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Development Combinatorics Realistic Mathematics Education Application based on the Android Mobile

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This development research aims to produce an Android-based combinatoric application as a learning medium for high school students and to find the quality of the combinatoric applications for use in mathematics learning. This research is a research and development (R&D) adapted from the 4D development model. There are four stages: Define, Design, Develop, and Disseminate. Data analysis techniques are used in the feasibility test and the quality test of the media. The results showed the feasibility of an Android-based combinatorics application based on the assessment of media experts was 75.00% with proper criteria, and the evaluation of 2 material experts was 82.32% with suitable principles. The media was tested publicly from 50 students of South Tangerang 6 Public High Schools and MA Kafila. The result of the public trial obtained an application quality result of 83.20% with suitable criteria. Based on the results of data acquisition, it shows that Android-based combinatorics applications are appropriate to be used as a source of mathematics learning at the high school level.

Keywords: *Combinatorics, Android, Android-Based Combinatorics Applications, M-Learning.*

Introduction

2 The 21st-century skills refer to a wide range of skills such as learning and innovation skills (critical thinking, creativity, collaboration, and communication) and information, media and technology skills (Binkley et al., 2012), and have been gaining more and more attention from researchers and practitioners (Chan & Yuen, 2014; J P Gee, 2005; James Paul Gee, 2003, 2008; Qian & Clark, 2016). For instance, the current school curriculum clearly emphasises the importance of students' creativity development, and as a result, teachers are encouraged to develop or adopt innovative teaching methods to foster students' creativity in the classroom (Chan & Yuen, 2014; Qian & Clark, 2016).



The 2013 curriculum emphasises ICT literacy in learning, where all subjects are integrated with the use of information and communication technology (ICT). Teachers and students are required to be able to utilise technology in the learning process. Teachers should realise the potential of mobile technology as a source of learning for students (Chao, Parker, & Fontana, 2011). With the rapid development of mobile devices and technological advancement, there is an opportunity to use mobile devices for learning because of the mobile nature of hand telephony and the ease of communicating (Churchill, 2008). The potential of mobile learning that is used to support activities in the world of education (Chao et al., 2011) opens opportunities for application development using smartphones (Demidowich, Lu, Tamler, & Bloomgarden, 2012).

The development of learning through mobile devices can improve the effectiveness and efficiency of student learning. Mobile learning technology can facilitate students in education (Portelli & Eldred, 2016). Mobile learning has practical characteristics and can be carried anywhere (Kennewell & Beauchamp, 2007). Students can study wherever and whenever while doing social media activities or entertainment through smartphones (García, Welford, & Smith, 2016). The mobile technology will continue to have a significant impact on students learning process (Churchill, Lu, Chiu, & Fox, 2015). The empowered with multimedia presentation capabilities, mobile technology has supported to deliver a range of multimedia such as video recording, graphic, and integrated media (Zhang & Wu, 2016). M-learning offered a new option for students-technology partnerships in the learning process. Students do not depend on teachers' material; however, students can explore other learning resources based on the internet. This learning model supports students in learning independently.

One of the considerations in developing smartphones into learning media for mobile learning is the basis of the system used. Data reported from the results of the Statcounter Global stats survey from November 2018 to November 2019, show that the android is the operating system that dominates the circulation of smartphones in Indonesia, as much as 93.75%, then followed by the iOS operating system 5.82%, Tizen 0.07%, Nokia 0,08%, series 40 0.07%, Windows 0.05% and below 1% (Statcounter Global Stats, 2019). This means that most smartphone users in Indonesia use the Android mobile operating system.

Android, Inc. is the name of the company that was built in October 2003 by Andy Rubin and his friends in Palo Alto, California (Wisudawan, Hendriana, Nuriadin, & Ramza, 2017). In 2005, Google bought Android, Inc., and took over its development as part of a strategy to include it in mobile space (W.-M. Lee, 2012). Android is a portable device platform that openly provides and makes it easy for developers to create applications as expected (Ichwan, Husada, & Rasyid, 2013; G.-Y. Lee, Yun, Lee, & Park, 2013). The android system that supports the development of its application is expected to produce representative learning media based on mobile learning (W.-M. Lee, 2012).

Wood (Sriyanti, 2009) argues that mobile learning (m-learning) refers to the use of mobile and portable IT devices, such as PDAs, cell phones, laptops, and tablet PCs, in teaching and learning. M-learning is unique because learners can access material, direction, and applications related to learning anytime, anywhere. It will increase attention on learning material, make learning pervasive, and can encourage learner motivation for lifelong learning. M-learning allows more opportunities for ad hoc collaboration and informal interaction between learners (Holzinger, Nischelwitzer, & Meisenberger, 2005).

