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EFFECTIVENESS OF ARDUINO MICROCONTROLLER-BASED NEWTON'S LAW APPLICATION EXPERIMENT TO IMPROVE SCIENCE PROCESS SKILLS

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Abstrak: The problem in this research is that the level of scientific processing skills in particle motion dynamics is still low. An attempt to overcome this problem is to conduct a practical experiment using the Newton's Law Application Experiment Tool based on an Arduino microcontroller. This study used a quasi-experimental type of study with a non-equivalent post-test control group design. The study sample included Grade XI SMA Negeri 3 Pekanbaru students in the 2023/2024 school year with a total of 72 students. Data analysis technique uses descriptive analysis based on students' Scientific Process Skills (SPS) criteria scale. The results of this study show that the application of experimental tools applying Newton's law on the Arduino microcontroller platform has the ability to improve scientific pr The average score of students in the control class was in the low category with a score below 54. Meanwhile, in the experimental class, there were more in the high category (>86). ocessing skills of grade XI SMA Negeri 3 Pekanbaru students learn on particle motion dynamic materials. This study only focused on short-term effects without assessing long-term retention of science process skills.

Keywords: Newton’s laws; Experimental Tools; Science Process Skills

INTRODUCTION

Physics is a part of education that involves the study of natural phenomena that can be measured systematically [1]. That physics is different from other sciences in that it has three aspects: knowledge, process and scientific attitude. Physics knowledge is a product, and one of its forms is learning media. Learning media is a tool that assists teachers in providing learning materials, and therefore aims to make the application of learning more practical and effective. Experimental tools are media used in the teaching and learning process to clarify and deepen concepts and understanding of learning material. Experimental tools encourage students to actively participate in experimental activities and provide opportunities to directly observe, try out, and understand scientific concepts. Participating in experiments allows students to gain direct experience and deepen their understanding of the concepts in the learning material [2].

When it comes to concepts, it is important that everyone has skills in the scientific process to solve everyday life problems. Scientific process skills themselves include the ability to think, reason, and act logically to explore and develop fundamental scientific concepts to address scientific problems. In the process of scientific competence, various aspects such as cognitive skills, psychomotor skills, and social skills are combined and contribute significantly to the formation of useful knowledge. In the context of 21st century science, the emphasis is on finding solutions and strategic approaches to create realistic learning, such as when solving everyday challenges. Therefore, if each student is equipped with scientific process skills, he or she can discover and develop concepts, principles, or theories as extensions of existing concepts, and even critically evaluate discoveries.

According to Fandy as cited in [3], this experiential activity engages students directly in a process, providing valuable experience and a deep understanding of the learning material, while provides strong empirical evidence to support a theory or theory. physics. Concept of existence. To carry out these practical experiments, support is needed, especially in the form of laboratory materials and LW (Learner Worksheets). The learner worksheets that will be used can be adapted to the needs of experimental equipment for particle motion dynamics. Learner Worksheets is considered a practical and flexible solution because it facilitates collaboration between students and teachers in the learning process.

After the interview, the author pointed out that the low quality of students' scientific processing skills is one of the impact, especially in learning physics. The limited application of laboratory equipment in schools is also one of the factors that hinders the training of students' scientific processing skills. This makes the author realize the need to conduct research on students' scientific processing skills using an experimental tool based on the Arduino microcontroller, which has been confirmed as one of the supporting materials in the learning process. Arduino Uno is a microcontroller that is widely used. This is because the implementation of Arduino Uno is easier and more economical and has very precise results [4]. The success of practical activities in physics learning is certainly influenced by the availability of adequate practical equipment, including demonstration tools. Along with that, technological developments provide many benefits, especially in the integration of demonstration tools based on the Arduino Uno microcontroller [5]. As part of this, the author will apply the tool to physics learning materials such as the dynamics of particle motion.

The Particle Motion Dynamics classified as abstract further supports experimental activities as a learning solution to inculcate scientific process skills (SPS) in students and optimize the experience and student's current learning experience. This research relates the use of an Arduino microcontroller-based Newton's Law application experiment tool to improve students' scientific processing skills on particle dynamics material.

