalysts Hypotheses: Each group should predict what are the factors that affect the rates of the following reactions • 50ml warm water with 20g sugar with 5g baking powder with heat • 50ml warm water with 40g sugar with 5g baking powder • Bread with saliva with Fehling solution • Bread with saliva with Fehling solution with heat • Bread with Fehling solution with heat Experiments: Each group should perform the following experiments: • 50ml warm water with 20g sugar with 5g baking powder with heat • 50ml warm water with 40g sugar with 5g baking powder • Bread with saliva with Fehling solution • Bread with saliva with Fehling solution with heat • Bread with Fehling solution with heat Materials: Each group had three pieces of bread, one beaker, 50ml of warm water, 50ml of hot water, Fehling solution, hot Fehling solution, sugar, baking powder, a digital balance and a spatula. Reports: A week later, each student should present a lab report which includes: the hypotheses, the materials used, the procedure followed, the observations, the analysis and the conclusion he or she made. Debate: In the following session, groups should expose the investigations they did during the week about laws they discovered and their limitations, then the class got together to try to reach a consensus about which hypothesis best accounts for their results and was the most accurate and useful. As part of this process, they have to criticize each other's hypotheses and conclusions and attempt to prove them wrong.

Instruments

Three achievement exams: Exam 1, Exam 2 and Exam 3, were constructed and used by the researchers to measure the effect of the I & R method on students' achievement. Exam 1 took place before the I & R implementation and was considered as a pre-test. Exam 2 took place three weeks after the I & R implementation at the end of the first lab session. Exam 3 took place at the end of the I & R implementation and was considered as a post-test. The three exams were validated by the head of Chemistry department in the school, as well as by two doctors in Chemistry Education from the faculty of Education at the Lebanese University. In addition, interviews were conducted with the experimental group students to collect data regarding their attitudes towards I & R teaching method, their motivation to learn, and the problems they have encountered during the implementation of the I & R method.

Data Analysis

The quantitative data were analyzed using the Statistical Package for the Social Sciences program "SPSS". In order to determine whether there was a significant difference between the mean scores of the students in the experimental group and those in the control group, an independent-samples t-test was used for each of the three exams. The 0.5 level of significance was accepted for all the analyses performed in this study. In addition, the experimental group students' responses to the interview were analyzed qualitatively by coding and grouping the responses into categories and then by quantifying them.

Results and Discussion

In order to provide answers to the first research question related to students' achievement, three exams were administered to both groups. Exam 1, was considered as a pre-test, Exam 2 was given few weeks later, while Exam 3 was considered as a post-test.

Results related to Exam 1

Prior to treatment, an independent samples t-test was employed to Exam 1 to determine if there was a statistically significant difference between the control and experimental groups. Results of the independent samples t-test are provided in Table 2 below. According to Table 2, the mean Exam 1 score of the experimental group was M = 9.078, while the mean Exam 1 score of the control group was M = 10.588, and the difference between the two groups was not significant ($p > 0.05$, $t = .310$). This result indicated that students' achievement in both experimental and control groups were similar at the beginning of the experimental study.

Table 2: Independent sample t-test results of Exam 1

Exam	Group	Number of students	Mean	SD	t	p
Exam 1	Control	19	10.588	6.142	.310	.758
	Experimental	19	9.078	5.615		

Results related to Exam 2

Results of the independent-samples t-test regarding Exam 2 are provided in Table 3 below. According to Table 3, Exam 2 mean score of the experimental group was M = 9.631 and of the control group was M = 9.470. The difference between the two means was not significant ($p > 0.05$, $t = -.187$) three weeks after the I & R implementation.

Table 3: Independent sample t-test results of Exam 2

Exam	Group	Number of students	Mean	SD	t	p
Exam 2	Control	19	9.470	6.801		
	Experimental	19	9.631	4.336	-.187	.853

Results related to Exam 3

Results of the independent-samples t-test regarding Exam 3 are provided in Table 4 below. According to Table 4, Exam 3 mean score of the experimental group was M = 12.552 and that of the control group was M = 9.294. The difference between the two means was significant ($p < 0.05$, $t = -2.525$) in favor of the experimental group.

