

Implementation of Information and Communication Technology Media in Project-Based Learning and Its Impact on Learning Outcomes in Electrolyte and Non-Electrolyte Solution Material

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ABSTRACT

Purpose of the study: This study aims to examine the influence of information and communication technology media applied in project-based learning on student learning outcomes in the material of electrolyte and non-electrolyte solutions.

Methodology: The research method used was a quasi-experimental design with a pretest and posttest design for two groups. Two classes were randomly selected as the experimental and control groups. The experimental group used information and communication technology media in project-based learning, while the control group used a demonstration method. Data were obtained through tests and analyzed to determine the effect of the treatment.

Main Findings: The analysis results show that the use of information and communication technology media in project-based learning has a positive impact on student learning outcomes. This is evidenced by the calculated t value being greater than the t table, which is 2.2, which is greater than 1.671. Furthermore, the posttest score for the experimental group was also higher than that of the control group, indicating a significant improvement in learning outcomes.

Novelty/Originality of this study: This study offers novelty by integrating information and communication technology media within project-based learning specifically for electrolyte and non-electrolyte solution topics, which are often abstract for students. It advances existing knowledge by demonstrating how technology-enhanced learning projects improve conceptual understanding and learning outcomes, providing a more interactive and student-centered approach compared to conventional instructional methods.

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1. INTRODUCTION

Education is a crucial factor in improving the quality of human resources in the era of scientific and technological advancement [1], [2]. An effective learning process is expected to optimally develop students' potential [3], [4]. However, in reality, much learning remains teacher-centered, resulting in student inactivity. This leads to poor conceptual understanding, particularly in chemistry. Therefore, innovations in learning that can increase student engagement are needed [5], [6].

Chemistry is a subject considered difficult by most students [7], [8]. Chemistry material is often abstract and requires in-depth conceptual understanding. One particularly complex topic is electrolyte and non-electrolyte solutions [9], [10]. This material requires students to understand the concept of electrical conductivity of solutions theoretically and practically [11], [12]. This difficulty impacts student learning outcomes.

To address this issue, a learning model is needed that can enhance student engagement and understanding [13], [14]. One model that can be used is project-based learning. This model provides students with opportunities to learn through hands-on experience and project completion [15], [16]. This allows students to develop critical and creative thinking skills. Project-based learning also encourages collaboration and communication among students.

In addition to learning models, the use of learning media also plays a crucial role in improving the quality of learning [17], [18]. Information and communication technology media can help present abstract material in a more concrete way [19], [20]. The use of these media allows students to learn interactively and engagingly. With the help of technology, the learning process becomes more effective and efficient [21], [22]. Therefore, the integration of Information and communication technology media in learning is essential.

Several previous studies have shown that project-based learning can improve student learning outcomes [23], [24]. Other studies have also suggested that the use of Information and communication technology media can enhance student motivation and understanding [25], [26]. However, research integrating these two approaches is still limited, particularly on electrolyte and non-electrolyte solutions. Furthermore, few studies have directly examined their impact on student learning outcomes. This indicates a research gap that requires further study.

This study is novel in integrating Information and communication technology media in project-based learning on electrolyte and non-electrolyte solutions. This approach is expected to provide a more meaningful learning experience for students. The urgency of this research lies in the need to improve chemistry learning outcomes through learning innovations relevant to technological developments. Furthermore, this research is also important for providing alternative, more effective learning strategies. Therefore, this research is expected to contribute to the development of chemistry learning. Based on this description, this study aims to determine the effect of the application of information and communication technology media in project-based learning on student learning outcomes.

2. RESEARCH METHOD

2.1. Type and Design of Research

The method used in this study was a quasi-experimental one. A quasi-experimental study is a type of experimental research that does not allow researchers to fully control all the characteristics and conditions of the sample being studied [27], [28]. However, this study still used a design that allows for variable control according to conditions in the field. This approach allows researchers to adapt the research implementation to the actual situation at hand.

The research design used was a pretest and posttest for two groups. In this design, two groups were randomly selected and then given a pretest to determine the initial conditions and to determine whether there were any differences between the experimental and control groups. The pretest results were considered good if there were no significant differences between the two groups [29]. Next, the learning process was carried out by providing treatment in the form of information and communication technology media to the experimental group, while the control group did not use such media. After the learning process was completed, both groups were given a posttest using the same questions as the pretest. The research design is as follows:

Table 1. Research Design

Group	Pretest	Independent Variable	Posttest
Experimental	T ₁	XE	T ₂
Control	T ₂		T ₂

2.2. Population and Sample

A population is the entire subject of a study. A population can also be defined as a generalized area consisting of objects or subjects with a specific number and characteristics determined by the researcher to be studied and then conclusions drawn. Meanwhile, a sample is a portion of the population selected using a specific technique known as sampling [30].

