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# Rounding-augmented reality book and smartphone for deaf students in achieving basic competence

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**Abstract.** Deaf students' hearing problem results in their mastery of language and mathematics lower than hearing students. Learning the topic of rounding is difficult for deaf students because it requires a good understanding of language and a true perception in math concepts, in which are abstract in nature. Learning concepts needs a special strategy for this type of students, as generally mathematics is difficult to be translated and communicated by sign language. This specificity forces them to possess unique behavior in understanding everything through visual power. This paper discusses a study of the creation of a book and smartphone applications as devices based on augmented-reality (AR) software on the topic of rounding accompanied by rich visualization to facilitate deaf students in achieving mathematical basic competencies. This study aims to describe and reveal the validity and the effectiveness of the designed devices through their implementation in a classroom. The research and development method refers to ADDIE which consists of five stages, namely: analysis, design, development, implementation, and evaluation. The results of this study show that the AR-Book and the AR-Smartphone application are valid used by deaf students and both devices are effective in achieving their mathematical basic competencies.

## 1. Introduction

Loss of hearing of deaf students results in obstruction of sound perception which has implications for lower language skills and communication than hearing students at their age. This deficiency causes them to have their own uniqueness in processing information and understanding something they learn. Their uniqueness as visual learners [1] and [2] results in them being more interested in observing and learning what is seen directly by eye. In other words, the way they understand, perceive and learn are different from those by hearing students.

Mathematics is a subject learned at every level of school education without exception for deaf students. This shows that the role of mathematics is very important in human life. However, deaf students generally show significant difficulties in mathematics learning [3-5] because mathematical properties that are difficult to be understood have many specific rules and the concepts are abstract in nature. Based on the results of the study [6], several barriers to deaf students were identified in learning mathematical concepts, other than barriers caused by mathematical language that is difficult to be understood. In general, abstract concepts are also difficult to be translated, represented and communicated through sign language or other non-verbal languages. Even the mutual agreement of



abstract symbols that are changed into sign language has not been uniform among communities and schools. These problems have implications to the reduced interest in learning and inhibits the understanding of solving problems in everyday life. Although juridically the government provided a special book for them, however it has not been fully effective, because it is not in accordance with their uniqueness and this kind of book is difficult to obtain. Therefore, it is necessary to create mathematical learning devices that are suitable for their uniqueness.

Entering the 21st century, the presence of information and communication technology especially the application of high tech and high touch approaches believed playing an important role in reconstructing learning devices and providing easy access for deaf people, so that they can study anywhere, be independent, effective, and efficient in obtaining information. Augmented Reality (AR) as one of the high tech products is capable to combine virtual environments and virtual reality which can integrate virtual and real objects into real environments that runs interactively in real time [7].

The Azuma AR shows the AR system through the principle of image detection, in the form of a marker. Markers are patterns that are made in the form of images that can be recognized by a camera. Markers are used to display 3D objects or animations that contain data or information. The working principle of AR is to use a camera or webcam that was calibrated so that it can detect markers, perform calculations on the data base or information stored in the marker and render the data into 3D objects. If not, then the information contained in the marker will not be processed.

The AR book learning device is one type of AR application that looks like a common textbook but the key element of AR book allows users to read books and view virtual information simultaneously [8]. The latest research that created type of book enriched with visual through augmented reality was introduced by Billing Hurst. The book is known as "Magic Book". This prototype allows users to see the real world through images displayed on the book as if the user is in the real world [9]. Some similar studies were developed including the benefits of the AR book for the field of chemistry [10], research related to the provision of AR books on 5 stand projects, namely black magic stands, solar system and orbit stands, volcano stands, historical artefact stands and eyeMagic virtual storybook [11], text book-AR research [12], AR book related to cultural heritage [13] and games [14]. Likewise, the usefulness of AR in the field of education has been studied to improve the quality, flexibility and interest in reading [15], and to help the learning of low vision children to read better [16].

## 2. Methods

The research and development method used refers to ADDIE model [18] which consists of five main stages, namely analysis, design, development, implementation and evaluation. The analysis stage includes problem analysis and needs analysis activities based on various relevant references and field studies so that the framework of this study is obtained. The design stage includes the construction of basic competency achievement test instruments, questionnaires for validators (material experts, media experts and practitioners), student responses and the creation of learning device prototype. At this stage the validity and reliability test of the test instrument are processed with Anates software after the score is calculated using a certain formula [17]. Preparation of validator questionnaires and student responses is based on three aspects, namely quality of content and objectives, instructional quality, and technical quality. The development stage includes expert and practitioner validation and prototype revisions. The results of the questionnaire assessment from the validators and student responses were calculated using the formula and the results will be classified in the categories of very poor, poor, good and very good [19]. Revised prototypes were obtained from suggestions given by the validators. The implementation stage is testing the AR book and smartphone application in school for 5 meetings with a duration of 2x40 minutes per meeting. The evaluation stage includes post-test, student response screening, and the final product after learning has been carried out. The data results of the test are calculated using the average formula and the results of the classification [19] while the responses of students use the percentage formula [17].

