Development of digital learning resources for realistic mathematics education in supporting virtual learning during covid-19

S Fiangga¹, E L W Palupi¹, D Hidayat¹, N R Prihartiwi¹ and T Y E Siswono¹
¹Mathematics Education, Universitas Negeri Surabaya
shofanfiangga@unesa.ac.id

Abstract. The use of digital resource for learning has been increasing since the Industrial Revolution 4.0 was enlivened. This was further strengthened by the government's policy to learn from home since the COVID pandemic 19. Various types of online learning can be effective but also sometimes do not succeed in achieving the expected learning goals. Drijver suggests that 3 main factors influence how digital learning resources can be effective in learning, namely how the design of digital content is, how the teacher's role in digital content is, and the use of the educational context used in digital content. Realistic Mathematics Learning can be an approach that can accommodate all the factors.

This study aims to provide appropriate digital learning resources for teachers and students during the COVID 19 pandemic. An adapted Plomp Design is used for developing digital content. This developmental research suggests that the characterization of RME supports the requirements for effective digital learning resources in a way that enables the student to foster their constructive learning activities. However, these rich didactical activities lack in providing an adequate presentation on the mathematics content.

1. Introduction

The global pandemic, Corona Virus Disease-19 (COVID 19) affects not only the health and economic sector but also education. The fact that COVID 19 could infect anyone urges the government to make a relevant policy, one of it is to learn from home. The Minister of education instructs teachers to hold teaching and learning from home [1]. This triggers the shifting of ways of teaching from teaching in the classroom to virtual teaching, from offline teaching to online teaching.

Supporting the instruction to study from home, the Minister of communication and information has provided free internet access and instructed service providers such as telecommunications providers in Indonesia and Google to provide free access to digital content/platforms that can be used during the study from home [2]. Therefore, the ability of educators to utilize online media is very crucial today. As there is free access to the internet and digital content/platforms, teachers have the opportunity to create or develop online learning resources to support the online teaching and learning process.

Borba et. al. categorized the various types of categories for the online learning, namely (1) learning through technology cellular, which uses applications on students' digital devices, (2) massive open online learning that can be widely accessed by students, (3) digital learning resources, which can be in the form of learning materials and interactive learning objects, (4) collaboration learning using digital
technologies, and (5) blended learning [3]. This suggests that the ability to use technology is crucial and a necessity for teachers.

Developing good digital learning media is not an easy thing since it needs not only mathematical and pedagogical knowledge but also knowledge about technology and or the skill to do programming. The ability of teachers in Indonesia to utilize technology is still inadequate [4]. Let alone being able to develop good online or digital mathematics learning resources, some teachers even still face difficulties in finding, choosing, and compiling the relevant good digital learning resources. Based on the interview, teachers state that it would be beneficial if there is a compilation of good digital learning resources, a ready to use resources. So, teachers could help students to achieve the learning objectives by its support. That fact enhances the needs of reliable online resources for learning that is ready to be accessed and used.

The use and the development of digital as well as an online resource for learning include mathematics, which has been increasing since the Industrial Revolution 4.0. However, some of them are reliable while others are not effective in achieving the expected learning goals [5]. Some of the learning resources have a good and interactive display and it is claimed to be effective to help the student understand a particular mathematics content. Yet, they only focus on the display while the mathematics content is delivered directly on the formal level and then focusing on the drill like exercise [5]. This suggests that not a few learning sources are developed yet not consider the educational context.

Drijver suggests that 3 main factors influence how digital learning resources can be effective in learning, namely how the design of digital content is, how the teacher's role in digital content is, and the use of the educational context used in digital content [6]. The first factor that influences the success of learning using digital content is how digital content is designed. The display and the use of relevant technology are very important to support the learning goals of digital content. The second factor is how the teacher's role in digital content. The important fact is that the use of technology as well as online learning resources in learning does not reduce or even replace the role of the teacher. Yet, this will make teachers have more to do since teachers need to choose and compile online or digital contents that are in accordance with learning material and meet the expectations of their students. The last factor suggests that online learning resources should promote educational context on it. This means that the resources should be developed based on students learning trajectory and should promote meaningful learning.

