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Meta-Analysis Study: Application of Technology Enhanced Learning Model on Student Learning Outcomes

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Abstract

This article discusses the application of the Technology Enhanced Learning (TEL) learning model and its impact on student learning outcomes. This study aims to evaluate the effectiveness of TEL in improving students' skills and understanding in vocational subjects. The method used was a quantitative research with an experimental design, involving two groups of students: one group using the TEL model and a control group applying traditional learning methods. Data was obtained through learning outcome tests, questionnaires, and observations. The results of the analysis showed that students who participated in learning with TEL had a significant improvement in learning outcomes compared to the control group. These findings indicate that the application of the TEL model can improve student motivation, engagement, and understanding, as well as provide recommendations for further integration of technology in the learning process. Thus, this research highlights the importance of innovation in learning methods to prepare students to face challenges in an increasingly digital world of work.

Keywords: Technology Enhanced Learning (TEL), Student learning outcomes, Student motivation, Learning innovation.

1. Introduction

The corona virus pandemic-19 forced the learning system to be changed to home learning or distance learning (Kuncoro & Thaha, 2023). Without realizing it, all of this has a negative impact on the learning and education system. The government has emphasized that it is prohibited to carry out activities that involve crowds such as going to school or learning face-to-face at school. One of the impacts of the corona virus pandemic-19 is that schools must carry out learning online or online and offline (mixed) (Wagino et al., 2024). The high or low learning achievement of students cannot be separated from the role of a teacher as an educator. The roles of a teacher include as a facilitator, learning resource, guide, manager, demonstrator, motivator, and elevator. To create effective learning, creativity is needed from a teacher to renew existing education, especially the methods, approaches, and learning models used to achieve a learning goal (Zulfa et al., 2022).

Learning the 2013 curriculum requires teaching materials in the form of LKPD, including in biology learning the main material of protists which is considered quite difficult because it requires an understanding of the concept, so that through the tasks or exercises contained in the LKPD as a support in understanding concepts that are difficult to learn. Along with the development of technology, innovations have now begun to be made in LKPD, namely what is usually in printed form into a digital form that can be run using a computer or even a cellphone or smartphone. Electronic LKPD can be made with the help of various applications, one of which is live worksheet. The application can be run online, so that students can access it easily. Especially during the Covid-19 pandemic, which does not support offline learning, the use of e-LKPD can be an innovation for teachers (Mispa et al., 2022).

The low learning outcomes of students are also a benchmark for researchers to conduct this research. Based on these problems, one alternative that can be done is to use learning models and media that can provide a new atmosphere in the classroom. One learning model that can be used is the discovery learning model. Currently, there are many media that can be utilized or applied in learning efficiently, one of which is Lectora inspire. Lectora inspire is one of the

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Authoring Tools (software) used to create presentations and develop e-learning content. This media can display images, videos, and symbols clearly, so it will make it easier for students to understand the material given, especially abstract material (Liyani & Zohri, 2023).

2. Research Methods

This study uses a meta-analysis approach, utilizing secondary data as the main source of information. Secondary data for this study were collected from the post-test scores of the experimental and control classes. The scores were based on papers related to vocational and vocational education that utilize TEL-assisted learning. This study uses research articles from domestic and international journals published from 2019 to 2024. The Project-Based Learning (TEL) approach has become a relevant trend to date since its inception in 2019. This study includes a total of thirty research publications that focus on the analysis of students in the vocational and vocational fields.

The steps in this meta-analysis study can be classified into several groups. Initial preparation stage. Data were collected from Google Scholar, namely from many papers on vocational education published between 2019 and 2024. Implementation stage. Collecting data from literature sources between 2019 and 2024. The research data can be summarized briefly as follows: The text provides information about the author, year of study, TEL used, department of vocational education, and job title -test results of the experimental and control groups. Data coding simplifies the analysis by simplifying the procedure.

The results of the analysis show that some of the most common problems faced by teachers are the lack of understanding of educators about TEL methods, low student participation in active learning, limitations in the use of interactive and innovative learning media; and lack of variation in teaching methods. To solve these problems, educators must be given special training to implement TEL, use more sophisticated media and technology, and develop more interactive and student-centered learning strategies.

