Effectiveness of Problem-Solving Method in Developing Metacognitive Knowledge at Secondary School Level

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ABSTRACT

This study was aimed to investigate the effectiveness of Problem-Solving Method (PSM) by using the acronym IDEAL in developing metacognitive knowledge at secondary level. The research was modeled in experiment-control groups design. A random selection of 120 students was taken from grade IX in the subject of General Science. These schools were randomly selected from the district on tehsil bases. 60 students from each school were divided into both control and experimental groups 30 students each randomly. The Revised Metacognitive Assessment Inventory (RMAI) was used to determine students' metacognitive knowledge i.e., declarative, procedural and conditional knowledge. An Independent Samples t-test was used for analysis of the data. The lecture method was used in the control groups while the PSM was employed in the experimental group. The post-test results of the experimental and control groups on the bases of knowledge about cognition i.e., declarative, procedural and condition knowledge shows the difference was significant to reject the null hypothesis of H01 to H04 confirming a significant difference between the post-test of experimental groups taught through lecture and problem-solving method. The significant difference between the mean scores of both tests shows that students taught through the problem-solving method had prominent increase in metacognitive knowledge i.e., declarative procedural and conditional knowledge.

KEYWORDS

Problem-Solving Method, IDEAL, metacognitive knowledge, secondary level, experimental design.

INTRODUCTION

Innovative concepts are welcomed and new trends in education are introduced through modern teaching. The goal of new, contemporary educational approaches is to foster creativity and higher order thinking skills. Deep and long-lasting learning are greatly enhanced when teachers innovate their teaching strategies to improve the learning environment. A lot of work is needed to make a real difference in science and technology and to meet all the challenges of daily living.

The primary goal of education and learning is to focus on in-depth study in order to develop higher order thinking knowledge and skills to explore new horizons of lifelong learning, but typically teachers use the traditional lecture method of instruction and concentrate only on instilling the subject material into the students' heads rather than helping them understand it conceptually. According to recent studies, secondary school students need to improve their conceptual learning outcomes. Unfortunately, Pakistani teachers' current methods of instruction and instructional strategies are unable to meet the varied requirements of the students. In large-scale classes, the lecture, chalk, and talk teaching technique is typically used.

These are the highest degrees of human thinking skills with the capacity to monitor one's own thought process so that one can correct oneself without assistance from others. Metacognitive skills, such as metacognitive knowledge and regulation of cognition, are critically important skills of the present era. Declarative, procedural, and conditional knowledge are the parts of metacognitive knowledge. Learning with IDEAL PSM can promote the development of metacognitive knowledge and self-regulation, and as a result, a learner's confidence can enhance metacognitive knowledge (Chua, Morris & Mor 2012).

Exactly why the present classroom teachings in Pakistan do not support the effective implementation of the child-centered interactive teaching method, is a difficult question to answer. The teacher's lack of knowledge of the individual needs of each student and their lack of access to a wide range of efficient teaching models, approaches, methods, and strategies to achieve the intended results may be the result of inadequate training. It is widely held that the traditional lecture technique currently in use falls short of meeting the needs of each student (Hafeez, 2021).

Although the value of metacognitive knowledge and skills within the learning process may be well understood, most classes today—even those for early childhood education—do not place a strong emphasis on its growth (Chatzipanteli, Grammatikopoulos & Gregoriadis,2014). Most educators place a strong emphasis on content while ignoring how students can improve their conceptual understanding and skill. The teachers make the supposition that the students can effectively acquire...
the necessary knowledge and skills on their own. According to Halai (2012), the majority of teachers employ the traditional lecture teaching technique across all subject areas, but especially in science, which is ineffective at fostering higher order thinking skills. Regulation of cognition and metacognitive knowledge are linked to one's own thought process, which takes into account what is already understood and what will be done (Greenstein, 2012).

