Interactive learning media innovation: utilization of augmented reality and pop-up book to improve user's learning autonomy

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Abstract. This study discusses the design of innovative learning media based on Augmented Reality (AR) and its development for students of Higher Education. Innovative Learning Media is now an important part of improving the quality of learning. Utilization of mobile device technologies such as android tablets and smartphones with camera features to run AR technology is the main point. Several students and expert of learning media were involved in this research and development. Questionnaires are used as measuring instruments. The results of this study are AR-based interactive learning media to improve user's learning autonomy and recommendations for further development.

1. Introduction
Various efforts and treatment to improve the quality of education have been done. This is related to the importance of education which is a vital need in developing the human resources of a nation. These efforts can include improvements in professionalism and pedagogy of teachers, education systems [1] and curricula, and learning facilities. Improvement of learning that needs to be considered is at the learning facility [2][3], especially the utilization of ICT in learning [4-6].

ICT is currently developing significantly. Some aspects of life are also influenced along with the development of technology, starting from the field of economy, politics, culture, art, and education. Especially in education, the advancement of ICT has changed the functioning of conventional books, teachers, and teaching systems. Many innovations are created to have a positive impact on education, such as the use of computers as a means of presentation [7], e-learning to improve students' learning motivation [8], smartphones to support student learning [9-11].

The existence of the smartphone has become an important spotlight. Almost every learner in senior high school and vocational high school to campus/university is a smartphone user. This is in accordance with the survey of smartphone ownership among the students on the history education program that 87% of total students have their own smartphones [12]. Smartphones can help students to learn where and whenever [13]. Therefore, the use of smartphones as a learning medium that capable of supporting the learning is needed to be considered.

2. Learning Innovation Using Smartphone and AR Technology
The use of smartphones as a learning support affects two things [14], namely: (1) improving access to education and (2) encouraging a new learning. One of the new learning that is being developed today is the utilization of AR technology on smartphones. AR is a combination of existing objects in the
virtual world (virtual) into the real world in the form of two dimensions and three dimensions that can be touched, seen, and heard. AR technology enables users to interact with the digital world, where real-world information is displayed in the digital world, and users can interact in the digital world as in the real world [15]. Implementation of the AR application can make learning more interesting [16] and assist students in improving the learning efficiency and the retention of knowledge [17] related to the lesson material they study.

There are 5 reasons why it is important to use AR technology in the field of education with media integration, these are: 1) interactive learning [18], students are able to understand the concept of teaching materials better through interactive learning; 2) portability and low cost [19], learning using AR technology does not require much funding, for teaching materials physically. For example, using prototypes or physical models and illustrations with multimedia animation; 3) flexible and easy to learn [20], students can access teaching materials when and wherever they are, utilizing AR technology; 4) life cycle completed learning [17], the use of AR technology can create a complete learning cycle with a learning experience on AR model that allows for lifelong learning, it is easy to remember for a long time, and integrated with other access media through internet; and 5) improving critical thinking [21], learning by utilizing AR technology is able to support students' critical thinking skills in a more interesting way of learning.

The implementation of media with AR for education is used in assisting the independent learning process. Optimization of AR needs to be done because it has aspects of entertainment that can increase students’ interest in learning and playing as well as projecting it real and involves the interaction of all the five senses. The enjoyments in learning not only increase students’ interest, it can motivate them to become better so as to produce a good learning achievement [22].

AR-based media embodies the current student learning styles that fall within the Z or "digital native" generation, a generation familiar with digital devices and easy to accept integrated learning models with ICT [23]. Z-generation students are equipped with better multitasking skills and are more productive than previous generations [24]. This is due to the fact that currently, ICT facilities, including the internet are very accessible to students, so the Z-generation has a good ability to process much of the information they collect [25]. Therefore, AR implementation in learning can assist students in developing the cognitive ability and technical skills.

3. Design of Prototype Development
This research and development use 4D model which has been developed by Thiagarajan, et al [26]. This model consists of four stages of development, namely define, design, develop, and disseminate. The stages are shown in figure 1.

![Figure 1. The research and development procedures.](image)

3.1. Define
Defining needs is done to establish basic problems in learning as well as the criteria used as a reference in developing the media. This stage is carried out by conducting interviews and surveys on Class of 2016 Informatics Engineering Education’s Students in Malang State University. The result is all students have their own personal smartphone with hardware specifications that are qualified (mid-end) and they are quite proficient in using it. They also gave a positive response to the use of a learning media that was easy to use, interesting, and interactive using 3D animation.
3.2. Design
This stage aims to prepare the prototype of learning media. At this stage the preparation of media and its support components consisting of four steps namely the preparation of materials, the selection of formats/features, and media design. The storyboard design of AR’s application is shown as in figure 2.

