

Augmented Reality in Indonesia's Primary School: Systematic Mapping Study

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Abstract – Augmented reality is an increase trending technology in education. Research in the field of AR for Education is increasing every year. A large number of research reviews have focused on the use of AR in education worldwide and at all levels of education, but there have not been many reviews of the use of AR at the elementary school level in Indonesia. This study aims to determine the trends of using AR in elementary school in Indonesia. This research used a Systematic Mapping Study approach, which consists of the stages of definition research question, conduct research, screening papers, keywording using abstract, and data extraction and mapping process. Subjects of elementary education, grade, type of AR application, and research method and facets, have been used in classifying AR. Inclusion and exclusion criteria were used in determining the relevant papers. This study examining 42 articles containing “augmented reality”, “elementary school” and “Indonesia” in their titles, abstracts, and keywords. Articles were published between 2017 and 2021. The results have shown that science learning is the most subject to be the object of AR research, followed by mathematics, language, and culture. Most of the AR implementations are implemented in class IV, V and VI. The most widely used type of AR application is marker-based AR. The most widely used research method is R&D which focuses on developing AR products.

Keywords: augmented reality, elementary school, systematic mapping study

I. INTRODUCTION

Augmented Reality (AR) is a technology that has been predicted to have a major impact on education [1, p. 25]. Augmented Reality is a technology that combines virtual objects into a real environment that can be seen by users in real time on a medium or space [2]. AR is like a graphical interface that has the ability to visualize information in real time [3], and interactive [4]. AR has an influence in changing the way technology is used for learning [5]. AR is an educational medium that is increasingly accessible to young users such as elementary school students [6]. AR is very interesting for students because it can display animated 2D and 3D objects, still images, audio, and video, so AR can motivate students to learn, increase student interaction with materials, allow students to recycle materials, and improve student learning progress [7], as well as being a solution for students to be able to repeat material anywhere and anytime in a fun way, especially for lessons that have limited face-to-face time in class [8]. AR is also proven to have pedagogical contributions and present pedagogical interactions such as enhanced enjoyment, increased learner engagement, fostered interest, provided collaborative opportunities, improved communication between learners and instructor, increased student interaction, and promoted self-learning [9].

The development of mobile computing causes AR systems to be integrated into mobile devices so that this technology is available to more users [10]. The implementation of AR in education follows a similar pattern to mobile learning [9]. AR learning applications is starting to be widely available in various applications for smartphones, and can be accessed via Google Play and the App Store. These applications are mostly aimed at learning specific materials, such as recognizing animals, letters, the solar system, which have not paid attention to the pedagogy aspect of education. In order to AR applications to be of value to education, the researchers suggest that AR is not solely based on the use of technology but is closely related to how AR is designed, implemented, and integrated into formal and informal learning settings [11].

Interest in AR to create effective learning experiences is increasing in the world [9]. In the literature, some researchers have drawn attention to the implementation of AR in education. A study reports, the number of research publications on AR in education is progressively increasing from year to year, where Science, Humanities and Arts are the fields that make the most use of AR [7]. The study also found that AR was most widely implemented in higher education, and the most widely used AR technology was marker-based AR.

A large number of research reviews have focused on the use of AR in education worldwide and at all levels of education, such as oleh Hartono et al [12], Saidin et al [13], Altinpuluk [14], Blanca and Delgado-Kloos [15], Chen et al [16], Alizkan et al [17], and Akçayır and Akçayır [18]. Until now, there have not been many reviews of the use of AR at the elementary school level in Indonesia. Will the trend be the same as the general AR trend ?. This study aims to determine the trends of using AR in elementary school in Indonesia by examining 42 articles containing "augmented reality" in their title and published between 2017 and 2021.

II. MATERIALS AND METHODS

This research uses a Systematic Mapping Study approach. The Systematic Mapping Study is designed to provide a broad overview of the research area, to determine whether research evidence exists on a topic and provide an indication of the quantity of research evidence [19]. This allows the identification of clusters to direct the focus of future research and to identify the main areas of study to be carried out. Figure 1 illustrates the steps in conducting a Systematic Mapping Study [20].

