Development of Hydraulic Cylinder Excavator Learning Media Based on Augmented Reality with Shapr3D

A Setiyawan\(^1\), L C Manggalasari\(^2\), T A Prasetya\(^3\), Towip Towip\(^4\) W Noviansyah\(^5\)

\(^1\)Department of Mechanical Engineering, Universitas Negeri Semarang, Semarang, Indonesia
\(^2\)Department of Technology and Vocational Education, Universitas Negeri Yogyakarta, Indonesia
\(^3\)Department of Mechanical Engineering Education, Universitas Negeri Yogyakarta, Indonesia
\(^4\)Department of Mechanical Engineering Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret Surakarta, Indonesia
\(^5\)Department of Civil Engineering Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret Surakarta, Indonesia

Email: andrisetiyawan@mail.unnes.ac.id

Abstract. The development process of augmented reality generally requires devices and software with high compatibility so that they are the only obstacles in its development. The purpose of this study was to design and produce an application of learning media on the hydraulic cylinder of excavator based on augmented reality with Shapr3d for prospective students of automotive engineering education and to see the product feasibility level of the test subjects and validators. This learning media development stage consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. For the data method using direct observation and closed questionnaires. The questionnaire of the research results was analysed using Likert scale analysis. The results of the material expert validator with a score of 91.25\% are very good category. Expert media design validator 92.5\% is included in the very good category with a very proper name. The response to product use from three lecturers of automotive engineering education with a proportion score of 88.34\% is in the very good category. The response to the use of the product was from twenty automotive engineering education students with a score proportion of 85.73\% in the very good category. This that the application of automatic learning media on excavator hydraulic cylinder based on augmented reality with shapr3d based on Augmented Reality technology that has been developed can be used in elementary schools as a learning media for technical education.

1. Introduction

The government's physical distancing policy to prevent transmission of the covid19 [1]virus caused changes in learning patterns from face-to-face learning to distance education[2]. Along with the rapid development of technology[3], the utilization of technology and its development in education is increasingly advancing and developing, requiring many updates to compensate for these developments[4]. The exponential growth of Information and Communication Technology (ICT) has changed the education systems and contributed to improving the learning process[5][6]. The presence
of ICT in the school system will undoubtedly improve the quality and access to better information[7]–[9]. However, scientific advancements that are becoming more advanced in education cannot be used entirely[10]. According to Pribadi, learning media in the form of IT was created to make it easier to communicate facts and awareness to many people[11]. Other teaching media should be used to mitigate problems with this one. Since there are still teaching media such as interactive films, PowerPoint presentations, interactive learning apps, and others that can distribute space-building resources. Augmented Reality is one immersive learning technology that can be used to teach space construction content. Augmented Reality is a device that uses a smartphone to view virtual objects in a real-world setting[12]. Geometry objects are converted into virtual objects using this technology, then projected on a physical object using a smartphone. In hydraulic material in excavator heavy equipment Engineering, Augmented Reality is used to visualize the hydraulic system on the excavator.

In the current era, there is an application in augmented reality modelling that is very easy to do through shapr3d. Shapr3D, launched in March 2016, is a direct modelling tool, which, though developed for professionals, is said to be easy to learn and easy to use. It runs everything through the iPad Pro device, meaning there’s no need to push files into the cloud, and it can also be used without an internet connection. Compatible with all major CAD software and ideal for 3D printing jobs, Shapr3D has integrated Parasolid for better geometric modelling and HOOPS Exchange as a leading CAD translation Software Development Kit (SDK)[13]. Shapr3d can model instantly for Augmented Reality. Developers use this high level of interactivity to create a variety of Augmented Reality-based learning media. Teaching content on standard house examples and human organs are two examples of Augmented Reality-based learning media[15]. Some of the benefits of using Augmented Reality in this broad learning are introducing students to technology in the field of education.

It supports the merdeka curriculum policy that requires the use of IT in learning and supporting government efforts in developing superior human resources for Indonesia’s golden generation in 2045, ready to face the industrial age. For all of these benefits, Augmented Reality is an excellent way to educate students about technology at a young age. This is also reinforced by previous studies[16][17], which found that Augmented Reality is suitable for use in school learning because of its high degree of interactivity. Knowing the advantages of using Augmented Reality in the world of education is in line with the purpose of this research, namely the hydraulic cylinder excavator learning media based on augmented reality with shapr3d for prospective students of automotive engineering education. This research was conducted because, generally, Augmented Reality is used to teach historical material, natural sciences, and other subjects. However, there has never been any research related to Augmented Reality as a learning media application, especially for hydraulic excavator material.