In this study, the target population was all 10th-grade students at State Senior High School 86 Jakarta. The research sample was determined using a purposive sampling technique, which involves selecting a sample based on specific considerations or objectives set by the researcher [31]. Based on this technique, two classes were selected from the six available classes. These two classes were then designated as the control group and the experimental group for the study.

2.3. Research Procedures

The research procedure in this study consisted of three main stages: preparation, implementation, and completion. In the preparation stage, the researcher first obtained a research permit from Syarif Hidayatullah State Islamic University Jakarta. Next, the researcher determined the learning materials and time allocation. The researcher also developed a lesson plan based on the specified materials and developed research instruments. Furthermore, instrument validation, coordination with the school, and sample selection were conducted.

The implementation stage is the core stage of the research after the preparation was complete. At this stage, the researcher administered a pretest to the predetermined classes: the experimental group and the control group. The learning process then utilized information and communication technology media in project-based learning for the experimental group. After all learning activities were completed, both groups were given a posttest to measure student learning outcomes.

The completion stage is the final stage of this research. At this stage, the data obtained from the research results were systematically processed and analyzed. Next, the researcher conducted hypothesis testing to determine the effect of the treatment. The results of this analysis were then used as the basis for drawing conclusions from the research.

2.4. Data Collection Instruments and Techniques

Developing an instrument is a crucial step in research. However, the data collection process plays a more crucial role, especially if the method used is potentially influenced by researcher subjectivity. Therefore, data collection must be conducted carefully to obtain data that aligns with the research objectives, namely measuring variables accurately. In this study, the data collection method used was a test. A test is a series of questions or exercises used to measure the skills, knowledge, intelligence, abilities, or talents of individuals or groups [32], [33]. The test used in this study was a chemistry learning achievement test in the form of objective multiple-choice questions. There were 25 questions with five answer choices for each question. This test was designed to measure students' mastery of the material taught. Therefore, the data obtained is expected to objectively reflect students' learning abilities. The use of objective tests also aims to minimize subjectivity in assessment.

A research instrument is essentially a measuring tool used in research activities. In this context, a research instrument is used to measure observed phenomena, both natural and social. The instrument used in this study was a chemistry learning achievement test. This test was used to determine the extent to which students understood the material presented. The test used was a written multiple-choice test on electrolyte and non-electrolyte solutions. Before using the instrument on the research sample, a pilot test was conducted on another group. This pilot test aimed to determine the instrument's validity and reliability. Therefore, the instrument met the eligibility criteria for use as a measurement tool in research. A valid and reliable instrument is expected to produce accurate and reliable data. This is crucial for supporting the validity of the research results.

2.5. Data Analysis Techniques

Data processing is a crucial part of research because the results are used to answer the problem formulation and test hypotheses. In this study, the test data were analyzed through several stages. The first stage was conducting prerequisite tests for data analysis before hypothesis testing. Once the prerequisite tests were met, the analysis continued with statistical hypothesis testing. This process was carried out to ensure the validity of the research results.

Prerequisite tests for data analysis included normality and homogeneity tests. The normality test aims to determine whether the data are normally distributed. In this study, the normality test was conducted using the Liliefors test with a significance level of 0.05 [34]. Data are considered normally distributed if the statistical value obtained is less than or equal to the value in the table. Next, a homogeneity test was conducted to determine the equality of variance between the experimental and control groups.

The homogeneity test was conducted by comparing the largest and smallest variances of the two groups. If the calculation results indicate that both groups have equal variances, the data are considered homogeneous. After the data met the requirements for normality and homogeneity, the analysis continued with hypothesis testing using parametric statistics [35], [36]. Hypothesis testing was conducted using the mean difference test. The significance level used in this test was 0.05.

Before conducting the hypothesis test, the increase in student learning outcomes was first calculated using the normalized gain value. This value was used to determine the level of improvement in student learning outcomes after treatment. Improvement categories were divided into three categories: high, medium, and low. This aimed to provide a clearer picture of learning effectiveness. This allowed for more in-depth interpretation of the analysis results.