M-learning can be classified based on the leading indicators, namely the type of device supported and the type of wireless communication used to access learning material and administrative information. From teaching technology, m-learning can be classified based on indicators, asynchronous and synchronous learning support, standard e-learning support, the availability of a permanent internet connection between the system and the user, the user's location, and access services to learning and administration material. According to the time the instructor and students share information, m-learning can be classified into: systems that support synchronous learning, systems that support asynchronous learning, and systems that support synchronous and asynchronous learning as well, as shown in Figure 1.

Figure 1. Classification of M-Learning



3 Learning mathematics using mobile phone technology is not a new concept of instruction (Hwang, Lai, & Wang, 2015). Recently, the mobile device has tremendously evolved in many kinds of features, and its impact is evident in the learning environment. The presence of technology has gradually enhanced the quality of teaching practice because the use of the mobile phone in the learning process has been extended for various purposes (Churchill et al., 2015). Trends in educational research indicate an increasing interest in how learning application may influence learning (Ke, 2011; Kebritchi, Hirumi, & Bai, 2008; Qian & Clark, 2016; Wu, Chiou, Kao, Hu, & Huang, 2012). For example, some studies (Boyle et al., 2014;



Dempsey, 1994; Qian & Clark, 2016; Randel, Morris, Wetzel, & Whitehill, 1992; Vogel et al., 2006) pointed out that learning application might be superior to traditional classroom instruction as it could increase students' motivation for learning and provide them with opportunities to explore and acquire new knowledge and skills.

Several studies that have been published in reputable international journals show that the use of ICT can improve self efficacy and student learning outcomes. The results showed that multimedia teaching materials could effectively increase attention to increase the potential and effectively develop reciprocal teaching functions (Chen & Kong, 2017). Calik (2013) research results show that the use of technology can improve self efficacy. Other research findings reveal that mobile-based learning applications can improve learning outcomes of ideal gas properties, such as Boyle's law, Charles's law, and Gay Lussac's law in high schools (Astra, Nasbey, & Nugraha, 2015).

Also, the results of Azhar, Kusumah, & Sabandar (2013) show that learning with the RME approach provides improved mathematical communication skills that are better and significantly different from conventional education at the Islamic Senior High School (Madrasah Aliyah) in Jakarta. The same thing was also found in Azhar's (2015) study, which showed that teachers and students were interested in using RME-based opportunity theory learning tools recorded in videos of learning activities.

Based on some of the research mentioned above, the writer wants to innovate mobile technology-based learning, that is "Development Combinatorics Realistic Mathematics Education Application based on the Android Mobile" at the high school level, which refers to the book "Learning Tools Opportunity Theory Based on Realistic Mathematics Education." That has been done by the author of previous research and has obtained IPR. The learning application developed in this research is a mobile android-based realistic mathematics education application for high school students which contains multiplication rules with examples of rules on how to dress, factorial concept material with examples of playing numbers, and permutation material with examples of class management arrangements, and learning evaluations for each material. This realistic mobile learning application based on android mobile is packaged and satisfying, so it is expected to be a practical and fun learning media that can be accessed anytime and anywhere, can increase students' interest in learning mathematics and can be used as a means for independent learning and as a student reference source.

Methods

The method used in this research is the research and development method. According to Sugiyono (2010), research and development methods are research methods used to produce specific products and test the effectiveness of these products. In the research and development



method (Research and Development), there are several types of models. The model used in this is the 4D model. The procedure consists of 4 steps: Define, Design, Develop, and Disseminate.

The data analysis technique used is qualitative and quantitative. Qualitative data were obtained using a feasibility test and a test of the quality of the media using a questionnaire instrument. To determine the appropriateness of applications that have been developed, this application will be tested for validation by material experts and media experts. To find out the quality of applications that have been developed will be publicly tested on students in partner schools before being disseminated.

The instrument used was a media validation questionnaire. The media validation sheet consists of a feasibility assessment sheet and a media quality assessment sheet prepared using a Likert scale. Feasibility assessment sheets for material experts, media experts and quality assessment sheets for public testing of students was used (Widoyoko, 2012).

