Design of Virtual Reality-Based Mathematics Virtual Lab with Constructivist Approach in Senior High School

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Abstract: *The purpose of this research is to produce a virtual reality-based high school mathematics virtual lab product with a constructivistic approach in an effort to improve the literacy and numeracy of high school students. The research method uses R&D by adopting the ADDIE model, namely Analysis (Analyze), Design (Design), Development (Development), Implementation (Implementation), and Evaluation (Evaluate). Researchers only conducted basic research so that the research stages only reached development. Data collection techniques used tests, questionnaires, structured interviews, and documentation. Data analysis used questionnaire analysis of student and teacher responses, feasibility analysis by experts, reduction of structured interview results and triangulation techniques. Test data was analysed using descriptive statistics. The results of this study are the production of virtual high school mathematics lab products as much as 10 materials that are attractively packaged based on virtual reality that have been validated by material experts and media experts with an average score of material experts = 89.70 and media experts = 90.38, meaning that this virtual mathematics lab product is very feasible to use in learning high school mathematics.*

Key Words*:* development; virtual lab; senior high school; virtual reality; numeracy literacy

Introduction

In learning mathematics both before the pandemic and after the pandemic, it must be admitted that teaching mathematics material to our children is really not easy (Gersten et al., 2005), the right strategies and methods are needed so that mathematics material can be conveyed properly to our children (Sugihatno et al., 2017), before the pandemic we taught by continuing face-to-face, since the covid 19 pandemic everything has changed to all being online, This makes our students develop new habits by learning online, even though online learning is quite good for time and energy efficiency (Yoo & Kweon, 2019), but for understanding mathematics material it is not at all optimal, because mathematics is an exact science and must be accompanied continuously so that students master mathematics material holistically (Donnelly & Patrinos, 2022).

After the covid 19 pandemic ended, it turned out that a new problem occurred, namely the occurrence of learning loss, with the weak absorption of students in mathematics. The weak capacity of students in receiving lessons, this is because students are accustomed to online learning with the leeway given by teachers to mastery of material by students (Igai & Yunus, 2022). Data from the 2021 National Assessment results show that 1 in 2 students have not yet reached the minimum competency for literacy and 2 in 3 students have not yet reached the minimum competency for numeracy. Even though these literacy and numeracy

skills are needed for the life skills of 21st century students in keeping up with the ever-changing and challenging times (Grotlüschen et al., 2020). Then based on the PISA test results (2018), Indonesia is ranked 72 out of 79 countries. Indonesia's literacy score is 371 out of an average of 487 while the numeracy score is 379 out of an average of 489 (Cahyanovianty & Wahidin, 2021). The PISA test results (2022) on the reading literacy score dropped 12 points and the average maths literacy score dropped 13 points (Kemendikbudristek, 2023b). The PISA data shows that Indonesia has not made significant improvements in learning mathematics in the last 10 to 15 years. Other research also shows that around 70% of 15-year-old students fall below the minimum competency in reading and maths (Kemendikbudristek, 2023).

The development of students' literacy and numeracy skills will be difficult when learning mathematics is still done conventionally and does not use modern learning media (Salminen et al., 2021). Abstract mathematics material makes it difficult for many students to understand (Putri Purwaningrum et al., 2022). In the process of learning mathematics, teachers should be able to apply the concept of constructivism where students are conditioned to carry out an active process of building new concepts independently and new knowledge based on factual data in the surrounding environment. The learning process must be designed and managed in such a way as to encourage students to organise their own experiences into meaningful knowledge (Umbara, 2017).

A survey by the Ministry of Education and Culture revealed that 67.11% of teachers experienced problems in operating digital devices (Kemendikbud, 2021). On the other hand, 88.7% of students lack supporting facilities such as laptops and gadgets. As a result, students do not concentrate on learning (51.1%). Observations and surveys of 10 high schools in Semarang City, Demak Regency, Grobogan Regency and Kendal Regency show that modern technology-based learning media are rarely used. 93% of teachers usually teach using printed books and learning media in the form of powerpoint slides. Based on the data description and findings, the quality of students' literacy and numeracy skills must be improved, including by designing learning innovations using virtual reality (VR).

To make students happy to learn mathematics and master mathematical material holistically, it is necessary to have interesting and effective learning media following the development of the 21st century era, one of the media is virtual lab media based on virtual reality (Buchori & Pramasdyahsari, 2020), Virtual Lab based on Virtual Reality (VR) is a user environment where physical reality and mathematical digital content are combined in a way that allows interaction with and between the real world and virtual objects (Yonghui Wang et al., 2009). In packaging mathematics learning based on virtual lab mathematics, an appropriate approach is needed, namely with a constructivist model that is able to substitute, augment, modify, and redefine appropriate learning media in virtual reality-based learning (Miranda & Mustika, 2023), with this constructivist model students are invited to modify learning media according to the learning style of our students so that it is easy to apply in learning this constructivist model (Maghfuroh et al., 2022). Thus, the purpose of this research is to produce a virtual reality-based high school mathematics virtual lab product with a

constructivistic approach in an effort to improve the literacy and numeracy of high school students.

