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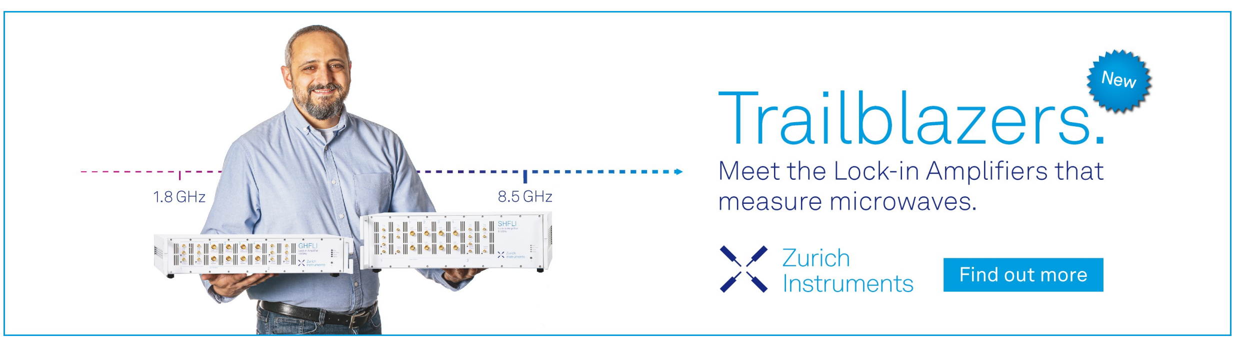
Ervin Azhar, Khoerul Umam and Edy Wihardjo



The Development of a Mobile Phone Application Based on RME Model for Probability of Union of Two Events

Ervin Azhar[1,a)], Khoerul Umam[1], Edy Wihardjo[2,b)]

[1]*Muhammadiyah Prof. DR. HAMKA University, Jakarta, Indonesia*
[2]*University of Jember, East Java, Indonesia*

[a)] *Corresponding author: Ervin.azhar.matematika@uhamka.ic.id*
[b)]*edy.fkip@unej.ac.id*

Abstract. This research is the third of three years fully funded and supported by the National Research and Innovation Agency for the 2019-2021 fiscal year. This study resulted in a mobile learning application design for the probability of the union of two events based on the RME model on mobile devices. The reference for developing this application is an RME-based high school mathematics learning guide book, especially probability material. Application development goes through nine stages, namely: (1) storyboard design; (2) graphic design; (3) animation design; (4) voiceover design; (5) animation video design; (6) consultation with mathematics education experts and teachers; (7) first revision based on suggestions and input from mathematicians and teachers; (7) trial use of the application on several students; (8) second revision based on student input. The average scores of two experts and two mathematics teachers were 93 for display, 89 for text, 94 for device engineering, and 87 for sound. Both teachers and their students love to use this app for learning. The final product of the research is an application that is available for free on the Google PlayStore and can be downloaded at: https://play.google.com/store/apps/details?id=com.uhamka.application_rme.

INTRODUCTION

Learning that connects mathematical concepts with human activities will be interesting, including probability material in Senior High School. This learning activity is known as Realistic Mathematical Education (RME). The results of Azhar's research (2013: 1-19) show that learning with the RME approach provides better mathematical communication skills results and is significantly different from conventional learning at the Islamic Senior High School (Madrasah Aliyah) in Jakarta[1]. The same thing was also found in Azhar's research (2015) which showed an interest in teachers and students in using RME-based probability theory learning tools recorded in 2014 learning activities videos[2]. Furthermore, this learning tool has been made into a book titled "Learning Tools for Probability Theory Based on RME" with ISBN 9786021078020 and HKI number 01920 from the Director-General of Intellectual Property the Ministry of Law and Human Rights of the Republic of Indonesia in 2017.

Several studies that have been published in reputable international journals show that the use of ICT can increase students' self-efficacy and learning outcomes. The results of Youcheng, Chen, and Deyi Kong's research (2017: 133-142) show that multimedia teaching materials can effectively increase the attention of prospective teacher students so that they can increase their potential and effectively develop reciprocal teaching functions[3]. The research of Calık, Muammar, and Karadeniz Technic (2013: 223-232) shows that using technology can increase prospective science teachers' self-efficacy[4]. The results of Astra's research, I Made Hadi et al. (2015) found that mobile-based learning applications can improve learning outcomes for ideal gas properties, such as Boyle's law, Charles' law, and Gay Lussac's law in high school[5]. Qudah's research (2013) showed a positive attitude of students in learning to use mobile phones[6]. The results of Mallampalli's research (2020) show that Mobile Assisted Language Learning (MALL) improves English skills at the tertiary level in Kurdistan[7].