Table 4: Independent sample t-test results of Exam 3

Exam	Group	Number of students	Mean	SD	t	p
Exam 3	Control	19	9.294	5.391	-2.525	.016
	Experimental	19	12.552	2.999		

Results related to students' improvement scores

The improvement scores of both groups from Exam 1 to Exam 2 appear in Figure 1 below. It shows that from Exam 1 to Exam 2, the control group students regressed slightly while the experimental group ones made a little progress. In fact, the control group students' mean decreased by a half-point, while the experimental group students' mean increased by a half-point.

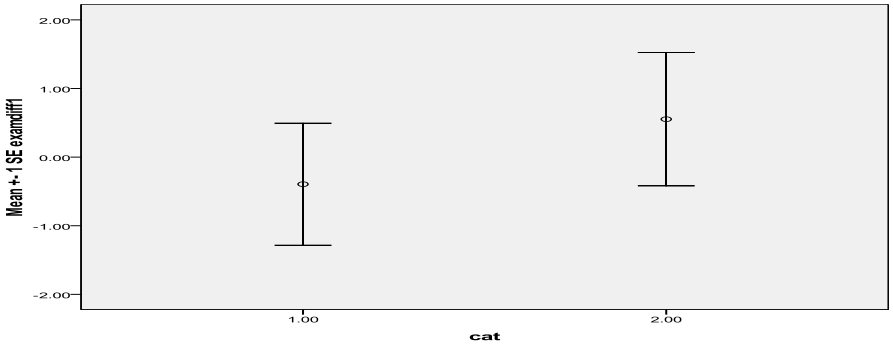

Figure1: Improvements in achievement of both groups from Exam 1 to Exam 2

The improvement scores of both groups from Exam 1 to Exam 3 appear in Figure 2 below. It shows that from Exam 1 to Exam 3, the control group students kept regressing, while the experimental group students continued progressing. In fact, the control group students' mean decreased by one point, while the experimental group students' mean increased by three points
.

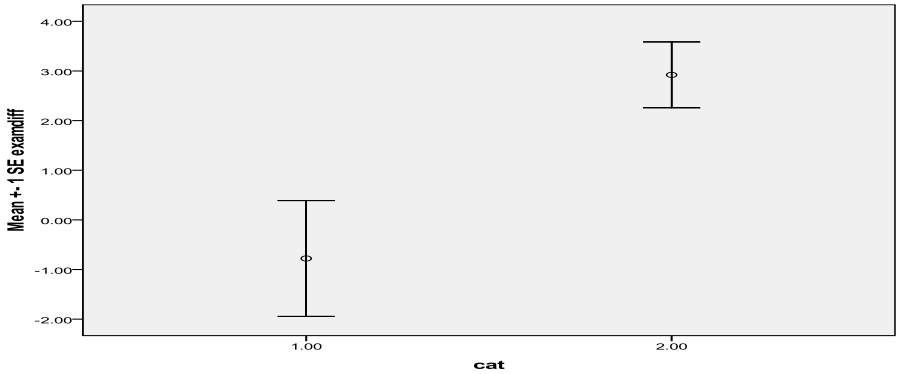

Figure 2: Improvements in achievement of both control and experimental groups from Exam 1 to Exam 3

The improvement scores of the students' achievement from Exam 1 to Exam 3 were then compared using the independent-samples t-test and results are provided in Table 5 below. It shows that the difference between the two groups was significant ($p < 0.05$, $t = -2.797$) in favor of the experimental group.

Table 5: Independent sample t-test results of students' improvements from Exam 1 to Exam 3

		N	Mean	t	p
Exam difference	Control group	19	-1	-2.797	.008
	Experimental group	19	+3		

To sum up, the I & R method of teaching improves significantly grade 8 students' achievement.

Students' Interviews

As for the second research question, the experimental group students were interviewed in order to determine their attitude toward this instructional method, at the end of the I & R implementation. All students were asked ten questions separately. Students' answers are reported in Table 6 below.

