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Practicality and Effectiveness of Digital Mathematics Teaching Materials in Improving the Problem-Solving Ability for Polytechnic Students

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Abstract

This study aims to determine the level of practicality and effectiveness of digital mathematics teaching materials to improve blended learning problem-solving abilities of polytechnic students. Teaching materials are formatted in the form of textbooks and student activity sheets (SAS). Research using the 4D model development method includes: Define, Design, Develop, and Disseminate, carried out at the Bali State Polytechnic (BSP). Practicality is seen from the ease of use, the attractiveness of presentation, and benefits. Effectiveness is seen from the achievement of problem-solving abilities in students. Data were collected through practicality questionnaires, and math problem-solving ability tests. Data were analyzed descriptively, t-test, paired t-test, and N-Gain Score test. The results show that the practicality of digital mathematics textbooks and SAS in terms of lecturers reaches 82.1% and 81.6% both are categorized as practical by students reached 81.4% in the practical category and 92.8% in the very practical category. The digital mathematics textbooks and SAS are quite effective in improving the ability to solve mathematical problems in blended learning. The implication is that digital mathematics textbooks and SAS can be used as teaching materials to accompany mathematics learning using blended learning.

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1 Introduction

The 21st century is a century based on science and technology, so it requires a country's human resources to master various skills. Vocational education is an educational program that prepares students to enter the world of work, both formal and non-formal (Westover & Westover, 2014). Vocational education is required to prepare quality graduates who can compete globally and master technological developments (Iswan & Bahar, 2018).

Polytechnic is an integral part of higher vocational education. Polytechnics produce graduates who can perform tasks in the industry professionally. Therefore, learning at polytechnics must be able to develop student work competence capabilities to be ready to solve various problems in society and the world of work, as well as enter positions in the 21st-century world of work. Learning in polytechnic education needs to be packaged following the 21st-century learning paradigm so that it can guarantee job readiness and work career development according to the demands of stakeholders' needs.

21st-century learning is learning characterized by learning skills and literacy skills. Learning skills, learning process development are needed to adapt and thrive in modern society. The learning activities use technology-based learning media, emphasizing the formation of collaboration, communication, and critical and creative thinking skills (Mailani & Syafii, 2020). However, in early 2020 the COVID-19 pandemic suddenly appeared and forced every activity to stop, including learning activities at polytechnics. The learning process at polytechnics must be able to take place continuously without space and time limits, learning is carried out through e-learning (Rahman, 2020; Hameed et al., 2008). Lecturers are required to innovate in preparing their devices and changing face-to-face learning patterns into full online learning patterns through e-learning.

During the COVID-19 pandemic, several vocational schools and polytechnics conducted e-learning. E-learning is a learning system without face-to-face directly between lecturers and students, through the internet network (Hofmeister & Pilz, 2020). E-learning uses a web-based Learning Management System (LMS) application equipped with absences, teaching materials, assignments, and assessments that are packaged in digital form (Engeness et al., 2020), can also be equipped with videos to increase student understanding (Mazin et al., 2020).

E-learning does provide many advantages, such as high flexibility, varied content, and low cost, it turns out that there are various difficulties encountered in online-based vocational learning (Olelewe et al., 2020). Vocational students experience boredom in participating in the learning process, tend to be unmotivated, and uninterested compared to face-to-face learning, online learning has limitations, especially in terms of practice (Mulyanti et al., 2020). The results also show that students want a learning environment, a supportive curriculum, interaction with friends and teachers, and project-based learning (Hunt & Oyarzun, 2020). To complement each other between e-learning and face-to-face learning, a mixed model is used which is commonly called blended learning (Okaz, 2015; Stockwell et al., 2015).

According to Semler (2005), blended learning combines the best aspects of online learning, structured face-to-face activities, and real-world practices. Blended Learning is a learning model that combines harmoniously, structured, and systematically the advantages of face-to-face and online learning (Nguyen, 2015; Garrison & Kanuka, 2004). This learning combines the advantages of face-to-face learning models in classroom learning and online learning that can be done anywhere and anytime.

Blended learning has been proven to be effective in improving the quality of learning outcomes: has a positive impact on student academic achievement (Obiedat at al., 2014), is effective for assisting students in learning (Isti'anah, 2017), have a positive impact on learning outcomes of skills, and attitudes (Almasaeid, 2014), and can improve student understanding (Bibi & Jati, 2015). The prerequisite is that learning devices such as teaching materials have been prepared properly by the lecturer (Abdullah, 2018).

