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Performance of Quantum Learning Methods and Conventional Learning Methods Regarding Nuclear Power Plant Materials

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Abstrak— Tujuan penelitian ini memberikan deskripsi mengenai kinerja metode pembelajaran quantum learning dan metode pembelajaran konvensional terkait materi Pembangkit Listrik Tenaga Nuklir (PLTN). Metode yang digunakan dalam penelitian ini adalah penelitian semi eksperimen. Paradigma dalam penelitian ini menggunakan the static-group comparison design atau disebut juga the intac-group comparison design. Analisis data yang digunakan adalah pengujian hipotesis dengan jumlah jenjang terstrata Wilcoxon. Penelitian ini menyimpulkan bahwa kinerja metode quantum learning mempunyai kelebihan dalam pembelajaran untuk materi terkait dengan pembangkit listrik tenaga nuklir dibandingkan dengan kinerja metode konvensional. Kesimpulan ini didapatkan setelah dilakukan pengujian hipotesis dengan jumlah jenjang terstrata Wilcoxon, pengujian hipotesis yang dilakukan menolak hipotesis nihil dan menerima hipotesis alternative berdasarkan hasil perhitungan, nilai R adalah 54,50 dimana nilai tersebut lebih kecil daripada nilai R dalam tabel sebesar 61.

Kata Kunci — pembelajaran, PLTN, quantum learning, reactor nuklir

Abstract *- The purpose of this study is to provide a description of the performance of the quantum learning method and conventional learning methods related to Nuclear Power Plants (NPP). The method used in this research is semi-experimental research. The paradigm in this study uses the static-group comparison design or also called the intac-group comparison design. Analysis of the data used is hypothesis testing with the number of Wilcoxon stratified levels. This study concludes that the performance of the quantum learning method has advantages in learning for materials related to nuclear power plants compared to the performance of conventional methods. This conclusion was obtained after testing the hypothesis with the number of Wilcoxon stratified levels, the hypothesis testing was carried out to reject the null hypothesis and accept the alternative hypothesis based on the calculation results, the R value was 54.50 where the value was smaller than the R value in the table of 61.*

Keywords: Learning, Nuclear Power Plant, Quantum Learning, Nuclear Reactor

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1. INTRODUCTION

The learning process always involves interaction with each other, and the effectiveness of the learning outcomes becomes a very important discourse. The learning method needs to be understood by the teacher in order to be able to carry out learning effectively in improving learning outcomes. In its application, learning methods must be carried out according to student needs because each learning method has different goals, principles, and main pressures (Zahran, 2019).

The Quantum Learning learning model is a learning method used by teachers by using the power of ambak (what is the benefit for me), the right learning environment, fostering a winning attitude, freeing up learning styles, accelerating learning, and using music (Agusnanto, 2013; Fitri, 2020). According to De Porter (2010), the Quantum Learning learning method is a knowledge and learning methodology that creates an effective learning environment, designs curriculum, conveys content and learning strategies to facilitate a successful and effective teaching and learning process. This method has been used and developed in Quantum learning in Supercamp. Supercamp is a learning institution located in Kirkwood Meadows, State of California, United States. De Porter together with his friends Greg Simmons, Mike Hernachi, Mark Reardon, and Sarah Singer-Nourine programmed and planned to implement the ideas of Quantum Learning. Quantum learning is intended to help improve the life and career success of teenagers at home, and can achieve higher success in school (De Porter, 2010).

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The quantum learning model is a learning that converts energy into light, in this case it is said that quantum learning can create an effective learning environment, by using the elements that exist in students and their learning environment. Everything in the moment of learning will always interact like an integrated orchestra. In the learning process carried out in a fun atmosphere (playing while learning), they compete in groups and show the best skills so that they can motivate students to learn more enthusiastically. Barriers that hinder the natural process of learning through deliberate efforts. Elimination of learning barriers which means streamlining and accelerating the learning process can be done for example: through the use of music (to eliminate boredom while strengthening concentration through alpha conditions), visual equipment (to help students with strong visual abilities), appropriate materials and the presentation is adjusted to the way the brain works, and active involvement (intellectually, mentally, and emotionally) (Huda & Marhaeni, 2013).