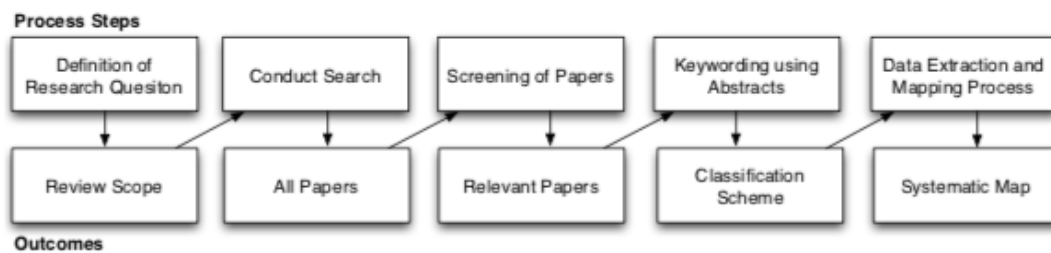


Figure 1. Steps of Systematic Mapping Study

A. Definitions of Research Question

The main purpose of a systematic mapping study is to provide an overview of a research area and identify the amount and type of research and the results available within it [19]. The research question of this study is:

- Q1: What subjects are the most focused on AR research?
- Q2: What grade are AR applications widely used?
- Q3: What the type of Augmented Reality application are the mostly used?
- Q4: Which research methods and research facet are the most widely used?

B. Conduct Search

The scope of research identified at the search stage includes published scientific literature related to the development or use of Augmented Reality in elementary schools in Indonesia.

The search includes various journal publications and conference proceedings accessed via the Google Scholar search engine. The publication period is between 2017 and 2021. The search string used is "augmented reality" AND "elementary school" AND "Indonesia" OR "Primary School" OR "Sekolah Dasar".

C. Screening of Papers

Inclusion and exclusion criteria were used in determining the relevant papers. Inclusion criteria are criteria that must be met by relevant research, while exclusion criteria are criteria for research that cannot be taken as a sample [20]. The inclusion and exclusion criteria were derived from the research question. The inclusion criteria used were: 1) Only research papers published by accredited journals or conference proceedings 2) Only research papers related to the Augmented Reality theme in the title or abstract or keywords; 3) Only research papers that describe AR used in elementary schools in Indonesia in the title or abstract or keywords; 4) Only research published between 2017 and 2021. While the exclusion criteria are: 1) The paper mentions Augmented Reality in the title or abstract or keywords but the output is not a product that is implemented in elementary schools in Indonesia. 2) The paper is a review study.

D. Keywording using Abstracts

The purpose of keywording is to obtain a classification scheme [20]. The steps taken are to read the abstract and look for keywords and concepts that describe the contribution of the paper and identify the context of the

research. At this stage the research classification is obtained on the dimensions or categories, namely: education level/grade, subject, research's method, and type of AR application.

E. Data Extraction and Mapping Process

Data extraction was carried out by sorting all relevant papers. In the first stage the paper is extracted using the term "Augmented Reality". The next stage of extraction is done using the research classification dimensions. Then the mapping process is carried out by distributing papers on each classification dimension. Analysis of the mapping results presents the frequency of papers for each category or dimension. From the mapping, it will be seen which categories or dimensions have been the focus of previous research so that gaps will be known that are of concern for future research [20].

III. RESULTS AND DISCUSSION

There are 42 augmented reality studies analyzed from 27 journals and 6 conferences (International Online Journal of Primary Education, Jurnal Penelitian Pendidikan IPA, Professional Journal of English Education, International Journal of Interactive Mobile Technologies , Journal of Engineering Science and Technology, Graphics and Multimedia, Mimbar Sekolah Dasar, International Journal of Instruction, Jurnal TECHNO Nusa Mandiri, International Journal of Education in Mathematics, Science and Technology, Indonesian Journal of Curriculum and Educational Technology Studies, International Journal of Applied Information Technology, International Journal of Advanced Science and Technology, Jurnal Pendidikan Tambusai, Telkomnika, Journal Of Education Technology , Jurnal Ilmiah PGMI, International Journal of Engineering & Technology, Heliyon, Journal of Education and e-Learning Research, Al-Ishlah: Jurnal Pendidikan, Jurnal Teknik Informatika, Jurnal Edukasi Elektro, Child Education Journal, Journal Of Development Research, Journal of Information Technology and Computer Science, Jurnal Edutech Undiksha, Journal of Physics : conference series, IOP Conference Series: Materials Science and Engineering, The East Indonesia Conference on Computer and Information Technology, Advances in Social Science, Education and Humanities Research, Advances in Intelligent Systems Research, and Seminar Nasional Industri dan Teknologi). The findings of the content analysis are presented in 5 sub-headings within the framework of the research objectives and research questions.

A. Subject of Education

Based on the mapping results, it is known that Augmented Reality research in Indonesia is mostly implemented in Science Learning subjects, which is 45%, followed by mathematics (21%), culture (17%), language (14%), and character education, as shown in Figure 2. In this review, AR research has not been found in Social Learning and History subjects.