Teaching materials are a set of learning materials (teaching materials) that are arranged systematically, showing a complete figure of competencies that will be mastered by students in the learning process (Dick & Carey, 2005). Teaching materials need to be adapted to the conditions of students and the learning strategies used by lecturers. Learning mathematics in the future leads to the use of blended learning models (Darma et al., 2020). Five keys to success in using blended learning to improve the quality of learning, namely: live events, self-paced learning, collaboration, assessment, and performance support materials (Carman, 2005; Karma et al., 2019). Performance support materials are devices and performance support materials, one of which is learning materials. Study materials are prepared in digital form and must be accessible to students both offline and online.

Teaching materials as learning substances can be in the form of written or unwritten materials. The forms include: textbooks, textbooks, modules, student activity sheets (SAS), handouts, and others. Two interrelated teaching materials widely used in education are textbooks and SAS (Woody et al., 2010; Törnroos, 2005). Textbooks are handbooks for a course that are written and compiled by experts in related fields and meet the rules of textbooks and are officially published and disseminated (Kemendikbud, 2017). Textbooks are open standards compiled by experts in their fields based on special provisions related to learning to meet needs, according to the characteristics and plans of student learning activities. Its position and function are very important in learning activities (Muslich, 2010). Textbooks have a significant effect on students in understanding information and knowledge related to the field of science being studied (Rockinson-Szapkiw et al., 2013).

SAS is printed teaching material in the form of sheets containing assignments that refer to basic competencies equipped with instructions or working steps so that students can study independently or with assistance from lecturers. In line with Prastowo (2015) and Trianto (2011), SAS is a teaching material that has been packaged in such a way, so that students are expected to be able to learn the teaching material independently. One of its functions can minimize the role of lecturers but activate students more (Trianto, 2012). SAS can educate students to be independent, confident, disciplined, responsible, and able to make decisions. SAS can also maximize understanding to form basic skills indicators of learning achievement indicators. SAS must be done by students to maximize understanding to form basic skills indicators of learning outcomes that must be achieved.

To improve the quality of applied mathematics learning through blended learning, it is necessary to develop teaching materials in digital packaging. In web-based learning, digital teaching materials are independent teaching materials that are packaged electronically for students to learn independently. In blended learning, in addition to digital textbooks, in the learning process students also use digital SAS (Idris, 2018; Majid & Rochman, 2014).

Digital teaching materials are teaching materials written using special applications to be read through digital devices such as smartphones or cellphones, laptops, and others. In general, documents can be formatted in the form of PDF, DOC, XLS, JPG, PNG, and others. The use of digital teaching materials can increase the effectiveness of learning because the content is equipped with various interesting simulations/animations as well as virtual experimental designs that can lead students to be involved or experience the science process (Kealey, 1989; Lau & Tsui, 2009). Digital teaching materials are considered more profitable than using ordinary or manual teaching materials. Especially in the 21st- century learning to integrate ICT, learning is done online or with a blended learning model.

Mathematics is one of the basic sciences taught at the Polytechnic and plays an important role in the development of science and technology. Mathematical skills and knowledge are very important in everyday life and as the basis for the development of science and technology (Omar, 2002; Curriculum Development Centre, 2003). Mathematics as a supporting tool prepares polytechnic students to be able to solve problems (Nagasaki, 2015). Mathematics is a medium in developing the attitudes and skills of polytechnic students in the 21st century.

Problem-solving ability is an inseparable part of learning mathematics. Problem-solving skills become an integral part of learning mathematics Wahyudin (2008), even become central in teaching mathematics (Ruseffendi, 2006). Branca (1980), emphasizes that the importance of having mathematical problem-solving skills in students is that problem-solving skills are the goal of teaching mathematics, even as the heart of mathematics. To facilitate students in achieving these skills, appropriate learning resources are needed following the 21st-century mathematics learning paradigm. One of these learning resources is mathematics teaching materials in the form of textbooks and blended learning-based digital SAS (Suharta et al., 2017).

The development of digital mathematics textbooks and MFIs must be based on instructional principles so that they can become good teaching materials. Some of the instructional principles that must be considered are the principle; relevance, consistency, and adequacy (Depdiknas, 2006; Akbar, 2013). While good teaching materials are teaching materials that are feasible, practical, and effectively used to support the activities of the learning process. Trianto (2007), states that teaching materials are said to be good if they meet: 1) aspects of validity, (2) aspects of practicality and 3) effectiveness. Furthermore, Rochmad (2012), states that the teaching materials developed are said to be valid if they meet content validity and construct validity. Practicality refers to the degree that users consider an intervention to be usable and preferable under normal conditions (Van den Akker, 1999; 2005). Meanwhile, effectiveness refers to the results with a purpose (Mulyasa, 2004). The effectiveness of teaching materials is the level or degree of application of teaching materials (Rochmad, 2012).