In recent years, there has been a growing emphasis on the importance of metacognition in the learning process. Metacognition refers to one's ability to monitor, evaluate, and regulate their own thinking and learning processes (Schraw & Moshman, 1995). Research has shown that the development of metacognitive skills is crucial for academic success, and that these skills can be taught and developed (Baker & Brown, 1984). One approach to developing metacognitive knowledge and skills is through the use of problem-solving methods in the classroom. This literature review explores the effectiveness of problem-solving methods in developing metacognitive knowledge at the secondary school level.

Problem-solving method is a teaching technique that allows students to think critically and apply knowledge to solve complex problems. The purpose of this literature review is to examine the effectiveness of problem-solving methods in developing metacognitive knowledge at the secondary school level. The literature review will cover the concept of metacognition, problem-solving method, and their relationship in educational settings.

Metacognition refers to the ability to reflect upon one's own thought processes and monitor one's own learning. It is an essential element of learning and helps individuals develop self-awareness, self-regulation, and self-evaluation skills. Metacognition is often seen as a key factor in academic success and is essential for critical thinking, problem-solving, and decision-making skills. Researchers suggest that metacognitive skills are malleable and can be developed through appropriate instruction and practice (Schraw & Moshman, 1995).

Problem-solving method is an approach that encourages students to analyze complex problems, develop possible solutions, and evaluate the effectiveness of their solutions. It involves a systematic process of identifying problems, generating alternatives, and evaluating solutions. Problem-solving method is an essential part of many curricula and is widely used in various disciplines, including science, mathematics, and social studies. It helps students develop critical thinking skills, creativity, and decision-making skills (Biehler & Snowman, 1986).

Several studies have explored the effectiveness of problem-solving methods in developing metacognitive knowledge. For instance, a study by Artzt and Armour-Thomas (1992) investigated the effects of problem-solving instruction on the metacognitive processes of middle-school students. The study found that problem-solving instruction had a positive effect on students’ metacognitive knowledge, self-efficacy, and problem-solving performance.

Similarly, a study by Brown and Campione (1990) examined the effects of problem-solving instruction on metacognitive skills in mathematics. The study found that problem-solving instruction helped students develop metacognitive knowledge and skills, including monitoring their own understanding, planning and organizing their work, and evaluating their performance.

Furthermore, a study by Dweck and Leggett (1988) investigated the effects of problem-solving instruction on metacognitive skills in reading. The study found that problem-solving instruction had a positive effect on students’ metacognitive knowledge and helped them develop self-regulation and strategic reading skills.

In another study, Jonassen and Grabowski (1993) investigated the effects of problem-solving instruction on metacognitive processes in science. The study found that problem-solving instruction helped students develop metacognitive knowledge, including planning, monitoring, and evaluating their performance.

Moreover, a study by Schoenfeld (1987) examined the effects of problem-solving instruction on metacognitive processes in mathematics. The study found that problem-solving instruction helped students develop metacognitive knowledge and skills, including monitoring their own understanding, planning and organizing their work, and evaluating their performance.

Several studies have investigated the effectiveness of problem-solving methods in developing metacognitive knowledge at the secondary school level. For example, a study conducted by Van Garderen and Montague (2003) examined the impact of problem-solving instruction on the metacognitive knowledge of middle school students. The results of the study showed that students who received problem-solving instruction demonstrated greater gains in metacognitive knowledge than those who did not receive such instruction.

Another study conducted by Chin and Brown (2000) investigated the effectiveness of problem-solving methods in developing metacognitive knowledge in the context of mathematics learning. The study found that problem-solving instruction was effective in promoting the development of metacognitive knowledge and skills, particularly in the areas of planning, monitoring, and evaluation.

Similarly, a study conducted by Muis, Bendixen, and Haerle (2006) investigated the effectiveness of problem-solving methods in developing metacognitive knowledge and skills in the context of science learning. The results of the study showed that problem-solving instruction was effective in promoting the development of metacognitive knowledge and skills, particularly in the areas of planning and monitoring.