Data Analysis Stages. The data obtained is calculated using the effect size formula as follows.

$$ES = \frac{M_e - M_c}{SD}$$

Description:
ES = Effect Size Value
Me = Average value of the experimental class
Mc = Average value of the control class
SD = Pooled standard deviation value
Furthermore, the combined standard deviation value can be found using the combined SD formula.

$$SD\ pooled = \sqrt{\frac{(N_e-1)SD_E^2 + (N_C-1)SD_C^2}{N_E + N_C - 2}}$$

Information:
SD pooled = Pooled standard deviation value
Ne = Number of students in the experimental class
Nc = Number of students in the control class
SDe = Standard deviation value for the experimental class
SDc = Standard deviation value for the control class

Once the "pooled standard deviation" is calculated, the mean of the experimental group is subtracted from the mean of the control group, and the result is divided by the standard deviation. The results of this calculation will be interpreted by referring to the effect size category table. The categorization of the treatment effect is determined based on the findings of this interpretation. Therapy in this case relates to the use of the Technology Enhanced Learning TEL Project in an educational setting, specifically in the vocational and technical disciplines.

Table 1. Effect Size Criteria

Effect Size	Information
0,00 – 0,20	Has a weak effect
0,21 – 0,50	Has low effect
0,51 – 1,00	Has moderate effect
> 1,00	Has a high effect

3. Results and Discussion

After an extensive review of 30 studies using Technology Enhanced Learning (TEL) in vocational and technical education, data from the post-test were collected. Data were obtained from both control and experimental classes collected during the study conducted between 2019 and 2024. Table 2 presents the collected data.

Table 2. Meta-Analysis Data

No.	Writer	Year	Kontrol		Eksperiment	
			Pretest	Posttest	Pretest	Posttest
1	Syamsudin & Subagiyo	2022	23,71	58,37	25,28	71,17
2	Aswad dkk.	2022	63,66	66,33	65,16	80,83
3	Arrosyad & Nugroho	2022	65,93	82,83	62,20	88,43
4	Made Rajendra & Made Sudana	2018	59,81	70,55	59,44	77,59
5	Gultom & Muchtar	2022	33,47	71,61	34,77	85,29
6	Harsiwi & Arini	2020	63,07	92,69	69,37	96,25
7	Solehudin dkk.	2020	16,15	24,87	19,70	39,58
8	Mispa et al.	2022	49,31	67,24	53,21	72,50
9	Riantika & Mukminan	2019	66, 35	67,88	67,52	80,23
10	Abdillah	2021	71,4	78,6	73,5	84,8
11	Siregar	2020	1,38	1,5	1,63	1,81
12	Dyanti dkk.	2022	3,.71	80,35	30,35	63,92
13	Alimah	2018	36,07	74,36	35,52	76,66
14	Nuroh & Ubaidillah	2024	57,78	90,56	49,44	86,11
15	B. E. K. Dewi	2020	19,85	74,42	20,40	89,45
16	Solihah	2023	38,3	56,3	41,3	71,7
17	Setyawan dkk.	2023	74,46	70,14	70,14	86,14
18	Sari	2022	29,69	53,44	30,63	70,63
19	Harsiwi & Arini	2020	63,07	92,69	69,37	96,25
20	Solehudin dkk.	2020	16,15	24,87	19,70	39,58
21	Zulfa dkk.	2022	47,07	55,86	42,24	60,17
22	Mispa dkk.	2022	49,31	67,24	53,21	72,50
23	Haslinda dkk.	2020	43,11	44,44	57,78	59,33
24	Basuki dkk.	2021	84,38	86,97	86,37	91,14
25	Dewi & Nurdiani	2023	61,0	68,5	60,5	80,2
26	Sukoco dkk.	2024	71,32	71,38	70,35	70,48
27	Liyani & Zohri	2023	50,00	66,32	53,68	82,37
28	Khotimah dkk.	2024	56,99	70,51	57,66	83,05
29	Akbar dkk.	2020	30,10	33,20	80,57	75,60
30	Siregar	2020	61,0	68,5	60,5	80,2
Average			48,14	64,417	51,96	73,79

The post-test data is presented graphically to facilitate analysis. A graph representing the post-test data is shown on Figure 1.