So far, there are no teaching materials that are following the learning paradigm demanded by the 21st-century educational paradigm and the COVID-19 pandemic conditions. Lecturers teach based on handouts even though learning is carried out by e-learning. On the other hand, teaching materials have a very important role in every education system (Widodo & Jasmadi, 2008; Arifin & Kusrianto, 2009; Prastowo, 2015; Tim Jago Nulis, 2016; Utama & Nuur, 2014). The use of appropriate teaching materials in the learning process can increase student activity

in learning (Prastowo, 2015). Sidiq (2020), proved Digital teaching materials in the form of Android-based interactive e-modules are effectively used to improve student learning outcomes in the learning process.
Teaching materials and blended learning play a very important role in supporting the development of education so that when the two are combined, it can be believed that they can educate students to be able to live in the digital era. This study aims to obtain good teaching materials following instructional principles in blended learning to improve mathematical problem-solving abilities. The research was carried out in stages. The first stage (2019) has obtained valid prototypes of textbooks and SAS. This stage (2020/2021) aims to determine the level of practicality and effectiveness of the prototype of textbooks and digital SAS mathematics in blended learning to improve mathematical problem-solving abilities (Karimi & Dowlatabadi, 2014; Lee & Kim, 2020).

2 Materials and Methods

This research is development research aimed at obtaining digital teaching materials in the form of textbooks and SAS mathematics for blended learning. It is carried out in stages in the field of Engineering at the Bali State Polytechnic. The subjects are Mathematics lecturers and students in Engineering at the Bali State Polytechnic. The approach using a 4-D model includes the stages: 1) Define, 2) Design, 3) Develop, and 4) Disseminate (Trianto, 2011).

Define needs analysis to determine goals and problems as a benchmark in the preparation of teaching materials. Design prepares prototype I teaching materials and evaluation tools that are valid based on data at the define stage (Nieveen, 2009). The development stage is to get prototype II of practical and effective textbooks and MFIs. This stage is carried out through group trials and limited tests. The assessment was carried out by filling out a practical questionnaire on prototype II (Akbar, 2013; Sugiyono, 2013). While the dissemination stage is the use of products that have been developed on a wider scale such as classes and other lecturers.

Data for practicality, collected using a practicality questionnaire. Practicality through small group trials, large groups, and limited trials. Aspects of measurement include: ease of use, the attractiveness of presentation, and benefits (Nieveen, 1999; 2009). The data from the practicality test is calculated using the formula developed by Purwanto (2010), as follows:

$$P = \frac{R}{MS} x100\%$$

Information:
P = Practicality value
R = Score obtained
SM = Maximum score

Interpretation of practicality categories of teaching materials using the categories in Table 1.

Table 1
Categories of learning device practicality

No	Achievement rate (%)	Category
1	85 – 100	Very practical
2	75 - 84	Practical
3	60 - 74	Practical enough
4	55 - 59	Less practical
5	0 - 54	Not practical

Source: Purwanto, 2004

Effectiveness refers to the degree that the experience and outcomes of the intervention are consistent with the intended learning outcomes. The effectiveness of teaching materials is seen from the results of the pretest and posttest of students' ability to solve mathematical problems. Effectiveness testing is carried out after the prototype of digital teaching materials is declared practical. The test was carried out through a quasai experiment with a one-group pretest-posttest design (Sugiyono, 2013), which can be seen in Table 2.

Table 2
One group pretest-posttest design

Pretest	Treatment	Posttest
Q_1	X	Q_2

Information:
O_1 = pretest math problem-solving ability before learning
O_2 = post-test of math problem-solving ability after learning
X = Treatment of blended learning using digital mathematics teaching materials

The effectiveness test was carried out in the field of Engineering at the Bali State Polytechnic in 2020/2021. Samples were taken purposively as many as 10 classes. The sample size of 130 was taken from 18 classes spread over 6 majors and 15 study programs. The sample class is taught using the Flipped Classroom version of the blended learning model with the LMS Schoology application and is facilitated with digital math materials.