The above studies suggest that problem-solving methods can be effective in promoting the development of metacognitive knowledge and skills at the secondary school level. However, it is important to note that the effectiveness of
problem-solving methods may depend on several factors, such as the content area, the type of problem-solving task, and the instructional approach used.

Several studies have investigated the factors that may influence the effectiveness of problem-solving methods in promoting the development of metacognitive knowledge and skills. For example, a study conducted by Alcala and Hashimoto (2006) investigated the impact of different types of problem-solving tasks on the development of metacognitive knowledge and skills. The results of the study showed that tasks that required students to generate multiple solutions were more effective in promoting metacognitive knowledge than tasks that required students to find a single correct solution.

Teaching method or the learning model may affect the metacognitive knowledge and skills enabling the learning process and the diverse academic ability of students (Muhlisin, Ahmad & Susilo, Amin, Mohamad & Rohman, Fatchur, 2016, Saglam & Sahin, 2017). The existing learning models or teaching methods used for the basic science concepts are least useful in enhancing the metacognitive knowledge and skills of students.

Scholars have been researching metacognition for more than 20 years. Most people agree that while cognitive skills are required to complete an assignment, metacognition is important to comprehend how an activity was completed. (1987, Garner). Furthermore, Flavell (1976) offers an alternative perspective to the distinctions made by the majority of academics between the two aspects of metacognition: metacognitive knowledge and control of cognition. People have more than the three categories of metacognitive cognition stated, including declarative, procedural, and conditional cognition, which is the comprehension of their own perception or idea in general (Brown, 1987; Jacobs &Paris, 1987; Schraw & Moshman, 1995). Declarative knowledge can be summed up as knowing something "about" something. Procedural knowledge is the understanding of "how" to execute something under specific circumstances.

The knowledge of how to carry out tasks is referred to as procedural knowledge. A lot of this knowledge is represented via heuristics and tactics. According to Pressley, Borkowski, and Schneider (1987), individuals with a high level of procedural knowledge are more likely to carry out tasks on instinct, have a larger toolkit, efficiently sequence approaches, and employ qualitatively different solutions to solve problems.

Conditional knowledge is the understanding of cognition with an eye towards the application of procedural and declarative knowledge, as well as the necessary rationale and logical chronology of when, how, and why it will be applied. (1990, Gardner). For instance, effective students are familiar with the topic and may review it as needed. Conditional knowledge is essential because it empowers students to develop strategies and invest their resources more wisely (Reynolds, 1992).

The secondary school curricula is not designed to address the underlying issue of selecting the most effective learning methods and strategies for determining the necessary knowledge, skills, and excellent performance of learners. When instructed to create and employ efficient learning strategies, students can be helped in becoming excellent learners. But since there haven't been enough studies on how to acquire conceptual knowledge and necessary life skills, there isn't yet a quick and efficient method to raise students' metacognition levels. Development of life and social skills is viewed as requiring the acquisition of fundamental metacognitive information and abilities.

In this experimental study, the researcher typically used IDEAL acronym for PSM to explain how metacognitive knowledge and skills evolve. PSM is concerned with identifying the root cause of the issue, categorizing, ordering, and selecting alternative explanations for the issue, as well as implementing a suitable fix. The PSM has received certification for its effective secondary and upper secondary educational strategies. The acronym IDEAL is commonly used to identify these five steps in the reflection of the overall problem-solving method (PSM): I: Identify the issues and circumstances, D: define goals and the nature of the issue. E: Examine options and tactics, A: anticipate the effects and take action. L: look back your prior learning as a foundation for acquiring social and living skills. (Branford &Stein, 1993).

The literature review shows that problem-solving methods are effective in developing metacognitive knowledge at the secondary school level. Studies indicate that problem-solving instruction helps students develop metacognitive skills such as self-awareness, self-regulation, and self-evaluation. Moreover, problem-solving instruction helps students develop critical thinking skills, creativity, and decision-making skills. The literature review suggests that the use of problem-solving methods in teaching can have a positive impact on students' academic performance and can contribute to their success in various disciplines.

