Development of Augmented Reality Based Stem Learning Models and Innovations for Improving Global Competence of Middle School Students in North Sumatera Province

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Abstract. Developing a STEM learning model as a supporting component for improving students' global competence today and in the future that is integrated with Augmented Reality (AR) based learning media is needed to make it easier for students to master abstract subject matter. This exploration aims to produce STEM literacy models and AR learning media products developed through science, technology, engineering, and mathematics inventions in class XI subjects at State High Schools of North Sumatra Province that are feasible and effective. The development of AR learning media models and products is assessed by conducting a feasibility test and testing the effectiveness of literacy models and media. The results of media confirmation by material experts and learning media experts showed that the product was veritably feasible to use.

Keywords: Development of STEM Learning Models and Innovations; Augmented Reality Learning Media; Feasible and Effective; State Middle School Students of North Sumatra Province.

1 Introduction

Global competency is a key priority for enhancing human resource capacity in Indonesia at the beginning of the 21st century. This competency is a guide to training people with the necessary skills to be competitive in the world of work. 21st-century learning is one way to realize the perfection of these skills to solve resource quality problems.

Indonesia's mortal coffers with the Human Development Index (HDI) in Indonesia amounting to 72.91 points in 2022. This score increased by 0.86 percent compared to the former time, which was 72.29 points [1]. Grounded on the exploration conducted by the OECD, a description of three (3) confines of literacy in the 21st century was attained: information,

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communication, ethics, and social influence [2]. Creativity is also an essential element in facing a complex world successfully [3].

The Partnership for 21st Century Chops (P21), grounded in the United States, identifies essential chops for the 21st century, specifically the "4Cs": communication, collaboration, critical thinking, and creativity. It's necessary to educate scholars on these chops in the environment of core literacy areas and 21st-century motifs. Assessment and Teaching of 21st Century Chops(ATC21S) categorize chops in the 21st century into 4 (four) orders, which are ways of thinking, ways of working, working tools, and chops for living in the world [4].

In 21st-century literacy, there are six essential chops to educate scholars. With these six chops or capacities, scholars can overcome any challenges. The 21st-century chops known as the "6Cs" include creative thinking, critical thinking, problem-working, communication, and collaboration: character and citizenship. Experimenters and education experts have linked the C- norms of 21st-century education, which include critical thinking, collaboration, communication, creativity, citizenship/ culture, and character education/ connectivity [5];[6].

For 21st-century learning, schools must develop models of science, technology, engineering, and mathematics (STEM) learning and innovation that teachers can use to nurture a student system [7]. Teaching STEM through digital technology today is essential for future student

Figure 1. Global Competence

Source: OECD, https://www.oecd.org/pisa/innovation/global-competence/

Students who possess global skills can think critically and creatively by considering a variety of previous approaches and the perspectives of others. They act ethically and collaboratively (innovatively) to contribute to local, regional, or global development. Students with global skills do not consider themselves capable of solving complex challenges alone. However, they may reflect on their ability to complete assigned tasks and seek opportunities to collaborate with others to complement their strengths.

Mutual respect and tolerance are essential to ensure that the views of individuals of all cultures are recognized and respected in a multicultural society. It is very important that students learn to listen to others, be flexible, and work together with contributors in teams from different cultures and fields of knowledge. This is a very important skill that 21st-century society should not ignore [10]. There are several connections between the three forms of literacy, including information, communication, media, and technology. Mastery of these skills enables mastery of other skills and competencies needed to succeed in life in the 21st century [11].

The International Commission on Education for the 21st Century has proposed four fancies of learning: knowledge, understanding, life chops, and action chops. Besides this vision, four principles were also formed, known as the four pillars of education, which are learning to understand, learning to do, learning to be, and learning to live together [12].

UNESCO has identified 18 IT skills teachers should aim for and divided them into 64 specific goals. Skills range from encouraging teachers to understand national priorities as identified in the National ICT Policy in Education to how ICT can support the curriculum, assessment strategies, methods of pedagogy, school and classroom organization, management, and continuous professional development [13].