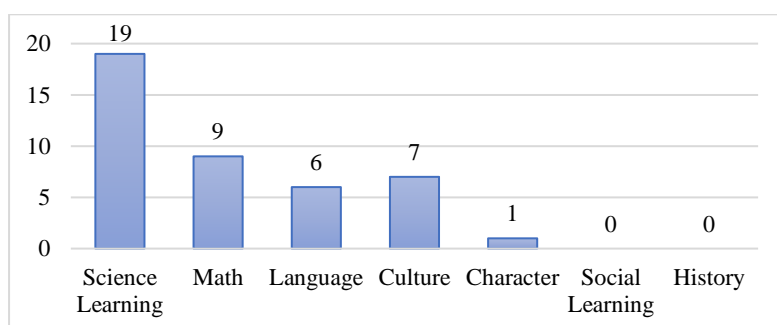


Figure 2. Number of AR papers per subject of education

B. Type of AR Application.

Augmented Reality is divided into 3 levels based on the complexity of the technology, namely level 0 physical world hyper linking, level 1 marker based AR, level 2 markerless based AR, and level 3 immerse augmented vision [21]. The results of the mapping show that marker based AR is the technology that is

mostly used. There are still very few studies that develop markerless based AR, and AR applications that use immerse augmented vision have not been found (Figure 3).

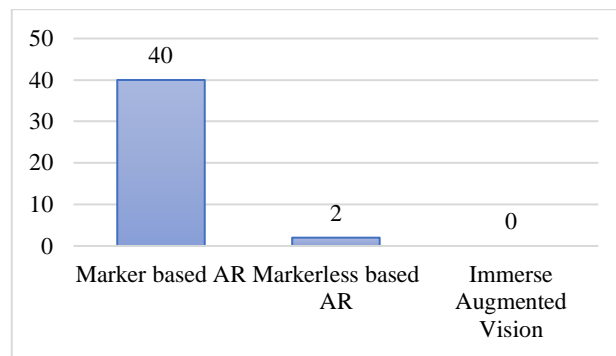


Figure 3. Work distribution by type of AR application

C. Grade

This category is the level where Augmented Reality is used. Elementary school in Indonesia consists of 6 levels. Based on the mapping results, it is known that AR is mostly implemented in grades IV, V, and VI, on the other hand, AR is still not widely implemented in lower grades (Figure 4). There are 23.8% of papers that do not know the target of using AR applications, and it is suspected that they can be used by all elementary school levels.

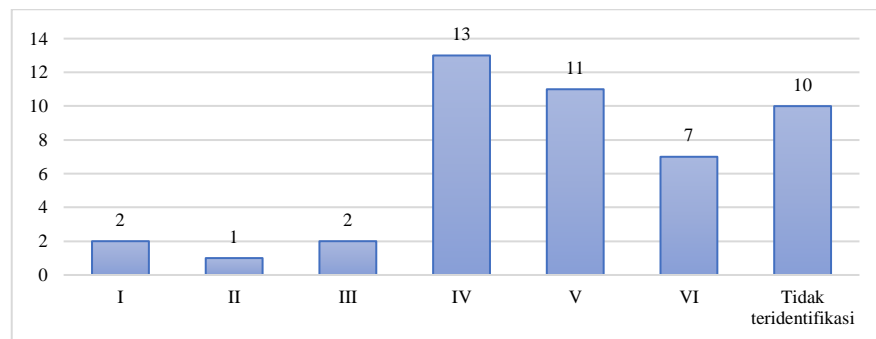


Figure 4. Work distribution by grade

D. Research Method used in AR papers

When the methods used in 42 papers related to the AR are examined (Figure 5), it is seen that most of the studies were conducted with research and development (R&D) method (30) or 71,43% of total studies. The most research facet is evaluation research (30) consist of 12 papers of quantitative research and 18 papers of R&D.

