Development of Mobile-Based Digital Learning Materials in Blended Learning Oriented to Students' Mathematical Literacy

Poppy Yaniawati, Dahlia Fisher*, Yudi Dwi Permadi, and Siti Ainor Mohd Yatim

***Abstract*—This study aims to analyze the development and effectiveness of mobile-based sequences and a series of digital learning materials through a blended learning model for students' mathematical literacy. This research is Analyze, Design, Develop, Implement, and Evaluate (ADDIE) model development research with the mixed method, the convergent parallel design. The population was from class X State Vocational School (SMK) in Majalengka, Indonesia, with a sample of 36 students of class X SMK. The instruments used were validation sheets, questionnaires, and tests of mathematical literacy skills. The results of this study indicate that: 1) mobile-based digital learning materials through blended learning models are oriented towards students' mathematical literacy skills, including appropriate use; 2) the implementation of blended learning in the use of digital materials with mobile-based sequences and series materials oriented towards mathematical literacy has great effectiveness; and 3) students' mathematical literacy using mobile-based digital learning materials in blended learning is in the moderate category.**

***Index Terms*—E-learning, numeracy skills, Microsoft Kaizala, vocational students, ADDIE model**

I. Introduction

The current COVID-19 pandemic has caused the education system in Indonesia to change from face to face to online learning. The Ministry of Education and Culture said several obstacles in the implementation of Distance Learning (DL) included difficulties for teachers in managing DL and their focus on completing the curriculum.

Mathematical literacy is one of the essential parts of learning mathematics based on an independent curriculum to learn contextually. This ability can train a person to make the right decisions and to develop or her thinking [1]. The purpose of learning mathematics is for students to learn mathematical concepts and literacy, which have emerged as essential concepts in mathematics [2, 3].

Mathematics is considered a complex subject for most students, resulting in students having difficulty understanding it because it is abstract. A teacher needs digital learning materials to train these two abilities based on the description above. Teaching materials are essential tools in teaching and learning activities in the classroom to improve teaching efficiency and student achievements [4, 5].

Therefore, there is a need to facilitate the learning needs of students at home. Research revealed that the use of digital tools for mathematics learning and learning communities during remote teaching is indispensable for better learning outcomes [6].

One solution is to use the mobile-based digital learning materials to help students enrich their knowledge of theories learned through structured learning activities with more flexibility. Mobile learning is a type of learning that offers students freedom of movement and interaction learning content [7]. More and more students today require intelligent mobile terminals to carry out fragmentation learning supported technologies such as the internet, cloud computing, and Internet of Things. This trend has recently resulted in interactive learning activities [8, 9]. Information technology-based learning, known as e-learning, contributed significantly to contemporary learning [10]. Applying mobile-based digital learning materials under current conditions will be more effective in a blended learning model. Blended learning is a type of online and offline learning that combines the benefits of online and conventional learning [11]. This learning model is now presented to personalized learning in a competency-based education system with analysis of the effectiveness of blended learning implementation in using mobile-based sequences. Series digital learning materials are oriented to students' mathematical literacy abilities and to analyze students' mathematical literacy skills in blended learning using mobile-based digital learning materials on number sequences and series.

There are still several identified problems, including: 1) students' mathematical literacy skills are still lacking; 2) students' low interest in learning mathematics in online learning; and 3) students are not active in the learning process. During this Covid-19 pandemic, digital learning materials that are appropriate and easy to access are one of the key elements to implement online learning.

Based on identification of the problems described above, the formulation of problems in this study is as follows: 1) How is the development of digital learning materials for application of the concept of number sequences and series, based on mobile learning and oriented to students' mathematical literacy abilities? 2) How is the effectiveness of the application of mobile learning-based digital learning materials in the application of the concept of sequences and number series oriented towards students' mathematical literacy abilities? 3) How are students' mathematical literacy abilities in learning using mobile learning-based digital learning materials in the material for applying the concepts of sequences number series?

Digital Learning materials are learning tools that must be

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present in the learning process in classrooms. The digital learning materials used should be arranged in an innovative, creative, practical, systematic, and dynamic ways, to achieve the learning objectives.

