Interactive e-books to enhance technical drawing abilities of mechanical engineering students in on-line classes in post-pandemic times

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ABSTRACT: The recent Covid-19 pandemic has changed face-to-face learning to on-line learning methods. Now, there are several alternatives available, but it is most likely that on-line learning for mechanical engineering drawing with interactive e-modules equipped with exercises will continue. In this on-line environment, students can practise drawing independently through self-regulated learning - they are free to organise their own learning. This study aimed to analyse student learning outcomes after implementing on-line learning supported by e-modules for mechanical engineering drawing at the beginning and end of the learning process. A one group pre-test - post-test research strategy was used in this quasi-experimental study with data analysed using the parametric paired-sample test. The findings indicate that students' learning outcomes improved significantly as evidenced by the hypothesis test's results with the value of significance < than 0.05 or H_o was rejected. In addition, the average value of student learning outcomes also increased, as the pre-test value was 59.88 and after the implementation of on-line learning assisted by e-modules, the post-test value increased to 89.20.

INTRODUCTION

The Covid-19 pandemic was triggered by a dangerous virus that had become increasingly virulent on a massive scale. As of 10 June 2020, there were 34,316 cases of Indonesian people exposed to Covid-19 [1]. This pandemic had put huge pressure on various sectors, including the economy, social culture and education. The effects of Covid-19 required all practitioners and users in various sectors to quickly adapt to the changed conditions. Especially in the education sector, teachers and lecturers were required to adapt quickly, changing from predominantly face-to-face teaching to on-line learning methods.

One of the Surabaya state educational institutions of higher learning, Surabaya State University (UNESA), immediately responded to these demands. Theoretical lectures were conducted virtually, as stated in the Chancellor's Circular Letter Number: B/152/UN38/TU.00.02/2020 [2], which addressed the necessary steps to stop the spread of Covid-19 at UNESA. In those changed circumstances all lecturers had to provide practical lectures and appropriate tasks to meet the learning accomplishment targets.

Several solutions had been provided, such as conducting face-to-face learning on-line using teleconference platforms, such as Zoom, Skype or Google Meet. However, these solutions were very burdensome for students considering that the number of required data packages was not small. Apart from that, for students whose homes are located in villages and far from busy cities, signal problems were yet another factor that hindered the implementation of the learning process. Another alternative was to carry out self-directed on-line learning.

In 2023, Indonesia's president pronounced that the Covid-19 pandemic had ended and altered the disease's factual status to endemic in Indonesia by Presidential Decree No. 17 of 2023. Consequently, the designation of the Covid-19 pandemic as a national disaster and the designation of the disease's spread as a non-natural disaster had been formally annulled.

Even though the status of Covid-19 has been changed, activities in the education sector continue to be delivered on-line. However, there are some policies on changing to a hybrid system; namely, using both on-line and off-line learning.

In the Mechanical Engineering Drawing course offered by the Department of Mechanical Engineering at UNESA, the on-line system is still used, with on-line lecture activities supported by interactive e-books. This is a basic theoretical course but the learning outcomes are of practical nature. Within the on-line system used students and lecturers meet on-line through the Google Meet application to support learning activity, in addition to using a project-based learning (PjBL) model assisted by interactive e-books to achieve the learning objectives. For a technical drawing course, this approach seems quite effective, considering that it does not require a large number of data packages.

Project-based learning has a lot of potential in improving skills in the 21st century as it involves students in real-world tasks [3]. The PjBL approach enables students to be prepared to face difficult situations, develop skills, and manage time and work well together [4]. Further, PjBL enables students to develop self-dependence and also a sense of responsibility for completing an activity. In learning, there is collaboration between students and lecturers; in PjBL a lecturer can be more intensely involved in guiding students to complete their projects. The advantage of PjBL for students is that the provided assignments are meaningful and relate to the material covered in class and the practical needs of the world of work [5].

Based on previous research, the use of e-books in this digital era has implications for the convenience of people's daily lives, especially those related to reading activities. The use of e-book facilities has a high influence ($g = 0.82$) on students' learning abilities [6][7]. Saripudin at al state that e-books have a positive effect on graduate achievement; however, when developed they need to be equipped with various learning media in the form of explanations, short audio and video, animations and infographics [8].

Considering this background, it can be stated that using e-modules should be successful as an alternative and assistance in the learning process. Thus, the problem formulation offered in this research is whether the ability to draw work objects can be improved by implementing on-line learning supported by the mechanical engineering drawing e-module?

Meanwhile, the main aim of this research is to analyse the increase in student learning outcomes after implementing on-line learning supported by e-modules for mechanical engineering drawing between the beginning and end of the learning process.

METHOD

Quasi-experimental research was conducted to find a causal relationship after treatment was given to the research subjects. One group of students was involved in the pre-test - post-test part of the research. All research participants were students of the UNESA Mechanical Engineering Department who were taking the Mechanical Engineering Drawing course. The pre-test activity was carried out at the beginning of the semester, first lesson on 4 September 2023, while the post-test activity was carried out at the end of the semester, 16th lesson on 1 December 2023.