2. Methods
This form of research is development research to produce a product. The development procedure consists of five stages: (1) analysis, (2) design, (3) development, (4) implementation/execution, and (5) evaluation/feedback. The development of an adaptive e-learning system is conducted by using the Instructional System Design (ISD) in which typically used for the development of an educational system. Allen (2006) defined that one widely accepted and use disthegeneric “analysis, design, develop, implement and evaluate” model or generally called as an ADDIE model [18][19]. This model is chosen because it has a structured and straightforward development sequence that makes it more accessible. The first step in this research is to analyze needs through observation and interviews; by doing so, more knowledge would be available, allowing the final product to be more efficient and targeted. The design can be defined as the process of implementing various kinds of techniques and principles to define the equipment, process or system in detail[18].
The third step is developing an application; at this stage, all previously prepared prototypes are executed until they become a finished product that can be used. This stage includes making the application interface design, drawing for 3d design and extract augmented reality using shapr3d without a marker. After this process is completed, the next step is to implement the application on the student of automotive engineering education.

Figure 1. Architecture of AR

Figure 2. Flowchart development AR

However, before implementation on the subject, the application must be checked on a validator. The goal is to determine how feasible the application is and identify any product flaws to be addressed before it is tested on the subject.
The content expert validator and the validation of learning media design expert are the validators in this report. Although closed questionnaires are used to collect study data from subjects and validators, questionnaires are created using application-based learning media eligibility criteria that adapt previous applicable research, such as the suitability of material content, language, graphic design, colour, ease, and interactivity. The expert judgment test was used to conduct the validity test for this questionnaire. The expert judges would evaluate the questionnaire's suitability as a measuring tool in this research development. The study validator receives the completed questionnaire. In addition, the scores obtained from each validator are evaluated using a Likert scale evaluation analysis to assess the appropriateness of the application submitted.

**Table 1. Analysis of Likert Scale Assessment**

| Score | Information            |
|-------|------------------------|
| 5     | Strongly agree         |
| 4     | Agree                  |
| 3     | Not agree              |
| 2     | Disagree               |
| 1     | Strongly disagree      |

Data obtained from the validator is analyzed using a Likert scale assessment, and this score will be collected from each of the validators. Furthermore, to be able to make decisions regarding the feasibility of the application using the following decision-making criteria:

**Table 2. Indicators of Questionnaire Score Decision**

| Level of Achievement | Qualification | Information         |
|----------------------|---------------|---------------------|
| 81-100%              | Very Good     | Very decent/Valid   |
| 61-80%               | Well          | Eligible/Valid      |
| 41-60%               | Pretty Good   | Inadequate/Less Valid |
| 21-40%               | Not Good      | Ineligible/invalid  |
| <20%                 | Very Poor     | Improper/very invalid |

Lecturers and students checked the product at Automotive Engineering education to assess the answer to using the application in learning until the percentage of validator questionnaire scores met the good qualifications. Data processing methods used in the study validator questionnaire were used to calculate scores and make decisions from the instructor and student questionnaires. The evaluation phase is the last step in this research, and it aims to evaluate the products from previous implementations to optimize the research's final product. This stage is completed by reviewing the validator's and test subjects' responses in the questionnaire's comment section. So that it can be determined if the application needs adjustment and can be corrected immediately to increase the quality of the development's performance.

**3. Result and Discussion**

The research results from this development include product results in the form of an Augmented Reality shooting application. The results of the study also present a description of the validation results in the form of media validation and the results of research that has been carried out. The results of the study also present the results of the pretest and posttest analysis. Needs analysis in this development includes hardware, software and material requirements needed for development. The hardware used is a 7th generation iPad with Apple Pencil.
Furthermore, IOS devices are used for product application implementation. The software used is AutoCAD and Shapr3d. The product design process includes object design and AR design.

![Figure 3. Drawing 3D Hydraulic Cylinder](image1)

![Figure 4. Merging part of Hydraulic Cylinder](image2)

Modeling of 3D object to view of all part which merging in 360° and evaluate the part of hydraulic excavator seem like real object in the field. The yellow color shows the part of hydraulic cylinder which easy to indicate by student.
Figure 5. Modeling 3D object

Figure 6. Trial modeling 3D in 360°

Trial of hydraulic excavator AR use Reality composer and IOS device. Camera will detected for the object such as flat object, and if success the model of 3D will appears.
Figure 7. Trial Hydraulic Excavator AR

The following are the results of the validity test of each validator, and this course is a research experiment:

| Table 3. Validity test of each validator |
|-----------------------------------------|
| Respondent                  | Percentage | Information |
| Material Expert Validator    | 91.25%     | Very decent |
| Media Design Expert Validator| 92.50%     | Very decent |
| Lecturer                    | 88.34%     | Very decent |
| Student                     | 85.73%     | Very decent |