The average posttest score of the experimental class was 73.79, while the control class had an average score of 64.417. The calculated combined standard deviation was 5.232. The final score of 1.79 was determined using the effect size algorithm. The number 1.79 is considered to have a fairly large influence, exceeding 1.00. The calculation is as follows:

$$\text{SD pooled} = \sqrt{\frac{(N_e-1)SD_E^2 + (N_C-1)SD_C^2}{N_E + N_C - 2}}$$

$$\text{SD pooled} = \sqrt{\frac{(30-1)5{,}215^2 + (30-1)5{,}25^2}{30 + 30 - 2}}$$

$$\text{SD pooled} = \sqrt{27{,}379} = \mathbf{5{,}232}$$

$$ES = \frac{M_e - M_c}{SD} = 1{,}79$$

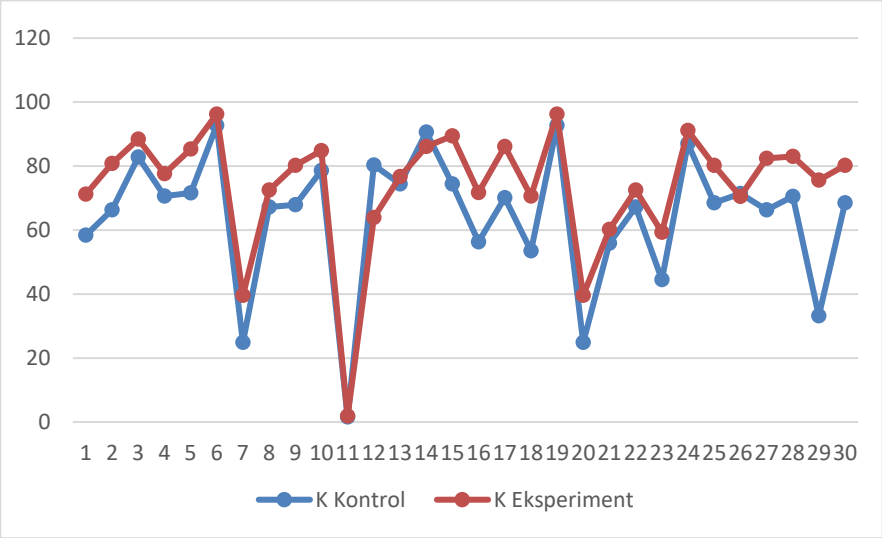

Figure 1. Tabulation of Meta Analysis Data

The figure 2 shows the TEL learning process that can be applied in learning.

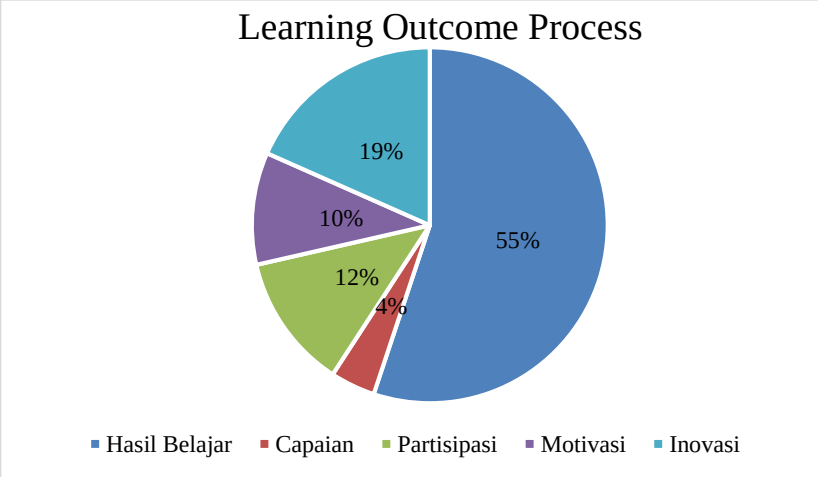

Figure 2. Learning Outcome Process

Based on statistics, by following the learning process that includes knowledge, skills, and attitudes, TEL can be used to improve students' understanding and skills. Learning outcomes are achievements achieved by students as a result of the TEL learning approach.

In addition, mobile learning is used to improve creative utilization in the educational process. This method was identified in about 19% of the 30 publications analyzed in this study. This value is the second highest, indicating that mobile learning is widely used to improve cognitive achievement in vocational education, especially at the vocational school level. Mobile learning differs from traditional learning models because it provides significant opportunities to improve the learning environment by making it more dynamic, portable, networked, and personalized.

Through the analysis of educational achievements and disciplines that integrate TEL into the learning process, we can produce data as in the attached image. After analyzing 30 collected articles, it is seen that TEL shows the highest learning outcomes.

The results of the study indicate that the use of TEL has a significant positive impact on students' cognitive achievement. Based on an analysis of 30 publications involving experimental and control classes, the average post-test score of students in the experimental class using TEL was 73.79, while in the control class it was 64.417. The effect size value obtained was 1.79 indicating a very large effect of the use of TEL in the learning process.