Results and Discussion

Define. The initial step of this application is the book "Learning Tools Opportunity Theory Based on Realistic Mathematics Education " that has been written by the author of previous research and has been awarded IPR. The advantage of this book is that it is the only RME book that touches high school mathematics; so far, the new RME approach is in elementary and junior high school mathematics learning, considering that in its native Netherlands, RME was developed at the elementary school level. In addition to being guided by the book Theory of Opportunity Learning Theory Based on Realistic Mathematics Education, a preliminary study was also carried out covering literature studies and field studies.

Literature studies conducted are mobile-based learning and realistic mathematical education (RME), relevant research such as Sulistyorini, Argarini, & Yazidah (2018), who analyse errors in solving combinatorics problems and Cholila & Hidayanto (2019) who develop mathematical learning media for windows-based combinatorics material for vocational students. The weakness that can be seen from previous research is that the application developed still uses Windows as the basis of the system. In contrast, this research is a practical mobile-based learning application for Android mobile high school students in which there is a material and evaluation of learning, whereas the field study conducted was about the use of RME in mathematics learning in high school, supervision of lesson plans, and teacher learning, as well as limited interviews with teachers and experts.

Design. This design phase aims to design media that can be used in learning. In this stage, a draft RME application was made with the steps of making storyboard designs (manual) and illustration designs (graphic design). The use of RME is divided into three things, namely Multiplication, Factorial, and Permutation Rules. Issues for Multiplication Rules are carried



out for how to dress, Factorial for Playing Original Number Cards, and Permutations for Arranging Class Managers. Based on the design stages carried out in each problem as follows:

1. Problems with how to dress, the process carried out consists of:

a. *Storyboard Preparation Manual.*

The Story Board Manual describes the narrative or manual storyline of the multiplication rules for how to dress to be applied. Table 1 shows a snapshot of the Story Board manual for the multiplication rules for how to dress.

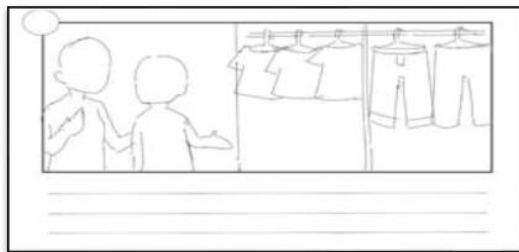
b. *Graphic Story Board*

Visual storyboards provide sketch depictions of the narrative storyline on how to wear clothes that show different ways they can be worn. Figure 2 shows an illustration of the Graphic Design Rules for Multiplication of Dressing

Table 1. Draft Story Board Manual for Dressing

Pictures / Videos	Sound / Dubbing
The Concept of Multiplication Rules	Opening Music or Introduction
When Zainal wants to go to an event. Zainal opened the door and then approached the cupboard. The cupboard has two doors on the left, hanging three different clothes. Each shirt is red, yellow clothes, and blue shirts. On his right hung two long pants with different models. Each one is made of cotton and levis.	"Can anyone help me to buy clothes that are suitable for the event that I want to go to," said Zainal (expression confused).

Figure 2. Illustration Design (Graphic Design) Multiplication Rules How to Dress



2. Problems are playing with number cards

a. *Storyboard Preparation Manual*

The Story Board Manual describes the narration or storyline of the Manually Playing Number Numbers Card that will be applied. The description tells the concept of multiplication rules obtained by many possible numbers formed. Many names are formed consisting of 3 number cards. Table 2 shows a snapshot of the Story Board stages of Playing Number Numbers Cards.

b. *Graphic Story Board.*

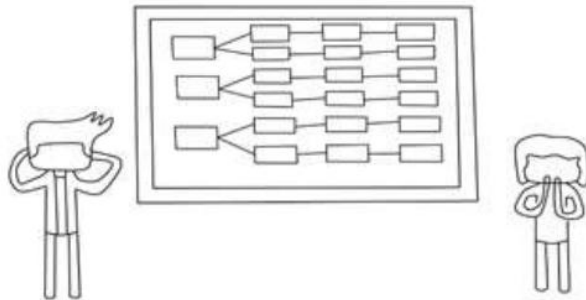
Visual storyboards provide a sketch picture of a factorial storyline/narrative for Playing Number Numbers Cards, which shows different ways to Play Number Numbers Cards. Figure 3 shows a factorial Graphic Design illustration for Playing Number Numbers.