Table 6: Students' answers to the attitude interview questions

Questions	Students answers	Number of students
1- Which method do you prefer: the traditional method or the I & R method? And why?	- The I & R method because it is more fun - The I & R method because it is more instructive. - The I & R method because it is easier and it allows us to follow and participate in the experiments.	9 4 6
2- What is your attitude towards the I & R method: Enthusiastic, indifferent or negative?	Enthusiastic	19
3- Which method allowed you to a better comprehension and assimilation?	- The I & R method because it allows us to discover laws and building our own knowledge. - The I & R method because it made chemistry concrete. - The I & R method because it encourages teamwork.	10 4 5
4- Did your thinking skills improve after the I & R implementation?	- The I & R method leads to the improvement of our problem solving skills. - The I & R method helped us to improve our analysis and interpretation skills, this teaching method gave us the habit to analyze and interpret results.	8 11
5- What are the problems you encountered in the I & R method?	- We didn't have any problem. - We had encountered problems with the limited time. - I, sometimes, was feeling stressed because of responsibility.	11 7 1
6- What do you prefer to avoid in the I & R method?	- we hoped to avoid writing long reports (because of our weaknesses in the French language) - some of the experiments were difficult.	16 3
7- What did you like to add to the I & R method?	- we would like to do more lab experiments	19
8- Would you like to learn Physics and Biology via the I & R method, or would you prefer learning them via the traditional one?	- we wish to use the I & R method in Physics and Biology. - We do not want to use the I & R method in Physics and Biology , because we will have too much work to do, such as reports, debates, researches… - we wish this implementation only in Biology because we are neither interested, nor high achievers in this matter.	12 4 3
9- What is your attitude toward the I & R method? negative; null; or positive?	- positive - indifferent toward this teaching method, because I was hoping to make risky and exciting experiments	18 1
10- If you were a teacher, which teaching method will you use?	- we chose to teach via the I & R method because it is more fun, easier and richer than the traditional method. - we could teach via both methods depending on the chapters. - I chose the traditional one because it allows me to explain the chapter in few minutes and students will not have to write reports.	16 2 1

Several questions in the students' interviews allowed us to measure their positive attitude toward the Inquiry & Reflection method. First, the majority of them described their attitude toward the I & R method as positive, and felt enthusiastic about it, since it allowed them to have a better comprehension because they were fully involved in the discovery of laws while gaining knowledge, as much as they began to see Chemistry as a concrete discipline. Second, they found that the I & R method is better than the traditional one because it is more instructive and it allows them to participate to all the experiments' steps. Third, they enjoyed studying Chemistry via the I & R method; as a matter of fact, they made the wish to do more experiments and lab sessions; and even some of them spent their breaks in the lab to prepare the materials instead of playing and having fun with their colleagues. Fourth, in their point of view, the I & R method was extremely motivating and exciting; thus, the majority of them hoped to use this instructional method in learning Physics and Biology. Finally, they said that in case they were teachers; eighteen of them would choose to teach via the I & R method because it is more fun, easier and more beneficial than the traditional method. Yet, some of students encountered problems while learning Chemistry via the I & R method, such as the limited time, the stress they were feeling because of the responsibility, the lab reports which were taking too much time (because of their French

language weakness), as well as some experiments which they found difficult. In questions 9 and 10, only one student was indifferent toward the I & R method, and prefer to learn via the traditional method; he also said that if he were a teacher, he would not waste time teaching his students via the I & R method. By contrast, he said earlier in questions 2 and 3, that he felt enthusiastic and that he understood better via the I & R method. While in question 7, he said that this method was not sufficient because he hoped to do more difficult experiments, specifying that the fourth experiment was too easy and somehow meaningless.

Discussion

Results of this study revealed that the control group students did not produce significant improvement in their achievement, while the experimental group students progressed significantly. Tests used to compare both groups students' achievement on the three exams, showed first, that before the I & R implementation, there was not a significant difference between the control and the experimental group students, since there was not a significant difference in their Exam 1 results; only after and because of the implementation of the I & R method, we detected a vivid significance between both groups' achievement. Similarly to Exam 1, both groups had the same achievement level on Exam 2 which was taken three weeks after the I & R implementation, since there was not a significant difference between them. At that phase the experimental group students had only learned the "Chemical Reactions" chapter via the I & R method, while they were taught the other chapters via the traditional one. We can say that three weeks are not sufficient to differentiate between both groups; in fact, students need more time to adapt themselves to the new instructional method and additional practice to improve their achievement. However at the end of the I & R implementation, the experimental group's achievement became significantly better than the control group's achievement; the experimental group students produced better results on Exam 3, thirteen weeks after the I & R implementation, while the quantitative analysis tests showed that the control group students were regressing.