Digital Learning materials also need to be adapted to the characteristics of students in the class. Digital Learning materials are systematically arranged in the form of information or texts that include competency standards to be mastered by students, in each subject and academic unit [12]. Digital learning is everything that teachers must prepare before carrying out the learning process. Teachers are expected to be able to conduct the learning process so that the planed educational goals can be met [13]. According to Rachman's research [14], technological developments that are increasing in various aspects of life have opened many opportunities to meet the needs of information technology to support learning activities. Thus, students' understanding of mathematics learning can be accelerated through use of technology.

Mobile learning is known as a learning channel for technology ready people. This channel requires proper infrastructures and educators with basic instructional skills. Mobile technology is a new technology in the world of education. Nowadays, technology affects all levels of society, rich and poor, educated and uneducated, because its access power can be used for almost everything. Devices that enable mobile learning include mobile phones and computers [15].

The current learning in use is blended learning. Some time ago, face-to-face learning was applied in a limited manner. Later, a combination of offline and online learning was implemented. The use of blended learning can add positive value to students' learning process. Blended learning thus can enrich students' learning experience because the learner can access unlimited resources from the internet while still receiving teacher guidance through face-to-face learning [16]. Mathematical literacy is also one of the components needed to build 21st-century skills.

Mathematical literacy is demonstrated by the students' to use the mathematics they have learned to solve everyday problems and to make decisions Mathematical literacy, also known as numeracy ability, is the ability to analyze and apply fundamental mathematical insights in everyday life [17]. Mathematical literacy supports students in exploring the mathematics rules that make references to reality and design judgments and provisions needed to show themselves as a society. Mathematical literacy refers to students' insight and ability to understand and use mathematical insights and skills gained from real-life and explore mathematics situations [18]. This includes reviewing the 'when' and 'how' to use those mathematical insights. Contributors of this study are the following:

1) For students, teaching materials based on mobile learning are expected to improve students' mathematical literacy skills and self-efficacy and to provide a new learning atmosphere in learning mathematics.
2) For teachers, this research is expected to be used as knowledge material in mobile learning-based teaching materials and the implications for students' mathematical literacy skills and self-efficacy.
3) For schools, this research is expected to be used as a reference for policies related to develop implementation of mobile learning-based teaching materials to evaluate and improve the quality of education.

II. Method

ADDIE research and development model consists of five stages [19], namely analysis, design, development, implementation, and evaluation, using the mixed method researching the convergent parallel design.

A. Analysis

Analysis in this research pays attention to student abilities experiences and characteristics, both in groups and as individuals in: 1) technology analysis to determine the available technologies; 2) situation analysis to know the learning environment experienced by students; 3) task analysis to record physical and mental needs the goals; 4) analysis of critical incidents, to determine which tasks students need to practice; 5) objective analysis to select performance and learning objectives in determining completion; 6) media analysis to determine appropriate media; 7) data analysis to understand which materials already exist and which ones should be made; and 8) cost analysis to understand the benefits to be gained compared to costs incurred.

B. Design

There are several elements to consider at this stage, namely:

1) Schedule, to explain activities, list of stages, delivery, and delivery time.
2) The development team consisting of persons and responsibilities.
3) Media specification, describing document types, presentation models, texts, graphics, fonts, symbols, and other items needed at the development stages.
4) Learning structures that explains the teaching and learning processes.
5) Control and revision cycles, explaining how to implement the above to run well.

C. Development

At the development stage, we aimed to produce a mobile learning-based teaching and learning process plan as has been revised based on expert input. This stage includes:

1) Selection of pre-production and production, in the form of preparing teaching materials according to plan, where the writer writes the teaching materials while the programmer makes media or programs with specified software.
2) Post-production revision cycle, in the form of validating results of writing, media, and programs that have been made and continued with revisions based on input from expert validators.
3) This cycle can be carried out repeatedly until the developed textbook or module is feasible to use.

D. Implementation

The Implementation stage is for testing students and the implementation can be accomplished in the form of:

1) Simulation, an activity to operationalize teaching and learning plans to check the implementation of teaching materials, time compatibility, and program reliability, etc.

2) Limited trial, which is performed in one class and the results will be evaluated as basis for the next revision.
3) Deployment, which is the stage of using learning tools on a broader scale to assess the effectiveness of mobile learning-based learning plans to be made.

This study's implementation was carried out only in the form of simulations and limited trials due to limited research time.

