P-ISSN 2664-0422	Pakistan Social Sciences Review	October-Dec 2024, Vol. 8, No. 4
O-ISSN 2664-0430	https://doi.org/10.35484/pssr.2024(8-IV)04	[39-49]

Pakistan Social Sciences Review
www.pssr.org.pk

RESEARCH PAPER

Effect of Reflective Learning Practices on Critical Thinking Skills and Motivation of Undergraduate Students

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ABSTRACT

The Partnership for 21st Century Skills emphasizes the importance of reflective practices to develop critical thinking skills and motivation in students. The aim of this study was to examine the effect of reflective learning practices on undergraduate students' critical thinking skills and motivation during chemistry course. In this study, a quasi-experimental design with one group pretest-posttest was applied, using convenience sampling to select a study group of 30 undergraduate students. In the experimental group, reflective learning practices were implemented. DOT-CCTTv3 (Danczak-Overton-Thompson Chemistry Critical Thinking Test) was used as the data collection tool. IMMS questionnaire was also used to get feedback about reflective learning practices in classroom and to what extent these practices affect their motivation. Descriptive statistical techniques such as mean and standard deviation were calculated, paired sample t test was used to determine the mean difference between the pretest and posttest scores of the groups. This difference was found to be in favor of the experimental group. In the study, when the pretest and posttest scores of the experimental group were checked, a significant difference was found between the DOT-CCTTv3 pretest and posttest mean scores. The results of IMMS questionnaire showed that all four factors greatly affect the motivation of students after reflective learning practices. Based on these finding, it is concluded that reflective learning practices have a positive effect on students' critical thinking skills and motivation. It is recommended that in regular curricula of schools reflective learning practices should be practiced including, reflective dialogue, group discussions, self- evaluation, thinking aloud for enhancing critical thinking learning comprehension among students. To keep students engaged and motivated throughout the course, teachers should ensure that they use problem-based approach, and developments in real life.

KEYWORDS 21st Century Skills, Critical Thinking, Motivation, Reflection, Reflective Learning

Introduction

The distinctive feature of humanity is their exceptional thinking skills (Spiller & Tuten, 2015). The educational community has long acknowledged the need to expose students to instructional situations that foster higher-order critical thinking that involves analyzing and evaluating various perspectives and ideas to arrive at more informed decisions and reflective practices necessary for life-long learning (Carlson, 2013). An ideal learning environment is one that is engaging and stimulating, since it encourages active participation from students in the learning process. This involves identifying and

addressing problems that arise from course conversations, allowing each student to assess the quality of their learning. Reflection is a cognitive process that frequently comprises the act of examining an event, experience, or idea, followed by a critical analysis. This process facilitates the learner in deriving meaning from their experiences and subsequently applying this comprehension to future encounters (Larrivee, 2017). It leads to a greater understanding of oneself, others, and society. The modern world has witnessed considerable improvements in scientific and technical domains across various areas of life. In the field of chemistry education, the significance of reflective learning cannot be overstated. Various strategies serve an essential part in facilitating students' ability to engage in reflection. Among these strategies, "Writing" stands out as a particularly effective means for students to articulate, investigate, structure, and consider their thoughts (Freeman & Horney, 2016).

According to Whitten and Brahmasrene (2011), critical thinking is a cognitive strategy that enhances problem-solving and decision-making abilities. Students should prioritize developing their thinking skills as a first step towards adjusting to the college learning environment. It is essential to enhance the cognitive abilities of new students at the earliest opportunity by introducing them with and providing them with a learning approach that promotes critical thinking and problem-solving, rather than simply asking what. The purpose of engaging in the thinking process of why and how is to facilitate the development of critical thinking skills, meaningful knowledge acquisition, and the application of knowledge to real-life situations. Motivation is a psychological term that stems from the desire to want something and provide fuel as the drive to continue pursuing the desire. Rapiudin (2019) stated that another scholar also agreed that motivation is one of the factors of learning. Some scholars also reinforced and cited that the reason for doing something often derives from the motivation itself (Par ikka, 2019). Scholars have also confirmed that motive underlies when someone is motivated to achieve their goals or obtain rewards using their own effort (Rapiudin, 2019). There are also some scholars who also believe that the expectation of rewards or pleasant consequences that might happen due to their hard work led students to do something or the motivation to do it (Brown, 2016). With regard to the psychological perspective, motivation refers to an internal process that activates, guides and maintains individuals' behavior over time (Slavin, 2019).