On this basis, it is clear that education has an important, even fundamental, role in providing 21st-century students with the opportunity to develop skills that allow them to live peacefully within cultural conditions and diversity (Carneiro and Draxler, 2008). According to the above, 21st-century skills are divided into three categories:

1) Learning skills

Study skills are skills that form learning skills. In this case, learning skills emphasize 21st-century skills, including the 4Cs (creative thinking, critical thinking, communication, and collaboration). Study Skills (4Cs) teach the mental processes needed to adapt and improve in the modern work environment. The reason is that critical thinking can help solve problems and find solutions. Meanwhile, creativity is used to find innovation. Cooperation and communication are used to have the ability to interact with others.

2) Literacy skills

Literacy skills focus on how well you can discern the truth, identify sources of information, resist misinformation (hoaxes), and know the technology behind it. This skill is essential in the rapidly evolving information age. There is a lot of information flooding the Internet, so you need to have skills in organizing and checking whether the information is accurate. The three 21st-century literacy skills (literacy skills) are Information literacy, understanding facts, figures, statistics, and data; Media Literacy, understanding the methods and channels through which information is published; and Technological Knowledge, understanding of the machines that produce information.

3) Life skills

Life Skills focuses on gaining survival skills and improving the quality of your personal and professional life. These skills can help and influence your career. Skills included in life skills include Flexibility, the ability to adapt easily and adapt when plans do not go as expected; Leadership: leadership is important in motivating a team to achieve its goals; Initiative: Initiate one own projects, strategies, and plans; Productivity: the ability to remain productive in a work environment full of distractions Social skills: the ability to socialize and connect with others for mutual benefit.

1.1. STEM Learning Model

21st-century learning is learning that combines three global skills, which are study skills, literacy skills, life skills, skills and attitudes, and technological proficiency. STEM-based learning models simultaneously apply knowledge and skills to accomplish something. This approach is presented as a 21st-century learning approach to create quality human resources in cognitive, psychomotor, and emotional skills [13].

Using a “questions first” approach, adaptive learning explores what students know and have mastered and where they are lacking and need instructional support. Through the right programs of study, adaptive learning can strengthen 21st-century skills and provide new knowledge about company-specific products, services, and processes. Adaptive learning is an educational method that allows students to learn and progress through lessons at their own pace. In the context of primary and secondary education, STEM education aims to develop students proficient in STEM [14] with the following details: first, have the knowledge, stations, and chops to perceive questions and problems in their life situations, explain marvels, design, and draw substantiation-grounded conclusions about STEM-related issues. Second, understand the specific characteristics of STEM subjects as mortal-initiated forms of knowledge, exploration, and innovation. Third, people know how STEM subjects shape the physical, intellectual, and artistic terrain. Fourth, the desire to probe STEM-related issues (e.g., energy effectiveness, environmental quality, limited natural coffers) constructively, minding, and thoughtfully, using ideas from wisdom, technology, engineering, and mathematics. Using a STEM approach to literacy allows scholars to understand that generalities, principles, and ways from knowledge, technology, engineering, and mathematics are used in an intertwined way in the development of products, processes, and systems and can especially inspire scholars to find suitable results that can be used in their everyday lives. In the literacy process, STEM may only incompletely and exhaustively represent some rudiments of the pores. There may be only 2 or 3 rudiments in a literacy exertion, and there's no rule that all rudiments must be present.

There are six key steps that education stakeholders must follow to achieve STEM education [15]. The six steps are: Apply rigorous math and science standards and improve assessments; Place and retain more qualified teachers in the classroom; Provide more rigorous preparation for STEM students; Use informal learning to extend math and science beyond the classroom; Improve the quality and supply of STEM teachers; and setting goals for post- secondary institutions to meet STEM employment needs.