This study generally aims to determine the effectiveness of using an experimental tool that applies Newton's law on the Arduino microcontroller platform in particle motion dynamics to improve scientific processing skills (SPS) of students. Specifically, this study aims to describe the effectiveness of using an experimental tool applying Newton's law on the Arduino microcontroller. Therefore, the author will conduct research with the title "Effectiveness of using the Newton's Law Experiment Tool based on Arduino microcontroller to Improve Scientific Processing Skills".

RESEARCH METHODS

This type of quasi-experimental research is an experimental research in which during the research process there are two groups of classes, namely the control class and the experimental class, but the class used is a subject that already exists in a study. The study group was not randomly selected [6]. In quasi-experimental research, the design used is simply a non-equivalent post-test control group design, as in. This study was conducted at SMA Negeri 3 Pekanbaru in September-December 2023, while the location of this study was at SMA Negeri 3 Pekanbaru. The data collection technique used in this study is probability sampling using a simple random sampling plan, with a sample of 72 people including classes XI KM 1 and XI KM 4. While the data collection techniques data collection is used as a testing technique, such as a test given in the form of post-test questions totaling 14 questions according to 14 scientific process skill indicators validated by lecturers of physics at Faculty of Teacher Training and Education, Riau University. Depending on the limitations of the research problem, 14 indicators are studied: observation, measurement, communication, classification, operational definition of variables, hypothesis building, prediction, variable identification, design experiments, explain relationships between variables, describe graphs, analyze surveys, collect data, analyze data, and draw conclusions.

Once the researcher has collected sample data, the data will be analyzed and processed to determine whether the research hypothesis can be achieved. This data analysis technique uses descriptive analysis based on students' Scientific Process Skills (SPS) criteria scale. The criteria for assessing scientific processing skills are presented in Table 1.

Table 1. criteria for assessing scientific processing skills

Science Process Skills Score	Category
86 – 100	Very high
76 – 85	High
60 – 75	Fair
55 – 59	Low
≤ 54	Very low

RESULTS AND DISCUSSION

The data used in this study are the results of the scientific processing skills of students in the control group and the experimental group on the particle motion dynamics device at SMA Negeri 3 Pekanbaru. Data collection was carried out using KPS tests on the control and experimental classes. during learning in the experimental class, the Arduino Uno microcontroller is used to assist the experimental activities carried out. The Arduino Uno microcontroller is connected to the practicum equipment and computer/laptop so that the results of the experiment are directly recorded on the computer or laptop. Experimental activities become more effective and more accurate in data collection. Students in the experimental class who use the Arduino Uno microcontroller are accustomed to conducting technology-based experiments so that their KPS can increase. Students also follow the guidelines for using the Arduino Uno microcontroller on the student practicum worksheet. While in the control class, they only learn in a conventional way.

In terms of description, it can be seen that the experimental group showed a significant increase in the ability to master scientific processing skills in learning by using the experimental tool applying Newton's law on microcontrollers. Arduino controller compared to a control group learning normally.

The average value of the experimental class is 82.11 while the average score of the control class is 45.50, which proves that the experimental class has higher scientific processing skills than the control class. The difference in the mean value between the two classes is 36.61, showing the positive impact of using the Arduino microcontroller-based Newton's law experiment tool in improving students' skills in scientific process aspect. The distribution of data on the acquisition of scientific process skills tests can be presented in Table 2.

Table 2. Description of the Number of Learners Based on Science Process Skills Test Results

Score	Category	Control Class		Experimental Class	
		Number of Students	Percentage (%)	Number of Students	Percentage (%)
86 – 100	Very high	0	0	18	50
76 – 85	High	0	0	11	30,56
60 – 75	Fair	0	0	7	19,44
55 – 59	Low	0	0	0	0
≤ 54	Very low	36	100	0	0

Score	Category	Control Class		Experimental Class	
		Number of Students	Percentage (%)	Number of Students	Percentage (%)
Total		36	100	36	100

Table 2 shows that the proportion of students with scientific processing skills is higher in the experimental class. In the results obtained, students with very high scientific processing skills in the experimental class accounted for 50% of the students, while in the control class there were no students with scientific processing skills in the experimental class very high grade. The distribution of post-test data analysis results on scientific process skills for each indicator can be explained based on Figure 1.