The statistical hypotheses used in this study consisted of a null hypothesis and an alternative hypothesis. The null hypothesis stated that there was no difference in average learning outcomes between the experimental and control groups. Meanwhile, the alternative hypothesis stated that the average learning outcomes of the experimental group were higher than those of the control group. This hypothesis testing was conducted to

determine the effect of using information and communication technology media in project-based learning. The test results formed the basis for drawing conclusions from the study.

3. RESULTS AND DISCUSSION

3.1. Testing Data Analysis Prerequisites

Before hypothesis testing is carried out, analysis prerequisite tests are first carried out in the form of normality tests and homogeneity tests.

3.1.1. Normality Test

In the experimental and control groups, normality tests were carried out using the Lilifors test and the results are shown in the following table:

Table 2. Data Results of Normality Test for Experimental Group and Control Group

Sample	N	L ₀ Count	L ₀ Table	Conclusion
Experiment	38	0.090	0.144	Normal
Control	37	1.1349	0.146	Normal

From the table above, for the experimental group, it is found that Lo count < Lo table, so the experimental group is normally distributed. The results of the normality test calculation for the control group also concluded that Lo count < Lo table, so the control group is normally distributed. So in this case, both the control group and the experimental group are normally distributed.

3.1.2. Homogeneity Test

After both sample groups were declared normally distributed, a homogeneity test was performed. The homogeneity test was conducted to determine whether the research data had homogeneous variance or not. In this study, the homogeneity test was conducted based on the equality test of two variances using the Fisher test at a significance level (α) = 0.05 with the following test criteria: if Fcount < Ftable then the data from both groups have the same variance or are homogeneous. From the results of the homogeneity test, the data obtained are in the following table:

Table 3. Homogeneity Test Result Data

F Count	F Table	Conclusion
1.429	2.26	Homogen

From the results of data processing presented in the table above, the calculated F value was 1.429 and the F table value was 2.26. Thus, it is concluded that the calculated F < F table so that the data is homogeneous.

3.2. Pretest and Posttest Results of the Experimental Group and Control Group

Based on the results of the pretest and posttest calculations for the experimental group consisting of 38 students and the control group consisting of 37 students, these are presented in the following table:

Table 4. Pretest and Posttest Results Data for the Experimental Group and Control Group

Data	Experimental Group		Control Group	
	Pretest	Posttes	Pretest	Posttes
Highest value	57.00	94.00	60.00	90.00
Lowest value	20.00	57.00	10.00	54.00
Mean	32.68	78.79	31.73	73.24
Standard deviation	7.0	10.28	7.5	12.29

Based on the table above, the measure of central tendency and distribution of pretest data for the experimental group are: the highest score is 57.00 and the lowest score is 20.00, the average pretest value is 32.68 with a standard deviation of 7.0. For the control group, the lowest score is 10.00 and the highest score is 60.00, the average pretest is 31.73 with a standard deviation of 7.5. From the table above, the measure of central tendency and distribution of posttest data for the experimental group are: the highest score is 94.00 and the lowest score is 57.00, the average posttest is 78.79 with a standard deviation of 10.28. Meanwhile, for the control group, the highest score is 90.00 and the lowest score is 54.00, the average posttest is 73.24 with a standard deviation of 12.29.

3.3. Description of N-Gain Value Data

The results of the calculation of the N-Gain value of the experimental group can be seen in the following table:

Table 5. Data on the Results of the N-Gain Values of the Experimental Group

Data	Pretest	Posttest	N-Gain
Highest value	57.00	94.00	0.91
Lowest value	20.00	57.00	0.45
Average	32.68	78.79	0.69

Based on the table above, it can be seen that in the experimental class, the highest learning improvement was achieved with an N-Gain value of 0.91, which is considered high. The lowest N-Gain value was 0.45, which is considered moderate. Meanwhile, the average learning improvement in the experimental group was 0.69, which is considered moderate.

The results of the calculation of the N-Gain value of the control group can be seen in the following table:

Table 6. Data Results of N-Gain Values of the Control Group

Data	Pretest	Posttest	N-Gain
Highest value	60	90	0.86
Lowest value	10	54	0.14
Average	31.73	73.24	0.60

The table above shows that the highest learning improvement in the control group was achieved with an N-Gain score of 0.86, which is considered high. The lowest N-Gain score was 0.14, which is considered low. Meanwhile, the average learning improvement in the experimental group was 0.60, which is considered moderate.

3.4. Hypothesis Testing Results

After conducting the prerequisite data analysis test, the results showed that the learning outcomes of both groups were normally distributed and had homogeneous variance. Next, the data were analyzed using a t-test. The testing criteria used were: if the calculated t-value is less than the t-table, the null hypothesis is accepted and the alternative hypothesis is rejected. Conversely, if the calculated t-value is greater than the t-table, the null hypothesis is rejected and the alternative hypothesis is accepted. The calculation results showed that the calculated t-value was 2.2, while the t-table value was 1.671.

