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Enhancing Problem Solving Skills of Physics Students Through Student Team Achievement Division (STAD) at Secondary Level

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Original Article

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Keywords

STAD, Problem solving skill, Numerical Problems, Teaching of Physics, Experimental Research

Abstract

Traditional pedagogy is often critiqued for conventional teaching methods that prevent students from developing their problem-solving skills. Therefore, this study focused on investigating the effect of a STAD approach on the problem-solving skills of secondary level students in physics. Quasi Experiment was conducted to compare the STAD method (experimental group) with traditional teaching methods (control group). Experiment was performed in a selected school having at least two sections of tenth grade. There were 30 students in each section and sections were randomly assigned as experimental and control groups. A test constructed by researchers was used to measure problem-solving skills before and after the experiment. Materials such as work sheets, lesson plans, quizzes, and rewarding certificates were designed to implement STAD methodology in the physics classroom. The dependent variable, physics problem-solving skills, was measured using researcher constructed ten items test consisted of physics numerical. The same tool was used as both pre and post measurement of problem-solving skills. The statistics indicated that the students taught through STAD improved their problem-solving skills in numerical problems of physics compared to those who were taught through traditional method. Additionally, post-test performance of students in groups was significantly different and experimental group outperformed the control group in problem-solving skills. This study demonstrated that the STAD is an effective teaching strategy for enhancing problem-solving skills of students at secondary level while using content of physics numerical.

Introduction

Teaching methods are undergoing a significant transformation, with traditional approaches proving less effective in engaging students. The conventional methods are argued to not help students with the creative and problem-solving skills. These methods do not incorporate the 21st-century skills that are crucial for student cognitive development. Therefore, the adoption of unconventional teaching methods is needed to enhance the critical thinking ability and problem-solving skills among students (Sak, 2011). Problem-solving skills are important for enabling students to think critically and create effective solutions to various challenges they may encounter. Many researchers and teachers are using different methods for the improvement of problem-solving skills of learners. According to Salvin (2010) problem-solving skills are defined as a rational application of concepts to accomplish a definite goal. Therefore, it means that innovative learning strategies should be adopted in the classrooms to promote problem-solving skills in learners (Scherer & Beckmann, 2014).

Research has shown that problem-solving skills have a direct effect on academic achievement (Ghatak & Mittal, 2019). STAD is a method lying under the umbrella term of cooperative learning strategy that may help to enhance the problem-solving skills of learners. This method is effective for many subjects to promote achievements and engage learners, but here in this study it is proposed to check its effectiveness for enhancement of problem-solving skills using physics numerical.

Cooperative learning

In recent years cooperative learning technique is considered as strongly aligned with theory of social constructivism. According to Piaget, the learning process cannot happen in a vacuum but needs a social context. Morphew (2002) views constructivism is the most used model of learning in education. In cooperative learning, teachers organize students into small groups. Learners comprehend content by working on tasks in a group, while working in groups they help each other to accomplish tasks collectively. This model of cooperative learning is accepted across the globe and across the disciplines, and it is believed that under well-defined conditions, this method can improve achievement in a variety of subjects and grade levels (Wolfensberger & Canella, 2015). Group sizes vary from two to many. A group member can be allotted a single task, or they can be given several tasks. Assessment of groups can be individual based, based on the performance of the group, or simply require the group to work together.

The study conducted by Aninion and Alegre (2021) determined that cooperative learning showed effective results in secondary level students as a method for solving word problems. Cooperative learning strategies are focused to enhance collaboration, attitude, social skills and classroom interaction that may leads towards enhancement of engagement and motivation in learning. Hashmi (2020) investigated the motivation of students toward learning computer science. The motivational level and achievement of students toward learning computer science were higher in the test as compared to the pre-test, indicating enhanced motivation for learning among the students.

STAD as Cooperative Learning Method

School and college teachers are inclined to use STAD in most school subjects, including mathematics, arts, language, and social studies. It is an applicable teaching method for various skills and subjects like geography, language, mathematics, computer sciences, and mechanics. This method is also valuable for teaching students from different ethnicities and backgrounds.

Slavin (1994) explained that in STAD, groups consisted of four students were formed using variation in performance level, gender, and culture. It primarily involves teacher lessons, student work, and assessments. The teacher delivers the lesson, working on the concepts and the content. Students are divided into groups and given tasks; they master the concept by helping each other (Garrett, 1989). The teacher acts as a facilitator, providing learning material and worksheets. After completing the tasks, students take quizzes. Students take individual quizzes without helping each other.

In this teaching method, a student score is compared to their previous test score. Based on improvement points, scores are summed. The scores of all students are collected to analyze the overall points of the team. Certificates are awarded to the groups that meet the criteria. This whole process takes four to five classes.