E. Evaluation

At this evaluation stage are assessments of mobile learning-based learning that have been carried out. Things to pay attention at this stage are:

1) Objectives, to determine the extent the learning objectives are achieved.
2) Validity, to determine whether teaching materials are valid according to established criteria.
3) Development of instruments and measurements, to determine what items will be measured, such as learning success through test scores and questionnaires.
4) Data collection and analysis: all research data are collected and analyzed to conclude whether the development of this teaching material is true according the design.

The development of digital learning materials for applying the concept of number sequences and series based on mobile learning in this study, with the use of Microsoft Kaizala.

This research, which used a blended learning model was carried out in one State Vocational School (SMK) in Majalengka Regency in the 2021/2022 academic year. The research population was students of all class in 24 classes with a sample of class X of 36 students. The researchers used a written test and a validation sheet to obtain data from this study. The data analysis is directed to answer questions in the formulation of the research problems resulting from the data collected, based on the research instruments. The analysis was carried out as follows: The data analysis technique for the feasibility of this mobile-based digital learning material was descriptive and analytical analysis; the data analysis of the mathematical literacy test instrument was by measuring the validity of the questions, the reliability of the questions, the level of difficulty, and the power of discrimination; the analysis of students' mathematical literacy skills was carried out by calculating the number/scores obtained by students in answering the test questions.

The test questions were tested in the class XI SMK, the class that has learned the material for the concept of sequences and number series. The questions were tested for validity, reliability, level of difficulty, and discriminating power of the questions. Table I shows result of validity test, Table II shows result of reliability of mathematical literacy ability, Table III shows result calculation results of difficulty index of mathematical literacy ability, and Table IV shows calculation result level of discrimination power of mathematical literacy ability.

1) Validity

TABLE I: RESULT OF VALIDITY TEST

No	Question Item Validation Value	r_{table}	interpretation
1	0.730	0.320	Valid
2	0.756	0.320	Valid
3	0.671	0.320	Valid
4	0.668	0.320	Valid
5	0.701	0.320	Valid
6	0.636	0.320	Valid

2) Reliability

TABLE II: RELIABILITY OF MATHEMATICAL LITERACY ABILITY

Reliability Statistics	
Cronbach's Alpha	N
0.755	6

3) Level of Difficulty (LoD)

TABLE III: CALCULATION RESULTS OF DIFFICULTY INDEX OF MATHEMATICAL LITERACY ABILITY

No	Average	Ideal Max Score	LoD	Criteria	After Corrected
1	6.55	10	0.65	moderate	easy
2	6.91	10	0.69	easy	easy
3	3.18	15	0.21	difficult	moderate
4	2.42	20	0.12	difficult	moderate
5	2.27	15	0.15	difficult	moderate
6	3.36	30	0.11	difficult	difficult

4) Discrimination power

TABLE IV: CALCULATION RESULT LEVEL OF DISCRIMINATION POWER OF MATHEMATICAL LITERACY ABILITY

No	Upper Class Average	Lower Class Average	Max Value	Dist power	Criteria
1	8.56	4.65	10	0.39	moderate
2	9.50	4.47	10	0.50	good
3	4.81	1.75	15	0.20	moderate
4	4.63	0.35	20	0.21	moderate
5	3.88	0.76	15	0.21	moderate
6	6.56	0.35	30	0.21	moderate

The development of digital learning materials to apply the concept of sequences and series based on mobile learning utilized applications on gadgets/smartphones. Through this digital learning material, it would be easier for educators to convey the material to their students, so students will still learn like in class only through their smartphones. It is hoped that developing these digital learning materials can improve the quality of student learning both during the Covid-19 pandemic and under normal conditions. The following is a framework for developing mathematics teaching materials based on mobile learning.

III. DATA ANALYSIS AND RESULT

Blended learning is widely used at various levels today in implementing this combination of learning by utilizing the use of technology that students use daily. Learning is done face-to-face or offline and also online, and in this case, mobile learning is learning using applications found on students' cellphones, such as Kaizala, using digital learning that are easy for students to understand. Implementing with mobile-based on blended learning using digital learning materials sequences and number series material oriented toward mathematical literacy, has great effectiveness, which was carried out face-to-face in several hours of lessons at school. After that, students were given discussion assignments in the online Kaizala forum, which can be accessed flexibly anywhere. ADDIE Model is a model that serves as a guide in elaborating effective, dynamic learning, and facilitates self-learning [20]. This model is one of the most used models in instructional design as a guide for

producing effective designs [21]. The following are the stages of the ADDIE model. Figs. 1–3 show display of digital learning material.