Specific objective of the study was:

1. To compare the metacognitive knowledge of students taught through problem solving method and lecture method.

**Hypotheses of the Study**

1. \( H_01: \) There is no significant difference in Declarative knowledge of students taught through PSM and lecture method.
2. \( H_02: \) There is no significant difference in the Procedural knowledge of students taught through PSM and lecture method.
3. \( H_03: \) There is no significant difference in the Conditional knowledge of students taught through PSM and lecture method.
METHODODOLOGY

This study was experimental in nature with true experimental design. The random assignment of subjects to the control and experimental groups is a requirement of a true experimental design. Revised Metacognitive Assessment Inventory was used as Pre-test and post-tests. All 9th –grader students in District Rahim Yar Khan enrolled in general science were population of the study.

Revised Metacognitive Assessment Inventory (RMAI) was initially introduced by Schraw and Dennison (1994), but the most recent studies have done a lot of work on it. The results of recent research (Terlecki & McMahon, 2018) demonstrated that the revised Metacognitive Assessment Inventory was useful as a pre- and post-test tool to gauge the students' growth in metacognition. Each inventory contained a five-point Likert measure with the choices "Always" to "Not at all."

The sample for the research consisted of 120 9th grade students, 60 were taken from Government girls secondary school Khan Pur and 60 from Government boys secondary school in 9th grade. These schools were chosen at random from the region. Each school's 60 pupils were split into control and experimental groups. 30 students were chosen randomly. Hence:

1. Control Group: Boys - 30, Girls - 30, Total - 60
2. Experimental Group: Boys - 30, Girls - 30, Total - 60
3. Grand Total: Boys - 60, Girls - 60, Total - 120

DATA ANALYSIS

The data was analyzed using an independent samples t-test in accordance with the study's objectives to compare the mean metacognitive knowledge scores of the girls and boys in both groups. The experimental group received PSM instruction as a form of treatment, while the control group received routine lecture instruction.

The mean post-test scores of the control and experimental groups were compared using the independent samples t-test to ascertain which group performed best based on the post-test results.

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<th>Type of test</th>
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<th>SD</th>
<th>df</th>
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Note: Dec: Declarative, Pro: Procedural, Cond: Conditional

Level of Significance α .05

Table I Indicates posttests comparison of control and experimental groups on Metacognitive Knowledge i.e. declarative, procedural and conditional knowledge.

Declarative Knowledge

According to the comparison between posttests of control and experiment groups, control group (N=60, M = 10.1, S.D.= 1.4), experimental group (N=60, M=23.3, S.D.=.8) and t-value = -67.62, at p= .00, As p value is less than α.05 the null hypothesis is rejected, confirming a significant difference between posttests of control and experimental groups taught through
traditional and PSM. The difference in mean scores of both tests show a prominent increase in the declarative knowledge of the students taught through PSM.

**Procedural Knowledge**

According to the comparison between posttests of control and experimental experiment groups, control group (N=60, M = 5.1, S.D.= 1.1), experimental group (N=60, M=12.3 S.D=.9) and t-value = -44.12, at p=.00, As p value is less than α.05 the null hypothesis is rejected, confirming a significant difference between posttests of control and experimental groups taught through traditional and PSM. The difference in mean scores of both tests show a prominent increase in the procedural knowledge of the students taught through PSM.

**Conditional Knowledge**

According to the comparison between posttests of control and experimental experiment groups, control group (N=60, M = 7.1, S.D.=.8), experimental group (N=60, M=16.5, S.D.=.5) and t-value = -76.2, at p=.00, As p value is less than α.05 the null hypothesis is rejected, confirming a significant difference between posttests of control and experimental groups taught through traditional and PSM. The difference in mean scores of both tests shows a prominent increase in the conditional knowledge of the students taught through PSM.