1.2. Augmented Reality

To achieve global capability, 21st-century literacy emphasizes advanced-order thinking (HOTS), or a literacy process that involves rudiments of advanced-order thinking. generally, 21st- century literacy uses design- grounded styles(design- Grounded literacy) or Inquiry-Grounded literacy. The loftiest function of education is to form a well-rounded individual able to face life in general [16]. Conforming new knowledge and integrating it into abstract fabrics will support nonstop literacy and, over time, will give rise to creativity, originality-defining habits, and new mindfulness. Learning creates an active and productive literacy community that can support deeper learning by accessing happy knowledge and developing particular and interpersonal chops [17]. Preceptors can use pupil responses to assess their readiness for deeper literacy and introduce applicable new generalities to challenge their thinking.

Using technology in the classroom requires easy-to-use tools to ensure engaging technology can deliver rich and dependable gests for preceptors and scholars. Stoked Reality, or AR, is a technology that combines real-time digital content created by a computer with the real world. Stoked Reality allows druggies to see 2D or 3D virtual objects projected onto the real world. AR can be displayed on colorful biases like cellphones, unique spectacles, cameras, defenses, webcams, etc. These biases will serve as affair biases. Why affair bias? Because it'll display information in the form of vids, images, robustness, and 3D models that need to be used. Stoked Reality or AR uses SLAM (contemporaneous Localization and Mapping) technology, detectors, and depth measures. For illustration, collecting detector data to determine a position, calculating the distance from a former place to a destination position, and so on.

Keller [18] states that "educational contrivers are faced with indeed greater challenges in tone-directed literacy surroundings than with traditional instruction, especially about satisfying the motivational requirements of learners." therefore, educated preceptors must eventually reconstruct their knowledge of practice for tutoring through" systematic inquiry into tutoring, scholars and literacy, subject matter, class, seminaries, and training. Learners need practical experience to question and reflect in ways that discord with the conception of knowledge-their living practices while integrating technology in their tutoring [19].

Saavedra and Opfer suggest nine principles for tutoring 21st-century chops: (1) Make learning applicable to the 'big picture'; (2) Coaching 10 with discipline; (3) Develop lower and advanced thinking capacities to promote understanding in different surroundings; (4) Encourage literacy transfer; (5) Training how to' learn to learn' or metacognition; (6) Correct misconstructions directly; (7) Promoting cooperation; (8) Exercising technology to support literacy; (9) Adding pupil creativity. What forms of pedagogy have the most implicit to empower critical capabilities and chops in a complex and uncertain future? [20].

2. Research Methods

The research approach used in this research is development research (Research & Development) by combining Dick & Carry's learning system design steps with the Borg & Gall research and development model. Borg & Gall [21];[22].. The results of developing a STEM learning model based on Augmented Reality can be described and referred to as the OMCDE learning model.

2.1. Development of an Augmented Reality Based OMCDE Learning Model

The OMCDE learning model has been designed and presented to help students understand the events around them so that students get real learning experiences from their own environment and enabling students to establish human and communicative relationships. with other people. This learning model also provides feedback in the of evaluation so that teachers can measure students' abilities after the learning process.

There are several stages in the OMCDE learning model that will be carried out as steps in realizing the learning process as can be seen in Figure 1.1 below:

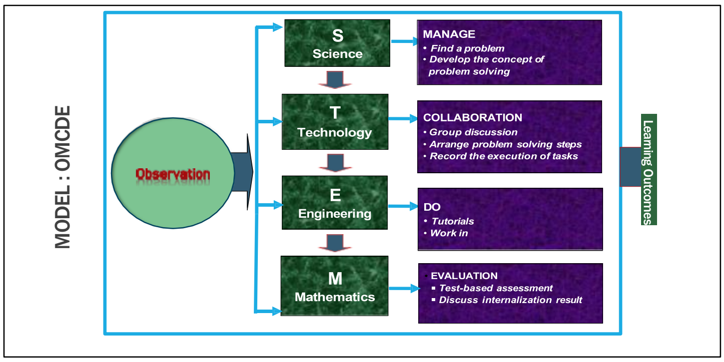

Figure 2. OMCDE Learning Model

The syntax for the steps in implementing the OMCDE learning model can be explained as follows:

1) Observation :

On the morning of literacy, the schoolteacher gives scholars the occasion to make expansive compliances of issues related to the girding terrain. This aims to create a dynamic literacy atmosphere full of enthusiasm for understanding current and unborn problems. Psychologically, scholars are said to be ready to participate in literacy, characterized by high provocation, confidence, and passion shown by a cheerful and attentive station when starting the literacy process through original knowledge from compliances made of the terrain and conditions in front of them. To prepare these conditions, piecemeal from conducting apperception, preceptors can start the literacy process by giving scholars the occasion to express their opinions regarding the results of their compliances and the literacy objects.

2) Manage :

Scholars must be suitable to manage their thinking patterns related to colorful information and problems grounded on the results of compliances and, at the same time, anatomized as a form of data, conception conformation, procedures, and metacognition so that a scientific construction is attained in the form of material substance that will be presented in the tutoring and literacy process so that scholars can connect the literacy material with wisdom (wisdom). Learning accouterments are named optimally to help scholars achieve faculty norms and introductory capabilities. Effects that need to be considered regarding the selection of literacy accouterments are the type, compass, sequence, and treatment of the literacy accouterments.

3) Collaboration :

Collaboration means that a group can work together in a coordinated manner to achieve a common thing through certain media. Each pupil can develop their capacity to produce the desired results through group conversations to change opinions, increase new thinking, and create collaborative studies and bournes that develop freely and where scholars inclusively and continuously learn together.

4) Do:

In the literacy process, scholars must witness what they learn. They must be suitable to take action, so scholars have experience and are brought to their original situation or job request. Learning by using colorful effects around scholars through their guests will laterally produce meaningful and pleasurable literacy so that the anticipated literacy objects will be fluently achieved. Indeed, through literacy by doing conditioning, scholars will spontaneously be involved in the literacy process. This stems from a sense of curiosity and practice by scholars regarding effects they do not yet know, encouraging active involvement in a literacy process.

5) Evaluation :

Evaluation is used as a measuring tool to determine the position of achievement of the results attained by Pegaseanf on the accouterments that have been presented so that with evaluation, the literacy objects can be known directly and convincingly. In conditions where scholars get satisfactory grades, it will have an impact in the form of encouragement and motivation so that scholars can further alleviate their achievements.

In the evaluation process, preceptors can find scarcities in the literacy process. From scholars being suitable to know the extent of success they've achieved while attending education, a schoolteacher must be responsible for perfecting his tutoring, so the schoolteacher must estimate his tutoring to make changes to what should be made in conditions where the results achieved aren't satisfactory. So scholars must also try to lessen their literacy conditioning. Still, it's essential to give positive encouragement from the schoolteacher so that scholars can ease their literacy in groups and collectively.

2.2. Validation of the OMCDE Learning Model

The expected result from developing this OMCDE learning model is that this learning model can be used in the learning process by integrating STEM, namely a form of science or knowledge obtained from observations of the surrounding environment until questions arise as a form of problem for which a solution will be sought; technology in the form of concepts formed as a basic basis for solving problems; engineering in which there is a pattern of critical and independent thinking so that students have space to develop their creativity which can create an appropriate procedure for solving the problem posed; Mathematics as a basis for consideration in making the right decisions in carrying out actual practice so as to obtain a product that can be used in everyday life.

2.3. Feasibility of the ABCD Learning Model

Grounded on the confirmation results from educational design experts, it can be concluded that the confirmation score interval by educational design experts of 4.03 is included in the" good" or" decent" order. The following are the results of confirmation by educational design experts in the form of a bar map in Figure 1.2 below.