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Due to the situation during the Covid-19 pandemic, it is necessary to create engaging learning with RME models on mobile phones. To present exciting learning with mobile learning, it is necessary to design an attractive learning model for learning on mobile phones.

Show that, by referring to the Probability Theory Learning Book based on Realistics Mathematics Education (RME) as the basis for presenting opportunity theory material with the RME model, then research was done with the title "Realistic Mathematics Learning Application Design for Senior High School in Mobile phone " with funding from DIKTI 2019-2021. This research is currently developing ten applications, one of which is "RME Model Application Design for Probability of Union of Two Events in The Mobile Phone." The presentation of the application begins with a real problem about three people who go to Anyer Beach. The application invites the user to create a model that connects the real problem with the Probability concept of Union of Two Events. Then conclusions about the usefulness of the probability concept of Union of Two Events. Last is the material quiz. The mean of expert validation was 93 for display, 89 for text, 94 for software engineering, and 87 for sound.

State of the literature

Mobile Based Learning

Mobile-based learning or mobile learning (m-learning) refers to handheld and mobile IT devices, such as PDAs, mobile phones, laptops, and tablet PCs, in teaching and learning [Wood, 2005][8]. M-learning is unique because students can access materials, directions, and applications related to learning anytime and anywhere. This will increase attention to learning materials, make learning pervasive, and encourage learner motivation for long-life learning. M-learning allows for more opportunities for ad hoc collaboration and informal interaction among learners [Holzinger et al., 2005][9].

M-learning can be classified based on the leading indicators, namely the supported devices and wireless communication used to access learning materials and administrative information. From the point of view of teaching technology, m-learning can be classified based on indicators; asynchronous and/or synchronous learning support, standard e-learning support, availability of permanent internet connection between system and user, user location, and access to learning materials and/or administration services. According to the time of the teacher and students sharing information, m-learning can be classified into; systems that support synchronous learning, systems that support asynchronous learning, and systems that support both synchronous and asynchronous learning.

Realistic Mathematics Learning (RME)

RME stands for Realistic Mathematics Education, which is a real mathematics learning approach for students. This approach was first developed in 1971 by the Freudenthal Institute in the Netherlands, based on Freudenthal's view, which states that "mathematics is a human activity" (Gravemeijer: 1995)[10]. This means that mathematics is a human activity. The main idea of the RME approach is that students should be allowed to rediscover mathematical ideas and concepts under the teacher’s guidance by exploring various situations and problems that are real to them. Furthermore, this learning model is designed for mobile phones.

There are many misunderstandings about RME. Learning with the RME approach doesn't mean you have to connect mathematical concepts with real objects, but concepts about the real in students’ minds. For example, suppose the child understands addition well. In that case, the concept of addition students’ minds of students, so to teach the concept of multiplication, it is enough to connect it with the concept of addition which is already real in students’ minds. Although high school students think formally, according to Piaget, it does not mean that RME is not suitable to be applied in high school.

This misunderstanding has been explained by Heuvel-Panhuizen (2001), who stated: Misunderstanding of “realistic.”[11]. The reason, however, why the Dutch reform of mathematics education was called “realistic” is not just the connection with the real world but is related to the emphasis that RME puts on offering the student's problem situations that they can imagine. The Dutch translation of the verb “to imagine” is “zich REALISEren.” It is this emphasis on making something real in your mind that gave RME its name. For the problems to be presented to the students, this means that the context can be a real-world context, but this is not always necessary. The fantasy world of fairy tales and even the formal world of mathematics can be very suitable contexts for a problem, as long as they are real in the student's mind.

RME Basic Principles

Based on the view of mathematics as a human activity, three principles have developed the basis of RME, namely: (a) guided reinvention through progressive mathematization progressively guided through mathematics); (b) didactical phenomenology (phenomena in learning); and (c) emergent models (generating models) (Gravemeijer, 1995:7)[12].

RME Characteristics

By the three principles above, in the process of learning mathematics, Van Reeuwijk (in Drijver 1995) says: "provides the following characteristics of Realistic Mathematics Education: 'real' world, free productions and constructions, mathematization, interaction, and integrated learning strands[13]." The characteristics of RME are: using real problems, using the results of thinking and model construction from students, mathematical modeling, interactions in classroom learning, and the relationship between subject matter. Real understanding here means real in students' minds, as explained by Drijver (1995): "Learning of mathematics starts from problem situations that students perceive as real or realistic. These can be real-life contexts, but they can also arise from mathematical situations to the students. The word 'real' thus refers to 'experientially real' rather than to 'real world"[14].