The main objective of learning in STAD is the enhancement of intellectual skills. The cooperative learning environment in STAD supports students in enhancing higher-order thinking skills. It has been observed that STAD activities promote active learning among students and positively affect their higher order thinking skills compared to traditional teaching methods (Kurniawan et al., 2020). The STAD learning model is particularly effective in improving the understanding of physics concepts at the college level (Henry et al., 2020).

In Pakistan, secondary level physics education faces challenges due to reliance on conventional teaching methods, leading to a focus on rote memorization. Several studies indicated that students face challenges in applying higher order thinking skills, particularly in solving numerical problems in physics (Docktor & Hellar, 2009; Zaman, 2020; Khan et.al., 2019). The conventional teaching methods prevalent in Pakistani institutions for teaching physics are criticized for their limited effectiveness in developing student's conceptual understanding and problem-solving abilities (Halai & Khan, 2011; Ali, 2011). As a result, students show undermining results in physics (Khan et al., 2016) and find difficulty in solving physics word problems (Zaman, 2020). Students lag in showing good problem-solving skills at college and university level. There is a dire need to explore ways to improve problem-solving skills.

Cooperative learning, especially STAD method, has been shown to promote deeper understanding and better retention of knowledge by fostering cooperative and collaborative learning. However, there is a need for empirical evidence to support the effectiveness of STAD specifically in the context of secondary-level physics learning.

The inadequacy of conventional methods has broader implications, suggesting a gap in producing graduates with innovation and problem-solving skills. Therefore, there is a prominent gap to improve, elevate problem-solving skills in students. Based on this scope, the researchers are interested in studying the effect of the STAD method on problem-solving skills of secondary students in Physics.

Rationale

Research studies indicate that lecture method and demonstration method are the commonly used techniques for teaching of Physics. Consequently, this leads to a deficient comprehension of concepts and poor analytical and reasoning skills in physics. In this context, it is a prime need for investigating the cooperative learning STAD method. Previous research studies have consistently shown that the STAD method as compared to the traditional methods, is more effective in developing high achievement, attitude, motivation, and higher-order thinking skills. Furthermore,

STAD as a cooperative learning strategy may be helpful in developing problem-solving ability of the learners. Therefore, this experimental study focused to investigate the effect of the STAD method on the problem-solving skills of 10^{th}-grade physics students. This study comprised only on problem-solving skills of the students in the subject of Physics.

Objective of the study

This research study was aimed to investigate the effect of STAD on the problem-solving skills of students in the learning of physics at the secondary level.

Hypothesis of the Study

H_0: There is no significant difference between mean scores of groups using STAD and traditional method while learning physics numerical at secondary level.

Methodology

An experimental study using quasi-experimental design to achieve the objective was conducted. All the secondary level students in the Science Group, aged 14 to 17, constituted the population of the study. A random selection of one school with over 60 students and two sections in grade X was chosen to ensure an adequate sample size. A numerical based test was used as pre- test and post- test. Both control and experimental groups were taught at same time, STAD was used for experimental group whereas traditional teaching method was employed for control group. Salvin (2010) technique for the implementation of STAD was followed. The key components of STAD method are heterogeneous teams, common team goal, team learning and worksheets, quizzes and team rewards.

This study was carried out for eight weeks. Content was taken from the Grade 10^{th} physics textbook based on National Curriculum 2016. Both groups were taught the same curriculum. For the intervention, grouping for implementation of STAD was performed based on pre-test scores of experimental group learners. Four students were taken in each group: each STAD group consisted of a high achiever, two average achievers and a low achiever learner. Learners were briefed about using the material and working in groups cooperatively. Students discussed the learning material in groups and solved the numerical problems together. The teacher observed the activities and acted as a facilitator.

Each week was divided into two days of discussion on concepts, one day solving worksheets within the groups, one day for a quiz, and one day for reflection on the quiz. Students discussed the new concepts for two days. On the other day, they solved worksheets based on numerical problems within the groups, working cooperatively and helping each other. After mastering the material, the teacher arranged an inter – group competition by using quizzes. Students attempted quizzes individually; they were not allowed to help each other. Quick scoring of the individuals and the calculation of the overall group score was conducted based on the sum of individuals improvement points (Salvin, 1995). The best group was awarded certificates based on their scores.

After the experimentation process, a post-test prepared by the researchers was used. The test was designed by following four major steps: designing the test, trialing the test, revising the test, and further preparing the test. Questions were based on the application level of Blooms Taxonomy. Ten numerical problems were given in the test, which had not been previously discussed in class. The test was piloted on twenty students at another school and validated by ten physics experts. The pre-test and post-test were the same.

The scoring rubric focused on indicators such as problem comprehension, strategy planning, implementation, and result evaluation. Data analysis was performed using independent sample t-test to compare the mean scores of the experimental and control groups.