3.3. Develop
A Development stage is intended to make the media in accordance with the design that has been done and validate the media so as to produce media that has been revised based on input from test subjects. Furthermore, the effectiveness test and the attractiveness of media in students’ group (group test) to produce tested media (final product). The development and prototype testing stage will be explained further in product development and testing.

3.4. Disseminate
Stages of dissemination are intended to publish media that have been developed to be utilized more widely. Distribution stage is done through international seminar and socialization to the educational community.

4. Product Development and Testing
The prototype developed using several software tools. Augmented Reality was developed using Unity and Vuforia applications. 3D animation for learning is developed using the Blender application. Some things need to be considered in developing software, which is the quality of 3D animation that will be made, with good quality estimation but not too burdensome device, then the size of Android Package (APK) file installer that is not too big.

The purpose of the product testing is to obtain something that can be used for the basis of revisions for the product (prototype) that have been designed to produce tested AR-based learning media products. This product testing uses descriptive design with a focus on needs analysis and field test. The tests will be conducted by a small group of students using questionnaires. Product testing by students group conducted on students who take computer network courses, to get responses from the users, whether the product is made can be used properly and feasible to be used or need to be revised again. Collected data were analyzed using descriptive analysis with formula percentage’s criteria as shown in table 1.

| Table 1. Assessment criteria of questionnaire data processing results. |
|-----------------------------------------------|
| Percentage (%) | Feasibility Level | Description                      |
| 1 | 76 – 100 | Valid | Feasible and need not be revised/need a little revision |
| 2 | 51 – 75  | Quite Valid | Quite feasible and need some revision |
| 3 | 26 – 50  | Less Valid | Less feasible and needs to be revised |
| 4 | < 26     | Invalid | Not feasible and total revision |

5. Results
A pop book has been created. AR application to generate 3D animation about computer network learning has also been developed. Several learning materials were selected based on survey results to
students who had studied computer networks. They are given a choice of several chapters in the lesson to choose which learning materials they want to learn by using interactive 3D animation help. A total of 5 learning materials were selected to be discussed and tested for implementation in the development of an AR-based interactive pop book. The five materials include computer network classification (LAN, MAN, and WAN), network transmission media, and network devices.

Pop-up book development is done with the help of a third party with a long working time of approximately one week. As a result, the resulting pop-up book is still less than satisfactory. The 3D display that appears in the book is still not maximized and impressed. So, it needs to be revised again about the 3D form that will appear in the book as an added value in attracting students' interest (figure 3). Furthermore, the AR application testing in the pop-up book by a small group (a class) of 30 students is done using a questionnaire. They were invited to use the application and give feedback through questionnaires. The results are as shown in table 2.

![Figure 3. Displaying 3D Models of Metropolitan Area Network with AR's Application.](image)

| Indicator (Sub-indicator’s items) | Min. Score | Max. Score | Avg. Score |
|----------------------------------|------------|------------|------------|
| Usefulness (6)                   | 40         | 100        | 80         |
| Ease of Use (6)                  | 60         | 100        | 80         |
| Ease of Learning (3)             | 20         | 80         | 60         |
| Satisfaction (5)                 | 20         | 80         | 60         |
| Total Average                    |            |            | 67.5       |

Based on the results, it is known that the average percentage of assessment scores is 67.5, which means that the prototype is quite valid and feasible with partial revisions. The presentation of the results of testing by students shows that the AR application prototype developed has shown the ease of use and good usefulness. This is indicated by the percentage score for both aspects which amounted to 80%. In more depth, the users stated that the application of AR in learning innovation has a better impact. The 3D animation model that is presented has accommodated the user to get a pleasant experience while learning (learning is enjoyment). AR applications are also easy to use, so users can try and use them without finding significant difficulties.

Prototype testing results by users also found several deficiencies, especially in the ease of learning and satisfaction aspects. This is indicated by the lack of resolution of some smartphone layers which causes difficulties in understanding learning material even though it has been packaged in interactive 3-D animation. This results in the satisfaction level of some users who use smartphones with screen resolutions of less than 5" (inches). However, users with smartphones that have screens larger than 5" stated that learning animation can run smoothly and clearly, so it has a fairly good level of satisfaction.

6. Conclusion
This article produces the design of an innovative learning media development by utilizing smartphone technology and augmented reality to improve student learning autonomy. A smartphone isn’t only supporting the learning activity by improving access to education, but also by encouraging new learning in many ways. Augmented reality technology can also improve the function of smartphones
in learning. Thus, the smartphone usage and augmented reality technology utilization in it can enhance student's learning autonomy that will improve the quality of education [27]. Then, the design of the prototype to be developed has been designed in such a way through a preliminary study of the utilization of ICT in education several stages of the development model. Further research will be carried out in the development process based on the design that has been appointed.

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