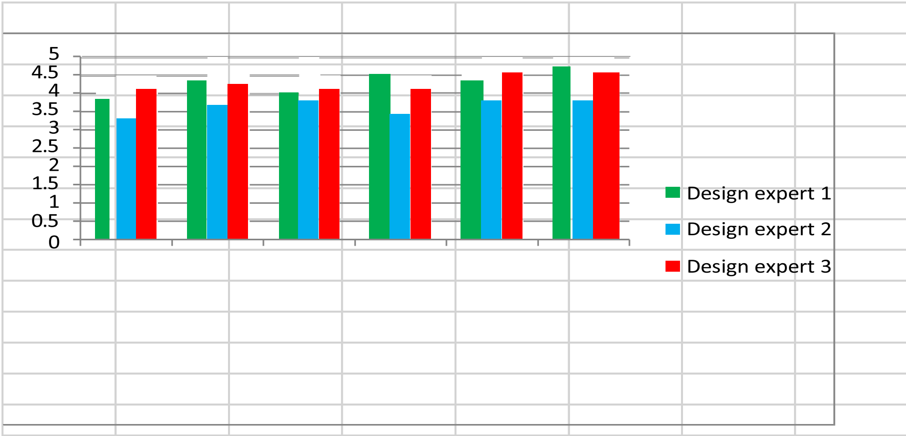

Figure 3. Bar Diagram of Validation Results of the OMCDE Learning Model by Instructional Design Experts

2.4. Practicality of the OMCDE Learning Model

Based on the assessment score interval for the initial practical field trial for teachers teaching at State High Schools and Vocational Schools in Balige, it was 3.97 and was included in the "very practical" criteria. Below are presented the results of the assessment score intervals for the initial practical field trials in the form of a bar chart in Figure 1.2 below:

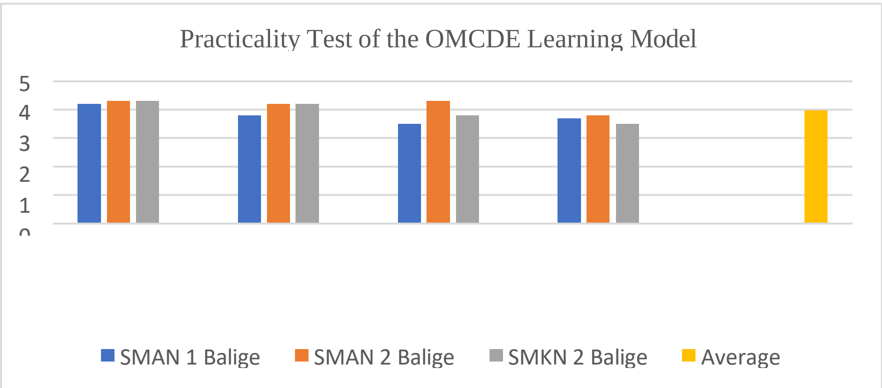

Figure 4. Bar Diagram of Practicality of the OMCDE Learning Model

2.5. Effectiveness of the OMCDE Learning Model

The pretest global faculty of scholars tutored using the stoked Reality- grounded OMCDE learning model attained the most miniature score of 52 and the loftiest score of 78; the average score was 66.03, and the standard divagation was 7.23. The frequent distribution of scholars' pretest global capabilities tutored using the stoked reality-ground OMCDE learning model can be seen in Figure 1.3 below.