Fig. 1. Display of digital learning materials.

Fig. 2. Display of digital learning materials.

Fig. 3. Display of digital learning materials.

A. Analysis

At this stage, the researchers found that monotonous printed books still dominated the digital learning materials. The digital learning materials used were minimally explained because they only contained a summary of the material, a collection of formulas, and practice questions that were not interesting yet interactive. In line with the opinion of Sujarwo that usually the student worksheets used are not interactive [22]. After all, communication only focuses on one direction, giving students a narrow perspective on the material. Students need digital learning materials that require interesting images of visualization on the material for applying sequences and series of numbers and can be used anywhere. Based on what Istiqlal [23] said, interactive learning media has great potential to stimulate students to respond positively to the learning material presented. One of the learning media is a computer. Therefore, this mobile-based digital learning material product is expected to be an alternative that can make it easier for students to understand the material for applying the concept of sequences and series of numbers.

B. Design

The process at this stage was to develop all the analysis results in the initial investigation. First, digital learning materials were designed in the form of modules, and then they were packaged in PDF form that can be used in applications on mobiles (mobile phones) and designing research instruments was needed at the implementation stage. At the design stage, the teacher planned how the digital learning materials to be developed would be effective and efficient so that students could use and understand the material in the digital learning materials [24]. At this stage, the researchers designed learning media, media assessment instruments, and learning outcomes instruments. The three designs were made to solve problems at the analysis stage. Media design was to create designs, layouts, and views that were made on PDF and then sent to the Microsoft Kaizala application.

C. Development

This stage was a continuation of the design step. Based on the previous stage, the design was used to make mobile-based digital learning materials and research instruments, namely, changing digital learning materials from Word into PDF. Finally, development was the process of creating a design that has been designed into an actual product [25]. The following is a display of the digital learning materials developed.

After the digital learning materials had been created, the next stage was for material experts and media experts to validate the digital learning materials. The results of the expert validation assessment of digital learning materials are presented in the following Table V.

TABLE V: Results of the Expert Validation Assessment of Digital Learning Materials

Aspect	Average	Category
Content Feasibility Aspect	4.17	Eligible
Aspect of Feasibility of Presentation	3.98	Eligible
Aspect of Language Feasibility	4.15	Eligible
Aspects of Mathematical Literacy	4.10	Eligible
Average	4.10	Eligible

Table V shows the material experts' assessment, an overall score of 4.10 was obtained, which was qualitatively categorized as feasible in terms of content, presentation, linguistics, and mathematical literacy assessment. Thus, digital learning materials could be used in the learning process.

The following are the results of the validation by media experts of digital learning materials presented in the following Table VI.

TABLE VI: RESULTS OF THE VALIDATION ASSESSMENT OF DIGITAL LEARNING MATERIAL MEDIA EXPERTS

Aspect	Average	Category
Display Aspect	4.62	Very eligible
Aspects of Use	4.67	Very eligible
Utilization Aspect	4.67	Very eligible
Average	4.65	Very eligible

The media experts' assessment was 4.65, which was categorized as very feasible in terms of appearance, use, and utilization aspects. Accordingly, digital learning materials can be used in the learning process. Based on the two tables above, mobile-based digital learning materials for use in blended learning are feasible to improve students' mathematical literacy.

D. Implementation

After being declared feasible by the validators, digital learning materials for applying the concept of sequences and series of numbers based on mobile learning was carried out in class X SMK were implemented. The learning process was carried out face-to-face and continued with the Microsoft Kaizala application. Fig. 4 and Fig. 5 show a photo of the implementation of learning using mobile learning.

Fig. 4. Research implementation carried out face-to-face.

Fig. 5. Research implementation with the Microsoft Kaizala application.

E. Evaluation

At this stage, the researcher evaluated the media. Things that needed to be evaluated and revised refer to trials on validators. In class X SMK, the students were tested at the implementation stage on the validation sheet of mobile learning-based digital learning materials by material experts and media experts and responded to questionnaire sheets. Research items that need to be revised and evaluated included answers to truncated examples of questions. In discussing Microsoft Kaizala, it was better not to discuss the discussion feature but rather discuss it in the comments column because the comment board cut off the discussion.