Materials related to electrical energy, especially those related to Nuclear Power Centers, are materials that require a good understanding of concepts. The material contains many important principles that must be understood very clearly because a wrong understanding will lead to many wrong perceptions. So that it can make someone very anti against the construction of nuclear power plants due to fear and ignorance. Seeing these conditions, it is necessary to take an action to implement a learning strategy that is expected to improve learning outcomes in the material. One alternative strategy that allows the development of thinking skills is the Quantum Learning Strategy

It is inevitable that the need for energy in Indonesia, especially electrical energy is increasing from year to year in line with the progress of the industry (Supriyadi, 1994). In the next few years, Indonesia will be increasingly faced with the electricity crisis. This is in line with the increasing demand for electricity, both due to population growth and higher industrial needs for sustainable development. However, the availability of this electricity supply will depend on the availability of energy sources for supplying power plants, which are now decreasing in number on the one hand and the need for clean energy on the other. To address this problem, the government in particular through Presidential Regulation No. 5 of 2006 has set a policy on the use of energy mix. Among the energy mix, the use of nuclear energy has been determined as one of the alternative solutions for power generation energy (Firdausy (Ed.), 2007; Suhaemi, 2016).

Energy demand is one of the important phenomena in international political economy and nuclear energy is one of the solutions in responding to the country's energy needs (Robertuan, 2017). There are many perceptions about nuclear technology in Indonesia. Many people still don't know about nuclear and its uses, therefore the Indonesian people still think that anything about nuclear must end up being dangerous. Indonesia already has a plan regarding the construction of a nuclear power plant and it is under consideration (Wijaya et al, 2021). Nuclear power plant is an electrical energy plant that uses nuclear energy sources as fuel (Hariyadi, 2016; Suharto. (2009). The building of a nuclear power plant consists of two main buildings, namely: the nuclear reactor section and the section related to electricity (Hadi, 1993; Sutarman (2005).

The reactor is a very efficient energy source (Ahied, 2015). Atomic/nuclear reactor is a chain reaction that involves controlled fission reactions. A reactor is an efficient energy source. It is from this nuclear reactor that new nuclear energy, radioisotopes, or nuclides are produced. The fission reaction of 1 gram of nuclide per day will generate energy of 1 MW (106 W), this is equivalent to burning 2.6 tons of coal per day to produce that much energy. Nuclear reactors are used for many purposes. Currently, nuclear reactors are the most widely used to generate electricity (Septiningsih et al, 2020). The energy released in a nuclear reactor arises as heat energy and can be taken by flowing liquid or gas for cooling, through the inside of the reactor (Dwiatmanto, 2016). Furthermore, the energy is transferred out of the reactor with a secondary cooler which will convert heat energy into steam energy that can be used to drive a turbine that will drive a dynamo/generator, so that electrical energy is obtained (Finahari, 2008).

A nuclear reactor is a place or device used to create, regulate, and maintain the continuity of a nuclear chain reaction at a constant rate (Benedictus, 2020; Arindya, 2016). Unlike the nuclear bomb, the chain reaction occurs on the order of fractions of a second and is not controlled. Nuclear reactors are used for many purposes. Currently, most nuclear reactors are used to generate electricity. Research reactors are used for the manufacture of radio isotopes (radioactive isotopes) and for research (Nurmawan et al, 2014). Initially, the first nuclear reactors were used to produce plutonium as a nuclear weapons material. Enrico Fermi was the first person to successfully set up a nuclear reactor at the University of Chicago which was successfully run in December 1942. The

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first generation of nuclear reactors was used to produce plutonium as a nuclear weapons material. From there then continue to develop other nuclear reactor technology that is used for various things.

This study intends to provide an overview of the performance of the quantum learning method and conventional learning methods related to Nuclear Power Plants (NPP) by comparing the performance of the two methods. Where quantum learning is treated as an experimental variable while conventional learning methods are applied as a control variable.

2. METHODS

The purpose of this study is to provide a description of the performance of the quantum learning method and conventional learning methods related to Nuclear Power Plants (NPP). The method used in this research is semi-experimental research. Frenkel et al. (2012) said, that "*Experimental research is one of the most powerful research methodologies that researchers can use. Of the many types of research that might be used, the experiment is the best way to establish cause-and-effect relationships among variables*". In general, the characteristics of experimental research in this study include:

1. Manipulation

   Researchers manipulate the independent variables by giving treatment. This treatment aims to achieve what the researcher hopes for in the research. The independent variable that was manipulated in this study was the Quantum Learning model/method on material related to Nuclear Power Plants (NPP).