Based on these results, the calculated t-value was greater than the t-table, so the null hypothesis was rejected and the alternative hypothesis was accepted. This indicates that the use of information and communication technology media in project-based learning has an effect on student learning outcomes in the topic of electrolyte and non-electrolyte solutions. With the acceptance of the alternative hypothesis, it can be concluded that the treatment provided in this study was proven effective. Learning that integrates information and communication technology in project-based learning can improve students' conceptual mastery. Thus, student learning outcomes in this material have improved.

The improved learning outcomes can be explained by the characteristics of project-based learning, which emphasizes active student involvement in the learning process. Through project activities, students not only passively receive information but also construct understanding through direct experience [37]. This process enables students to connect learned concepts to real-world situations. This involvement contributes to the development of deeper conceptual understanding, thus making learning more meaningful for students.

The use of information and communication technology media also plays a crucial role in supporting the learning process. This media can present abstract material in a more concrete and understandable way. The visualization and interactivity offered help students grasp difficult concepts [38]. Furthermore, this media can increase student interest and motivation in learning. This indirectly impacts improved learning outcomes.

The integration of project-based learning and information and communication technology media creates a more dynamic learning environment. Students are encouraged to think critically, work collaboratively, and solve problems independently and in groups [39]. These activities not only enhance knowledge but also develop science process skills. This type of student-centered learning aligns with the demands of twenty-first-century education. Therefore, this approach is relevant for application in chemistry teaching.

Furthermore, the differences in treatment between the experimental and control groups suggest that conventional learning methods are less able to optimally accommodate students' learning needs. Learning that focuses solely on demonstrations tends to make students less active, resulting in fewer opportunities for students

to explore knowledge independently [40]. Conversely, innovative approaches provide space for students to be directly involved in the learning process. This involvement is a crucial factor in improving the quality of learning.

Overall, the findings of this study reinforce the view that innovation in learning is essential for improving student learning outcomes. The use of information and communication technology media combined with project-based learning has been shown to provide a more effective learning experience [41], [42]. This suggests the need for teachers to develop creative and adaptive learning strategies. This ensures that learning focuses not only on achieving grades but also on in-depth conceptual understanding. These implications are important as a basis for future learning development.

This research has a positive impact on the development of chemistry learning, particularly in encouraging the application of information and communication technology media integrated with project-based learning. The results can serve as a reference for educators in designing more innovative, interactive, and student-centered learning, thereby enhancing deeper conceptual understanding. Furthermore, this research also contributes to enriching research on the effectiveness of technology use in science learning at the secondary school level.

However, this study has several limitations. The first limitation lies in the relatively limited sample size, which was drawn from only one school, so generalizations of the research results should be approached with caution. Furthermore, this study focused only on one learning material, namely electrolyte and non-electrolyte solutions, so it cannot yet describe its effectiveness on other materials. Another limitation is the limited research timeframe, which prevented the observation of long-term impacts on student learning outcomes. Therefore, future research is recommended to involve a wider sample size, more diverse materials, and a longer observation period.

4. CONCLUSION

It can be concluded that the application of information and communication technology media in project-based learning has a positive influence on student learning outcomes. This is indicated by the calculated t value being greater than the t table, which is 2.2 greater than 1.671, as well as the posttest score of the experimental group being higher than that of the control group. Furthermore, students in the experimental group showed a higher level of activeness and enthusiasm during the chemistry learning process compared to the control group.

Based on these limitations, further research is recommended to involve a larger and more diverse sample size to ensure stronger generalizability. Furthermore, the study could be expanded to include other chemistry materials to assess the consistency of learning effectiveness. Future research is also expected to utilize a longer timeframe to assess the long-term impact on student learning outcomes and skills. Furthermore, the development of more innovative information and communication technology media should be explored to improve the quality of learning.

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AUTHOR CONTRIBUTIONS

Conceptualization, R.K.; Methodology, R.K.; Software, R.K.; Validation, R.K.; Formal Analysis, R.K.; Investigation, R.K.; Resources, R.K.; Data Curation, R.K.; Writing – Original Draft Preparation, R.K.; Writing – Review and Editing, R.K.; Visualization, R.K.; Supervision, R.K.; Project Administration, R.K.; Funding Acquisition, R.K.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

Not applicable.

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