Learning media applications on material based on Augmented Reality technology was developed through five stages, starting from the Analysis, Design, Development, Implementation, and Evaluation stages. The previously designed research design, and product validation by the validator and the test subjects, namely lecturers and students, was carried out at the implementation stage by employing a measuring instrument in the form of a closed questionnaire that had previously been validated by an expert judgment[20]. The certification of the application to the material expert validator involves the material suitability criteria, the design of the material in the application. The application is validated by the content expert using a questionnaire that contains these requirements. The validation results of the application of two material experts were rated on a scale of 5 (excellent) to 4 using a questionnaire (good). So, from the aspect of the material contents included in the criteria very well with a percentage of 91.25% score and is feasible to be applied in higher education as a learning media. The material in this application consists of a hydraulic excavator for the heavy equipment class. The results of the subsequent validation are done by the instructional media design expert and the content expert. Then the confirmation by the media design expert is done using a questionnaire that adapts the feasibility requirements of IT-based media previously done by the media design expert[21]. The appearance of graphic design, colour, interactivity, and ease of operation requirements for media design experts. And, based on the findings of two media design experts' validation, most of the validator scores of the application design aspects ranged between 5 (excellent) and 4 (good).

There is also a "guide" feature that can make it easier for users to operate applications; this is in line with study, which found that ease of operation of applications is critical in developing IT-based media. The findings of the validation conducted on three lecturers in automotive education are presented next. Validation is accomplished by using a questionnaire that adapts the eligibility requirements of IT-based media. The evaluation findings on a scale of 5 (very good) to 4 (poor) based on the results of trials on three teachers who were tested using a questionnaire with elements of the assessment including the contents of the subject, product design, and implementation feature (good). Learning media in the form of this application earned a positive response from elementary school teachers, with a percentage score of 88.34 per cent, which is included in an outstanding certification with very decent knowledge, according to the results of this evaluation.

The final validation result was conducted on students from the automotive engineering faculty of education at Universitas Negeri Semarang to obtain product validation from small groups and obtain feedback on the product's use. This is typically done based on a past investigation by Hidayat [22], which states that item utilization reaction is required when creating an item, particularly for everyday objects that understudies have not attempted. Based on survey information gotten from understudies, the evaluation scores shifted with a extend of scores between 5 (exceptionally great), 4 (excellent), 3 (adequate), and 2 (less). Based on the comes about of this appraisal, a rating score of 85.73% is included in a great capability with exceptionally conventional data. Based on these comes about, the students' reactions to the created application are great, and the application is attainable to be connected in higher instruction as a implies to bolster learning, particularly in automotive engineering.
Referring to the comes about of information investigation gotten in this ponder of validators and test subjects that the application of automotive education media on the hydraulic cylinder of excavator material based on augmented reality with shapr3d innovation is doable to be utilized a learning media with exceptionally great qualifications. The additional significance to past investigation conducted by Hamzah[23] concerning the plan of applications based on Expanded Reality innovation

4. Conclusion
Based on information investigation the comes about of this ponder can be concluded as takes after: (1) The improvement handle incorporates five stages, namely the Analyst (Analysis), Design / Development, Implementation/execution (Implementation), and Evaluation/feedback (Evaluation), this inquire about the show was adjusted from nd past inquire about by who utilized a comparable demonstrate. (2) Augmented Reality application developed is valid/feasible to be used as a media of application of education media on the hydraulic cylinder excavator based on augmented reality with shapr3d innovation with the results of data analysis from the validator and the test subjects as follows: (a) the material expert validator states the application is very feasible with a percentage score of 91.25%, (b) the validator of the media design expert said the application was very feasible with a percentage score of 92.50, (c) three automotive engineering lecturer stated the application was very feasible with a percentage score of 88.34%, (d) fifteen students stated the application was very feasible with the percentage score of 85.73%. Based on the percentage of the study results, the application of automotive education media on the hydraulic cylinder of excavator material based on augmented reality with shapr3d innovation that has been developed can be used in higher education as a learning media. As a result of the findings of this study, it is recommended that lecturers be able to use IT-based media more often to arouse students' interest in learning. Students can also take advantage of today's numerous learning media, such as the application created in this research, which can teach them even outside of the classroom. Finally, researchers and other creators should be able to increase the output of IT-based media that is more eligible both in terms of design and quality of material to increase the diversity of media used in student learning.

