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The Effectiveness of Problem-based Physics learning strategies to enhance HOTS and Critical Thinking Skills of High School Students of NIS, Chemistry and Biology, Shymkent.

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Abstract

This study aimed to analyse whether the gain of student's creative thinking and High order thinking skills by using conventional learning and problem-based learning model; to analyse whether the gain of creative thinking and High order thinking skills of student's taught by the problem-based learning (PBL) model was better than conventional learning. , two groups of sixty Science NIS, Shymkent students from tenth grade participated in a controlled experiment with pre- and post-tests. The experiment included both a test of knowledge and an assessment of creative and critical thinking abilities. The sample of this research were taken by using class random sampling technique consisted of two classes. Class X-B was experimental class taught by problem-based learning model; Class X-D was control class taught by conventional learning. The instruments of the research were valid essay test of creative thinking and High order thinking skills. The data were analysed by using t-test. The results showed that: the average gain of student's creative thinking and High order thinking skills taught by conventional learning was in low level and the mean gain of student's creative thinking and High order thinking skills taught by problem-based learning model was in medium level. The average gain of student's creative thinking and High order thinking

skills taught by problem-based learning model was better than conventional learning. There was an effect of problem-based learning model on student's creative thinking and High order thinking skills.

We found PBL to be effective in improving the critical thinking and High order thinking skills ofthe students based on the result of the mean analysis, standard deviation, and t-test. The researchers recommend that problem-based learning may improve the level of critical thinking skills of the students and improve the teaching- learning process

Keywords: Problem Based Learning Model, Creative Thinking Ability, High order thinkingskills.

INTRODUCTION

Teachers, professors, lecturers, and other members of the academic staff always focus on the best practises when preparing students for their studies. According to Asio & Riego de Dios's (2019) analysis of what constitutes a qualified teacher, the ability to think creatively about how to instruct students is crucial. Today's classrooms are different from those of even a few decades ago. Teachers might be subjected to a wide variety of degraded experiences from their students. The worrying prevalence of student bullying of teachers has been highlighted in the literature (Asio & Gadia, 2019; Asio, 2018). Therefore, it is crucial to create a method that is botheffective and critical in imparting knowledge to students.

Teachers' ultimate goal, regardless of subject matter, is to instil critical thinking skills in their charges. The ancient Greek philosophers Plato and Aristotle are often credited as the earliest proponents of critical thinking. Critical thinking was a value that was emphasised by Dewey aswell.

The favourable effects of problem-based learning on pupils are supported by studies such as those conducted by Burris (2005) and Masek and Yamin (2011). Problem-based learning is amethod to multidisciplinary education, as described by Stentoft (2017).

Students in the 21st century should be able to demonstrate higher order thinking skills (HOTS)[1]. The cognitive domain's learning outcomes follow a hierarchical pattern of memory, comprehension, application, analysis, evaluation, and production [2]. Higher Order Thinking Skills (HOTS) refers to the final three tiers of human cognitive ability, as defined by Bloom's revised taxonomy [3].

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Solving a physics problem involves thinking analytically about a wide range of facts, concepts, and principles. Students' success in solving physics problems hinges on their ability to employ the most appropriate method for each unique situation. A learning strategy is a plan for how youwill go about acquiring the knowledge and skills you need [5].

How a pupil learns is the focus of constructivism. Important to the adoption of constructivists inthe classroom is the activity of pupils developing their own knowledge [6, 7].

Applying what students have learned in one context to another through the application of problem-solving skills encourages them to engage in higher-order thinking as they study [8,9,10,11,12,13]. There are certain strategies developed through studies of physics education that have been shown to boost students' HOTS-based constructivism. Students' HOTS in physicscan be improved through the use of learning strategies that actively engage students in the process of learning, such as the problem-solving strategy [4].

To solve a problem, one must be able to piece together relevant information from several sourcesin order to arrive at a workable solution [14]. Four steps make up the problem-solving process:

1) gaining insight into the issue at hand, 2) developing a strategy to address the issue at hand, 3) putting that strategy into action, and 4) checking back to make sure everything went as planned [15]. Students who have been taught problem-solving skills will be better equipped to deal with awide range of challenges [16].