Pretest and posttest data were collected using a mathematical problem-solving ability test developed by the researcher himself. The instrument validity level ranges from 0.44 to 0.76, the reliability is 0.77, the difficulty level ranges from 0.63 to 0.83 with a discriminating power index between 0.23 to 0.55. Data were analyzed descriptively, t-test and t-test were related and n-gain score. Previously, the analysis requirements were tested, namely the normality test. The normality test used the Kolmogorov-Smirnov test. The effectiveness of teaching materials is measured based on a review of the percentage of the N-Gain Score. The three results of the analysis identify the effectiveness of textbooks and SAS as alternative teaching materials in improving students' mathematical problem-solving skills in blended learning. The category of obtaining the N-Gain Score value can be determined based on the N-Gain Score value or from the N-Gain Score value in the form of a percent (%). In this study, the N-Gain Score value is in the form of a percent (%). The level of effectiveness of teaching materials using categories from Hake (1999) in Table 3.

Table 3
Categories of Interpretation of the Effectiveness of N-Gain Score

Percent (%)	Interpretation
< 40	Ineffective
$40< g < 55$	Less effective
$56< g <75$	Effective enough
>76	Effective

Source: Hake, 1999

3 Results and Discussions

This research is development research using a 4-D model, currently being carried out in the development and dissemination stages to determine the level of practicality and effectiveness of textbooks and SAS so that they are ready to be disseminated. At the previous development stage, the results of testing the validity of the prototype of digital mathematics textbooks and SAS showed that it was feasible to be used as teaching material in blended learning, but minor revisions were needed according to input from the validator. The eligibility rate reached 83.1% and 83.7%, both valid categories. Both have been proven to have high content and construct validity and can be continued in the practicality and effectiveness test stages.

The practicality test was conducted through small group test, large group test, and limited trial test. Meanwhile, the effectiveness test was carried out through a quasai experiment. The subject of practicality testing includes lecturers and students in the field of engineering. While the subject of the effectiveness test is students who get

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applied mathematics courses in the field of BSP engineering in 2020/2021. The recapitulation of practicality test results by lecturers and students is presented in Table 4 and Table 5 below.

Table 4
Recapitulation of practical results for textbooks and digital BSP applied mathematics for blended learning by lecturers

Teaching materials	Aspect	Lecturer (L)					Average (%)	Category
		L_1	L_2	L_3	L_2	L_3		
Textbooks	Ease of Use (%)	77.5	87.5	87.5	87.5	82.5	84.5	Practical
	Serving Attractiveness (%)	80.0	80.0	80.0	80.0	85.0	81.0	Practical
	Benefit (%)	80.0	80.0	84.0	84.0	84.0	82.4	Practical
	Average (%)	79.2	82.5	83.8	83.8	83.8	82.6	Practical
SAS	Ease of Use (%)	77.8	84.4	84.4	82.2	82.2	82.2	Practical
	Serving Attractiveness (%)	80.0	80.0	80.0	85.0	85.0	82.0	Practical
	Benefit (%)	82.9	80.0	80.0	80.0	80.0	80.6	Practical
	Average (%)	80.2	81.5	81.5	82.4	82.4	81.6	Practical

Table 5
Recapitulation of practical results of textbooks and digital SAS applied mathematics for blended learning by students

Teaching materials	Aspect	Group Test			Average (%)	Category
		K_1	K_2	K_3		
Textbooks	Ease of Use (%)	83.3	85.6	84.2	83.3	Practical
	Serving Attractiveness (%)	80.6	75.6	86.1	80.6	Practical
	Benefit (%)	79.1	83.6	85.3	79.1	Practical
	Average (%)	81.4	82.3	84.9	81.4	Practical
SAS	Ease of Use (%)	83.1	85.3	84.4	84.3	Practical
	Serving Attractiveness (%)	80.0	76.0	86.7	80.9	Practical
	Benefit (%)	81.3	83.6	85.3	83.4	Practical
	Average (%)	96.3	97.1	85.0	92.8	Practical

Description: K1 = small group; K2 = large group; K3 = Limited test

The practicality test by the lecturer was carried out by field testing on 5 lecturers and other potential users outside the engineering field of the Bali State Polytechnic. Aspects of practicality testing include ease of use, the attractiveness of presentation, and benefits. The results of practicality testing by lecturers and other users on textbooks and LKM reached 82.1% and 81.6% both were categorized as practical with minor revisions. The results of practicality testing by students on textbooks and MFIs reached 81.4% categorized as practical and 92.8% categorized as very practical. The two teaching materials after minor revisions were tested for effectiveness.

The effectiveness test begins with measuring the initial ability through a pretest of mathematical problem-solving ability. After the learning process ends, it is continued to measure the final ability through posttest. The results of the pretest showed the ability to solve mathematical problems, a minimum of 36, 8, and a maximum of 46,9. While the posts reach a minimum of 74.9 and a maximum of 85.8. The average pretest and posttest scores of students' mathematical problem-solving abilities were 42.8, and 80. The normality test of the pretest and posttest data showed statistical values of 0.59 and 0.51 both with sig probabilities. 0, 200 > 0.05. The pretest and posttest score data are normally distributed, the normality of the data has been met.