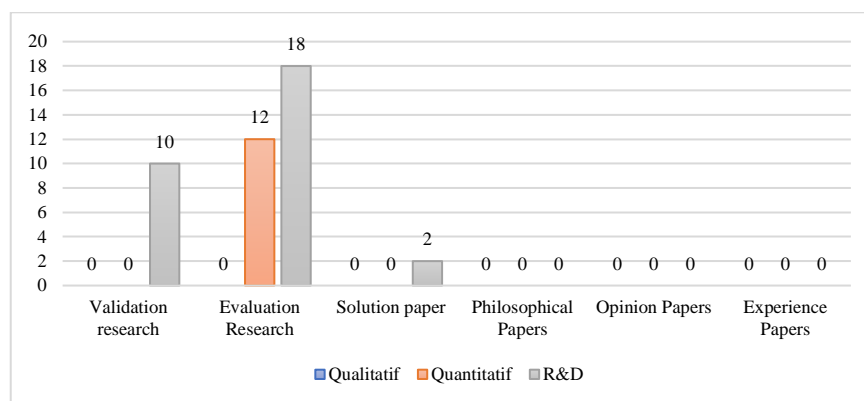


Figure 5. Research method and research facet used in AR papers

IV. CONCLUSIONS

Research in the field of AR has increased from year to year. The aim of this study is to review the direction and trends of AR research in primary education in Indonesia. This study uses 4 categories in classifying AR research, namely subjects of elementary education, grade, type of AR application, and research method and facet. There are 42 papers that have been reviewed, obtained from various journal publications and conference proceedings accessed via the Google Scholar search engine. Based on a systematic mapping study, it is known that science learning is the most subject to be the object of AR research. Most of the AR implementations are implemented in class IV, V and VI. The most widely used type of AR application is marker-based AR. The most widely used research method is R&D which focuses on developing AR products.

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APPENDIX 1

| Papers | Grade | Subjects | Type of AR Application | Research Method | Research Facet |
|--------|-----------|--------------------|------------------------|-----------------|---------------------|
| [22] | V | Science | Marker based | R&D | Evaluation Research |
| [23] | V | Science | Marker based | R&D | Evaluation Research |
| [24] | II | Language : English | Marker based | Quantitative | Evaluation Research |
| [25] | IV | Culture | Marker based | R&D | Solution Proposal |
| [26] | N/A | Science | Marker based | R&D | Evaluation Research |
| [27] | N/A | Culture | Marker based | R&D | Evaluation Research |
| [28] | N/A | Culture | Marker based | R&D | Validation Research |
| [29] | N/A | Language : English | Marker based | R&D | Validation Research |
| [30] | IV | Mathematic | Marker based | Quantitative | Evaluation Research |
| [31] | N/A | Cultural | Marker based | R&D | Evaluation Research |
| [32] | VI | Mathematic | Markerless based | Quantitative | Evaluation Research |
| [33] | III | Science | Markerless based | R&D | Validation Research |
| [34] | V | Mathematic | Marker based | R&D | Validation Research |
| [30] | IV | Character | Marker based | Quantitative | Evaluation Research |
| [35] | IV | Science | Marker based | Quantitative | Evaluation Research |
| [36] | IV, V, VI | Mathematic | Marker based | R&D | Validation Research |
| [37] | N/A | Science | Marker based | Quantitative | Evaluation Research |
| [38] | IV | Mathematic | Marker based | Quantitative | Evaluation Research |
| [39] | V | Science | Marker based | R&D | Validation Research |
| [40] | VI | Science | Marker based | R&D | Evaluation Research |
| [41] | VI | Science | Marker based | R&D | Evaluation Research |

| Papers | Grade | Subjects | Type of AR Application | Research Method | Research Facet |
|--------|-------|--------------------|------------------------|-----------------|---------------------|
| [42] | IV, V | Science | Marker based | R&D | Evaluation Research |
| [8] | IV | Language : English | Marker based | R&D | Validation Research |
| [43] | VI | Science | Marker based | Quantitative | Evaluation Research |
| [44] | IV | Mathematic | Marker based | Quantitative | Evaluation Research |
| [45] | IV | Science | Marker based | Quantitative | Evaluation Research |
| [46] | N/A | Science | Marker based | R&D | Evaluation Research |
| [47] | V | Science | Marker based | R&D | Evaluation Research |
| [48] | V | Mathematic | Marker based | R&D | Evaluation Research |
| [49] | IV | Culture | Marker based | R&D | Evaluation Research |
| [50] | III | Mathematic | Marker based | R&D | Validation Research |
| [51] | IV | Mathematic | Marker based | R&D | Evaluation Research |
| [52] | IV, V | Science | Marker based | R&D | Evaluation Research |
| [53] | VI | Science | Marker based | Quantitative | Evaluation Research |
| [54] | I | Language : English | Marker based | R&D | Evaluation Research |
| [55] | V | Science | Marker based | R&D | Evaluation Research |
| [56] | VI | Science | Marker based | R&D | Evaluation Research |
| [57] | N/A | Language : Bahasa | Marker based | R&D | Solution Proposal |
| [58] | N/A | Culture | Marker based | R&D | Validation Research |
| [59] | N/A | Culture | Marker based | R&D | Validation Research |
| [60] | V | Science | Marker based | R&D | Evaluation Research |
| [61] | I | Language : Bahasa | Marker based | R&D | Evaluation Research |