Method

This research uses the RnD method by adopting the ADDIE model with the steps being Analyse, Design, Development, Implementation, and Evaluate (Rayanto & Sugiyanti). However, in this study, researchers only conducted basic research so that the research stages used were only up to development. Thus, the basic research activities that will be carried out in this basic research are (a) the analysis stage includes learning gap analysis, analysis of students' literacy and numeracy skills, resource analysis, and material analysis; (b) the designing stage, namely the design of a VR-based high school mathematics virtual lab with a constructivist model; and (c) the development stage, namely the creation of VR-based high school mathematics virtual lab content with a constructivist approach and expert validation. The research subjects are class XII high school and high school mathematics teachers in the sampling technique using purposive sampling. The following research flow chart illustrates what has been done during the proposed time.

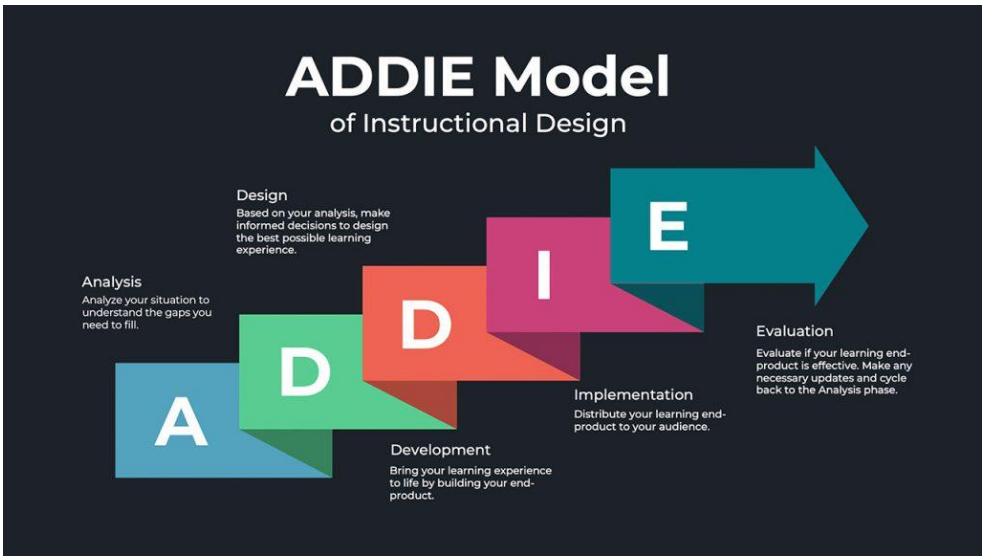

Figure 1. Research Flowchart

Results and Discussion

In this study using ADDIE model development research with the following results: In the analysis stage, it is carried out by analysing the needs of UPGRIS Lab School high school students related to mathematics learning which is felt to require breakthroughs in explaining difficult mathematics material to be fun and enjoyable for students, so far at UPGRIS Lab School high school has not used renewable media using virtual reality, This is because at SMA Lab School students and teachers are still unfamiliar with the application of virtual reality in learning mathematics in the classroom, then the facilities at SMA Lab School UPGRIS need to be improved related to computer labs that are able to make VR applications that support mathematics learning, therefore it is necessary to train and assist students and teachers in making virtual reality media so that virtual reality adds to student understanding.

Then the design stage is carried out by making the design of high school mathematics materials that have been made as many as 10 materials, namely (1) mathematical logic, (2) linear inequality of two variables, (3) linear program, (4) matrix, (5) limit of algebraic function, (6) derivative of algebraic function, (7) indefinite integral, (8) trigonometric equations, (9) circle equations, (10) geometric transformations, all products are made using the teasys application online with assets including material images made with JPG-shaped canva, then instrumental music is prepared and 360 photos are made.