Critical thinking and reflective practices are additionally associated with motivation. Student motivation is essential for developing critical thinking skills and capacities, since it is a supportive condition like metacognition, as those lacking motivation are unlikely to exhibit critical thinking. Challenging exercises, particularly those focusing on higher order thinking skills, can considerably encourage students. Motivation can be accomplished by designing learning activities that attract students' attention, connect with their learning objectives, and give a sense of confidence and fulfillment (Allen & Woolfolk, 2019). Since the use of reflective learning practices is not common in Pakistan, this study is an attempt to see the possibility of its implementation, through a small-scale experiment, in Pakistani chemistry classroom.

Literature Review

John Dewey (1933) is renowned for his use of reflection in theoretical literature. Reflective thought involves actively studying opinions or knowledge considering its premises and conclusions. Reflection aids individuals in comprehending and enhancing an expanding knowledge base. By adopting reflective cognition, individuals convert appetitive, blind, and impulsive actions into intellectual action, improving their learning

and knowledge. Knowledge is a constant process impacted by its interaction with experience and conscious critical thought (Kinsella, 2007; Moon, 2004).

Reflection on Experience

Kolb's contributions had a major influence on the contemporary understanding of experiential learning in adult education literature. This understanding has received attention in reflection literature. Without this time, learning may not be informed or lasting. In the professional world, practitioners often follow technical rationality, adhering to positivistic notions of natural scientific measurement and approach. This allows for informed and lasting learning experiences (Schon, 1983).

Reflection as Metacognition

In adult education, learning often involves problem-solving, requiring students to engage in a problem-solving process. This approach encourages responsibility, requiring learners to take ownership of their learning rather than passively receiving knowledge (Lindeman & Knowles, 2001). Reflection helps analyze views and assumptions, fostering a more active and effective learning experience. Learning, as emphasized by Jack Mezirow and other thinkers, is a process that involves reflection and problem-solving, enhancing overall learning outcomes (Reynolds & Vince, 2004). Mezirow and Loughran emphasize the importance of reflection in understanding problem content and problem-solving processes.

A learning model is essential for constructing learning scenarios that involve reflection and activities. A reflective learning model emphasizes self-reflection, past experiences, and future intentions (Morrow, 2009). It encourages academic imagination and helps students understand phenomena in their surrounding areas. This model helps students construct learning scenarios that involve reflection and activities, enhancing their understanding of the phenomena and events in their surroundings (Getz, 2008). Bain's reflective learning model comprises five levels of reflective thinking, known as the 5Rs frames: the process involves reporting, responding, relating, reasoning, and reconstructing (Bain, 2002). The reporting level is responsible for describing various situations, phenomena, symptoms, or problems. The responding level involves developing an emotional response to problems, while the relating level connects phenomena with theories. The reasoning level systematically explains events using facts and analogies, following problem-solving methodological concepts. The reconstructing level involves developing action plans based on theoretical perspectives and experience, allowing for a comprehensive understanding of the problem.

The Assessment of Critical Thinking

Good teaching requires assessment that accurately reflects the objectives an educator wants students to achieve (Magno, 2013). Traditional assessment methods, like summative exams and expository laboratory reports, are limited in evaluating students' critical thinking skills. A study of over 80 chemistry tests in the UK and Australia found that 90% of questions were algorithmic, with familiar methods and closed-ended responses (Bennett, 2008). Domin's 1999 content analysis of 13 standard chemistry laboratory manuals revealed that students primarily used lower levels of Bloom's taxonomy in laboratory activities, rather than higher cognitive abilities like analysis, synthesis, and assessment (Ramirez, 2021). Bennett (2008) found that students became skilled in closed problem-solving skills, but their capacity to solve issues with incomplete

data, foreign methodologies, and open-ended outcomes remained under-assessed (Thomas, 2015).

Educators have been utilizing various strategies and evaluation systems to enhance students' critical thinking skills. Flynn (2011) utilized clickers in large, flipped classrooms with 200 to 500 chemistry students to teach problem-solving and critical thinking by providing real examples of complex organic compounds with various retrosynthetic techniques. Students were asked to propose a retrosynthetic pathway and reagents for their strategy, despite the declarative nature of their thinking and lack of data to support critical thinking development. The authors believed the complexity of challenges and diverse approaches represented critical thinking.Motivation is a multifaceted concept involving beliefs, perceptions, values, interests, and actions. It can be influenced by cognitive behaviors or non-cognitive aspects. Academic motivation is characterized by enjoyment of learning, mastery orientation, curiosity, persistence, and challenging tasks. Cognitive engagement involves voluntary use of self-regulated learning strategies, such as attention, connection, planning, and monitoring (Turner, 2023).