Table 2. Draft Story Board Manually Playing Numbers Numbers Card

Pictures / Videos	Sound / Dubbing
The text "2. Factorial Rules "	We will learn factorial rules with realistic mathematics
The text "2.1. Appears Playing card."	Let's play cards
3 number cards appear with swapping arrangements such as:	"Can anyone help me to arrange 3-digit numbers that can be formed from 3 number cards 1, 5, and 6."

1	5	6
1	6	5
5	1	6
5	6	1
6	1	5
6	5	1

Figure 3. Factorial Design Illustration (Graphic Design) Playing Numbers Numbers



3. Problems Arranging Class Managers

a. *StoryBoard Preparation Manual*

The Story Board Manual describes the narration or storyline of the Permutation manual for Arranging Class Administrators. The description tells the concept of Permutation for

Arranging Class Administrators. Table 3 shows an excerpt of the Story Board stages of Organising the Classroom.

b. *Graphic Story Board.*

The graphic storyboard provides a sketch overview of the Permutation storyline/narrative for Arranging Class Managers that shows the many ways to Arrange Class Managers. Figure 4 shows a factorial Design Graphic Illustration for Arranging Classroom Managers.

Table 3. Draft Story Board Manual Arranging Class Managers


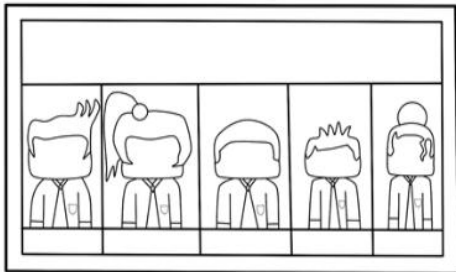
Pictures / Videos	Sound / Dubbing
The text "3. Learning Permutation "	We will learn permutation with realistic mathematics
Text appears "Arranging Class Managers"	Let's arrange the class administrator
Image appears: <div data-bbox="267 793 735 1087" data-label="Image">  <p>Class XI A will elect the Class Chair and Class Secretary from 5 candidates. See the following picture</p> <p>Class Management Candidates</p> <p>A B C D E</p> </div>	Class XI A will hold a class management election consisting of 5 prospective administrators, namely A, B, C, D, and E.
	Of the 5 people as shown in the Figure, one of the 5 candidates will be chosen as Class Chair. One of the remaining 4 candidates will be chosen as a secretary.
	How many possible class arrangements are composed of class leaders and secretaries?
The message appears: "chosen by the Chair and Secretary of the 5 candidates. First the chairman is chosen and then the secretary "	

Figure 4. Illustration Design (Graphic Design Permutation Arranging Class Management)



Development. This development phase aims to apply the design into a medium that can be used in learning. In this stage, a draft of the RME application was made with the steps of the process of animation (visual effect), narrative dubbing, and motion graphic animation video (merging illustrations and dubbing).



1. The Process of Animation (Visual Effect), Dubbing Narrative, and Motion Graphic Animation Video (Combining Illustration and Dubbing) of the Problem of Dressing.

In this process combining multiplicative frames for how to dress that has been poured in the visual effect and then given a voice-based on the narrative dubbing; the next manual is editing the finished video. The next step is the resulting video must pay attention to the duration, dubbing, and transitions between frames. Figure 5 shows the animation process (Visual Effect), Dubbing Narration, and Motion Graphic Animation video.

Figure 5. Visual Effect, Dubbing Narration, and Motion Graphic Animation Video (Combining Illustration and Dubbing) for Multiplication Rules for Dressing



2. The Process of Animation (Visual Effect), Dubbing Narrative, and Motion Graphic Animation Video (Combining Illustration and Dubbing) of Problems Playing Number Numbers Cards. In this process, combining factorial frames for playing numeric cards that have been poured in visual effects and then given a voice-based on narration dubbing; the next manual is editing the finished video. The next step is the resulting video must pay attention to the duration, dubbing, and transitions between frames. Figure 6 shows the animation process (Visual Effect), Dubbing Narration, and Motion Graphic Animation video for Playing Numbers Number Cards.

Figure 6. Animation Process (Visual Effect), Dubbing Narrative, and Motion Graphic Animation Video (Combining Illustration and Dubbing) Factorial Playing Number Numbers Cards



3. Animation Process (Visual Effect), Dubbing Narrative, and Motion Graphic Animation Video (Combining Illustration and Dubbing) of Problems Arranging Classroom Managers
In this process, combining Permutation frames for Arranging Class Managers have been outlined in the visual effect and then voting based on narration dubbing; the next manual is editing the finished video. The next step is the resulting video must pay attention to the duration, dubbing, and transitions between frames. Figure 7 shows the animation process (Visual Effect), Dubbing Narration, and Motion Graphic Animation video for Arranging Classroom Managers.

