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# EFFECT OF PROBLEM-BASED LEARNING ON STUDENTS' METACOGNITION AND ACADEMIC ACHIEVEMENT IN SECONDARY LEVEL CHEMISTRY

**Sundas Majeed[*1], Mubashra Tayyaba[2], Zeshan Haider[3], Saqib Raza[4]**

[*1]University of the Punjab; [2]Lecturer at Clinical Psychology Department, NCBAE Gulberg Lahore; [3]Higher School of Economics, Moscow, Russia; [4]Nazarbayev University, Astana, Kazakhstan

[*1]Sundasmajeed731@gmail.com; [2]mubashratayyaba@ncbae.edu.pk; [3]zeesshaaan@outlook.com; [4]socsaqibraza@gmail.com

Corresponding Author: *

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## ABSTRACT

This research aims to examine the impact that learning through problem-solving has on secondary students' academic performance and metacognition when they study chemistry. To enhance the students learning different kinds of problems were assigned to the students' according to the topic. Pretest and posttest nonequivalent control group design was used in this Quasi-experiment research. This study comprised 70 students, conveniently selected from public sector secondary school 9th grade. Two intact groups were selected, and two groups were assigned: thirty-five students in the experimental group and thirty-five students in the control group. The research organization was exposed to different problems while the control group was taught traditionally. The researcher asked some questions related to the topic to check the students' prior knowledge. Each group was given 1-2 problems, and a chapter test was taken at the end. The experiment was conducted for 12 weeks. An accomplishment test and a metacognition awareness inventory questionnaire were the two research tools used to gather data. Acceptable reliability coefficients for the achievement test were 0.8 and the questionnaire's 0.7. Descriptive and statistical inference, such as paired but individual sample t-tests, were accustomed to analyzing the required data. This study shows that students' academic performance and metacognition in secondary-level chemistry are more significantly impacted by the use of learning for the solution of various problems.

**Keywords:** Learning problems, metacognition, academic achievement.

## INTRODUCTION

In their daily life, people face various kinds of problems and to find the solution to those problems they use their previous knowledge and experiences. According to Ali, (2010); and Chin & Chia, (2004) Students need to learn how to confront and deal with challenges that arise during their learning process.

In the 1960s the term Problem-based learning was first implemented at Toronto's McMaster University in a medical education curriculum. In problem-based learning, more responsibilities are given to students than teachers, it is a learner-centered approach and learners can learn independently. In PBL the education material and guidance that facilitate learning are given by the teacher to the learner which is based on real-life problems. PBL also helps students enhance their capacity for critical thought and self-directed learning, which helps them remember and apply knowledge to novel or unfamiliar circumstances (Evenson & Hmelo, 2000). David, (2014) explains the simple definition of PBL; it is an instructional hands-on method, based on active learning-centered and the resolution of real-world problems.

PBL fosters the idea of "learning by doing" and allows students to gain knowledge via problem-solving experience. In PBL, the instructor serves as a facilitator, keeping an eye on the cognitive growth of the students and contributing significantly to their learning. In past studies on PBL, the facilitator's role was to ask metacognitive questions like why and how, how do you know this? It is advised that teachers who do not provide information to students

also do not directly evaluate the contribution of students. Moreover, the teacher must model reasoning with questions like, “Do you have any idea what that means?” also “How does it affect things?” it is expected that by modeling this metacognition approach, students will begin critically analyzing information that will be present in the same way (Wee, 2004).

Over the past two decades, the rise in self-awareness among individuals has led to a greater emphasis on metacognition in cognitive psychology. According to Baykara (2011), students with high levels of metacognition typically possess higher levels of metacognitive awareness and are more adept at managing, monitoring, and evaluating information. They are also better at evaluating persons with low levels of metacognitive awareness. Senocak (2013) states that metacognition entails applying what is learned, solving problems based on analysis, and reflecting on what is already known.

One kind of teaching is called problem-based learning which focuses on hands-on active learning through the investigation of real-world problems. The fundamental definition of metacognition is thinking about thinking (Blakery & Spence, 1990).

**Literature Review**

To raise the standard of science instruction, Pakistan created a new national curriculum in 2006, according to the Ministry of Education. The curriculum's primary design principle is student-centeredness (Government of Pakistan, 2006). This curriculum was created with the student-centered approach in mind. Furthermore, this study is carried out to support and encourage the importance of problem-based knowledge in science instruction. The new education strategy in Pakistan has emphasized and supported the application of creative teaching instructions in the classroom (Government of Pakistan, 2009).

Constructivism and problem-based learning are two instructional strategies; they are the keys to describing learning methods. Individual construction and peer interaction all play an important role in the appearance of metacognition. Jean Piaget's popularized theory the constructivist theory of knowledge applies to PBL. According to Piaget, when the individual interacts with the environment and experiences knowledge, it helps to integrate it into the brain (Piaget, 1958).

Richardson (2003) explained that people construct their acquired knowledge based on their experiences. While Piaget emphasized on individual and Vygotsky's theory extended to society.

According to PBL theory, students' requirement to develop the talent of lifelong learning is problematic (Jonassen, 2010). Additionally, he asserts that the ultimate objective of education is problem-based learning:

1. Learning is a deliberate process.
2. The information is more pertinent to the students
3. The knowledge that is used in a practical setting is easier to recall.