Moreover, we compared the improvement of each student in both groups from Exam 1 to Exam 3, by calculating the difference between their grades, and found a significant difference in the improvement between both groups. These results confirmed our earlier interpretation which says students need more time and practice to refine the Inquiry cycle in order to improve their achievement.

Therefore, students in the experimental group have significantly better achievement than the control group students. This result might be obtained first, because the I & R approach is a student-centered instructional method and second, because it is also a cooperative method of learning.

First, according to Tebabal & Kahssay (2011), when student-centered instruction is used, it is highly probable that this significantly causes better understandings of scientific conception and elimination of alternative concepts. Moreover, in his study, Lott (1983) from the Institute for Research on Teaching Michigan State University, East Lansing, stated that students' achievement showed an increase when the discovery inquiry method was used. In addition, White & Shimoda (1999), Abdi (2014) as well as Khan (2011), found that Physics, Science and Chemistry students taught through inquiry outperformed students taught with conventional methods. In addition, the present work supports Al-oqleh (2019) and Rezvan's (2006) findings that metacognitive guidance has positive effects on students' academic achievement. However, studies based on the conjuction betwwen inquiry and metacognition are only limited to the study of White and Fredericksen (1998), which results are in line with the present study.

Second, Wachanga and Mwangi (2004) investigated the effects of cooperative class experiment (CCE) teaching method on high school students' educational achievement; they found that CCE caused facilitation in learning Chemistry. Although we detected some problems related to group work that we have experienced in classrooms (waste of time, compatibility of group members, etc…), we have also recognized that group work can be a powerful teaching strategy that allows for a wide range of academic abilities. Several researchers have recognized and studied this as well (Wachanga & Mwangi, 2004; Hendricks, 2009). The numerous findings of these researchers that effectively argue in favor of cooperative group learning in heterogeneous classrooms, several key features seem to stand out, such as the delegation of authority (Cohen, 1994) and the regulation of learning processes (Viau, 1994). Cooperative groups provide learners with the opportunity to practice generating causes and effects, hypothesizing, categorizing, deciding, including, and problem solving (Solomon, Davidson, & Solomon, 1992). When the group works on an assignment where there is no clear right answer, everyone in the group benefits from the interaction. Frequency of interaction on the task consistently predicts individual group learning when groups are working on discovery problems (Cohen, 1991). This kind of activities motivates largely the students who find themselves in a context of challenge and responsibility (Compaore, 2009).

In terms of students' motivation and attitude toward Chemistry learning, their answers on the interview questions revealed their enthusiasm regarding the I & R approach which allows them to have a better comprehension, being fully involved in the discovery of laws and gaining knowledge. Therefore, the positive attitude towards learning Chemistry increased the performance of the academic achievement, while the proper performance (during the first semester) did not cause a positive attitude. Furthermore, according to the observer's field notes, the passive and unmotivated students, who were neither participating in class nor studying regularly, became gradually interested, responsible and academically engaged after the I & R implementation. Moreover, low achieving students and shy ones, developed stronger personalities, and improved their self-esteem. One of the low achiever might illustrate the best

example: At the beginning of the year, he was extremely feeble, unmotivated and irresponsible, while after the I & R method implementation he exhibited a strong desire to learn and became fully involved in the learning, to the extent where he became the leader and the innovator in the lab sessions and spent his breaks in the lab to prepare the experiments, and finally presented one of the best reports by stating hypotheses, explaining the procedures, describing the various observations he had made and writing adequate analysis and conclusions. This result supports findings in earlier research studies concluding that inquiry based activities promote students' motivation (Holbrook and Kolodner, 2000; Bayram, 2013), and that metacognitive activities motivates students (Öz, 2016). In a similar vein, Gibson and Chase (2002), as well as Shimoda, White and Frederiksen (2002) found that inquiry based activities were likewise metacognition (Eblen-Zayas, 2016) influential in students' having positive attitudes towards science learning.