Implementation was carried out on an effect size test in blended learning the concept of number sequences and series to improve students' mathematical literacy and to test effectiveness of the implementation of teaching materials on mobile-based number sequences and series. The following is the calculation of the effect size test using Cohen's d formula.

Cohen's Formula:

$$d = \frac{\overline{m_A} - \overline{m_B}}{\sigma}$$

Description:

d: Effect size index

$\overline{m_A}$: Pretest average

$\overline{m_B}$: Postest average

σ: Deviation standard of the difference between the Pretest and Posttest scores

TABLE VII: CALCULATION OF EFFECT SIZE TEST

Mean		**Deviation Standard**	***Effect Size* / Cohen's d**	**Category**
Pretest	***Postest***			
29.75	64.83	18.22	1.92	High

In the Table VII above, the Cohen's d index is 1.92. The effect size classification table states the effectiveness of mobile-based digital learning materials in blended learning on the material of sequences and series of numbers to improve the mathematical literacy of vocational students, is in high category. This is in line with the results of research by Farhatin [26] that lectures on derived material calculus courses using mobile learning media are quite effective when viewed from student learning outcomes. Based on the analysis conducted at each face-to-face meeting and by using the Microsoft Kaizala application, students were required to play a more active role in obtaining the opportunity to build their knowledge by discussing it among their group of classmates. As a result, they gained an in-depth understanding and a more varied learning process, such as discussing directly (offline) or online in their learning. This is relevant to the opinion of Cahyaningsih [27], that sharing knowledge through group discussions, better known as peer tutors, can motivate students to learn better in class. The increase in students' mathematical literacy was due to a conducive, active atmosphere and students' interest and enthusiasm were visible compared to the usual learning, especially in terms of distribution of material that was not centered only on the teacher. Mobile technology has a solid didactic potential to improve the quality of mathematics teaching and support the professional development of personality. Mathematical literacy ability is the basis for developing new digital solutions [28].

IV. Result

A. Blended Learning System

The learning implementation was carried out in 10 meetings for 20 hours of lessons with one hour lesson for 30 minutes (20×30 minutes). The distribution of learning time was two hours face-to-face lesson (60 minutes) and two hours lesson (60 minutes) conducted online by taking turns. Online learning was carried out using the Microsoft Kaizala application by individual students at home. At the end of each lesson, students were given questions to practice in the learning module. Table VIII show a schedule for implementing mobile learning based on learning.

TABLE VIII: Research Implementation Schedule

No	Learning Type	Date	Activity	Time Schedule
1	Face to face	07-03-2022	*Pretest*	2×30 minutes
2	Face to face	10-03-2022	Topic 1	2×30 minutes
3	Online	10-03-2022	Topic 1	2×30 minutes
4	Face to face	14-03-2022	Topic 1	2×30 minutes
5	Online	14-03-2022	Topic 1	2×30 minutes
6	Face to face	17-03-2022	Topic 2	2×30 minutes
7	Online	17-03-2022	Topic 2	2×30 minutes
8	Face to face	21-03-2022	Topic 2	2×30 minutes
9	Online	21-03-2022	Topic 2	2×30 minutes
10	Face to face	24-03-2022	*Posttest*	2×30 minutes

B. Data of Students' Mathematical Literacy

The results of the achievement of students' mathematical literacy skills are presented in the following Table IX.

TABLE IX: Percentage of Scores for Mathematical Literacy Aspects

score	Percentage of Indicator *Posttest (%)*					
	I_1	I_2	I_3	I_4	I_5	I_6
0	2.78	2.78	2.78	2.78	8.33	25.00
1	5.55	0	5.55	2.78	2.78	2.78
2	11.11	0	36.11	5.55	19.44	13.89
3	41.67	13.89	8.33	72.22	22.22	25.00
4	38.89	83.33	47.22	13.89	47.22	33.33
Average	67.78	91.67	63.1	60.0	66.67	55.28
Overall Average						67.50
Category						moderate

Note:
I_1 : *Mathematising*
I_2 : *Representation*
I_3 : *Using mathematics tools.*
I_4 : *Communication*
I_5 : *Using symbolic formal and technical language and operation.*
I_6 : *Devising strategies for solving problems.*

Based on the table above, it is found that mathematical literacy based on indicators in this study is moderate. Students already have moderate mathematical literacy using mobile-based digital learning materials in blended learning. Nevertheless, students' mathematical literacy in learning mathematics still has to be improved. Overall, students' mathematical literacy is classified as moderate for all indicators. The representation indicator is included in the very high category. Fig. 6 shows the results of students' answers on the representation indicator.