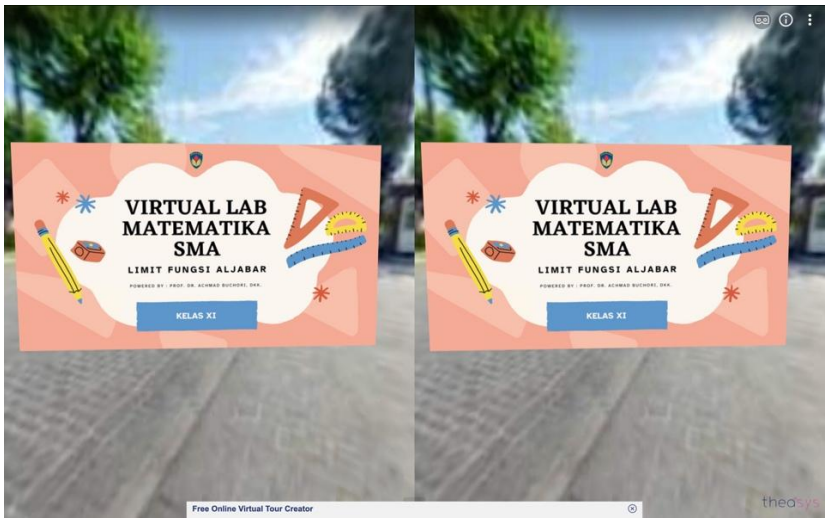

Figure 2. Preliminary design of virtual lab for high school mathematics

In the process of designing this virtual maths lab product, there were several obstacles, namely the unstable internet became the main problem in making this media because all assets were made online.

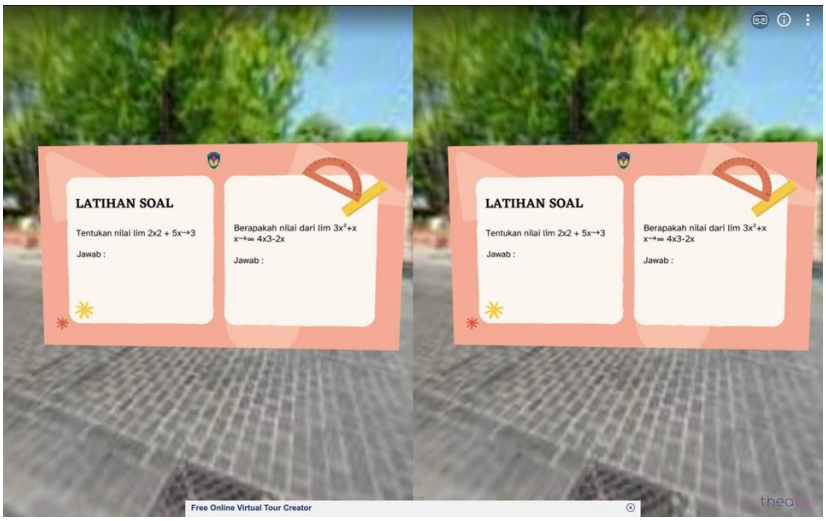

Figure 3. Problem design in virtual lab for high school maths

At the development stage, 10 high school mathematics virtual lab materials have been made which are attractively packaged and have been validated by material experts and learning media experts with the following results:

Figure 4. Learning Material Expert Validation Results

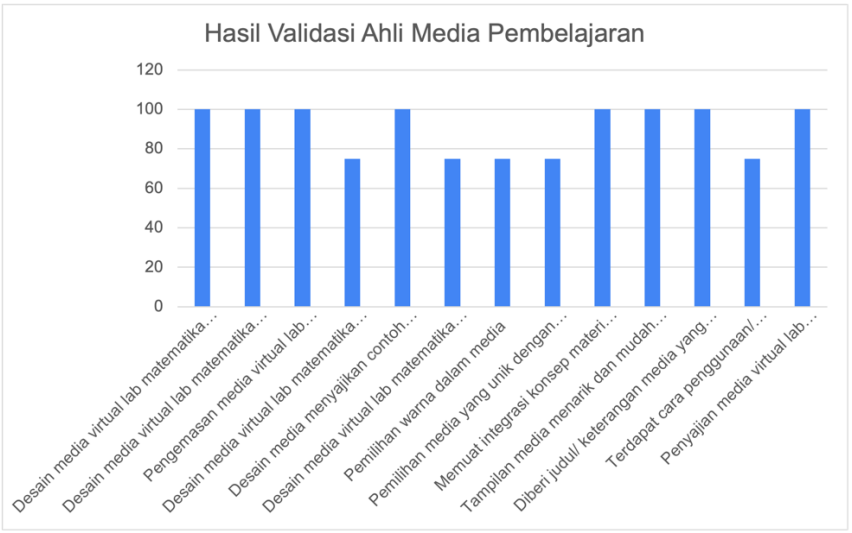

Figure 5. Learning Media Expert Validation Results

This high school mathematics virtual lab product has been validated by learning material experts and learning media experts with an average score of material experts = 89.70 and media experts = 90.38, meaning that this mathematics virtual lab product is very feasible to use in learning high school mathematics.

Conclusion

From the results of this study resulted that: (1) 10 materials related to high school mathematics virtual lab products have been produced, (2) high school mathematics virtual lab products have been validated by material experts and learning media experts and are suitable for use as a learning media supplement in the classroom.

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