Conclusion

The Inquiry & Reflection method implementation has shown to enhance students' academic achievement. This instructional method motivates students' to learn Chemistry by putting them in a situation of competition, challenges and responsibility in real life contexts instead of the virtual scientific context of the classroom. Furthermore, students develop a positive attitude toward the I & R method since it is a student-centered approach, where they enjoy assuming responsibilities, discovering laws, constructing easily their own knowledge and getting higher scores . Therefore, this instructional method provides students with relevant life skills.

References

Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. *Universal Journal of Educational Research, 2*(1), 37-41.

Al-Baddareen, G., Ghaith, S., & Akoura, M. (2015). Self-efficacy, achievement goals, and metacognition as predicators of academic motivation. *Procedia - Social and Behavioral Sciences, 191*, 2068 – 2073

Al shammari, M. (2015). The effect of using metacognitive strategies for achievement and the trend toward social studies for intermediate schools students in Saudi Arabia. *International Journal of Education, Learning and Development, 3*(7), 47-54.

Al-oqlet. A. (2019). The Effectiveness of Metacognition on Academic Achievement among the Jordanian Universities Students. *International Journal of Academic Research in Business and Social Sciences, 9*(9). 460-478.

Bayram, Z., Oskay, Ö, Erdem, E., Özgür, S., Şen, S. (2013). Effect of inquiry based learning method on students' motivation. *Procedia - Social and Behavioral Sciences, 106,* 988 – 996.

Bouffard, T., Boisvert, J., Larouche, C., Vezeau, C. (1995). The impact of goal orientation on self- regulation and performance among college students. *British Journal of Educalional Psychology*, *65,* 317-329

Bransford, J.D., Brown, A.L., Cocking, R.R. (Eds) (2000). *How people learn: brain, mind, experience, and school expended edition.* National Academics Press, Washington DC.

Burke, L.A., & Williams, J.M. (2008). Developing young thinkers: An intervention aimed to enhance children's thinking skills. *Thinking skills and Creativity, 3*, 104-124.

Caswell, C.J., & LaBrie, D.J. (2017). Inquiry based learning from the learner's point of view: A teacher candidate's success story. *Journal of Humanistic Mathematics, 7*(2), 160-186.

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: Analysis of a new learning management model for Thai high schools. *Journal of International Studies, 11*(2), 37-48.

Compaore, G. (2009). *La motivation des élèves*. Ressources Didactiques.

Cohen, E. G. (1991). Teaching in multiculturally heterogeneous classrooms: Findings from a model program. *McGill Journal of Education, 26,* 7-23.

Cohen, E. G. (1994). *Designing group work: Strategies for the heterogeneous classroom* (2nd ed.). New York: Teachers College Press.

Crawford, B. A. (2000). Embracing the essence of inquiry: new roles for science teachers. *Journal of Research in Science Teaching, 37*(9), 916-937.

Davidowitz, B. and Rollnick, M. (2001). Enabling metacognition in the laboratory: a case study of four second year university chemistry students. *Paper presented at the 32nd Annual Conference of the Australasian Science Education Research Association.* Sydney, July.

Davidowitz, B. & Rollnick, M. (2003). Enabling metacognition in the laboratory: A case study of four second year university chemistry students. *Research in Science Education. 33,* 43-69

Eblen-Zayas, M. (2016, July 20-21). The impact of metacognitive activities on student attitudes towards experimental physics. Paper presented at Physics Education Research Conference 2016, Sacramento, CA. Retrieved July 25, 2020, from https://www.compadre.org/Repository/document/ServeFile.cfm?ID=14205&DocID=4557

El Hassan,K. (2019). International Assessments as a Lever of Change: Lebanon. [PowerPoint slides]. Retrieved June 24, from https://www.slideserve.com/jhayden/international-assessments-as-a-lever-of-change-lebanon-powerpoint-ppt-presentationEslinger, E., White, B., Frederiksen, J., & Brobst, J. (2008). Supporting inquiry processes with an interactive learning environment: Inquiry Island. *J Sci Educ Techno, 17,* 610-617.