Realistic Mathematics Learning can be an approach that can accommodate all the factors conveyed by Drijver. Realistic Mathematics sees mathematics as a human activity [7]. This view suggests guiding students to find both understanding and valuable skills in such a way that they can also easily understand a mathematical concept. There are three main characteristics in the implementation of PMR in mathematics learning, namely: (1) guided reinvention, where students can rediscover a mathematical concept while still involving the role of the teacher, (2) didactical phenomenology, where students do the learning process through phenomena/events experienced with using the right educational context and (3) emergent modeling or development of non-formal models to formal [8,9]. Realistic Mathematical Education (RME) theory itself requires the need for learning to apply (1) guided reinvention, where students can rediscover a mathematical concept while still involving the role of the teacher, (2) didactical phenomenology, where students do the learning process through phenomena/events experienced with using the right educational context and (3) emergent modeling, which can bridge the informal to formal level using thinking models of the right content design. In other words, Realistic Mathematics Education as one of the Domain Specific theories in mathematics education can be a framework used by mathematics teachers or media developers in designing qualified online digital mathematics learning resources.

As for the framework used to analyze the educational context, as well as pedagogical content of the online learning resources, is Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPCK). Kohler. The PCK is defined as knowledge related to how knowledge of subject topics, especially mathematics, is adapted by a teacher into learning [10]. The PCK framework, adapted from Baker & Chick, and Maher, Muir, & Chick, could help the teacher to evaluate whether the developed online learning resources are developed with consideration to the pedagogical and educational context [11,12]. Furthermore, the TPCK is the knowledge that covers the content, pedagogical, and technological interaction [13] by which the quality of the developed digital content is
ensured. Therefore, TPCK is important to ensure that the digital content framework with the RME approach can be effective as a digital learning resource.

The need for good online learning resources that consider not only the interesting and interactive display but also consider the educational context that can be accessed and used by teachers is the main reason for this study. This study aims to provide appropriate digital learning resources for teachers and students during the COVID 19 pandemic. Therefore, the development of Realistic Mathematics digital content has been carried out to support more mathematics teaching as human activities.

2. Method
This developmental research is conducted as stages, namely: (1) analysis, (2) design, (3) realization, and (4) implementation [14]. However, this paper presents the proses from analysis to realization only which is focused on the materials of eight grade. The digital contents were developed first by analyzing both the instructional theory on the topics in grade 8th and the development of digital content theory. In the stage of realization, a collection of learning trajectories was constructed as teachers’ guidelines in delivering the digital content during this pandemic situation. In the realization stage, the mathematics’ digital content was developed and validated using the TPCK framework (see table 1 at Knowledge and Categories Columns). The framework in testing the content validity was constructed based on the Maher et al for PCK construction and Koehler for TPCK [12,13]. Content validity is used to validate this initial development of the digital content where most research does not report this validity in their research [15]. Furthermore, Yaghmale stated that this content validity needs two judgments on scaled criteria [15](see note for table 1). The validation of the Learning Trajectories involved two validators that expert in mathematics’ teaching and teacher training.

Table 1. Validating Framework for Digital Content Involving RME Approach, PCK, and TPCK. The content validity covers how the digital content used the RME approach as the framework. Then, PCK and TPCK theories are used for assuring the digital content will assure the intended learning knowledge for the teachers who will use these digital contents for their learning.

| Knowledge         | Categories                      | Description of Level (0-3)                                                                                                                                                                                                 |
|-------------------|---------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Mathematics       | Realistic Approach              | 0. Nothing displayed as Realistic Mathematics Approach                                                                                                                                                               |
|                   |                                 | 1. Display one principle of the Realistic Mathematics Approach                                                                                                                                                    |
|                   |                                 | 2. Display two principles of Realistic Mathematics Approach                                                                                                                                                    |
|                   |                                 | 3. Display three principles of Realistic Mathematics Approach                                                                                                                                                    |
| Students’         | Creation Alternatives           | 0. Nothing displayed as Students’ Creation in the lesson design                                                                                                                                                    |
|                   |                                 | 1. The design mention Students’ Creation without any further explanation                                                                                                                                       |
|                   |                                 | 2. Students’ Creation is clearly explained without examples                                                                                                                                                    |
|                   |                                 | 3. Students’ Creation is clearly explained and added with clear examples                                                                                                                                       |
| Cognitive         | Activities                      | 0. Nothing displayed as Cognitive Activities                                                                                                                                                                   |
|                   |                                 | 1. Cognitive Activities is mentioned in the design without further information                                                                                                                                   |
|                   |                                 | 2. Cognitive Activities is explained                                                                                                                                                                           |
|                   |                                 | 3. Cognitive Activities is clearly explained and added content relation                                                                                                                                       |
|                   |                                 | 0. Nothing displayed as a content explanation                                                                                                                                                                   |
| TPCK              | Mathematics’ Content Presentation | 1. The content explanation cover incomplete respective material                                                                                                                                               |
|                   |                                 | 2. The content explanation cover complete respective material                                                                                                                                                  |
|                   |                                 | 3. The content explanation cover complete respective material and added with appropriate explanation element (e.g diagram, symbol, etc)                                                                            |
|                   | Examples of Problems and Context | 0. Nothing displayed as an example in the design                                                                                                                                                    |
|                   |                                 | 1. The examples of the context are not realistic                                                                                                                                                    |
|                   |                                 | 2. The examples of the context are realistic                                                                                                                                                    |
|                   |                                 | 3. The examples of the context are realistic and rich                                                                                                                                                        |
|                   | Variations of Learning Resources | 0. Nothing displayed as the usage of a resource for learning content                                                                                                                                       |
|                   |                                 | 1. Several resources are mentioned as a lesson but do not have the appropriate connection on the content                                                                                                    |
|                   |                                 | 2. Several resources are mentioned as a lesson with appropriate connection on the content                                                                                                                       |
|                   |                                 | 3. Essential relevant resources are mentioned as lesson adequately                                                                                                                                         |
3. Result and Discussion