The technique used in sampling was random sampling based on the Slavin formula. Through this technique, a maximum sample size of 154 undergraduate mechanical engineering students were selected from a population of 250, comprising 10 females and 144 males.

The technical drawing material was designed in eight meetings, during the implementation the lecturer and students met on-line every two weeks, or every two meetings there was only one face-to-face. So, during lectures with technical drawing material, the lecturers met students face-to-face on-line four times.

During the first meeting, when issues were determined (determining issues phase), the lecturer gave pre-test questions and delivered the material to students, as well as the technical implementation instruction of the lectures and shared e-books with them.

The second meeting was the communication phase. During that meeting the lecturer confirmed students' knowledge after reading the e-book, apart from that the lecturer provided reinforcement related to e-books and projects.

The third meeting was the mentoring and discussion phase, during which the lecturer provided mentoring regarding the achievement of the assignment and held related discussions on difficulties in the project work.

The fourth meeting was the dissemination phase, during which students collected their completed assignments and made short presentations related to the assignments. Apart from that, in this phase the lecturer gave a post-test to measure the learning progress of the students.

Data were collected from the pre-test conducted before the treatment and from the post-test after the treatment. The test items were in the form of performance test on a worksheet with five work orders. For data analysis a normality test, a homogeneity test, and a hypothesis test with the help of SPSS 16 software were applied. Normality tests were carried out using the Kolmogorov-Smirnov test [9], while the Levene test was used for homogeneity testing [10].

RESULT AND DISCUSSION

In quasi-experimental research, there are two important stages that must be carried out before carrying out hypothesis testing. The first stage is to test the normality of the data using the Kolmogorov-Smirnov test. This step aims to evaluate the extent to which the data used has a normal distribution. The importance of this stage lies in the ability of the data to represent the research population, so a test is needed to check if the data meets the normal distribution criteria. The results of the data normality test can be found in Table 1.

Table 1: Kolmogorov-Smirnov test for one sample.

One-sample Kolmogorov-Smirnov test			
		Pret-test	Post-test
N.		154	154
Normal parameters[a,b]	Mean	59.88	89.20
	SD	4.142	4.120
Most significant gaps	Absolute	0.066	0.065
	(+) Positive	0.064	0.060
	(-) Negative	-0.066	-0.065
Test statistics		0.066	0.065
Asymp. 2-tailed sig.		0.200[c,d]	0.200[c,d]
a. It is a normal test distribution			
b. Determined by data			
c. Correction of Lilliefors significance			
d. This represents the genuine significance's lower bound			

If the significance value has a value greater than 0.05, the data is defined as normally distributed (approve H_0) with regard to the Kolmogorov-Smirnov test criteria. In a situation when the significance value of the Kolmogorov-Smirnov test is less than 0.05, the data is defined as non-normally distributed or H_0 is rejected. The significance level for the e-module pre-test value was 0.200, and the e-module post-test value was also 0.200, according the findings of the Kolmogorov-Smirnov test results. Hence, H_0 is accepted, indicating that the data is normally distributed, because the significance values of the e-module pre- and post-tests are greater than 0.05. The findings of this study are consistent with those of Auly et al [11]. This shows that if the research data meets the data normality test criteria or the resulting significance value is greater than 0.05, then the research data is called *normal*. In addition, Miot and Miot, also explained that the normality test of data distribution is an important technique that can be used to adequately describe samples and their inferential analysis [12].

Levene's test of equality of error variances was used to conduct the second prerequisite test - the homogeneity of variance test. The purpose of this test is to demonstrate that the sample data originates from a population with the same variance. The homogeneity of variance test was run on the e-module pre-test and post-test outcomes in this study. Table 2 displays the results of the homogeneity of variance test.

Table 2: Test of homogeneity of variance - results.

Test of homogeneity of variances					
		Levene's statistics	df-1	df-2	Sig.
Pre-test and post-test on the e-module	Determined by mean	0.051	1	306	0.822
	Determined by median	0.049	1	306	0.824
	Determined by median and with adjusted df	0.049	1	305.405	0.824
	Determined by trimmed mean	0.052	1	306	0.821

When the significance value of the data is more than 0.05, it is considered to have homogenous variance (accept H_0) according to Levene's test of equality of error variances. Nonetheless, the data is classified as lacking homogenous variance or rH_0 is rejected, if the outcomes of Levene's test of equality of error variances reveal a significance value less than 0.05. A significance value of 0.824 was derived from the outcomes of Levene's test of equality of error variances.

H_0 is deemed acceptable since the significance value is higher than 0.05, which means the sample has a homogeneous variance. This explains that homogeneity of variance generally requires that the variances in each population must be the same [13]. If the variance is not homogeneous, then it can be stated that the underlying population is heterogeneous. However, Levene's test is an alternative to Bartlett's test, despite being less sensitive to departures from normality [14].