2. Control

   Control or control is done by adding other factors or adding other factors that the researcher does not want from the variables studied. These other factors are also known as control variables. This control variable is controlled and made constant so that the influence of the independent variable on the dependent is not influenced by other factors not examined.

3. Observation

   After the treatment is given for a certain period of time, the researcher makes observations or measurements to determine the effect of the manipulation/treatment given to the variables studied. Observations were made through data collection in the form of posttest.

The paradigm in this study using the static-group comparison design or also called the intac-group comparison design, is illustrated as follows:

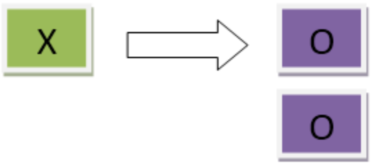

Figure 1.

The Static-Group Comparison Design

Information:
X = treatment/treatment given (independent variable)
O = posttest (observed dependent variable)

In this design, there is one group that is used for research, but is divided into two, namely half the experimental group (which is treated), and the other half is for the control group or the untreated group. The sampling technique used for this design is purposive sampling.

Analysis of the data used is hypothesis testing with the number of Wilcoxon stratified levels. In essence, this method is applied to test the truth of the null hypothesis which states that the average value or the sum of the values of the two groups is the same. Meanwhile, the alternative hypothesis states that the average value or the sum of the values of the two groups is different. In

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this hypothesis testing method, the rating of the level for each member is carried out in each strata separately. After that, the overall level scores for each sample group are added up. The total number of grades in each smaller sample group is chosen as the R value.

3. RESULT AND DISCUSSION

The notion of Quantum Learning was first applied at a learning institution located in Kirkwood Meadows, the State of California, United States. The initial application was carried out in 1982 by Bobby De Porter at the Supercamp school. At Supercamp it combines self-confidence, learning skills, and communication skills in a fun environment. Quantum is defined as an interaction that converts energy into light. All life is energy. The famous formula in quantum physics is mass times the speed of light squared equal to energy, or is commonly known as E=MC2. The human body is physically material, as a student, the goal is to reach as much light as possible, interaction, connection, inspiration to produce light energy. One of the reasons why students can learn well is that they feel happy following the learning process, as stated by Hernowo that Learning is most effective when it‟s fun.

In addition to a sense of pleasure, the creation of a comfortable learning atmosphere and conditions is very necessary. One way to achieve this, the method that can be used is through the application of the Quantum Learning method. This is in line with the opinion of Collin Rose and Malcolm J. Nichol that there are several ways that can make learning fun and successful, namely;

a. Create a stress-free environment, which is a safe environment to make mistakes, but high expectations for success.
b. Ensure that the subject matter of the lesson is relevant, by knowing the benefits and importance of the lesson.
c. Ensure that emotional learning is positive. Generally when learning is done with others there is humor, regular breaks, and enthusiastic support.
d. Consciously involve all the senses as well as the left brain and right brain thoughts.
e. Challenges the brain to be able to think ahead and explore what is being studied.
f. Consolidate learned material by reviewing it in relaxing periods. Quantum learning is actually an assembly of various theories or views of cognitive psychology and neurology or neurolinguistic programming that have existed long before.

In addition, coupled with personal views and findings empirical findings obtained by De Porter when developing the initial construct of Quantum learning. Among some of the root views and thoughts that form the basis of Quantum learning proposed by De Porter above, it cannot be denied that the views of the theory of suggestology or accelerated learning (Lozanov), the theory of multiple intelligences (Gardner), the theory of NLP neurolinguistic programming (Grinder and Bandler), and experiential or experiential learning (Hahn) and recent neurolinguistic findings regarding the role and function of the right brain dominate or strongly color the profile of Quantum learning. Multiple intelligence theory, neurolinguistic programming theory, and the latest findings of neurolinguistics greatly influence the basic view of Quantum learning about human abilities as learners – especially the abilities of the learner's brain and mind. In addition, to a certain extent the theory and findings also affect the basic view of Quantum learning about designing, presenting and facilitating the learning process to develop the learner's self-potential, especially the ability and strength of the learner's mind.