Problem-based Learning

Both students and educators can benefit from Problem-based Learning in numerous ways. Evidence suggests that problem-based learning (PBL) can be an efficient learning strategy (Gorghiu, Draghicescu, Cristea, Petrescu & Gorghiu, 2014; Fatade, Mogari, & Arigbabu, 2013; Mustafa, 2016; Sindelar, 2010); has positive effects on teaching (Padmavathy & Mareesh, 2013);improves students' problem-solving abilities and sense of competence (Rokhmawati

Sungur and Tekkaya (2006) found that, in comparison to classes that used more traditional methods of instruction, those that used problem-based learning boosted students' motivation andengagement, helped them find greater meaning in their work, improved their analytical skills, and encouraged them to develop their own strategies for managing their own learning.

Furthermore, students develop a high sense of responsibility, originality, and resourcefulness

when they solve the task or problem on their own, as well as critical thinking, systematic workhabits that will serve them well into adulthood (Salandanan, 2012).

Sahin and Yorek (2009) find that, contrary to the findings of other studies, the PBL approach has no positive effect on students' accomplishment and expectations about physics and physics learning. PBL has been shown to have a small but favourable impact on students' attitudes, a finding corroborated by Demirel and Dagyar (2016). Both Anazifa (2017) and Djukri (2017) found the same thing: PBL had no noticeable influence on students' critical thinking. Dochy, Segers, van den Bossche, and Gijbels (2003) found that the claimed impacts of PBL varied across the three tiers of the knowledge hierarchy. Argaw, Haile, Ayalew, and Kuma (2017) contended that using PBL did not significantly increase student motivation.

Critical Thinking Skills

When it comes to elevating the standard of human capital, education is where it's at. Educators can help raise the standard of human resources by adapting curricula to meet the requirements of the times. The teachings of Greek philosophers like Socrates, Plato, and Aristotle inspired this idea (Staib, 2003; Burbach, Matkin, & Fritz, 2004). Utami, Saputro, Ashadi, Masykuri, and Widoretno (2017) assert that developing students' capacities for critical thinking should be an institution's top focus. Whitten and Brahmasrene (2011) discovered that when students were categorised by college type, high school GPA, high school rank, SAT verbal scores, SAT mathematical scores, gender, race, and major, there were significant variances and connections in critical thinking scores and its components. Female faculty members' ability to think critically in the classroom is influenced by the organization's learning culture (Sabri, Ilyas, & Amjad, 2015). A weak correlation was found between students' critical thinking attitudes and their ability to solve problems, according to research by Ozyurt (2015).

Nonetheless, research by Horenstein and Niu (2011) showed that same pedagogical interventions could have varying impacts depending on how they were implemented. These were used to identify student traits that indicated whether or not a teacher had observed pupils engaging in critical thinking. Solomon (2005) argues that contextual learning, information processing theory, and collaborative learning are the theoretical underpinnings of PBL. It produces people with higher-level problem-solving abilities.

Pagander and Read (2014) provided evidence that project-based learning (PBL) is grounded in

constructivism as a "student-centered" approach to instruction. Students are given more say in their learning by negotiating with teachers and focusing on where they are in the learning processrather than where they need to be. Therefore, these factors are weighted differently depending onthe task at hand. Socratic inquiry as a tool for problem-based learning is relevant to modern pedagogy, claims Orig (n.d.). A issue is a collection of related classroom questions. One questionwill act as a central conundrum around which others will form.

METHODOLOGY

Research Design

The study used an experimental method to test the effect of independent variables, referring to the opinion of Gall and Borg [17]. The study describes the level of critical thinking and HOTS ofstudents before and after applying the technique using formative evaluation like quizzes, group/pair exercises, and tangible outputs.

The researcher would like to find out if there is a clear manifestation of a relationship between the two variables. Moreover, if there shows such, it would be of a great addition to the research a community for having a study that is done.

The findings of this study would be helpful to a variety of professionals that may find the article reliable to some extent either in their own field or even just for a simple discussion and citation in research.