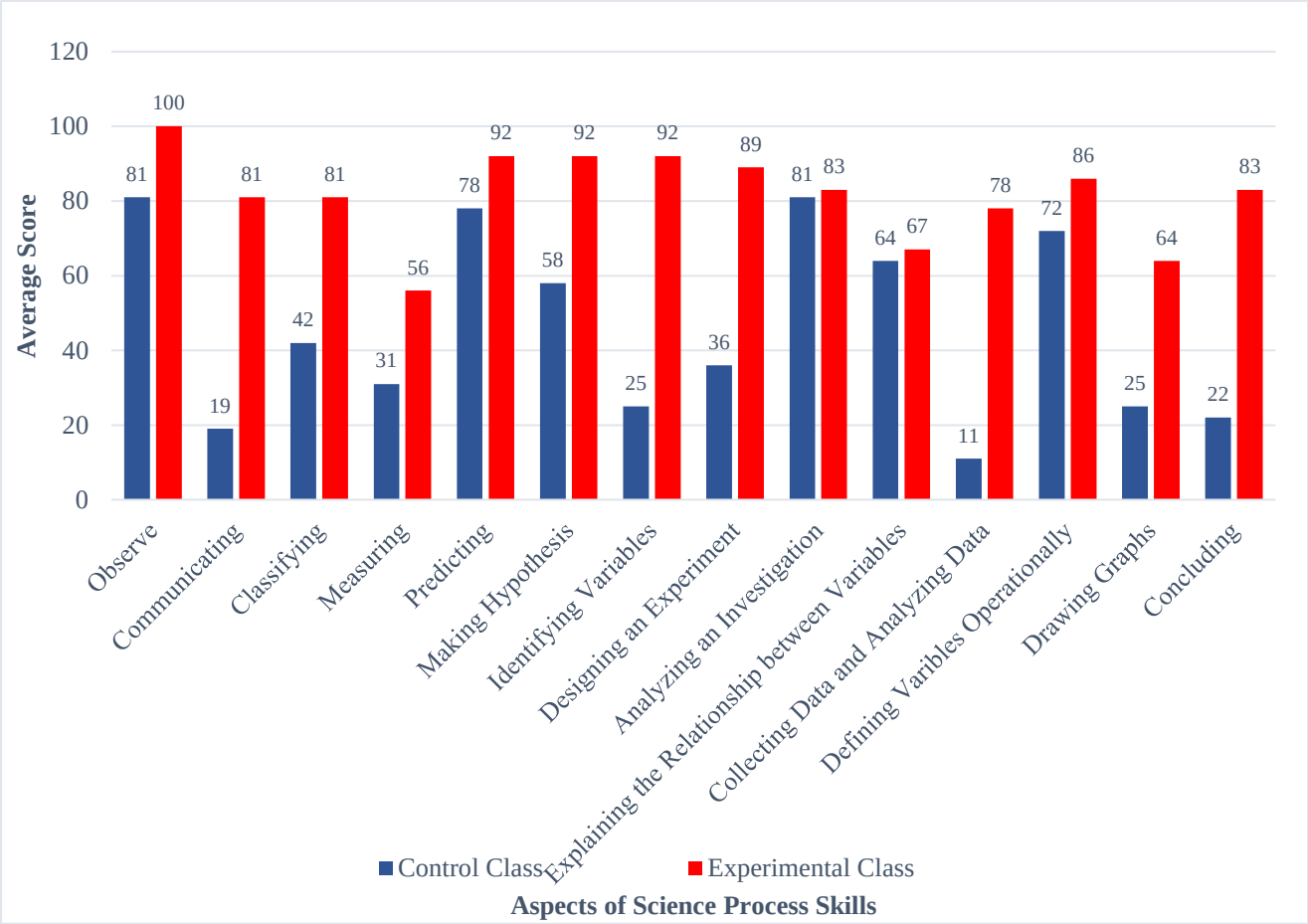

Figure 1. distribution of post-test data analysis results on scientific process skills