The ARCS model, which stands for Attention, Relevance, Confidence, and Satisfaction, is considered the best technique for improving motivation. To effectively engage learners, it is important to attract their attention and keep them involved in the learning process. Relevance and related experiences are essential, as is confidence, which is linked to the learner's expectations and interests. Motivation significantly impacts educational processes, with age, personality, and motivation being the three major factors influencing knowledge acquisition (Cook, 2000). Teachers significantly impact students' motivation levels, influencing teaching styles, course structure, assignments, and interaction.

The literature review was conducted on critical thinking, reflective learning, and chemistry education to design reflective learning activities (Colley, Bilics & Lerch, 2012; Kramarski et al., 2013; Lan, 2007; Taggart & Wilson, 2005). The study examines successful strategies in chemistry education, including writing, journal writing, group discussion, reflective dialogue, self-evaluation, and thinking aloud. These strategies direct students to think, discuss, question, and develop problem-solving skills, focusing on the use of these practices in chemistry education. After determining the practices to be implemented, the researcher designed structured materials to effectively manage the reflective learning process.

The findings of successful research were analyzed for their application in the editing of reflective learning materials (Brockbank & McGill, 2006; Kohen & Kramarski, 2012; Lan, 2007; Mevarech & Kramarski, 2014; Michalsky & Kramarski; 2015; Mitchell & Coltrinari, 2001; Taggart & Wilson, 2005; Wilson & Jan, 1993). In the direction of these research, the design of journal, group discussion form, reflective dialogue form, and self-evaluation form materials was made for the implementation of reflective learning practices. The reflective activities were based on the second-year inorganic chemistry course, covering topics such as environmental chemistry, analytical chemistry, and biochemistry.

Material and Methods

In this quasi-experimental research, quantitative approaches of data gathering were applied. Dörnyei (2007) believes that the quantitative data gathering tools may be effective for an experimental study since it may demonstrate a clear cause-effect

relationship. The study employed a one group pretest and posttest design because the purpose of this research was to assess the effectiveness of reflective learning practices in a specific group, and it also allows researcher to evaluate the changes within the same group over time. Therefore, a pretest and a posttest were employed for data collecting from treatment group. In addition, a structured questionnaire was also used to gather the data of the students about the usage of reflective practices in classroom and to what extent these practices effect their motivation.

Sampling

The sample of this research was undergraduate students of science in Government Degree College for Women in Raiwind, Lahore. There are 30 female students of BSc chemistry (Part II) with the ages ranging from 18-20 years old, that were assigned as samples in this research.

Instrumentation

Pretest and posttest were employed as the key tools for this study. Pretest helped the researcher to know the level of students' critical thinking in chemistry so that the effect of the treatment could be calculated clearly. After the experiment was over, data from a posttest was used to measure the critical thinking abilities of the students. The researcher adopted and utilized DOT-CCTT v3 (Danczak-Overton-Thompson Chemistry Critical Thinking Test) which was developed by Danczak, Overton and Thompson at Monash University, Australia in 2017, as a pretest and posttest. The DOT-CCTT consisted of 30 multiple choice questions, separated into five sections: Making Assumptions, Developing Hypotheses, Testing Hypotheses, Drawing Conclusion and Assessment of Argument. The test was presented in a paper-based style and the students responded to the multiple-choice questions directly onto the test. This test had five parts which had to be completed within 30 minutes. A total of 30 second year chemistry students attempted the DOT-CCTT. Rubric for the marking of pretests and posttests was available online.

Keller's Instructional Materials Motivation Survey (IMMS) questionnaire was also adapted and used to get the feedback of the treatment group about to what extent reflective learning practices motivate them. The IMMS, initially 36 5-point Likert-scale items, was reduced into 30 multiple choice questions after discussion and validation, focusing on the factors of attention, relevance, confidence, and satisfaction.

Data Analysis

Data obtained through pretest and posttest was also analyzed by measuring the mean score difference (by t-test) with the help of SPSS. The frequency and percentage scores of the participants' responses were used for analyzing the questionnaire data.

Results and Discussion

Pretest and Posttest Statistical Summary

The pretest mean score of the group was 11.86, the posttest mean score was 17.63. The Minimum and maximum scores of pretest (Min=2, Max=23) and posttest (Min=9, Max=29) also increase. There was a difference between the pretest and posttest mean scores of critical thinking test of the experimental group which increased to 17.63 from 11.86. The posttest scores exhibited the large standard deviation value (SD=5.30), indicating that students' responses were diverse across different questions within the posttest. However, the pretest scores have the low standard deviation value (SD=5.23),

indicating the least amount of variety in the students' responses. The results showed an increase in posttest mean scores of the experimental group which revealed the effectiveness of reflective learning practices. Table 1 shows the mean and standard deviation of both pretest and posttest.