Fig. 6 shows that many students can present problems through drawings or sketches. Handayani and Juanda [29] stated that representation can help students make problems more concrete, and representation skills can help build understanding of mathematical concepts. Thus, students' ability in representation is excellent, and they can form their own understanding in solving problems in the form of images or graphics. The indicator that is still low is the indicator of devising strategies for solving problems. Fig. 7 shows the results of students' answers on the indicators for devising strategies for solving problems.

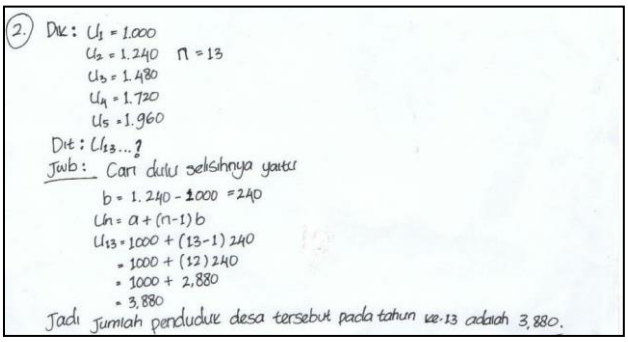

Fig. 6. The results of students' answers on the indicator of representation.

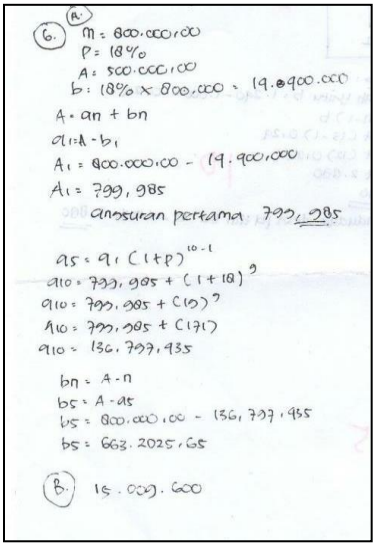

Fig. 7. Results of students' answers on indicators of devising strategies for solving problems.

Based on Fig. 7 above, some students were not able to write down the answers, determine the right strategy, solve problems, and write conclusions from what was asked. This is because students were not used to conveying mathematical problems and solutions and problem-solving and were not familiar with the learning process of mathematical literacy. This is in line with the opinion of Hertiandito [30] that, so far, Indonesian students are considered less able to apply basic algorithms and interpret the results of mathematical calculations in the context of problems at hand. This result is also supported by Mahiuddin's research [31] that the mathematical literacy of grade IX junior high school students is still low. Moreover, the results of Rifai and Wutsqa's research [32] show that the mathematical literacy of junior high school students is in the deficient category.

This study has a school level that is not far from the research conducted, namely in class X SMK, so that the opinions presented can be relevant to the results of the analysis. Still, low indicators were caused by students who were lacking understanding towards the problem and the procedure to solve the questions. This is in line with what Masjaya and Wardono [33] conveyed: the demands of

students' ability in mathematics are not only to have the ability to count but also to reason logically and critically in problem-solving. Solving this problem is not merely a problem in the form of routine questions but also on daily problems.

V. Discussion

This development research produced a prototype of a mathematics learning instrument in the form of a PDF mobile learning material for application of the concept of sequences and number series. The PDF is acceptable according to the experts. The process of developing prototypes of mobile learning-based teaching materials in the material for applying the concept of sequences and number series, according to the model development steps was the development of Dick and Carey modified by Lee and Owens, namely: Analysis, Design, Development, Implementation, and Evaluation (ADDIE). Based on the opinion of Barokati and Annas [34], the ADDIE model is a model as working a guide in elaborating effective, dynamic learning, and helps learning itself. The ADDIE model is a model that is considered more logical and more complete than other models [35]. These five stages produce a prototype in the form of valid (decent) mobile learning-based learning media in the form of a PDF that can be used via mobile phones, using the Microsoft Kaizala application.