Quantum Learning

Quantum learning is a learning model that views the implementation of learning like a music orchestra-symphony game where the teacher creates a conducive, dynamic, interactive, participatory, and respectful atmosphere. Four characteristics of the conceptual framework on the steps of the quantum learning model, namely: 1) the presence of elements of democracy in teaching; 2) the existence of self-satisfaction in students; 3) there is an element of stabilization in mastering the material or a skill being taught and 4) there is an element of ability in a teacher in formulating the findings produced by students, in the form of concepts, theories, models, and so on (Astutik, 2017; Arifin, 2011).

The steps of quantum learning, namely:

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a. The teacher motivates students to learn.
b. Structuring a conducive learning environment.
c. Teachers cultivate a winning attitude in students.
d. The teacher frees students to determine their learning style.
e. The teacher familiarizes students with taking notes and reading
f. Teachers encourage students to be more creative in learning.

Nuclear Power Center

A. Work Process

The working process of a nuclear power plant is actually almost the same as the work process of a conventional power plant such as a steam power plant (PLTU), which is generally well known. The difference between the two types of power plants is the heat source used. Nuclear power plants get their heat supply from nuclear reactions, while nuclear power plants get their heat supply from burning fossil fuels such as coal or petroleum. Power reactors are designed to produce electrical energy through nuclear power plants. The power reactor only utilizes heat energy arising from the fission reaction, while the excess neutrons in the reactor core will be removed or absorbed using a control rod. Because it utilizes the heat produced by fission, the power reactor is designed to have high thermal power of the order of hundreds to thousands of MW. The process of utilizing the heat produced by fission to produce electrical energy in a nuclear power plant is as follows:

1. Nuclear fuels carry out fission reactions so that energy is released in the form of enormous heat.
2. The heat from the nuclear reaction is used to evaporate the cooling water, it can be primary or secondary, depending on the type of nuclear reactor used.
3. The water vapor produced is used to rotate the turbine so that motion (kinetic) energy is produced.
4. The kinetic energy of the turbine is then used to turn the generator so that an electric current is generated.

B. The basic components of a nuclear reactor

The basic components of a nuclear reactor are as follows

1. Nuclear fuel, in the form of metal rods containing radioactive material in the form of plates
2. Moderator, functions to absorb neutron energy
3. Reflector, functions to reflect back neutrons
4. Coolant, in the form of gas or liquid metal to reduce heat energy in the reactor
5. Control rod, functions to absorb neutrons to regulate fission reactions
6. Shield, is a protection from the process of dangerous fission reactions

C. Reactor Classification

Types of reactors are distinguished by use, neutron power and component names and operating parameters.

By use:

1. Power reactor
2. Research reactor including material test and training
3. Isotope production reactors are sometimes also classified as research reactors

Judging from the power of the neutrons that carry out the cleavage reaction, reactors are divided into:

1. Fast reactor: GCFBR, LMFBR, SCFBR
2. Thermal reactors: PWR, BWR, PHWR, GCR.

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Based on other parameters can be called:
1. Graphite reflector reactor: GCR, AGCR
2. Light water cooled reactor: PWR, BWR
3. High temperature reactor: HTGR

D. Classification based on the type of nuclear reaction
1. Fission Nuclear Reactor

All commercial nuclear power plants in the world use nuclear fission reactions. In general, this type of reactor uses Uranium nuclear fuel and this type of reactor will produce Plutonium, although it is also possible to use the Thorium fuel cycle. Fission reactors can be divided into 2 major groups based on the energy of the neutrons used in the fission process, namely:

- Thermal reactors (slow) use slow neutrons or thermal neutrons. These reactors are characterized by having a neutron moderator/slowing material which is intended to slow down the neutrons until they have the average kinetic energy of the surrounding particles, in other words, until they are "heated". Thermal reactor, this type of reactor uses slow neutrons or thermal neutrons. Almost all reactors currently available are thermal reactors. This reactor has a neutron moderating material that can slow down the neutrons until they reach thermal energy. There is a greater probability of a fission reaction between thermal neutrons and fissile materials such as Uranium 235, Plutonium 239 and Plutonium 241 and will have a lower probability of a fission reaction with Uranium 238. In this type of reactor, the coolant usually also functions as a neutron moderator, This type of reactor generally uses high-pressure cooling water to increase the boiling point of the cooling water. This reactor is housed in a reactor tank which is equipped with reactor monitoring and control instrumentation, radiation shield and containment building.
- Fast reactor, this type of reactor uses fast neutrons to produce fission in nuclear reactor fuel. This type of reactor does not have a neutron moderator, and uses a refrigerant that is less neutron moderator. To keep the nuclear chain reaction running, a fissile material fuel with a higher uranium content of 235 (more than 20%) is needed. Fast reactors have the potential to produce less transnuranic waste because all actinides can be cleaved using fast neutrons, but these reactors are difficult to build and expensive to operate.

