The Influence of Quantum Teaching on Problem-solving skills in the Context of Lifelong Learning

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Abstract. Quantum teaching states that the learning environment and learning media are designed to be able to provide knowledge that can be accepted by students. Quantum teaching also implies that every student^s learning efforts should be recognized and every achievement should be celebrated. These principles are in accordance with the principles of equitable and lifelong learning as stated in the Sustainable Development Goals. One of the skills for sustainable education and lifelong learning is problem-solving skills. However, students' problem-solving skills are still in the low category. This was found in class xi MIPA Senior High School 9 Garut, West Java, Indonesia through a preliminary study. The Researchers applied quantum teaching to overcome this problem. The research method used was quasi experiment with non-equivalent control group Design. The research population used was the entire class XI MIPA Senior High School 9 Garut consisting of 6 classes totaling 218 students. Researchers used cluster random sampling technique as a sampling consisting of 2 classes, namely XI MIPA 1 totaling 36 students as experimental class and XI MIPA 5 totaling 37 Students as the control class. The research instrument used was a problem-solving Ability essay test of 9 questions. The data analysis techniques used are t-test and N-gain test. Based on the results of t-test for post-test score and N-gain, at the 99,5% confidence level, the Quantum Teaching has a significant effect on problem-solving skills. In Addition, based on the N-gain results, it was found that the use of the quantum teaching can improve problem-solving skills by 0,65 in the medium category compared to Direct Instruction learning model which is 0.29 in the low category. Quantum teaching is influential because its learning activities stimulate students to be actively involved in problem solving steps, provide direct experience, and increase positive attitudes towards learning.

Keywords: Lifelong Learning, Problem solving skill, Quantum Teaching

Introduction

Quantum teaching states that the learning environment and learning media are designed to provide knowledge that can be accepted by students. Quantum teaching also implies that every student's learning effort should be recognized, and every achievement should be celebrated. These principles are in accordance with the principles of

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F. Khoerunnisa et al. (eds.), *Proceedings of the 9th Mathematics, Science, and Computer Science Education International Seminar (MSCEIS 2023)*, Advances in Social Science, Education and Humanities Research 860,
https://doi.org/10.2991/978-2-38476-283-5_19

equitable and lifelong learning as stated in the Sustainable Development Goals. One of the skills for sustainable education and lifelong learning is problem-solving skills.

Quantum teaching is a process that can change various kinds of interactions that include elements of effective learning in and around learning moments so that they can influence student success. These learning elements include freedom, comfort, interest, fun, and motivation [1]. These interactions are intended to transform students' skills acquired during learning into benefits for themselves and others [2-3]. Quantum Teaching is in accordance with the social constructivist learning theory. Social constructivism is a learning theory based on reflection on experience and interaction with others [4-7] According to [8-9], constructivism learning theory posits that students can express themselves independently and change complex information to verify new information. Social constructivism is a learning theory that emphasizes the importance of social interaction and cooperative learning when building cognitive and emotional images of reality [9-10]. Social constructivism is learning that is based on solving real-life problems that occur socially through shared experiences and discussions with other people so that new ideas are matched with existing knowledge [6]. Based on these opinions, it can be concluded that social constructivism is a learning approach based on problem-solving and emphasizes the role of social interaction and shared experience in the process of forming knowledge useful for problem-solving.

It is very important for high school students to have problem-solving skills in acquiring physics concepts because physics plays an important role in the development of technology and science. Therefore, physics can be considered the basic capital in forming good Human Resources (HR) to face the 21st century. According to [11-13], one of the competencies and/or skills that 21st-century HR must acquire to face the era of society 5.0 is problem-solving skills. This aligns with [14-15] who state that problem-solving skills are essential for the future, including in physics learning, the basis for which is why problem-solving is central to students' lives. According to [16-17], both university and high school students' physics problem-solving skills in Indonesia are still in the low category.