Paired t-test results show that the correlation between initial ability (before) and final ability (after) the learning process is 0.73 with a probability (sig.00) of less than 0.05. The correlation between abilities before and after the learning process is positive and very strong and is related significantly (significantly). The results of the t-test showed -267.1 with a probability (two-sided sig.) 0.00 00 is less than 0.05 and the mean difference is 37.2. Ability before and after the learning process is significantly different.

Digital teaching materials can significantly improve mathematical problem-solving skills. Furthermore, the percentage of N-Gain Score pretest with a minimum posttest of 56.6% and a maximum of 73.65%. The average percentage of N-Gain Score between pretest and posttest was 65.06% which was categorized as quite effective. The development of digital mathematics teaching materials is quite effective in improving mathematical problem-solving abilities. This indicates that the developed mathematics textbooks and digital SAS are quite effective in improving the ability to solve mathematical problems in blended learning.

Mathematics digital textbooks and LKM for blended learning, the material refers to the 2014 KKNI curriculum, divided into two textbooks and LKM. Its structure: Introduction Pages, Nas Pages (Body of the Book), and Ending Pages. The Preface page consists of the title page, table of contents, list of figures, list of tables, introduction, preface, and discourse. The Nas Page (stem) contains a detailed description of each chapter, sub-chapters accompanied by examples, practice questions. At the end of each chapter is given a summary to make it easier for the reader to remember the important things. The final page consists of attachments, bibliography, directions (index), and glossary. While the MFI structure; Title, table of contents, study instructions, Course Learning Outcomes, Achievement Indicators, supporting information, assignments or work steps, and evaluations (Prastowo, 2015). The learning approach uses problem-based learning.

Teaching materials are packaged into textbooks and SAS Applied Mathematics I and II. The selection of the material is based on the principles: relevance, consistency, and sufficiency (Widodo & Jasmadi, 2008; Noviarni, 2014). The depth refers to the aspects contained in the learning outcomes of subjects and learning sub-achievements, while the structure of the content of the material is based on a hierarchical approach (Depdiknas, 2006; Widodo & Jasmadi, 2008). Both are formatted using Flip PDF and integrated into the Schoology model LMS. In some parts of the material, audio and video tutorials are inserted. The delivery approach uses problem-based learning. Learning evaluation uses the form of a test that is packaged in a competency test at the end of each chapter.

Blended learning mathematics is implemented using the Schoology application. Both teaching materials are uploaded to www.schoology.com and integrated into the resource menu. Both are inserted audio, video tutorials explain a real problem so that it can enrich the student learning experience, can be stored and read in electronic communication storage (smartphones). Students can access it through the website www.Schoology so that it can be carried everywhere, can be read, studied anywhere without the need for a special room.

The material content of these two digital mathematics teaching materials is also constructed based on the material that has been determined and described following Competency Standards, Basic Competencies, Indicators, and learning outcomes adapted to the problem-based learning model. The material is very interesting, easy to operate, helps understanding concepts, helps students learn independently. Besides that, it can also make it easier for students to practice independently by following the available learning video steps. So that these teaching materials support the learning process, students can be actively involved, learning becomes interesting and meaningful. Learning with digital teaching materials can train students to become problem solvers. Because learning using digital teaching materials can direct students' attention and encourage student interest in learning: understanding problems, planning solutions, solving problems according to plan, and re-examining the results obtained. Teaching materials can provide opportunities to grow problem-solving skills, especially on indicators of understanding problems and solving problems. The application of these two digital teaching materials as a result of development does not always require an internet connection. Practical and effective digital mathematics teaching materials are used for blended learning, but for optimization, small revisions are still needed, so that the material learned by students becomes more meaningful and systematic. The implication is that these digital mathematics teaching materials can be used as complementary teaching materials in blended learning of applied mathematics at polytechnics.

4 Conclusion

The practicality of digital mathematics textbooks and LKM in terms of lecturers reached 82.1% and 81.6% both were categorized as practical. Practicality by students reached 81.4% categorized as practical 92.8% categorized as very practical. Mathematics digital textbooks and SAS are quite effective in improving mathematical problem-solving skills in blended learning students. The implication is that digital mathematics textbooks and SAS are quite effective in being used as teaching materials to accompany mathematics learning using blended learning.

Conflict of interest statement
The authors declared that they have no competing interests.

Statement of authorship
The authors have a responsibility for the conception and design of the study. The authors have approved the final article.

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