Learning Outcomes are statements that are expected as a result of the learning process. It includes the knowledge, skills, and attitudes that students should have after completing a program or curriculum. proven to be very effective in enhancing students' creativity TEL, which was identified in about 19% of the publications analyzed, also showed a high level of effectiveness, providing greater flexibility and accessibility for students. TEL in education not only helps to overcome current challenges, such as the limitations of physical interaction, but also contributes to improving the quality of learning and students' digital skills. Thus, the implementation of TEL in education can be considered an important long-term strategy to improve educational standards and prepare students for the challenges of the digital age.

In addition, these findings indicate that the application of TEL in education opens up opportunities to develop more interactive and collaborative learning methods. With TEL, students not only act as recipients of information, but also as active participants in the learning process, which encourages them to work together in teams and contribute significantly to the projects being carried out. This method facilitates discussion, exchange of ideas, and collective problem solving, thus creating a dynamic and engaging learning environment. Through this approach, students can develop important social and communication skills, while deepening their understanding of the subject matter.

The use of Technology Enhanced Learning (TEL) as the primary approach in learning has proven effective in helping students understand complex concepts through engaging visualizations and animations. For example, students can participate in projects that involve creating models or simulations that depict scientific phenomena, so they can see and experience firsthand the applications of the theories they are learning. In this way, TEL not only increases student engagement, but also allows them to better internalize information, making learning more enjoyable and meaningful. This method encourages students to think critically and creatively, and encourages them to explore various aspects of the material being studied.

Furthermore, this study shows that the effective implementation of TEL can bridge the gap in digital literacy that has been an obstacle for many graduates. By getting used to using various tools and applications during the learning process, students not only improve their academic knowledge but also digital skills that are essential for the future world of work. This increase in digital literacy is expected to reduce the unemployment rate among vocational graduates, considering the skills of students. This study emphasizes the importance of implementing effective learning methods in vocational education, which focus on developing practical skills and industry relevance. By using an interactive and collaborative approach, students can be actively involved in the learning process, thereby improving their understanding and abilities in the field being studied. The right method not only helps students master the material, but also prepares them to face challenges in the world of work, making vocational education more responsive to future needs.

Although these findings show positive results related to the implementation of Technology Enhanced Learning (TEL) in vocational education, there are several challenges that need to be considered in its implementation. These challenges include the availability of adequate technological infrastructure, teacher readiness in using this method, and the gap in student access to the necessary devices. To overcome these obstacles, collaborative efforts are needed to increase resources and training, so that TEL can be implemented effectively and provide maximum benefits for students in preparing them for the world of work.

Second, Teachers' readiness and competence in implementing Technology Enhanced Learning (TEL) method is a crucial factor that influences the success of learning. To ensure the effectiveness of PjBL, adequate training for teachers is needed, so that they can master the appropriate teaching techniques and integrate this method into the curriculum well. With proper training, teachers can create a supportive learning environment, facilitate collaboration between students, and encourage active involvement, all of which are essential to achieving the goal of quality vocational education.

Third, there is an urgent need to ensure that all students have the necessary tools to engage in Technology Enhanced Learning (TEL). The availability of adequate tools and resources is essential for students to be actively engaged in

projects designed to enhance their understanding and practical skills. Without the right tools, students may struggle to collaborate, access information, and complete tasks required in TEL. Therefore, educational institutions need to take steps to provide the necessary tools, ensuring that all students, regardless of economic background, can fully participate and gain maximum benefits from this learning approach.

Next It is important to continuously evaluate and update Technology Enhanced Learning (TEL)-based learning methods to remain relevant to technological developments and dynamic industry needs. By conducting regular evaluations, educators can identify strengths and weaknesses in the implementation of TEL, and adjust teaching strategies to improve learning effectiveness. This update includes not only the integration of the latest tools and resources, but also the development of a curriculum that is responsive to job market demands. Thus, students will be better prepared to face challenges in the professional world and can optimally utilize the skills they learn through TEL.

This study confirms that the use of TEL in vocational education not only improves student learning outcomes but also offers great potential to improve the education system as a whole. Challenges in implementation must be addressed through infrastructure improvements, teacher training, and student support, so that TEL integration can provide maximum and sustainable benefits for vocational education in Indonesia.

4. Conclusion

The implementation of Technology Enhanced Learning (TEL) in education has a significant impact on learning outcomes, as indicated by the estimated effect size of 1.79. This value, which exceeds 1, indicates that PjBL not only increases students' engagement in the learning process but also substantially improves their understanding and skills. Thus, PjBL can be considered a very effective method in improving the quality of education and student learning outcomes.

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