Table 1
Summary of pretest and posttest statistics

Groups	N	Mean	Standard Deviation
Pretest	30	11.86	5.23
Posttest	30	17.63	5.30

The test scores for critical thinking clearly demonstrated a rise in posttest scores, indicating that the use of reflective learning practices was beneficial in educating students with the ability to think critically and effectively when resolving encountered situations.

Paired Samples T-Test

Furthermore: to see the statistically significant difference of the mean scores of experimental groups, a paired sample t-test was used.

Table 2
Paired samples t-test

Variable	Pretest		Post test		Mean Difference	t	p	Cohen's d
	Mean	SD	Mean	SD				
Critical thinking Test	11.86	5.23	17.63	5.30	-5.766	-11.13	.000	1.09

The results of paired sample t test indicates that the significance value is less than 0.05 (sig <0.05), demonstrating a significant difference between the pretest (M =11.86, t = -11.13, p = 0.000), and posttest values (M =17.63, t = -11.13, p = 0.000). Moreover, the effect size is large which shows the effectiveness of reflective learning practices which means that the hypothesis is rejected.

Table 3
Feedback of the students about learning through reflective learning practices

Variable	Items	Mean	Standard Deviation
Attention	8	4.23	0.337
Relevance	8	4.25	0.299
Confidence	8	4.04	0.410
Satisfaction	6	4.24	0.341

The ARCS model consists of four sub-factors, each with a different set of items. The "Attention" factor had 8 items, "Relevance" had 8 items, "Confidence" had 8 items, and "Satisfaction" had 6 items. The mean scores for "Attention" (M = 4.23), "Relevance" (M = 4.25), and "Satisfaction" (M = 4.24) were the highest and nearly the same. This indicates that students' attention, perception of relevance, and satisfaction with reflective learning practices positively influenced their motivation. A good but relatively low mean score than other factors was observed for "Confidence" (M = 4.04) which shows that the teacher may reassess the activities to enhance their positive impact on students' confidence.

Discussion

The findings of the study revealed that the chemistry course with reflective learning practices significantly improved students' critical thinking skills posttest scores compared to pretest scores. The mean scores of these indicators show a considerable

increase in posttest after reflective learning practices (Wulandari & Shofiyah, 2018). However, after implementing reflective practices, the students' proficiency in this area significantly improved (Shah & Levis, 2019). It means that students showed a positive impact on their critical thinking skills, indicating that a classroom environment with reflective learning practices positively influences their learning experience (Facione, 2018). This suggests that structured activities in classrooms can enhance students' critical thinking abilities.

The study found that in posttest students who excelled in making assumptions were more likely to develop hypotheses and analyze arguments. This aligns with Fortus' (2009) research, which demonstrated that making assumptions aids students in understanding problems and analyzing solutions. Students who can make reasonable assumptions are more likely to develop critical thinking and analytical skills, as a result enhancing their overall skill development (Saeger, 2020).

The low mean scores in hypothesis testing, conclusion making, and argument analysis contribute to difficulties in science learning, as the process is complex and time-consuming (Wackerly,2018). According to Bloom's taxonomy, some of the most difficult aspects of science are developing conclusions, testing hypotheses, and analyzing arguments (Malik, 2018). This gives rise to questions about how 21st century educational goals will be implemented in terms of university-level learning.

The findings of the study showed that writing and journal writing strategies effectively enhance critical thinking skills in students of experimental group, a conclusion supported by previous research (Fullana, 2016). Studies reveal that students in chemistry courses convey their reasoning, correctness of answers, and thinking processes through writing and engage in reflections regarding the chemistry learning process (Freeman et al., 2016). Suhaimi et al. (2016) found that journal writing in chemistry courses enhances students' communication and critical thinking skills by organizing their thoughts. In this study, focused group discussion was a key factor in enhancing students' critical thinking skills. King et al. (2013) and Gibson (2008) found that systematically structured group conversations significantly enhance critical thinking skills of students. Wulandari & Shofiyah (2018) stated that the intensity of the reflective discussion has a good impact on enhancing other students' skills, one of which is the ability to think critically. Research also indicates that students engage in critical reflection on their learning process through peer dialogues, questioning their knowledge and focusing on their activities significantly improved communication and thinking skills (Wille, 2017).