Based on Figure 1, it shows the heterogeneity of students' abilities in the KPS aspect in the experimental class and the control class. In the experimental class, students in the very high category predominate with a ratio of 50, then in the high category with a ratio of 30.56 and the remaining students in the adequate category are only 19.44. Meanwhile, in the control class, students in general make up very few students in the class. The experimental class achieved higher results than the control class because the experimental activity required students to be more active in the experiment to complete LKPD using the Experimental Tool applying Newton's law on the Arduino microcontroller platform, this is also expressed through the difference in average scores. number of points achieved. by both classes. Therefore, learning with experimental tools applying Newton's law on the Arduino microcontroller platform has the ability to improve scientific processing skills. The use of Arduino Uno provides students with the opportunity to utilize microcontroller technology so that they can practice independently. Practicums with Arduino Uno microcontrollers also provide more precise results so that they are more skilled in practical activities. This is in line with the study conducted by [7] showing that there is an effect of using simple physics experiment tools on students' KPS on Laws materials. Newton. These results add to the growing body of evidence that an active learning approach using experimental tools can improve understanding and mastery of concepts in a specific area, such as dynamics of particle motion.

In all aspects of scientific processing skills, the experimental class outperformed the control class. This is supported by the findings of previous researchers. One of them concerns the communication aspect, supported by the findings of [8] showed that the communication aspect of students who worked with learner worksheet would increase because students would have a better understanding of the results of the experiments that would be presented to the class. In addition, the measurement

aspect is emphasized by the study of [9] showing that the measurement aspect in the experimental class is very good. Furthermore, according to what was conveyed by [10], if students understand the meaning of independent and dependent variables in an event then these students are capable of solving problems. Resolve related issues well. to the identification of variables. Furthermore, the design aspect of the experiment is supported by results demonstrated by [11], which shows that the use of experimental tools can override the design aspect of the experiment. in very good category. The post-test results on the analytical aspect of the survey are supported by the findings of [12] shows that the analytical aspect of the survey is categorical. The average scientific processing skills of the experimental class are better than the control class, proven by the research results of [9], who claim that the operational definition aspect of variables is of a very good kind. [10] also believe that the skill of identifying variables can be acquired well if students can clearly understand this concept. Finally, the concluding aspect is in line with the results highlighted by [7], showing that the final skills of the students are of good quality. If considered in more detail, introducing processing methods through experimental activities using experimental tools applying Newton's law on the Arduino microcontroller platform has a very positive impact on student learning. The use of Arduino Uno microcontrollers in physics learning can support learning activities, facilitate experimental activities, and improve students' understanding of concepts so that their science process skills improve [13]. In addition to being able to improve scientific processing skills, using an Arduino microcontroller-based Newton's law experiment tool also realizes the concept of matter more deeply than conventional methods, therefore, the average scientific processing skills possessed by the experimental class were higher than those skills. of the control layer.

Based on the discussion of the post-test average scores for each aspect of scientific processing skills achieved in the experimental and control classes, it shows that the average scientific processing skills score of the experimental group is high. than the average skill score in the scientific process of the experimental group. control group. Therefore, it can be concluded that using experimental tools applying Newton's law on the Arduino microcontroller platform has the ability to improve the scientific processing skills of students of grade XI SMA Negeri 3 Pekanbaru.

CONCLUSION

The average scientific processing skills of the experimental class were at a high level while the control class was at a very low level. At that time, the scientific processing skills of experimental class students for each indicator were also at a high level. This shows that using the experimental tool applying Newton's law on the Arduino microcontroller platform is considered effective in improving the scientific processing skills of grade XI SMA Negeri 3 Pekanbaru students. Hopefully, this research result will become one of the reference materials for experimental activities in learning particle motion dynamics to help make learning more interesting for students. Furthermore, the results of this study will also provide references for further research, not only on some aspects of scientific processing skills but also on other aspects.

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