Respondents

There were 60 respondents from NIS, Shymkent. These respondents were from Grade X of the academic year 2021-2022. The researchers used a purposive sampling technique for the study.

2.3 Research Instrument

Aiken's V validity index is 0.82 and the reliability coefficient is 0.64 for the five essay exams used to evaluate students' HOTS, and for the thirty-one multiple-choice tests used to evaluate students' beginning abilities, the validity index is 0.82 and the reliability coefficient is 0.82. TheHOTS issue, adapted from the development research on HOTS by Haratua Tiur Maria S [26], was utilised as the testing instrument. The questions on a high-quality HOTS test should be moderately challenging at most, and their readability should be adequately tested to match the test's features.

The t-test was employed to analyse the survey data. Normality tests for all groups related to the treatment plan and homogeneity of variance tests are undertaken when analysis passes the test requirements. SPSS 17.0 was utilised for the analysis of the research data.

RESULTS AND DISCUSSION

The research data showed the results of student groups learning physics according to the treatment plan. The treatment group consisted of a group of students who learn by problem-solving strategies as an experiment group and who learn by rehearsal strategies as a control group. Recapitulation of students' HOTS as given in table 1.

Table 1. Recapitulation of Students Learning Outcomes Score

	HOTS Score Average	
	Pre-test	**Post-test**
Experiment Group	10,47	15,78
Control Group	10,96	13,22

As a result of evaluating the hypothesis with a t-test, it was discovered that the learning outcomes of students' problem-solving strategies are higher than those of rehearsal groups. Thiswas discovered after taking into consideration the prior knowledge of the students.

After accounting for students' prior knowledge and skill levels, the results of this study show that students who employ problem-solving techniques outperform those who employ rehearsal strategies in terms of HOTS as learning outcomes. When used to the study of Physics, the problem-solving technique enhances students' conceptual understanding and application of what

they have learned. Students are required to engage in continual reflection, the results of whichcan be used to inform and enhance their approaches to learning.

Furthermore, critical thinking is a process that requires organisation. Table 4 displays student performance on a variety of learning-related tasks, including analysis, evaluation, and creation.

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Table 2. Level of Students' Proficiency in the Pre-test

	A	E	C	Weighted Mean
Average Number of StudentsPercent	9.	8	9	9
	30.83	26.19	28.44	28.47%

*Legend: A-Analysis, E-Evaluation, C-Creativity

Pre-test results show that nine students (30.83%) demonstrated strength in the area of Analysis, whereas eight (26.19%) demonstrated strength in the area of Evaluation, and nine (28.44%) demonstrated strength in the area of Creativity.

The Impact on Students' Critical Thinking Skills

The Post-Test scores of 10th-grade Physics students who had used Problem-based learning todevelop their critical thinking skills were consistent with those of students who had not.

To determine if there was a discernible improvement in students' critical thinking abilities, we analysed their post-test scores and displayed the results in Table 7.

Table 3. Frequency and Percent Distribution of the Students' Scores in Post-test

Class Interval	Frequency	Percent	Descriptive Rating
19-24	8	29.63	Above Average
13-18	16	59.26	Average
7-12	3	11.11	Fair
Total	27	100	WM: 16.19

Sixteen students (or 59.26%) were deemed to be average, eight (or 29.63%) were deemed to beabove average, and three (11.11%) were deemed to be fair based on the post-test results.

The performance of the class was considered to be average, with a computed mean of 16.19 anda

standard deviation of 3.78. This demonstrates that students' critical thinking skills can be improved through the use of problem-based learning.

On the post-test (Table 8), 28 students, or 48.96% of the total class, performed the domains of learning. This is more than half of the class.

Learning through problem-solving as part of the journey towards knowledge physics as the process of finding solutions to difficulties in student activities; hence, the process of knowledgedevelopment begins with the presentation of a genuine physics problem or one that is connectedto everyday life. The stages of problem-solving, which include recognising the problem, developing a strategy for solving the problem, putting the plan into action, and evaluating the process of resolving the problem that has already been done, serve as a guide for the direction that the learning process takes. Some of the HOTS questions include pictures or diagrams to

make it simpler for students to comprehend the problem. When there are no images provided,students are tasked with presenting their solutions to the problem in the form of a physics diagram or picture. Previous research found that students who created pictures or sketches, as well as motion diagrams, during research were able to get higher scores than students who didnot [18]. This was the case regardless of the subject matter.