The term metacognition is about awareness of how to learn, examining the learning needs, making techniques to fulfill those needs, and then applying the strategies (Hacker, 2009).

A descriptive survey on the epistemological beliefs of teacher candidates in primary education was carried out by Belet & Guven (2011). The Department of Primary Education's seven education faculties produced 820 primary school teacher candidates.

As per Downing's (2009) findings, research indicates that when it comes to raising students' metacognitive levels, problem-based learning has a comparatively greater impact than conventional teaching approaches. Demirel and Turan conducted research in 2010, that looked at how PBL affected middle school pupils' metacognitive abilities. Students in the experimental group's metacognitive levels who got PBL were shown to differ significantly from those of the control group students who received standard teaching approaches.

Few research has examined how Problem-Based Learning (PBL) affects students' metacognitive awareness levels in the body of extant literature (Downing, 2009; Taskesenligil & Tosun, 2012). These studies, though, are mostly concerned with elementary school pupils. This study is significant since it focuses on how PBL affects secondary school students' levels of metacognitive awareness. It is significant because it contrasts how PBL affects students' learning in the subject of chemistry and their metacognition.

**Research Design**

The research methodology used in the study was positivist, and it was experimental. It used a pre-test-post-test methodology with a non-equivalent control group design in a quasi-experimental setting.

Seventy ninth-grade students from public secondary schools made up the study's population. There were thirty-five pupils in each group (the experimental and control groups).

| Groups | Sample size (N) | Pre-test | Treatment | Post-test |
|---|---|---|---|---|
| Experimental group | 35 | Achievement test | Problem-Based Instruction | Achievement test |
| Control group | 35 | Achievement test | No treatment | Achievement test |

Before the study started, both control and experimental groups carried out a pretest experimental design.

**Instrumentation**

The researcher employed a metacognition questionnaire and an accomplishment exam as two tools to evaluate the effect of learning via problems on the metacognition of secondary school pupils.

1. Achievement test.
2. Metacognitive Awareness Inventory Questionnaire.

**Data Analysis**

To analyze the data, inferential as well as descriptive statistics were applied. The independent sample t-test was used to compare the means of the two groups (control and experimental), and a paired sample t-test was used to compare the means of the group experimenting with the control group.

**Results**

The experimental and control groups' approaches to problem-based learning were very different from one another. The results of the post-test were compared for the experimental and control groups using an independent sample t-test. The experimental group's mean score was 14.06 (SD = 3.514) compared to 9.77 (SD = 2.474) for the control group, with a p-value of 0.000, below the 0.05 limit. Given that problem-based instruction results in a higher mean score of 14.06 compared to traditional education, which provides a score of 9.77, the study's null hypothesis was rejected as a result of these findings. This shows that teaching secondary students chemistry through problem-based learning has a higher effect on their academic achievement and metacognition.

**Discussion**

Medical schools have been the focus of the majority of studies on PBL's efficacy. These investigations have produced contradictory results. Pecorce (2009) drew attention to these contradicting findings and proposed that PBL has a major impact on medical schools. On the one hand, PBL increased students' motivation and interest, according to Vernon and Blake, as reported by Sahin (2009). However, in contrast to their peers in traditional learning environments, students in PBL programs showed a more positive attitude towards their learning. (Chin and Chia, 2004; Greenwald, 2000; Major and Palmer, 2001; & Sahin, 2009). These comprehensive results demonstrate the complexity and need for additional research regarding the consequences of problem-based learning (PBL) in medical schools.

Van de Kamp et.al (2015) conducted a study with 147 secondary school students in visual arts education to examine the effects of explicit instruction of meta-cognition on students' divergent thinking. Results showed that explicit instruction had a positive effect on fluency and flexibility, but not on originality.

**Conclusion**

The results of the study indicate that, when it comes to teaching chemistry, problem-based learning works better than conventional methods. This method helps students learn chemical concepts more quickly and effectively. By building on their past knowledge and motivating them to solve problems, problem-based learning can help students understand complicated subjects more quickly. Students taught using problem-based learning demonstrate higher proficiency in chemistry, and their academic performance is evaluated through achievement tests conducted both after a 12-week intervention and during the intervention period. The results of the analysis show that the mean scores of the experimental group and the control group differ statistically significantly. Furthermore, the results

show a substantial difference in the before and after test scores. In summary, "problem-based learning" effectively improves secondary students' academic performance and chemistry comprehension.

**Ethical Consideration**

Before attempting the pretest, each participant was given clear and comprehensive information from the researcher. Students were reassured that their participation would have no impact on their grades. Official permission was obtained from the head of the institution and the relevant class teacher.

**Recommendations for future call**

1. Extend the duration of the experiment so that students have sufficient time to break away from traditional teaching methods and become more acquainted with scientific inquiry in the science course.
2. Undertake more research to find out how problem-based learning affects secondary students' academic performance and metacognition in chemistry.
3. Studies demonstrate that problem-based learning improves secondary students' metacognition and academic performance. Similar practical trials should be carried out in different disciplines and grade levels.
4. It is evident from the research that students' academic achievement in chemistry has significant outcomes. Therefore, it is suggested to conduct a study using a success assessment.

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