Mobile Learning Model Material Probability Based on RME Model

This study will implement a probability learning model using a mobile device to use a Realistic Mathematics Education (RME) approach. The probability learning model referred to in this study is a combination of two events where t where real will be modeled using a realistic mathematics education (RME) approach with the characteristics of using real problems, using thinking results and model construction from students, mathematical modeling, the occurrence of interactions in classroom learning, and the interrelationships between subject matter.

Contribution of this paper to the literature

The long-term goal of this research is to produce applications (animations) for learning mathematics with a realistic mathematics approach or Realistic Mathematics Education (RME) that are packaged in such a way on mobile devices that make it easier for teachers and especially students to learn practical probability materials used anywhere and anytime using mobile devices. The starting point of this application is a high school mathematics learning guidebook through the RME approach produced in previous research. The advantage of this book is that it is the only one that touches on high school mathematics, which so far, the RME approach has only been in elementary and junior high school mathematics learning. Given that in the Netherlands, RME was developed at the elementary school level. The resulting product is an animation of mathematics learning based on the RME model for the concept of the combined probability of two events, which can be used on computers (PCs/Laptops) and mobile devices (smartphones or tablets) to support online learning, which is increasing due to the pandemic.

METHODS

Research and development methods produce a mobile learning application for the combined probability of two events based on the RME model. According to Astra's research (2015:1083) and the development method has four main steps: 1) planning, 2) development, 3) evaluation, 4) product manufacture[15].

In more detail, the four main steps are described into nine stages of application development as described below: (1) storyboard design; (2) graphic design; (3) animation design; (4) voiceover design; (5) animation video design; (6) consultation with mathematics education experts and teachers; (7) the first revision based on inputs and suggestions from mathematicians and teachers; (7) limited trial of the use of the application on some students; (8) second revision based on student input and observations.

The RME-based High School Mathematics book was adapted into animation to use mobile devices in the early stages. The animations made are judged by experts and then revised by the team of creators ten times. After that, it was tested on a limited basis to students in many schools, including getting input from teachers as users of mobile-based learning software.

The teachers and students involved came from schools in the Jabodetabek area, namely: SMA Negeri 6 Tangerang Selatan, Madrasah Aliyah (MA) KAFILA International Islamic School (KIIS), SMA Sejahtera Depok, SMA Negeri Parung, SMA Negeri 9 Bekasi, and SMA 67 Jakarta. In addition to teachers and students, institutionally, it also involves several Education Offices in East Jakarta, Tangerang City - Banten, Bogor Regency, Depok City, and Bekasi City - West Java.

The data in the study were obtained from expert validation instruments on the RME-SMA application draft, student response sheets, teacher interview sheets, and students' mathematical ability tests.

Then the research development data were analyzed descriptively and inferentially. Descriptive analysis was carried out on the data obtained during the preliminary study process, the design of the RME-SMA application draft, expert validation, student responses, teacher interviews. At the same time, the experimental data for the RME-SMA application were analyzed inferentially.

This development is a mobile learning application for the combined probability of two events based on the RME model, which can be used on mobile devices to support online learning.

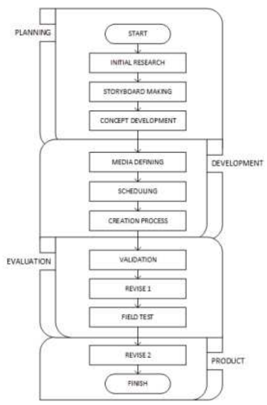

FIGURE 1. Reserch Desain for Astra (2015:1083)

FIGURE 2. Welcome Screen of Application

RESULT AND DISCUSSIONS

In this section, we will discuss the applications that have been created. This application is one of ten applications, to be precise, the eighth application of my research.

This research begins with designing mathematics learning applications. This application is made by collecting data and designing mathematical concepts of probability material. Then the probability material is developed into several sub-materials by the competency standards of the material. In this discussion, we will discuss the concept of probability. The application creation process uses scripts described in detail and then designed by a team of editors to create the application.

FIGURE 3 shows a picture containing the concept of combined probability, starting by telling three people to the beach. Then proceed with **FIGURE 4**, which contains the next slide about a real problem made with illustrations. As for Anita, Gareng, and Petruk always go to the beach, but Anita goes once a month, Gareng every two months, and Petruk every three months. They go to the beach on the third Sunday of the week from 10 am to 4 pm. The slides explain the actual problem conditions.