Before conducting research, researchers first conducted pre-research at Senior High School 9 Garut, West Java, Indonesia. Based on the results of an interview with one of the physics teachers, information was obtained that problem-solving skills at Senior High School 9 Garut were still relatively low. According to the teacher, students still have difficulty in determining the known data along with the requested data. Students lack understanding in identifying relevant concepts to solve problems. Concept identification needs to be done so that students can determine the appropriate equation and solve the problem correctly. Apart from that, according to the teacher, when they got the answers, they did not evaluate whether the answers they got were appropriate based on existing concepts or formulas as well as mathematical calculations.

Teaching activities that can help improve students' problem-solving skills are quantum teaching. One of the characteristics of quantum teaching is that it is oriented towards mastery and experience [18] as well as problem-solving skills [19]. In quantum teaching, there are several principles, one of which is that everything speaks and has a purpose. Quantum teaching encompasses everything from the environment, the teacher's appearance, body language, teaching aids, and learning plans, all of which contain purposeful learning and experience in solving a problem [20]. With sources and presentation of learning materials originating from the environment, based on the theory of situated learning, learning will become more contextual and assist learners in constructing knowledge and problem-solving processes. Through modeling processes [21-22] and the segmenting principle [23], the learning objectives in quantum teaching, which are focused and organized step by step to achieve problem-solving skills, will support a problem-solving learning environment and facilitate learners in acquiring the problem-solving process.

Previous research that applied quantum teaching to physics problem-solving skills [24], which showed that students' physics problem-solving skills were higher when using Quantum teaching. In line with the research results shows that quantum teaching influences learning activities and problem-solving skills [25]. Research [26] regarding the influence of Quantum Teaching on motivation and learning outcomes on substance stress material. The results of this research show that there is an influence of Quantum Teaching on student motivation and learning outcomes. Therefore, Quantum teaching can be used to increase students' activeness and low ability in solving physics problems. The purpose of using quantum teaching is as a learning process to gain knowledge so that students can become accustomed to and trained in solving problems in everyday life. Furthermore, the aim of this research is to determine the effect of quantum teaching on problem-solving skills and determine the quality of the changes based on the normalized gain category.

2 Method

This research uses a quasi-experimental method. The design used is a *non* -equivalent control group design. Nonequivalent control group design is a research design consisting of an experimental class and a control class. In this research design, the test was given twice before and after treatment. In this study, both groups were given a pre-test, then the experimental group was subjected to treatment in the form of quantum teaching, while the control group was subjected to treatment in the form of Direct Instruction. The syntax of quantum teaching consists of the phases: Cultivate, Experience, Name, Demonstrate, Repeat, and Celebrate. After that both groups were given a post-test.

The population in this study was class XI MIPA Senior High School 9 Garut, West Java, Indonesia with 6 classes containing 218 students. The population in this study is homogeneous and has relatively the same characteristics, indicated by the results of the Bartlett test calculation, namely $x^2_{count} = 0.55 < x^2_{table} = 16.7$. The sampling technique used in this research is cluster random sampling. In this research, the samples used were two classes consisting of the experimental class, namely class XI MIPA 1 (n = 36) and the control class, namely XI MIPA 5 (n = 37).

The research instrument used by researchers was a 9-question problem solving ability test. This test is structured in the form of an essay on traveling waves and stationary waves. The results of the problem solving ability test were evaluated based on the synthesis of [27-28], namely recognizing problems, designing strategies, implementing strategies, and evaluating solutions. The questions have been tested and declared valid ($r_{calculated}$: 0.365 – 0.553) and reliable (r_{11} : 0.725). Data analysis used t-test and n-gain.

3 Results and Discussion

This research was carried out at Senior High School 9 Garut in the even semester of the 2022/2023 academic year on traveling waves and stationary waves. Data obtained in the form of pre-test and post-test scores. The maximum test score is 90. Pre-test and post-test statistical data are presented in Table 1.