Table 1.

Posttest Results

Student Characteristics	Quantum Learning Method	Conventional Method
SMA IPA		
Student 1	8.75	8.00
Student 2	9.00	7.75
Student 3	8.00	7.50
Student 4	8.25	7.;50
Student 5	8.50	8.25
SMA IPS		
Student 1	8.25	8.00
Student 2	8.00	7.50
Student 3	8.75	7.50
Student 4	8.25	7.25
Student 5	8.00	8.00
SMK		
Student 1	8.50	7.50
Student 2	8.25	7.50
Student 3	8.00	7.00
Student 4	7.75	8.00
Student 5	8.00	8.25

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2. Fusion Nuclear Reactor

   This type of reactor is a nuclear reactor technology that is still in the experimental stage, generally using hydrogen as fuel.

   This study applies a comparison between the two learning methods to see the performance of the two methods. The methods compared include quantum learning and conventional learning methods. After the method is given as a treatment or treatment in the study, scores are taken through the provision of posttest. The following are the posttest results obtained from both methods.

Quantum Learning has proven to be effective for the learning process both at school and in the business world. This learning model combines learning skills, communication skills and students' self-confidence with a pleasant learning environment. The essence of this learning model is to bring their world into our world or it can be said to bring our world within their scope. This model provides a dynamic learning atmosphere with excellent presentation, a supportive environment, flexible facilities, learning skills and a strong atmosphere (Rahayu et al, 2016; Ernawati et al, 2020). Systematically, the performance advantages of the Quantum Learning method are described as follows, so that if you look at the results of the post-test scores, it is very visible.

It can be seen in the table that the posttest scores of students with different characteristics and using different learning methods are basically different. Are the two learning methods actually able to produce students with the same or different grades? This question is answered by applying a series of hypothesis testing procedures with the number of Wilcoxon stratified levels. The series of steps that must be carried out in this research are:

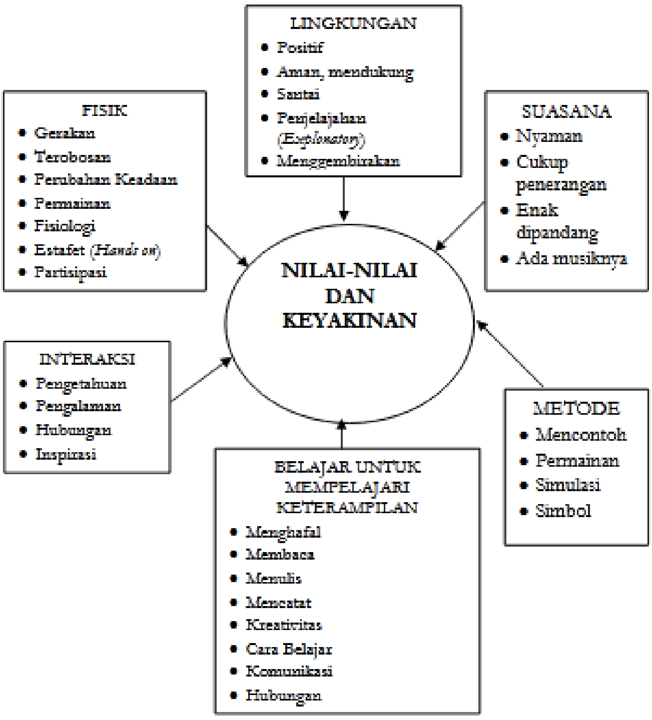

Figure 2.