Colley et al. (2012) found that reflective learning environments are essential for educating individuals who think critically. The findings of this study align with previous research on the impact of reflective learning environments on critical thinking skills (Silva et al., 2016). This study revealed that students developed critical perspectives by analyzing peers, providing feedback, analyzing thoughts, interacting, and making statements in reflective learning groups, fostering a more collaborative and effective reflective learning environment.

The study found that attention and relevance were the most important factors influencing students' motivation during reflective learning practices. The reason for the highest score in attention and relevance indicates that the material was engaging and captivating, capturing students' interest due to its relevance to their needs (Leonard & Buss, 2016). According to Huang et al. (2010), a high satisfaction score is important because it shows that students believe their efforts were fairly rewarded for the learning

outcome. Bolliger et al. (2010) discovered that the satisfaction subscale had the lowest mean in their research, indicating a potential relationship between motivation and satisfaction. Confidence was the factor have good but relatively low mean score than other factors.

Small and Gluck (2017) found that the confidence subscale received the lowest mean in their study, which suggests that to improve these scores, teachers may revise reflective practices, add more interesting activities, maintain challenges, and ensure they aren't too difficult for students. Students generally wanted to stay in the experimental session and requested more time to study with this method of teaching. Students offered options in their responses to IMMS questions after the 5 (Strongly agree) mark to express their liking for reflective learning practices or agreement with statements or concerns. Some even included lines and questions on their intent to continue the course next year. The Chemistry curriculum (2018) was expected to foster high-level thinking skills, but the strategies, activities, and materials for enhancing these skills were not adequately included. Therefore, reflective learning activities are a valuable tool for fostering a student-centered environment and enhancing critical thinking skills.

Conclusions

Reflective learning is increasingly crucial for individual, organizational, and school success. Teachers may encourage students to display reflective abilities to create an effective learning environment. This approach encourages students to reflect on their learning experiences, relating lessons to their own lives and making sense of the material. It goes beyond passive learning, allowing students to step back and improve their critical thinking skills. This leads to the development of analysis, a higher order thinking skill, of their personal experiences. Reflective learning practices applied in the form of reflective dialogue, focused group discussion, self-evaluation and thinking aloud have a positive and significant impact on students' critical thinking skills. All the indicators had a low mean score in the pretest. After the application of reflective practices, the mean score of posttests for all indicators significantly increases. In the posttest, the highest mean score was found for making assumptions and developing hypotheses. The mean scores for three critical thinking indicators in chemistry classes were low: hypothesis testing, conclusion development, and argument analysis.

The study also examines the effect of a nine-week reflective learning practices course on students' motivation. The course aims to enhance their interest in reflective practices and motivation to solve problems based on real-world objects, thereby enhancing their learning experience. The study used the IMMS to measure students' motivation after a nine-week reflective learning course. Approximately ninety-seven percent of students showed positive responses regarding reflective practices. High scores were obtained in the attention, relevance, and satisfaction factors, indicating students felt good about the reflective activities in motivating and engaging classroom environment and the activities used in classroom were useful in studies and in real life. However, the confidence factor had relatively lower scores than other factors. These findings suggest that redesigning the course in future editions should consider these factors. Maintaining learners' interest in a material for nine weeks was challenging, and even in the last week, most students requested the continuation of the reflective learning course the next year.

Reflective learning is crucial for expert education as it encourages students to integrate theory with practice, understand the world from their own perspective, and make each life experience a new learning opportunity. It was observed that students were motivated and engaged when actively participating in classrooms, solving problems

based on real-life objects, so this research supports the possibility of designing and promoting reflective learning-based school courses. This study focused only on examining the effect of reflective learning practices on critical thinking skills and motivation of students. Therefore, it suggests that future research may investigate the combined effects of cooperative learning techniques and other reflective learning activities on academic achievement, self-regulation, metacognitive skills, and attitudes.

During the study, the teacher encountered challenges in managing technology. Therefore, it is recommended that to effectively implement reflective practices, teachers may possess technology and engineering knowledge to prepare activities, and to address any doubts about the objects of the study likely to appear during sessions.

Recommendations

1. It is recommended that in regular curricula of schools reflective learning practices should be practiced including, reflective dialogue, group discussions, self-evaluation, thinking aloud for enhancing critical thinking learning comprehension among students.

2. To keep students engaged and motivated throughout the course, teachers should ensure that they use problem-based approach, and developments in real life. This approach also employed makes students remain focused and even improves their chances of being able to associate whatever they are learning in class to real life situations.

3. Teachers should undertake further professional development when it comes to the use of technology and engineering to respond to the technological tools and undertakings in reflective learning sessions. This training will assist the teachers to overcome these issues in relation to use of technology in order to enhance their capacity in facilitating the students.

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