The first stage is analysis of the essential elements to develop mobile learning-based digital learning materials. Based on the analysis, it was found that students needed digital learning materials that required interesting visualization images on the application of sequences and number sequences that could be used anywhere. This is in line with opinions of Puspasari [36] and Fisher *et al.* [37] that interactive learning media can stimulate students to respond positively to the learning material presented. Mobile learning-based digital learning material products are expected to be an alternative that can make it easier for students to understand the material for application of concept of sequences and number series. The scope of the material developed consists of 1) growth, 2) single interest, 3) compound interest, and 4) annuity. To facilitate the depiction of material, mobile learning-based digital learning materials were made in the form of applications that can be used on mobile phones, namely the Microsoft Kaizala application.

The second stage is design. According to the research of Yaniawati *et al*. [38] at the design stage the teacher planned how the digital learning materials to be developed will be effectively and efficiently so that students can use and understand the material in these digital learning materials. Therefore, at this stage, the researcher designed learning media, media assessment instruments, and learning outcomes instruments. The three designs were made to solve problems at the analysis stage. Media design was designing designs, layouts, and views that were created on PDF and then sent to the Microsoft Kaizala application.

The third stage is development. According to the research of Pujiastuti and Mutaqin [39], development is the process of creating a design that has been designed into a real product. So, at this stage, digital learning materials in the form of PDFs, questionnaires of material experts and media experts to be given to the validator were produced. Furthermore, digital learning materials were validated by six material experts and two media experts who were experts in their fields, and afterward the digital learning materials were declared feasible by experts.

The next stage is the implementation stage. Implementation in this research was a process of testing teaching materials in learning mathematics in the classroom. So, the implementation phase was carried out for SMK students using mobile learning-based teaching materials.

The last stage is evaluation. The evaluation stage is the stage of evaluating the teaching materials that have been developed. So, at this stage, the researcher evaluated the media. Things that needed to be evaluated and revised referred to trials on validators and when trials on SMK students were carried out at the implementation stage, both on mobile learning-based digital learning material validation sheets by material experts and media experts as well as student response questionnaire sheets.

Results of the data analysis show that the teaching materials used have great effectiveness on students' mathematical literacy skills. The application of mobile learning-based digital learning materials also shows great effectiveness. This is in line with results of research from Husna [40] that lecturing calculus courses on derivative material using mobile learning media is quite effective when viewed from student learning outcomes.

Based on the analysis of mathematical literacy skills, there are six indicators, mathematizing, representation, using mathematics tools, using symbolic, formal and technical language and operation, devising strategies for solving problems, and communication. The ability of students' mathematical literacy was classified as moderate for all indicators. The ability on the mathematizing indicator (mathematization) was in the medium category. This shows that the students were quite capable of transforming real problems in the form of mathematics well. Based on the opinion of Papadakis *et al.* [41], the use of mathematical modeling will make it easier for students to solve mathematics story problems because this mathematical modeling follows the students' concrete-semi-concrete, enactive-iconic, or concrete-pictorial ways of thinking, so that SMK students are quite good at mathematization indicators. Furthermore, the representation indicator was found to be in the very high category. This shows that there were already many students who were able to present problems in the form of pictures or sketches. Based on the opinion of Nursyarifah *et al.* [42] that representation can help students to make problems more concrete, and representation skills can help shape understanding of mathematical concepts. Thereby, students' ability in representation was very good and could form their understanding in solving problems in the form of graphic images. Mobile-based digital learning materials for the application of the concept of mathematics that are suitable for use the findings of Soboleva *et al.* [43] show that touch screens positively affect learning.

The next indicator, using mathematics tools, was found to be in the low category. This shows that many students still have not been able to use the right tools/formula to solve problems. Based on the analysis of Wijayanti *et al.* [44], the ability of mathematical literacy in students with high learning