Figure 7. Animation Process (Visual Effect), Dubbing Narration, and Motion Graphic Animation Video (Combining Illustration and Dubbing) Arranging Class Managers





Dissemination. After the application is complete, the next is product validation by material experts and media experts. This stage includes testing and authorisation from experts. The results will be in the form of criticism and suggestions that can be used as a basis for revising the developed media so that the media can become even better.

Material validation aims to assess the appropriateness of the material presented on a mobile android based realistic mathematics learning application for high school students. Material experts provide an assessment and advise on the material presented in the form using a Likert scale of 1 to 4. Validation was carried out by two people, namely, Nurlaela Rahmawati, S.Pd as a mathematics subject teacher at South Tangerang 6 Public High Schools, which became a partner school in this study, and Rudi Dwi Pramono, S.Pd, as a mathematics subject teacher and school principal at MA Kafila International Islamic School, who is also a partner school in this study.

The results of Nurlaela Rahmawati, S.Pd's assessment as the first material expert in the material aspect, were 85.71% with the right criteria; the learning aspect was 80.00% with reasonable measures, the evaluation aspect was 81.25% with suitable rules. The results of the assessment of Rudi Dwi Pramono, S.Pd as the second material expert in the material element amounted to 85.71% with the right criteria; the learning aspect was 80.00% with reasonable measures, the evaluation aspect was 87.50% with suitable rules. Overall the quality of the material in the learning media assessed by two material experts was 82.32% with appropriate criteria.

Media validation of realistic android based mobile mathematics learning applications for high school students are tested before being tested on partner school students or the general public. The aspects that are tested are the aspects of appearance, elements of writing, aspects of software engineering, and dubbing. Validation was carried out by one person, namely, Prof. Dr. Zulkardi, M.I.Komp., M.Sc. Sriwijaya University Professor, who is an expert in mathematics education in RME and Computer Science.

The results of the assessment of media experts in the aspect of display quality are 75.00% with the right criteria; the writing aspect is 75.00% with reasonable measures, the software engineering aspect is 75.00% with consistent standards, and the sound dubbing aspect is 75.00% with the criteria good. Overall the quality of instructional media assessed by a media expert was 75.00% with suitable measures.

The product trial phase is carried out by testing and distributing applications to students in partner schools, namely South Tangerang 6 Public High Schools and the MA Kafila International Islamic School. It is done to verify the functioning of the application on various types of Android-based smartphones and measure the level of product eligibility through the Google form http://bit.ly/ujicoba_product. Before the app is used, respondents are asked to install the application on their Android smartphone device. Request spreading is made via



Bluetooth, SHAREit, and the <http://bit.ly/aplikasikombinatorik> download link from Google Drive prepared by researchers.

The results of a public trial of 27 students of South Tangerang 6 Public High Schools, obtained the results of application quality in the aspect of display quality by 80.56% with reasonable criteria, writing characters by 86.34% with perfect measures, software engineering aspects by 84.26% with consistent standards, and sound dubbing aspects of 82.10% with suitable criteria. The results of a public trial of 23 students at the MA Kafila Internationa Islamic School, obtained the results of the quality of the application in the aspect of display quality by 84.24% with reasonable criteria, and writing characters by 85.60% with suitable measures. The results of aspects of software engineering was 85.73% with consistent standards, and sound dubbing aspects at 76.81% with appropriate criteria. The overall quality of learning applications assessed by 50 students from partner schools is 83.20% with suitable measures. The results of data acquisition show that practical mobile learning applications based on Android mobile are appropriate to be used as a source of learning mathematics at the high school level.

After the trial was limited to students in partner schools through the Google Form and the application was revised, the next step was the dissemination stage. The purpose of this stage is to disseminate the use. In this research, the form that has been made is planned to be distributed through the Google Play Store, but the research team has not yet uploaded the application to the Google Play Store.