Data Analysis and Results

At the beginning, groups were compared based on pre-test scores to check whether the groups were equal or not at the start of the experiment. For this purpose, t-test was used, and summary is presented in the table below.

Table 1.

Summary of Comparison of Groups before experiment

Groups	N	Pre-test Mean	SD	*df*	t- value	p-value
Experimental	30	3.23	3.97			
				58	0.38	0.70
Control	30	3.60	3.38			

$p<0.05$

The above table indicates that the p-value is greater than 0.05. It is significant to accept the null hypotheses of no difference. It means that groups were equal regarding problem-solving ability before the start of experiment. Although there was minor difference in the mean scores of the groups, it was not statistically significant so, groups were assumed equal regarding problem-solving ability at the start of the experiment. This is also highlighted in the figure below.

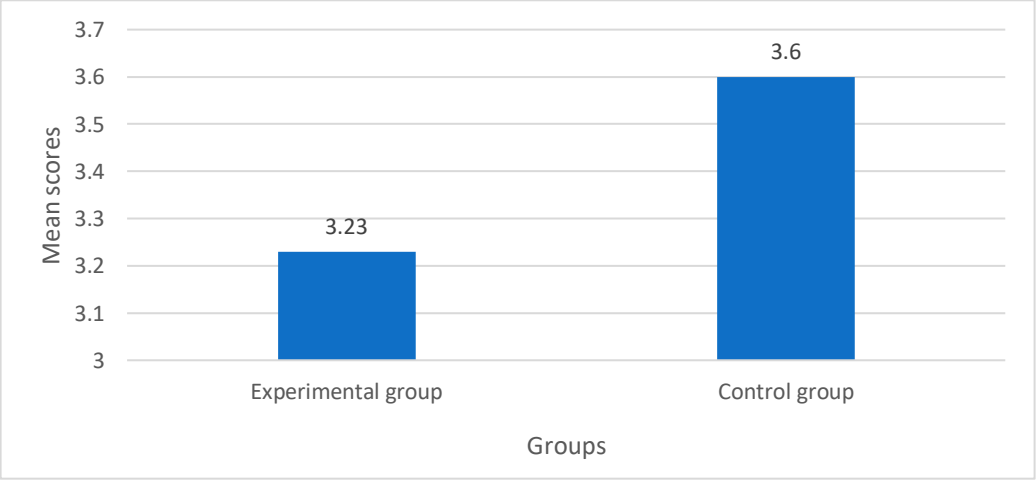

Figure 1. Graphical Representation of Comparison of Groups before Experiment

Figure 1 above shows that mean scores of experimental and control groups were very close and low on the test measuring problem-solving skill before the start of experiment. After the intervention of eight weeks, treatment of experimental group using STAD and control group by traditional method to teach physics numerical. A post-test to measure problem-solving skills was conducted. Again, the analysis of post test scores was done by using t-statistics to compare the scores. The summary of the analysis is presented below.

Table 2.

Summary of comparison of groups after treatment

Group	N	Post Test Means	SD	*df*	t-value	p-value
Experimental	30	46.76	14.00			
				58	9.94	0.00
Control	30	15.86	9.70			

$p<0.05$

The above table 2 indicates that mean scores of both groups are significantly different with t= 9.94 and p=0.00. This allowed to reject the null hypothesis that there is no difference between the mean scores of experimental and control groups after treatment. The higher mean score of experimental group shows that learners of experimental group were more skillful in solving problems as compared to learners taught through traditional method.

The difference in skill is an indication of the positive impact of the STAD method on problem-solving skills when it is combined with numerical of physics for 10 grade students. The following graph clarifies the difference created by the STAD method.

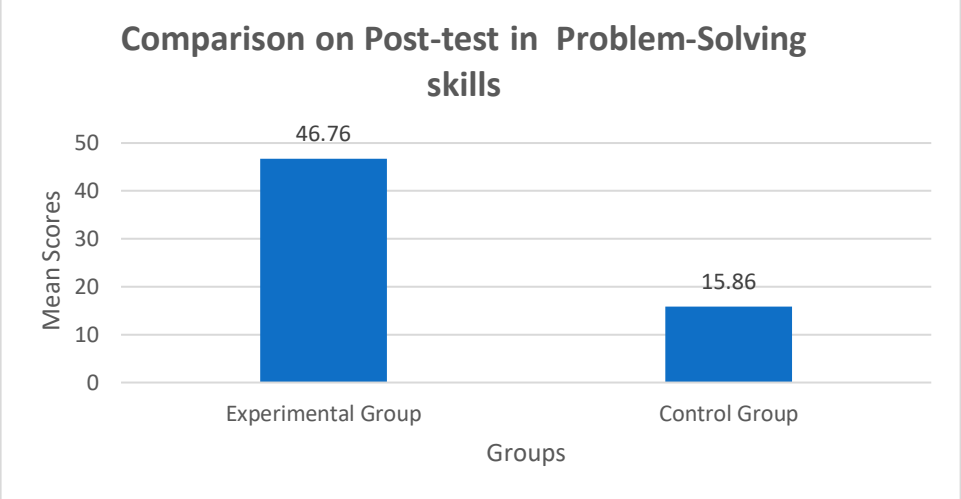

Figure 2. Graphical Representation of Comparison of Groups after Experiment

The post-test mean of experimental group as graphed above was too high as compared to post-test mean of control group. It shows that the experimental group outperformed the control group.