It was established that the data was normally distributed and originated from homogeneous variance based on the outcomes of the prerequisite analytical tests. The next step was to use SPSS 16 software to conduct a hypothesis test using the paired sample *t*-test. Table 3 displays the paired sample *t*-test findings.

Table 3: The paired-sample statistics.

Paired samples statistics					
		Mean	N	SD	Std. error mean
Pair 1	Pre-test on the e-module	59.88	154	4.142	0.334
	Post-test on the e-module	89.20	154	4.120	0.332

In the paired sample *t*-test, a significant increase in student learning outcomes is determined, if the significance value is less than 0.05 or if H_0 is rejected. On the other hand, it is declared that there is no discernible improvement in student learning outcomes, if the significance value is larger than 0.05 or if H_0 is accepted. Based on the average score data in Table 3, it is evident that before implementing on-line learning supported by e-modules, the average student score was 59.88 (pre-test). Then, this score increased by 49% to 89.20 after implementing on-line learning supported by e-modules.

Table 4: Paired-sample test.

		Paired-differences							
					95% confidence interval of the difference				
		Mean	SD	Std error mean	Lower	Upper	*t*	df	Sig. (2-tailed)
Pair 1	Pre-test on the e-module - post-test on the e-module	-29.325	5.767	0.465	-30.243	-28.407	-63.107	153	0.000

Apart from that, and following the execution of the hypothesis test in Table 4, the findings show that the significant value was less than 0.05, indicating the rejection of H_0 or the acceptance of H_1. These findings indicate that there has been a notable increase in learning outcomes after students carried out on-line learning activities supported by e-modules. So, the research hypothesis that on-line learning supported by e-modules can improve the learning outcomes of mechanical engineering undergraduate students in the Mechanical Engineering Drawing course is proven.

This achievement cannot be separated from the selectively chosen e-module material, as the book also presented examples related to technical drawings so that students could practice drawing according to given examples. To create drawings like the given examples, the e-module includes guidance on how to draw. Below is an example of an e-module original description related to training features.

Training

Using a compass and a ruler

1) Dividing a line into equal lengths. (Figure 26 a)
   How to do it
   a. Draw a line A-B (arbitrary)
   b. Draw a circle of radius r_1 with point A as its centre
   c. By changing the radius ($r_1 = r_2$), circle r2 with centre point B, so that it intersects at C and D
   d. Draw a line from C to D until it intersects line A-B at E, so that AE = EB
2) Dividing a line into n equal parts (Figure 26 b)
   How to do it
   a. n = a number greater than 2
   b. Suppose n = 15 equal parts
   c. Draw a line AB, the base of the line is called point A, the end of the line is called point B
   d. Divide the line into 15 equal parts and give consecutive letters according to the alphabet at each point
   e. Draw a help line from point A down with an arbitrary slope
   f. Determine the value of r_1 using a term with an arbitrary radius

The results of these investigations reveal that, following the implementation of on-line learning, there is a considerable change between the pre-test and post-test scores of the students supported by e-modules. This shows that if lecturers are able to implement on-line learning according to the characteristics of the course and students, then students' learning outcomes tend to increase. The same results as in this research were obtained by Jaenudin et al, who pointed out that using media in the classroom is one of the most efficient ways that can stimulate students to learn actively [15]. The effective application of problem-based e-module learning can be used to make learning more interesting and students can be motivated to participate in learning [16]. Besides that, the learning that takes place will be meaningful even if it is done on-line [17].

Another study where the results showed an n-gain test result of 0.6, which means that they were placed in the medium category, was conducted by Serevina et al [18]. This means that there was an increase between before and after e-module learning based on problem-based learning (PBL). Similar research on e-modules based on project-based learning (PjBL) methods was also conducted by Ningtyas and Jati [19]. The results show that the e-module was in the category suitable for design experts and very suitable for material experts. Evaluation in the beta test found that the percentage of 8.6% was in the quite feasible category, 71.4% was in the feasible category, and 20% was in the very feasible category. Moreover, Yulando et al created an interactive electronic module, where expert validation results stated that the interactive electronic module was suitable for use and was in the *very good* category with a feasibility percentage of 93.4% [20].

CONCLUSIONS

The study's findings show a considerable improvement in student learning results. This is demonstrated by the hypothesis test findings, which showed that H_0 was rejected or that the significance value was less than 0.05. In addition, the average student score improved steadily. Before implementing on-line learning assisted by e-modules, the pre-test score was 59.88; after that, the post-test score increased by 49% to 89.20. Thus, the study hypothesis that e-module-supported on-line learning can enhance undergraduate students' learning outcomes in the Mechanical Engineering Drawing course for mechanical engineering students is validated. Furthermore, the e-module from this research can be used by lecturers, students and students in other vocational schools as one of the learning media for technical drawing materials.

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