Figure 8. Expert Material Assessment

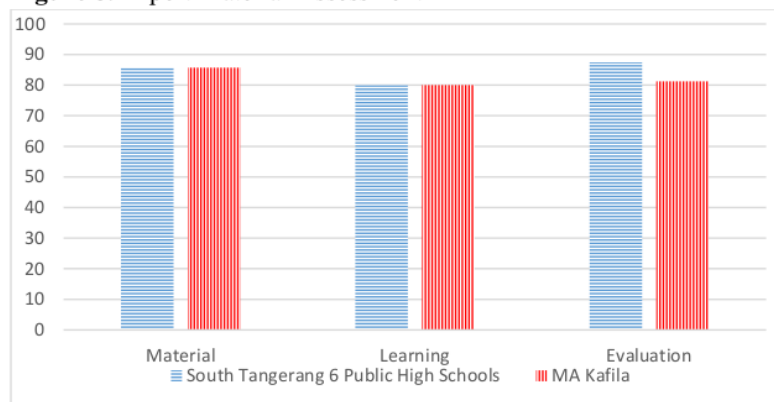




Figure 9. Media Expert Rating

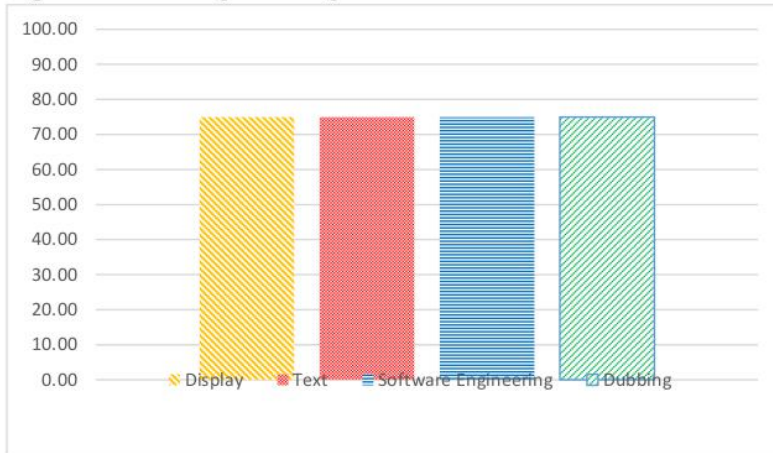
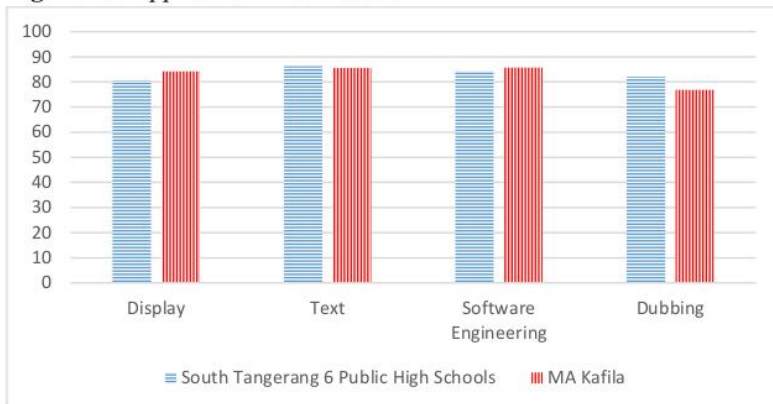


Figure 10. Application Trial Results



Conclusion

Based on the research development that has been done, the following findings can be obtained: Development of learning media for mobile android based practical mathematics learning applications for high school students was named "Combinatorics Application" using the 4D model. Define was in the form of preliminary studies, including library studies and field studies.

Design was in the way of making RME application drafts with the stages of storyboard design (manual), graphic design, animation (visual effect), dubbing narrative, and motion graphic animation video (merging illustrations and dubbing). Develop (development) was in the form of an expert validation stage and product trials, and Disseminate (dissemination). The final



product is a Combinatorics Realistic Mathematics Education Application based on the Android Mobile for high school students named "Combinatorics Application" with the extension .apk (dot apk). This application was developed as a learning medium for high school level students. This application contains multiplication rules with examples of rules on how to dress, factorial concept material with examples of playing numbers, permutation material with examples of class management arrangements, and learning evaluations for each material that can be accessed with an Android-based smartphone. This application is packaged as interesting, so it is expected to be a practical and fun learning media that can be accessed anytime and anywhere. It can increase students' interest in learning mathematics and can be used as a means for independent learning and as a student reference source.

The results of the overall material validation assessed by two material experts were 82.32% with suitable criteria. The results of the media validation were validated by the media expert obtained a percentage score of 75.00% with appropriate measures. The results of product trial on 50 students in partner schools got quality results of 83.20% with functional categories. Based on the results of data acquisition, it shows that practical mobile learning applications based on the Android mobile should be used as a source of mathematics learning at the high school level.

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