5. References
[1] Setiyawan A and Kurniawan A, 2021 The Effect of Pandemic Covid-19 into Internship Activity of Mojokerto Vocational High Schools JOVES (Journal Vocat. Educ. Stud. 4, 1 p. 125–130.
[2] Prasetya T A Harjanto C T and Setiyawan A, 2020 Analysis of student satisfaction of e-learning using the end-user computing satisfaction method during the Covid-19 pandemic J. Phys. Conf. Ser. 1700, 1.
[3] Hariyanto D Mustaqim I and Maruanaya R F, 2021 The Development of Android-based Control System for Reinforcing the Electronic Control Subject J. Phys. Conf. Ser. 1737, 1.
[4] Husaini M, 2014 Pemanfaatan Teknologi Informasi Dalam Bidang Pendidikan (E-Education). J. Mikrotik 2, 1 p. 1–5.
[5] Setiyawan A and Sunyoto, 2020, 50 succes story wirausahawan nasional dan internasional : mata kuliah kewirausahaan : suplemen bahan ajar.
[6] Setiyawan A Priyanto Prasetya T A and Hastawan A F, 2021 Usability evaluation of assignment and monitoring information learning system of internship students based on SMS Gateway with Raspberry Pi Usability evaluation of assignment and monitoring information learning system of internship students based on SMS G IOP Conf. Ser. Earth Environ. Sci.
[7] Setiyawan A Prasetya T A and Hastawan A F, 2021 Usability evaluation of assignment and monitoring information learning system of internship students based on SMS Gateway with Raspberry Pi in IOP Conference Series: Earth and Environmental Science 700, 1 p. 12021.
[8] Setiyawan A, 2020 ASSIGNMENT AND MONITORING INFORMATION SYSTEM OF PRAKERIN STUDENTS BASED ON SMS GATEWAY WITH RASPBERRY PI VANOS J. Mech. Eng. Educ. 5, 1.
[9] Setiyawan A, 2017, Pengembangan Sistem Informasi Penugasan dan Monitoring Siswa
Prakerin Berbasis SMS Gateway dengan Raspberry Pi, Universitas Negeri Yogyakart.

[10] Sawitri, E., Sumiati, M., & Fitriani Y, 2019 Hambatan Dan Tantangan Pembelajaran Semin. Nas. Pendidik. Progr. Pascasarj. Univ. PGRI Palembang p. 202–213.

[11] Pribadi B, 2017 Media & Teknologi dalam Pembelajaran Jakarta: Kencana.

[12] Azuma R T, 2010 A Survey of Augmented Reality Malibu: Hughes Research Laboratories.

[13] Davies S, 2017, Shapr3D integrates Siemens PLM & Tech Soft 3D software to bring 3D modelling capabilities to iPad Pro users, 12 December 2017. [Online]. Available: https://www.tctmagazine.com/additive-manufacturing-3d-printing-news/shapr3d-siemens-plm-tech-soft-3d-modelling-ipad-pro/.

[14] Pramono A, 2013 Media Pendukung Pembelajaran Rumah Adat Indonesia Menggunakan Augmented Reality 11, 1 p. 122.

[15] Santoso A, 2013 Rancang Bangun Aplikasi Pembelajaran Organ Tubuh Berbasis Augmented Reality 8.

[16] Mareta A, 2015, Implementasi Media Ajar Bangun Ruang Berbasis Augmented Reality Pada SMPN 2 Selomerto Kabupaten Wonosobo. Semarang: Jurusan Teknik Elektro, Universitas Negeri Semarang, Universitas Negeri Semarang.

[17] Huda, K., Bagus et al., 2018 Pengembangan Media Pembelajaran Berbasis Android Menggunakan Augmented Reality Pada Materi Bangun Ruang Sisi Datar J. Pendidik. Mat. dan Sains 6, 01 p. 61–69.

[18] Haryanto D, 2016, An Adaptive E-Learning System based on Student’s Learning Styles and Knowledge Level (The Design Step). [Online]. Available: https://www.researchgate.net/publication/323277109_An_Adaptive_E-Learning_System_based_on_Student’s_Learning_Styles_and_Knowledge_Level_The_Design_Step.

[19] Allen W C, 2006 Overview and Evolution of the ADDIE Training System Adv. Dev. Hum. Resour. 8, 4 p. 430–441.

[20] Sugiyono, 2017 Metode Penelitian Pendidikan (Pendekatan Kuantitatif, Kualitatif dan R&D) Bandung: Alfabeta.

[21] A Fujiastuti, 2018 Pengembangan media pembelajaran retorika berbasis ARCS dengan aplikasi flash Pros. SAGA p. 16–24.

[22] I. F. Hidayat Baron, 2015 Implementasi independent t-test pada aplikasi pembelajaran multimedia ragam dan gerak seni tari daerah kalimatan selatan Kumpul. J. Ilmu Komput. (KLIK), 2, 1 p. 11–21.

[23] Hamzah S, 2019 Pengembangan Media Pembelajaran Perangkat Keras Jaringan Berbasis Augmented Reality Pada Platform Android. Vokasional Tek. Elektron. dan Inform. 7, 3 p. 1–12.