The participants in this research were 7th grade students of Junior High School for Special Students (better known as Sekolah Menengah Pertama Luar Biasa Tunarungu, SMPLB-B) in the odd semester

of the academic year 2018/2019. The research was conducted in Junior High School for Special Students SLB-B Negeri Cicendo Bandung and SLB-B Prima Bhakti Mulia Cimahi, Indonesia. The number of participants in SLB-B Negeri Cicendo is 8 students and the number of participants in SLB-B Prima Bhakti Mulia is 7 students.

### 3. Result and Discussion

#### 3.1. Analysis Stage

At this stage, an analysis of the problems experienced by students in learning mathematics and an analysis of the need for tools and materials needed to create AR Book and smartphone application are carried out. Problems analysis was done with literature studies and field studies. The results of the literature study were obtained from various relevant sources such as journals and books. Field studies were conducted by visiting and making observations at the schools where the research were conducted, as well as interviewing the practitioners or teachers at the school. The results obtained from this stage are formed into a framework for creating visualization media adapted to fit the characteristics of deaf students.

#### 3.2. Design Stage

At this stage, three devices were constructed including a book which contains the concept of rounding, AR applications designed with augmented reality software and test instrument. The test instrument is arranged in the form of written tests for students and validation questionnaires for experts. The test instrument consisted of 4 essay questions compiled based on the basic competencies set by the 2013 Curriculum. Validation questionnaires for experts were designed based on predetermined assessment aspects [20]. The questionnaire assessment for material expert and practitioner includes two aspects, namely the quality of the content and objectives of the material and instructional quality, while the questionnaire assessment for media expert is only on the aspect of technical quality.

The designed AR book was given markers as the image target for smartphone camera that has previously been installed with AR application. The AR smartphone application is designed through four main steps consisting of: 1. Design 3D models in Blender and Adobe Photoshop applications; 2. Making a Quick Response (QR) code marker on <https://www.the-qrcode-generator.com>; 3. Making QR data base with unity editor format; and 4. Making an AR project in Unity software. The book and the AR application devices are the initial products before being validated by experts.

#### 3.3. Development Stage

At this stage, validation test was carried out on three devices that had been designed at the design stage. The validity and reliability of the test instrument was processed after the question items were tested beforehand to five 7th grade deaf students in one of the SMPLB in Cimahi city. The results of the reliability and validity test using Anates were 0.94 and 0.89 respectively. Thus, the instrument has high validity and reliability. The validator questionnaire data were calculated based on the percentage of assessment [17] and the result was interpreted based on predetermined criteria [19] as shown in Table 1.

**Table 1.** Results of validators assessment of book and augmented reality smartphone application

Experts	Assessment (%)	Criteria
Material	85.33	Very Good
Media	97.50	Very Good
Practitioner	86.00	Very Good

Based on Table 1, both AR devices can be implemented in the field, but revisions were made on AR book related to the simplification of language, contrasting the colors of several 3D objects contained in smartphone application and the addition of the user manual for AR.

### 3.4. Implementation Stage

Product implementation were carried out in two schools, namely in SLB-B Negeri Cicendo and SLB-B Prima Bhakti Mulia. During the implementation, the researchers act as instructor by referring to the learning implementation plan that has been made. Each student used the AR application that has been installed on their smartphones and obtained the revised AR book for five meetings as shown in Figure 1. Figure 1 shows student activities when using a revised learning device in the previous stage. They seemed to be interested in the conducted learning, and they can use the devices anywhere because the application can be directly downloaded at <http://bit.ly/2VR5rTW>. Their interest in AR devices was revealed from their informal responses related to AR that are interactive and that can trigger them to explore and investigate the concept of rounding. They did not even realize that there were some mathematical rules that must be used because the application was intuitively easy to understand so that they can deduce the mathematical rules by their own way. In other words, 3D visual displays produced by AR make it easier for students to understand the concepts and contexts of problems that are difficult to be expressed through verbal or sign. This result is relevant to the previous research [15,16] that AR media evoked interest, stimulate good activities and enhance ability that is greater than before even the use of AR device developed student's self-regulation.



**Figure 1.** Students Learn with the book and AR smartphone application

### 3.5. Evaluation Stage

This stage is about processing the data of the mathematical basic abilities test results and student responses to learning that has been carried out in two SMPLB-B schools. Based on the average test results, the average minimum classical completeness criteria in the two schools are 85 and 96 respectively. Thus the use of AR book and AR smartphone application in both schools is effective and is categorized very high in achieving mathematical basic competencies.

## 4. Conclusion

Based on the results of discussion and data processing, it can be concluded that the learning device products in the form of AR book and AR smartphone application meet the valid and effective criteria for deaf students in achieving mathematical basic competencies. The two devices also received very good responses from the students.

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