independence stands out in the components of communication and using mathematics tools. So, in the indicator for using mathematics tools, students must improve their affective abilities. The next indicator was using symbolic, formal and technical language and operation. This indicator was included in the moderate category. This shows that students were able to use language and symbolic, formal and technical operations, and involve understanding, interpreting, manipulating, and using symbolic expressions in a mathematical context then making mathematical solutions well. Based on the analysis of Rosyada *et al.* [45] and Yaniawati *et al.* [46], students with a field independent (FI) cognitive style have excellent mathematical literacy skills in the components of communication, mathematics, representation, reasoning, and argument, using symbolic formal and technical language and operations. To improve indicators of mathematical literacy ability on indicators for using symbolic formal and technical language and operation students need to be trained to use the cognitive style needed to improve these indicators. Furthermore, the indicator for devising strategies for solving problems was in the low category. This shows that students cannot determine the right strategy and able to solve problems properly. And the last is the communication indicator. This indicator is in the low category. This shows that students have not been able to properly convey problems and mathematical solutions and problem solving. Based on the analysis, the indicators that were still low were the indicators of devising strategies for solving problems, and communication. This is because the students were not familiar with the learning process with mathematical literacy skills. This is in line with the opinion of Stacey [47] that so far Indonesian students have been considered to be unable to apply basic algorithms or interpret the results of mathematical calculations in the context of the problems they face.

VI. Conclusion and Recommendation

A. Conclusion

Digital learning materials for application of the concept of sequences and number series based on mobile learning which are developed, include analysis, design, development, implementation, and evaluation are feasible to use. The stages that passed were: 1) an analysis based on the results of interviews with vocational mathematics teachers and the author's field experience; determination of material, objectives, schedules, time and place as well as follow-up on student determination; 2) the design of digital learning materials for applying the concept of sequences and number series has been discussed with the supervisor. Mainly, we prepared initial drafts in PDF form and determined validation sheets for mobile learning-based digital learning materials which was compiled based on Badan Standar Nasional Pendidikan (BSNP) criteria (National Education Standards) and containing mathematical literacy, students' mathematical literacy ability tests which were compiled based on The Organization for Economic Co-operation and Development (OECD) experiences, student response questionnaires for mobile learning-based digital learning materials, and finally, self-efficacy questionnaires which was compiled based on Bandura theory; 3) the development of this study resulted in digital learning materials for applying the concept of sequences and number series based on mobile learning in the form of PDF modules arranged based on the design stage. At this stage it can be stated that the digital learning material for application of the concept of sequences and number series was in the very feasible category and was useful. This statement is based on validation assessments from six material experts consisting of lecturers and mathematics teachers and two media experts consisting of arts and culture teachers in the field of fine arts and graphic design teachers; 4) the implementation was carried out in Vocational Schools using digital learning materials based on mobile learning on the material for the concept of sequences and number sequences that are oriented towards students' mathematical literacy; and 5) On evaluation, at this stage, the researcher evaluated the media as a whole. Things that needed to be evaluated and revised were referred to the validators; and when trials on SMK students were carried out at the implementation stage, both on mobile learning-based digital learning material validation sheets including were scratimized by material experts and media expert's student response questionnaire sheets.

Mobile-based digital learning materials for the application of the concept of sequences and series of numbers have categories that are suitable for use. The implementation of mobile-based digital learning materials in blended learning on sequences and series of numbers oriented to students' mathematical literacy, can be used and dramatically improves the mathematical literacy of SMK students. While using these digital learning materials, students were accustomed to being more active during learning by discussing with their classmates. The practice questions in the digital learning materials were also based on mathematical literacy indicators, so students were accustomed to working on questions oriented to their mathematical literacy.

The mathematical literacy of SMK students who use mobile-based digital learning materials in blended learning on the material of sequences and series of numbers was found to be in the moderate category. The highest percentage of mathematical literacy achievement overall was representation, which means that students can well present problems in drawings or sketches. In comparison, the lowest percentage of mathematical literacy was devising strategies for problems solving, which means that students have not been able to determine the proper strategy and to solve problems well.

B. Recommendation

1) Researchers with other media are invited to further develop the digital learning materials.
2) Due to time and budget constraints, the stages of implementation in this research were only implemented in one school. It is hoped that future researchers can develop digital learning materials with wider implementation stages for more optimal digital learning materials.
3) Efforts to increase the mathematical literacy and self-efficacy in this study, is still in the medium category. There is need to do it repeatedly and continuously for maximum results, namely to reach the high category.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS

Poppy Yaniawati: Conceptualization, design, analysis, writing, final approval, securing funding. Dahlia Fisher: Design, Analysis, supervision, acquisition. Yudi Dwi permadi: Editing, reviewing, supervision. Siti Ainor Mohd Yatim: Editing, reviewing, supervison. All authors had approved the final version.

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