The Advantages of a Set of Quantum Learning Methods

Formulating the null hypothesis and the alternative hypothesis, in accordance with the previous explanation, when associated with the description in this case, the null hypothesis states that the performance of the quantum learning method is the same as the performance of the conventional learning method. While the alternative hypothesis states that the performance of the quantum learning method is different from the performance of conventional learning methods. Symbolically, these two hypotheses are formulated as:

H_0 : $\mu_{\text{Quantum Learning Method}} = \mu_{\text{Convensional Method}}$

H_1 : $\mu_{\text{Quantum Learning Method}} \neq \mu_{\text{Convensional Method}}$

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Determining a certain level of significance, related to this research, the level of significance is determined at 1%. The number of strata (in this case the characteristics of students by major) is 3 and the sample size in each stratum (the number of students with certain characteristics) is 5. In the table, the R value for the number of strata 3 and the sample size of each stratum 5 and a significance level of 1% is 61.

Formulating the test criteria, the test criteria applied in this study is that the null hypothesis is accepted if:$R \geq 61$, *while* the null hypothesis is declared rejected if: $R < 61$.

Counting the number of stratified levels and R values, if the testing procedure has reached this stage, the number of stratified levels must be calculated first to determine the R value through several steps that have been explained. The calculation to find R is shown in table 2. The numbers in brackets are the level values of the total post-test scores of students from each characteristic of school majors who are treated with quantum learning methods and conventional learning methods. The following is the determination of the level and work table in determining the level:

For the characteristics of students based on the major of SMA IPA

Order	1	2	3	4	5	6	7	8	9	10
Mark	9.00	8.75	8.50	8.25	8.25	8.00	8.00	7.75	7.50	7.50
Level	1	2	3	4.50	4.50	6.50	6.50	8	9.50	9.50

For the characteristics of students based on the majors of SMA IPS

Order	1	2	3	4	5	6	7	8	9	10
Mark	8.75	8.25	8.25	8.00	8.00	8.00	8.00	7.50	7.50	7.25
Level	1	2.50	2.50	5.50	5.50	5.50	5.50	8.50	8.50	10

For the characteristics of students based on vocational majors

Order	1	2	3	4	5	6	7	8	9	10
Mark	8.50	8.25	8.25	8.00	8.00	8.00	7.75	7.50	7.50	7.00
Level	1	2.50	2.50	5	5	5	7	8.50	8.50	10

Table 2.
Calculation of the number of stratified levels of the number of students' posttest scores

Student Characteristics	Quantum Learning Method	Conventional Method
SMA IPA		
Student 1	8.75(2)	8.00(6.50)
Student 2	9.00(1)	7.75(8)
Student 3	8.00(6.50)	7.50(9.50)
Student 4	8.25(4.50)	7.50(9.50)
Student 5	8.50(3)	8.25(4.50)
SMA IPS		
Student 1	8.25(2.50)	8.00(5.50)
Student 2	8.00(5.50)	7.50(8.50)
Student 3	8.75(1)	7.50(8.50)
Student 4	8.25(2.50)	7.25(10)
Student 5	8.00(5.50)	8.00(5.50)
SMK		
Student 1	8.50(1)	7.50(8.50)
Student 2	8.25(2.50)	7.50(8.50)
Student 3	8.00(5)	7.00(10)
Student 4	7.75(7)	8.00(5)
Student 5	8.00(5)	8.25(2.50)
	$R_1 = 54.50$	$R_2 = 110.50$

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From the calculation steps carried out, the total number of stratified levels obtained is 54.50 (the number of post-test scores of students who are treated using the quantum learning method) and 110.50 (the number of post-test scores of students who are treated using conventional learning methods). As previously stated, the calculated R value is a smaller value. In this case study, the calculated R value is 54.50.

Based on the calculation results, the R value is 54.50. This value is smaller than the R value in the table of 61. Thus, based on the applied test criteria, the null hypothesis which states that the performance of the quantum learning method is the same as the performance of the conventional learning method is declared rejected. While the alternate hypothesis which states that the performance of the quantum learning method is different from the performance of the conventional learning method is accepted.

4. Conclusion

This study concludes that the performance of the quantum learning method has advantages in learning for materials related to nuclear power plants compared to the performance of conventional methods. This conclusion was obtained after testing the hypothesis with the number of Wilcoxon stratified levels, the hypothesis testing was carried out to reject the null hypothesis and accept the alternative hypothesis. Suggestions for other research, it is also necessary to compare the quantum learning method with other more sophisticated learning methods to see the given performance.

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