In this section, the developmental result will be presented in three stages.

3.1. Analysis

In the analysis stage, the instructional theories relating to the topics are reconstructed and the framework to assure the quality of the realistic mathematics digital content resources is adapted. This instructional theory consists of several studies that provide a theoretical background for the planned instructional design. The digital content was developed based on the curriculum of secondary school with Curriculum 2013 in Indonesia (see Table 2 for the list of topics in grade 8). The frameworks used to validate the content are elicited from both PCK and TPCK. The categories form PCK and TPCK is described practically into level descriptors for validating instruments (see Table 1 descriptor column).

Table 2. Topics in Grade 8

| Units                        | Topics                  |
|------------------------------|-------------------------|
| Algebra Operation            | Analysis                |
| Function                     | Analysis                |
| Linear Equation              | Analysis                |
| Two Variables Linear Equation System | Analysis            |
| Coordinate System            | Analysis                |
| Quadratic Equation           | Analysis                |
| Proportion                   | Geometry                |
| Pythagoras Theorem           | Geometry                |
| Circle                       | Geometry                |
| Three Dimensional Figures    | Geometry                |
| Statistics                   | Probability and Statistics |
| Probability                  | Probability and Statistics |

3.2. Design

Learning trajectories for each unit were developed based on the local instructional theories. These learning trajectories served for both the starting points in developing the digital content and teachers' guidance when using the digital content in their classes. The Learning Trajectories are developed in two parts which are learning description and learning activities. In the learning description section, the basic competencies, prerequisite knowledge, and its relation with Curriculum 2013 are presented. While, in the learning activities, sequences of activities are provided along with the illustration, aims, and conjectured students' thinking (see Figure 1 and 2).
3.3. Realization

In this stage, the digital content was created and curated following the designed learning trajectories. The content consists of replicable digital materials on the website and interactive digital content (see Figures 3 and 4). The digital content was arranged from own developed materials or public accessed digital content.

The digital content, then, validated by two experts in mathematics teaching and teacher training based on PCK/TPCK instrument from table 1 valued 0 to 3. The results on three different topics are presented in Figure 5. The validation categories fall into six different criteria, which are Mathematics Realistic Approach, Students’ Creation Alternatives, Cognitive Activities, Mathematics’ Content Presentation, Examples of Problems and Context, and Variations of Learning Resources.
The result of validation provides level 3 for five out of six categories. This means the contents have already displayed three principles of realistic mathematics approach. They also are given with students’ creation that is clearly explained and added with clear examples. The cognitive activities provided in the content are clearly explained and added content relation. Also, the examples of the context are realistic and rich, moreover, the essential relevant resources are mentioned as lesson adequately. Nevertheless, regarding the content presented on mathematics concept, the content explanation covers the respective material but lack with detailed mathematical explanation and representation. This content validity yields that the categories level are minimal at level 2 which is can be interpreted that the content has fulfilled the

4. Conclusion
These stages of the developmental research suggest that the characterization of RME supports the requirements for effective digital learning resources in a way that enables the student to foster their constructive learning activities as proposed by Drijver [6]. However, these rich didactical activities lack in providing an adequate presentation on the mathematics content. This finding is valuable before progressing into the next implementation stage. Therefore, we are going to test the construct validity and, regarding the validity result, an improvement will be made.

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