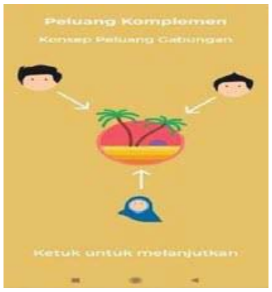

FIGURE 3. Three people are going to the same

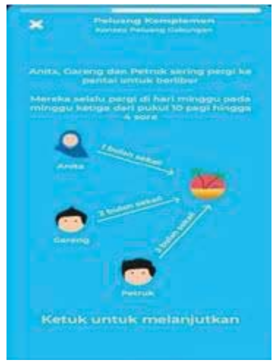

FIGURE 4. Real problems with a real illustrations

FIGURE 5. Presentation of questions with illustrations (models)

FIGURE 5 shows the next slide, which contains the problem to be solved. The problems shown and asked when they can meet 1) "Anita meets Gareng every year," 2) "Anita meets Petruk every year," 3) "Anita meets Petruk and Gareng every year," 4) "Anita meets Petruk or Gareng every year." Figure 5 Lifting the completion step with the RME model, starting from the first step, namely the symbolization of the story in the form of a set. Figure 6 shows the second step of the solution, namely making a diagram based on the set that has been created.

FIGURE 6. Symbolize as the first to enter RME

FIGURE 7. Problem models

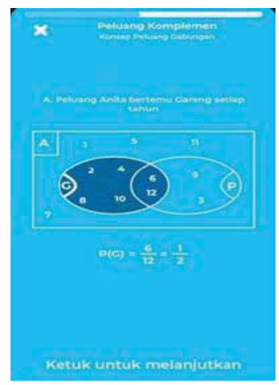

FIGURE 8. Two intersecting sets focus on the set G

FIGURE 8 shows a model that explains all members of set G, i.e., the number of months from Gareng to the beach, compared to the months Anita and Petruk go to the beach. Focus on the set G, $P(G) = \frac{6}{12} = \frac{1}{2}$ for probability G or Anita's probability meets Gareng every year. The following slide in Figure 8 shows a model that describes all members of the set P, i.e., the number of months from Petruk to the beach, compared to the set of months Anita and Gareng to the beach. Focus on the set P, $P(P) = \frac{4}{12} = \frac{1}{4}$ for probability P or the probability that Anita meets Petruk every year. Figure 9 shows Anita's settlement to meet with Gareng and Petruk every year. Anita's group is the universe because Anita always goes to the beach every month. So, $P(P \cap G) = \frac{2}{12} = \frac{1}{6}$ for Anita's probability of meeting Gareng and Petruk every year. Figure 10 shows a slide containing a formula for solving a problem. Anita meets Gareng or Petruk every year. The slide explains the solution formula, which is $P(G \cup P) = P(G) + P(P) - P(G \cap P)$.

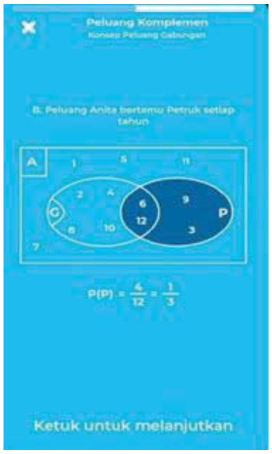

FIGURE 9. Two intersecting sets focus on the set P

FIGURE 10. Two intersecting sets focus on the intersection set

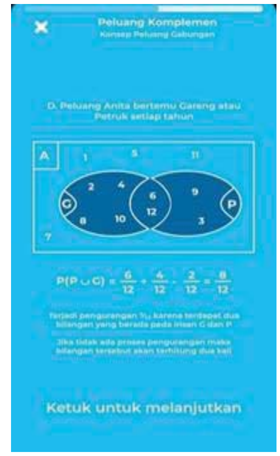

FIGURE 11. Two intersecting sets focus on the combined set

FIGURE 14 shows the user's questions regarding the probability of combining two sets. Next, in **FIGURE 14**, the user is asked to fill in the combined probability of the two sets presented on the slide. Then, **FIGURE 15** displays the following question; the user is asked to fill in the probability set A. **FIGURE 16** displays questions to be filled about the probability set B. As a guide to finding Back, then in **FIGURE 17**, this application invites the user to think, "Is $P(A) + P(B) - P(A \cup B)$ is not equal to zero?". For the first to fourth questions, If the answer is wrong, a "Your answer is not correct" sound will appear. On the other hand, if the answer is correct, the voice "You are great" will appear so that the user can know whether the answer that has been filled in is correct or not.