Discussion on Results

Preceding studies indicate that the STAD cooperative learning method can improve student's achievement, academic performance, learning, creative writing skills, efficacy, motivation, attitude, numerical ability and learning interest. This experimental study was conducted to find the effect of STAD teaching method on problem-solving skills of students in physics at the secondary level.

This investigation studied the increase of problem-solving ability through the STAD method of teaching. The experimental group taught with STAD has significant improvement in problem-solving skills, as evidenced by the data. The t- value (9.94) was greater at a 0.05 level of

significance. The mean score of problem-solving skills among the control group and the experimental group was 15.86 and 46.7, respectively. Participants taught with the STAD method exhibited higher problem-solving skills which shows similar results found in the improvement of word problem-solving in mathematics (Poore, 2008 & Aninion et al., 2021) and problem-solving ability in physics (Kaewvichit, 2021).

Problem-solving skills of participants in physics improved through the STAD cooperative teaching method. This experiment also showed that attributes of problem-solving skills, such as focusing on the problem, describing the problem, planning the strategy, implementing the plan, and evaluating the result, improved in the experimental group.

Problem-solving skills is one of basic higher order thinking skills. This study showed that students will be able to solve a Physics problem at the application level of Blooms Taxonomy. This finding aligns with the previous studies illustrated that the use of cooperative method can improve critical thinking skills, higher order thinking skills, comprehension, analysis, synthesis, and evaluation level (Sholikh et al., 2019, Kurniawan et al., 2020 & Lantajo et al., 2017).

The study showed that the overall score in post-test increased by using STAD method of teaching, indicating improved student learning. These findings reinforce the previous experiments which demonstrated that the cooperative learning method results in improved student learning (Hashmi et al., 2020; & Jabeen et al., 2020).

It was observed during the study that students participated in quizzes, completed worksheets, and actively participated in group work. This indicates that the STAD method fosters active learning, participation, and a positive attitude towards learning, similar of Desnita et al., (2021), Nureva et al., (2022), Majoka, (2010), Jack et al., (2021), Uno et al., (2019), Ocampo et al., (2015) and Wichhadee, (2005). The study shows that all students of experimental group performed exceptionally well in the tests, which aligns with the outcomes reported by Yaduvanshi et al, (2019). Additionally, it was observed that student's scores in quizzes improved after each lesson cycle with STAD. This finding is comparable to the studies by Hashmi et al., (2020), Kaewvichit, (2021), Marjo, (2022), Zahara, (2016) and Uno et al., (2019).

Conclusions

In conclusion, the use of STAD in secondary level classrooms has shown positive effects on students problem-solving skills when it was clubbed numerical of physics at 10^{th} grade. Students who are taught physics using the STAD method have been found to enhance their problem-solving abilities through teamwork, collaboration, and increased engagement in their learning. Students showed better results in problem-solving skills compared to those exposed to traditional method of teaching physics. Therefore, implementing the STAD method in secondary level classrooms can be beneficial in developing students' problem-solving skills, preparing them for future academic and professional success. The implementation of the STAD method in secondary level classrooms has been found to have a positive effect on students' problem-solving skills. Students who are exposed to the STAD method show improvement in their problem-solving abilities through teamwork and cooperation.

Significance of the Study

Most of the previous research in cooperative learning has focused on academic achievement, efficacy, attitude and motivation. This article reports the results of an investigation into problem-solving skill of students. The study adds to existing literature on cooperative learning and offers empirical evidence on the specific effect of STAD on problem-solving skills while using physics numerical as content. This study may prove helpful for teachers in introducing innovative and effective teaching strategies to enhance students' overall problem-solving skills. It unfolds a beneficial teaching strategy in the modern era for the development of higher order skills.

Recommendations

1. Teachers can be trained to use the STAD method by learning the elementary components of cooperative learning i.e. positive interdependence, equivalent participation, optimistic motivation, reinforcement, and peer-to-peer learning.

2. Comprehensive in-house training and in-service training may be conducted to train teachers in the use of the STAD method in science.

3. It is recommended that further research use STAD cooperative learning in a blended mode of learning.

4. Further research should also analyze the effect of the STAD method in combination with Problem Based Learning.

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