Table 1. Pre-test and post-test results of control and experimental classes

Statistics	Pre-Test Experiment (N = 36)	Control (N = 37)	Post-test Experiment (N = 36)	Control (N = 37)
Highest score	42	42	82	61
Lowest score	23	22	59	40
Average score	33.50	32.49	70.36	48.97
Variation standards	4.79	4.34	5.98	5.32
Variance	23	18.87	35.78	28.25

Table 1 shows that the pre-test standard deviation value in the experimental class is greater, namely 4.79, compared to 4.34 in the control class. This means that the pre-test data in the experimental class is more evenly distributed than in the control class. Apart from that, it is known that the pre-test variance value in the experimental class is greater, namely 23, compared to 18.87 in the control class. This means that the pre-test data in the experimental class is more varied than in the control class.

Based on Table 1, it is also known that the posttest standard deviation value in the experimental class is greater, namely 5.98, compared to 5.32 in the control class. This means that the post-test data in the experimental class is more evenly distributed than in the control class. In addition, variance calculations are carried out to determine the diversity of the data. It is also known that the post-test variance value in the experimental class is greater, namely 35.78, compared to 28.25 in the control class. This means that the post-test data in the experimental class is more varied than in the control class.

To determine the effect of quantum teaching on problem-solving skills, a hypothesis test was carried out using the t-test. The t test was used after it was stated that the data was normally distributed and homogeneous. The results of the t-test showed that the value of t_{hitung}: 16.46 > t_{tabel}: 2.66 with a confidence level of 99.5% so that the decision Ha was accepted. This means that based on the t test criteria, quantum teaching has an effect on students' problem-solving skills in traveling and stationary wave material in class XI MIPA Senior High School 9 Garut. Measuring the quality of improving problem-solving skills was carried out using analysis of the pre-test and post-test results for each class using N-gain. Analysis using N-gain shows that there are differences in the quality of N-gain improvement in the experimental class and the control class. In the experimental class, the N-gain was found to be 0.65, meaning there was an increase in problem-solving skills in the medium category. Meanwhile, in the control class, it was found that the increase in problem-solving skills that received Direct Instruction learning treatment was 0.29, which means a low increase.

Quantum teaching exerts a significant influence on the development of problem-solving skills. This impact stems from the inherent advantage of quantum teaching, where students are consistently encouraged to actively engage and tackle challenges throughout the learning process. According to [29], quantum teaching not only stimulates students' creativity but also serves as a motivational force, fostering sustained activity and proficiency in problem-solving. In addition, quantum teaching has a positive influence on students in problem-solving. In line with what [1] stated, one of the advantages of quantum teaching is instilling a positive attitude in students and avoiding negative views of learning material. With a positive outlook, students can more easily be involved in learning and problem-solving activities. Aligned with [30] research, it was observed that students' engagement and problem-solving aptitude saw an increase, with students expressing overwhelmingly positive responses following exposure to quantum teaching. This finding aligns with the conclusions drawn [25], emphasizing the impact of quantum teaching on both learning engagement and proficiency in problem-solving. Additionally, research findings indicate that quantum learning has the potential to enhance students' problem-solving skills [20].

Quantum teaching exerts an impact on problem-solving skills due to its alignment with the characteristics of social constructivism. Social constructivism, as articulated [8-9], entails individuals actively acquiring new knowledge through experiences and interactions with others. Consistent with the perspectives [31-32], students engage with teachers and peers, drawing on their life experiences to formulate strategies for addressing specific problems. Social constructivism places emphasis on active thinking and problem-solving skills, as noted [33-34], making learning more meaningful and enhancing student learning outcomes. Moreover, collaborative efforts among students, as emphasized [35-36], foster an environment that encourages the exploration of solutions to problems.