Farah, N. & Ayoubi, Z. (2020). Enhancing the critical thinking skills of grade 8 chemistry students using an inquiry and reflection teaching method. *Journal of Education in Science, Environment and Health (JESEH), 6*(3), 207-219. DOI:10.21891/jeseh.656872

Fennimore, T.F., & Tinzmann, M.B. (1990). *North central regional education laboratory.* NCREL, Oak Brook, 1990.

Garrison, D.R. (2002). Inquiry and critical thinking- reflective inquiry. *University of Calgary.* http://commons.ucalgary.ca

Gbollie, C. & Keamu, H. P. (2017). Student academic performance: the role of motivation, strategies, and perceived factors hindering Liberian junior and senior high school students learning. *Education Research International, 17*, 1-11.

Gholamshahian, Z., & Aojinejad, A. (2016). The effect of metacognition on educational performance and self-directed learning in sixth grade female students of Shiraz zone two. *Mediterranean Journal of Social Sciences 7*(2), 49-53.

Gibson, H.L. and Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education, 86*, 693-705.
Gourgey, A.F. (1998). Metacognition in basic skills instruction. *Instructional Science, 26,* 81-96.
Hendricks, C. (2009). *Improving Schools through Action Research, a Comprehensive Guide for Educators.* Pearson Education: Upper Saddle River, New Jersey 07458.
Holbrook, J. and Kolodner, J. L. (2000). Scaffolding the development of an inquiry-based (science) classroom. *Fourth International Conference of the Learning Sciences,* 221-227.
Isik U., Tahir O. E., Meeter M., Heymans, M. W., Jansma, E. P., Croiset G. & Kursukar, R. A. (2018). Factors influencing academic motivation of ethnic minority students: A review. *Sage Open, 8*(2), 1-23.
Kaplan, A. (2017). Evaluation of studies on the critical thinking approach through content analysis. *International Journal of New Trends in Arts, Sports & Science Education, 6*(1), 9-17.
Karaali, G. (2015). Metacognition in the classroom: Motivation and self-Awareness of mathematics learners. *Problems, Resources, and Issues in Mathematics Undergraduate Studies, 25*(5), 439-452.
Karakoç, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science, 6*(7), 81-84.
Kaur, P., Saini, S., & Vig, D. (2018). Metacognition, self-regulation and learning environment as determinant of academic achievement. *Indian Journal of Health and Well-being*, *9*(5), 735-739.
Khan, M.S., Hussain, S., Ali, R., Majoka, M.I., & Ramzan, M. (2011). Effect of inquiry method on achievement of students in chemistry at secondary level. *International Journal of Academic Research, 3*(1), 955-959.
Kusurkar, R. A. (2012). Motivation in medical students: A PhD thesis report. *Perspectives on Medical Education, 1*(3), 155-157.
Laursen, S., Hassi, M.-L., Kogan, M., Hunter, A.-B., & Weston, T. (2011). *Evaluation of the IBL Mathematics Project: Student and Instructor Outcomes of Inquiry-Based Learning in College Mathematics.* (Report to the Educational Advancement Foundation and the IBL Mathematics Centers) Boulder, CO: University of Colorado, Ethnography & Evaluation Research. Available at http://www.colorado.edu/eer/research/steminquiry.html
Lott, G. (1983). *Ways of Going Wrong in Teaching for Conceptual Change.* The Institute for Research on Teaching Michigan State University, East Lansing, Michigan, 48824.
Madden, K. (2011). *The use of inquiry-based instruction to increase motivation and academic success in a high school biology classroom.* Montana State University Bozeman, Montana.
Magulod, G. C. (2019). Learning styles, study habits and academic performance of Filipino University students in applied science courses: implications for instruction. *Journal of Technology and Science Education, 9*(2), 184–198.
Moore, R. 2006. Class Attendance: How students' attitudes about attendance relate to their academic performance in introductory science classes. *Research and Teaching in Developmental Education, 23*(1), 19–33.
Mozafari, M., Safari, Y., Abasifard, Z., Safari, M., & Sharafi, K. (2016). Assessing dimension of metacognitive skills and its relationship with academic achievement in high school students. *Acta Medica Mediterranea*, *32*, 899-903.