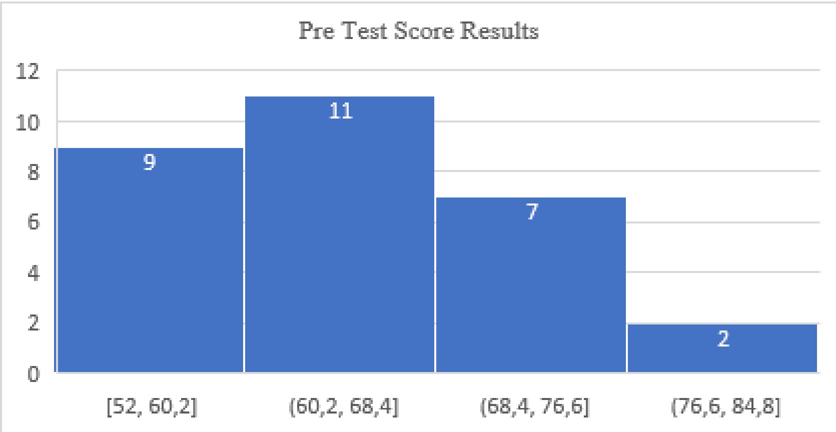

Figure 5. Bar Diagram of Pretest Score Results

The posttest global faculty of scholars tutored using the stoked Reality- grounded OMCDE learning model attained the most miniature score of 65 and the loftiest score of 92; the average score was 80.52, and the standard deviation was 7.67. The frequent distribution of scholars'post-test global capabilities tutored using the stoked Reality- grounded OMCDE learning model can be seen in Figure1.3 below.

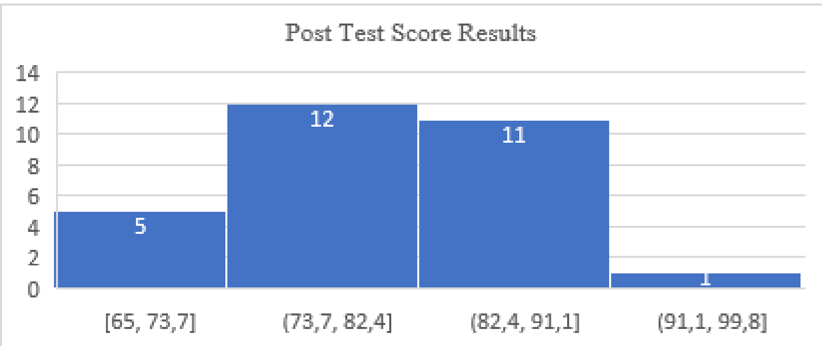

Figure 6. Bar Diagram of Posttest Score Results

Grounded on the results of exploration data processing, there are differences in the global capability of scholars who use the stoked reality-ground OMCDE learning model—grounded on the t-test results, count = 2.16 while table = 1.67. Because count = 2.16> table = 1.67, it can be concluded that scholars' posttest global capability using the Augmented Reality- grounded OMCDE learning model is more advanced than scholars' pretest global capability. This can be seen from the average posttest score (82.52), which is more advanced than the pretest score (66.03). This data proves the OMCDE literacy model grounded on stoked Reality can ameliorate scholars' global capability.

3. Conclusion

The OMCDE learning model based on Augmented Reality is stated to be good in terms of product and suitable for use to support student activity in learning at school; stated to be practically used to make it easier for teachers to carry out the teaching and learning process in schools; and declared effective in increasing students' global competence.

4. Discussion

There's essential debate about what constitutes intertwined STEM education, and thus, there's also disagreement about how to approach instruction when integrating STEM disciplines most effectively [24] [25]. For this systematic literature review, we examined STEM systems that involve interdisciplinary or transdisciplinary integration of at least two disciplines [26]. Interdisciplinary integration involves connecting nearly affiliated generalities and chops from two or further scientific disciplines with the end of heightening knowledge and chops [27]. Transdisciplinary integration applies knowledge and chops from two or more fields to real-world problems and systems, forming a literacy experience [28].

Global capability requires colorful chops that a person must master, so it's hoped that education can prepare scholars to master these colorful chops in order to become successful individuals in life. Critical chops in the 21st century are still applicable to the four pillars of life, which include learning to know, learning to do, learning to be, and learning to live together. This frame of study is still considered applicable to current educational interests and can be developed according to the requirements of the 21st century [28]. Each of these four principles contains specific chops that need to be empowered in learning conditioning, similar to critical thinking chops, problem working, metacognition, communication chops, collaboration, invention and creation, information knowledge, and colorful other chops.

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