**Knowledge about Cognition**

According to the comparison between posttests of control and experimental experiment groups, control group (N=60, M = 22.4, S.D.=1.9), experimental group (N=60, M=52.2, S.D.=1.8) and t-value = -90.25, at p=.00, As p value is less than α.05 the null hypothesis is rejected, confirming a significant difference between posttests of control and experimental groups taught through traditional and PSM. The difference in mean scores of both tests show a prominent increase in the knowledge about cognition of the students taught through PSM.

**CONCLUSION**

According to the study, students who were taught using the PSM method had greater gains in declarative, procedural, and conditional metacognitive knowledge than those who were taught using the lecture method. As a result, it demonstrates how training with PSM promotes the development of metacognitive knowledge. Teachers of secondary school students are encouraged to use PSM to plan and teach their lessons, particularly when they come to teach science subjects, as PSM focuses on metacognitive skills.

**DISCUSSIONS**

The fundamental goal of education and learning is to concentrate on in-depth study in order to develop higher order thinking skills for exploring new horizons of lifelong learning. However, typically, teachers use the lecture method of instruction and only care about getting the students to retain the subject material, not their conceptual understanding. The most recent study shows that secondary school students struggle with conceptual learning outcomes. Unfortunately, Pakistan's teachers are unable to address the wide range of problems raised by the pupils using the current teaching methods and strategies. Lecture is currently the most popular teaching method.

Metacognitive skills are much needed skills of the time; these are the highest level of human thinking skills on how to keep an eye on self-thinking process through which someone can rectify him/herself without depending on the others to solve his problems. Metacognitive skills include metacognitive knowledge and regulation of cognition. Learning through problem solving may increase the self-assurance and confidence of a learner and lead to improve metacognitive skills.

The analyses depend on quantitative data. The data analysis clearly demonstrated that students of experimental groups taught through problem solving method made significant progress in the post test than control group with respect to metacognitive knowledge i.e. declarative knowledge, procedural knowledge and conditional knowledge. Findings of the current study are supported by the research of Idawati, Setyosari, Kuswandi, & Ulfia (2020) that problem solving method can develop metacognitive knowledge better than lecture method. Haryani, Wijayati, & Kurniawan (2018) also reported that the problem-based learning method improves students’ metacognitive knowledge greatly.

According to Song & Park's (2017) research, PSM should be widely used by teachers to encourage students to continue believing in themselves and organizing the information at their disposal in order to find solutions to problems on their own. The knowledge provided here will serve as a starting point for the students as they acquire new skills. Some studies have contradictory findings regarding the major impact of the problem-based learning approach on metacognitive abilities and criticize the application of this method (Ramadhani, Huda & Umam, 2019). It may be due to the difference of ground realities in local setting.

The current research came to the conclusion that PSM has a significant impact on cognitive skills. The research by (Muhlisin, Susilo, Amin & Rohman, 2018) supports the idea that by using a method, anyone who is clear on their learning goals can quickly find the most effective ways to carry out the task at hand, assess their progress as they go, and develop their metacognitive abilities. The current research further confirmed that the effect of a lecture-based teaching approach was only
marginally favorable in terms of metacognitive knowledge and its constituent parts of declarative and conditional knowledge, but it was least favorable in terms of procedural knowledge.

**RECOMMENDATIONS**

It is advised that secondary school teachers be made aware of the advantages of PSM over the lecture method because the research found that students instructed using PSM improved more metacognitive knowledge than students instructed using the lecture method. They could receive training in this approach to help secondary school students in the teaching of science topics to develop their metacognitive skills.

**CREDIT AUTHOR STATEMENT, ***

**Ali Abbas Sajid:** Conceptualization, Methodology, Software, Data curation, Writing- Original draft preparation. **Dr. Sidra Rizwan:** Supervising, Visualization, Investigation, Reviewing and Editing

**COMPLIANCE WITH ETHICAL STANDARDS:**

It is declared that all authors don’t have any conflict of interest. Furthermore, informed consent was obtained from all individual participants included in the study.

**REFERENCES**