At the end of the class, the students were asked to reflect on the success of the plan and the implementation of the problem-solving process that has been done. This is where problem- solving solutions are revealed to the students. Students are encouraged to actively think about what they think and do during the learning process in order to generate physics problem-solvingtechniques that are most appropriate for themselves. Reflection is frequently done and is expected to provide positive habits for students to actively think about what they think and do during the learning process. According to the findings of the study conducted by Sucipto, Mustaji, and Maryono [19], which demonstrated that problem-solving is one of the learning strategies that can develop students' higher order thinking skills, this agrees with the findings ofthe study.

Students can become familiar with rehearsal tactics and choose ways that are believed to be beneficial for reading Physics instructional materials, which are offered to them. Reading comprehension requires the use of certain learning strategies, such as highlighting the most essential ideas in the passage, taking marginal notes about the most relevant ideas, or writing asummary of the reading material.

Encourage students to reflect on how well they are performing in their learning by thinking aboutthe effectiveness of the strategy that they have chosen and the way in which it will be implemented.

We also understand that critical thinking is a process that includes steps like analysis, assessment, and innovation. Wilder (2015) agreed that it is impossible to say that problem-basedlearning is more effective in expanding students' subject-matter expertise. Only about a third of the students in the class passed the test in all three areas. According to Utami, Saputro, Ashadi, Masykuri, and Widoretno (2017), people can make more informed judgements when they have the ability to analyse, synthesise, evaluate, etc.

The results of the students' quizzes during the formative assessment revealed a significant shift intheir scores, indicating an improvement in their critical thinking abilities. Student performance has improved as a direct result of problem-based learning, as seen by a notable rise in quiz scores. Wilder (2015) added support for the idea that learning through problems improves student performance in the classroom. Conceptual comprehension and practical application were more heavily weighted than rote memorization of facts. according to (Polanco, Calderon, & Delgado, 2004)

The findings of the students' post-tests are indicative of the improvement in their critical thinking skills as a result of the problem-based learning intervention. It went from having fair critical thinking skills to just average ones. This is further evidence that pupils' critical thinking skills improve through problem-based instruction. Problem-based learning, as suggested by Tarhan andAyyildiz (2015) and Schmidt, Rotgans, and Yew (2011), is an active learning strategy that produces high-quality new knowledge. From an initial one-third of the class, nearly half of the class now possesses mastery over the three domains (Analysis, Evaluation, and Creation) in terms of proficiency. The results of this study showed that problem-based learning is more successful than lecture and discussion methods of instruction. For instance, (Mergendoller, Maxwell, & Bellisimo, 2000)

There was a significant improvement in test scores between the study's beginning and end, as measured by the pre- and post-tests. According to the research of Sungur and Tekkaya (2006), problem-based learning is associated with improvements in students' ability to think critically, their awareness of their own cognitive processes, and their ability to self-regulate their learning.A similar finding—a large improvement in critical thinking across the board—was reported by Gholami, Moghadam, Mohammadipoor, Tarahi, Sak, Toulabi, and Pour (2016).

We used a t-test to compare the scores before and after the test to see if the differences were

statistically significant. Since the computed t-value of 14.618 is larger than the tabular t-value (atthe 0.05 level of confidence), there is a statistically significant difference between the scores.

Given these findings, it's clear that problem-based learning is preferable to the more traditional lecture and discussion method of training. For instance, (Mergendoller, Maxwell, & Bellisimo, 2000) The good effect of problem-based learning was also shown in a study by Kang, Kim, Kim,Oh, and Lee (2015).

CONCLUSION

We draw the following conclusions from the data presented:

1) Students' critical thinking skills were above average before the approach was introduced.
2) Students' critical thinking improved to an above-average level after adopting the strategy.
3) Students' HOTS are higher when they apply problem-solving tactics than when they rely on rehearsing for an exam, according to the study's findings.

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