Wachanga, S.W. and Mwangi, G.J. (2004). Effects of the cooperation class experiment teaching method on secondary school students' chemistry achievement in Kenya Nakuru district. *International Education Journal*, *5*(1), 26-36.
Öz, H. (2016). Metacognitive awareness and academic motivation: a cross-sectional study in teacher education context of Turkey. *Procedia-Social and Behavioral Sciences, 232,* 109-121.
Perry, J., Lundie D., & Golder, G. (2019). Metacognition in schools: what does the literature suggest about the effectiveness of teaching metacognition in schools? *Journal Educational Review, 71*(4), 583-600.
Rezvan, S., Ahmadh, S., and Abedi, M. (2006). The effect of metacognition training on the academic achievement and happiness of Esfahan University conditional students. *Counseling Psychology Quarterly, 19*(4), 415- 428.
Rickey, D. & Stacey, A.M. (2000). The role of metacognition in learning chemistry. *Journal of Chemical Education. 77*, 915-920.
Schleicher, A. (2017). Seeing education through the prism of PISA. *European Journal of Education, Research, Development and Policy,* *52*(2), 124-130.
Shimoda, T.A., White, B.Y. and Frederksen, J.R. (2002). Students' goal orientation in learning inquiry skills with modifiable software advisors. *International Science Education Journal, 88*, 244-263.
Singh, K., Granville, M. & Dika, S. (2002). Mathematics and Science Achievement: Effects of Motivation, Interest, and Academic Engagement. *The Journal of Educational Research, 95*(6), 323-332.
Smallhorn, M., Young, J., Hunter, N., & Burke da Silva, K. (2015). Inquiry-based learning to improve student engagement in a large first year topic. *Student Success, 6*(2), 65-71.
Solomon, R. D., Davidson, N., & Solomon, E. C. L. (1992). Some thinking skills and social skills that facilitate cooperative learning. In N. Davidson & T. Worsham (Eds.), *Enhancing thinking through cooperative learning* (pp. 101-119). New York: Teachers College Press.
Tebabal, A., & Kahssay, G. (2011). The Effects of Student-Centered Approach in Improving Students' Graphical Interpretation Skills and Conceptual Understanding of Kinematical Motion. *Lat. Am. J. Phys. Educ., 5*(2).
The National Academies. Center for Science, Mathematics, and Engineering Education Staff. (1998). *Every Child a Scientist: Achieving Scientific Literacy for All.* Washington, D.C
Thomas, P. G. and McRobbie, C. J. (2001). Using a metaphor for learning to improve students' metacognition in the chemistry classroom. *Journal of Research in Science Teaching*, *38*(2), 222–259.
Ungar, S.J. (2010). "Seven Major Misperceptions about the Liberal Arts". *The Chronicle of Higher Education Feb. 28.*
Uribe Enciso, O.L., Uribe Enciso, D. S., & Vargas Daza, M. del P. (2017). Critical thinking and its importance in education: Some reflections. Rastros Rostros, 19(34). DOI: 10.16925/ra.v19i34.2144
Viau, R. (1994). *La motivation en contexte scolaire.* St-Laurent, Éditions du Renouveau pédagogique.
White, R.T. & Mitchell, I.J. (1994). Metacognition and quality of learning. *Studies in Science Education, 23*, 21-37.
White, B., & Frederiksen, J. (1998). Inquiry, modeling, and metacognition: Making science accessible to all students. *Cognition and Instruction, 16*(1), 3-118.
White, B., & Shimoda, T. (1999). Enabling students to construct theories of collaborative inquiry and reflective learning: Computer support for metacognitive development. *International Journal of Artificial Intelligence in Education, 10,* 151-182.

Windschitl, M. (2001). Inquiry Projects in Science Teacher Education: What Can Investigative Experiences Reveal About Teacher Thinking and Eventual Classroom Practice? Curriculum & Instruction, University of Washington, Seattle.

Zohar, A., & Aharon-Kravetsky, S. (2005). Exploring the effects of cognitive conflict and direct teaching for students of different academic levels. *Journal of research in science teaching, 42*(7), 829-855.