Activities in quantum teaching, namely Experience, Demonstrate, and Repeat, enable the teacher to assist students in constructing knowledge and engaging in modeling in the resolution of physics problems. Modeling problem-solving approaches will aid students in acquiring problem-solving skills [21-22]. In addition to the teacher's modeling of problem-solving, the acquisition of problem-solving skills by students is further reinforced during the Repeat phase. At this phase, problem-solving skills are trained by providing opportunities for students to repeat the material with group friends and work on practice questions. Students can independently practice the problem-solving process, followed by feedback from the teacher. By repeating learning activities, students get used to solving problems, but it can also strengthen students' memory for understanding the material This aligns with the use of retrieval practice, which can enhance problem-solving skills [37-38]. When the retrieval process occurs, the information taken from long-term memory will be reconstructed by the brain so that it can be used. In line with research [39-40], repetition of material can strengthen memory, thereby making students' cognitive structures stronger. However, it should be noted that retrieval practice conducted in the Repeat phase may not necessarily influence the acquisition of problem-solving skills from worked examples [41].

Quantum teaching includes demonstration activities that can help problem-solving skills in evaluating student understanding. In this activity, students present the process of a work tool to reach a conclusion based on the results of group work obtained in the previous learning stage. Demonstration activities were followed by discussions. Through group discussions, students can exchange ideas accompanied by providing guidance, so that students are able to interpret and understand the learning material [42]. The implementation of collaborative activities can enhance learning outcomes and reasoning skills [43]. Additionally, supplemented this by emphasizing that collaborative activities within a group [44], marked by joint responsibility and a well-defined structure with some flexibility to suit the needs of the groups, can effectively fostering collaboration, facilitate discussions and teamwork, and ultimately leading to the successful completion of complex assignments. In line with research [45] which states that discussion activities between groups can improve students' problem-solving skills.

The quantum teaching incorporates a "Celebrate" phase in its syntax, during which each student's efforts receive recognition and are celebrated through applause or commendation [29]. This feature contributes to the overall satisfaction and happiness of students engaged in learning activities, fostering active participation and a pursuit of optimal results. In quantum teaching, teachers acknowledge and celebrate each achievement, consistent with Thorndike's law of effect. This principle suggests that linking positive feelings or satisfaction with a student's response to stimuli enhances of learning success [10]. In accordance with research findings [46], the practice of offering positive praise within the framework of quantum teaching further yields positive impacts on students.

Students who have problem-solving skills can support the achievement of sustainable development goals related to education [47-49]. Sustainable education supports lifelong learning and equitable learning. Quantum teaching can support this through the principles on which it is based. The learning environment and media in quantum teaching must be designed to facilitate meaningful learning so that students can construct knowledge. Every student's learning outcomes need to be recognized and celebrated as a form of appreciation that can have an impact on their learning process.

4 Conclusion

Based on an array of research endeavors, comprehensive data analysis, and hypothesis testing, it can be concluded that quantum teaching significantly influences the problem-solving skills of students, specifically in comprehending topics related to traveling waves and stationary waves within the context of Class XI MIPA during the even semester at Senior High School 9 Garut, academic year 2022/2023. The results were obtained from hypothesis testing using the t-test, yielding a value of $t_{\text{calculted}}$: 16.46 > t_{table}: 2.66 with a confidence level of 99.5%. These findings are further supported by the normalized gain analysis of 0.65, indicating a moderate level of improvement in the quality of change. This assertion stems from the meticulous cultivation of each problem-solving indicator throughout the various stages of quantum teaching. Furthermore, quantum teaching exhibits inherent characteristics that contribute to the enhancement of students' problem-solving skills.

Physics educators are encouraged to consistently facilitate collaborative learning activities, fostering an environment where students engage in discussions with their peers, exchange opinions, and develop independence in exploring the subject matter. Teachers should acclimate students by presenting pertinent questions and providing suitable solutions based on the systematic steps of problem-solving, thereby nurturing proficient problem-solving skills.

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