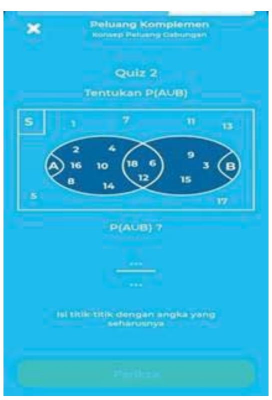

FIGURE 12. Set A and set B that

FIGURE 13. Ask the user to fill in the probability of the intersection of two sets

FIGURE 14. Ask the user to fill in the probability of joining two sets

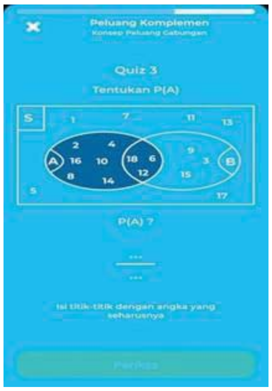

FIGURE 15. Ask the user to fill in the probability set A

FIGURE 16. Ask the user to fill in the probability set B

FIGURE 17. Ask the user to fill in the combined probability of the two sets

FIGURE 18 presents a question that invites users to understand, "why $P(A) + P(B) - P(A \cup B) \neq 0$?" Furthermore, in **FIGURE 19**, the 6th question is shown, where the user must fill in the number of times the slice members are counted. Users can use for $P(A) + P(B)$, the slice member is counted two times while for ( ), the slice member is counted once. **FIGURE 20** presents questions about the "RME Model" to lead to the concept. Reinforcing the concept is shown on the next slide, which is in **FIGURE 21**. As a challenge for users, because they have followed all the learning content and problems in the application, there is a challenge at the end. This challenge contains higher-order thinking questions, which can be seen in **FIGURE 22**.

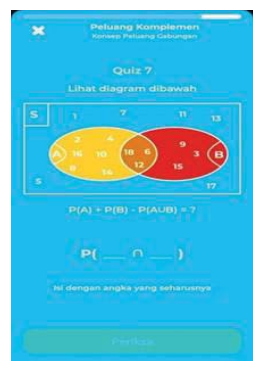

FIGURE 18. Why is P(A) + P(B) – P(A ∪ B) not equal to zero?

FIGURE 19. Why is it calculated two times for P(A∩B)

FIGURE 20. Model for RME guide to concept

Experts carry out validity to assess several elements in the application. Among them are display, text, engineering devices, and sound. A scale consisting of a score of 1-100. The data are shown in **FIGURE 23**. As shown in **FIGURE 23**, the average scores for the assessment were 93 for display, 89 for text, 94 for device engineering, and 87 for sound in applications. The average number shows that this application is perfect for use as a learning medium.

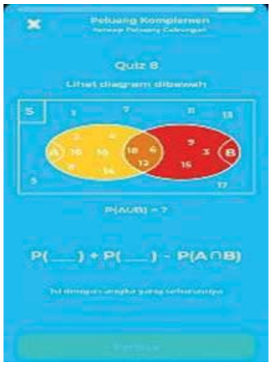

FIGURE 21. Strengthening understanding of the concept

FIGURE 22. Higher order thinking questions

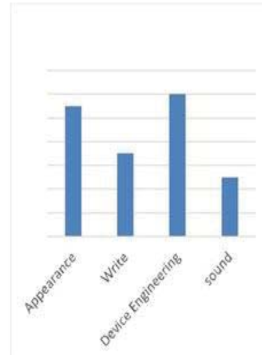

FIGURE 23. Validation results

CONCLUSION

The result of this research is the application of the RME model for the combined probability of two events. This learning model is presented in an Android-based mobile phone. This application guides users to follow the RME model to be interested and easy to understand mathematical material. Experts carry out validity to assess several elements in the application. Among them are display, text, engineering devices, and sounds. The scale consists of scores from 1-100. The data are shown in **FIGURE 23**. The mean scores for the assessment were 93 for display, 89 for text, 94 for device engineering, and 87 for sound in applications. The average number shows that this application is perfect for use as a learning medium. The final product of the research is an application that is available for free on the Google Play Store and can be downloaded at: https://play.google.com/store/apps/details?id=com.uhamka.aplikasi_rme.

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