Journal of ICSAR
ISSN (print): 2548-8619; ISSN (online): 2548-8600
Volume 6 Number 2; DOI: http://dx.doi.org/10.17977/um005v6i22022p151

Development of Augmented Reality Media Based on Cybernetic Learning Theory to Stimulate Spatial Abilities

Andriyani Andriyani*, Joko Lianto Buliali, Yudhiakto Pramudya

Universitas Ahmad Dahlan, Yogyakarta, Indonesia
*E-mail: andriyani@mpmat.uad.ac.id

Abstract: Hearing impairment students have limited vocabulary and have difficulty understanding abstract terms, which affects learning the concept of a plane solid figure that they know at school. Deaf students tend to have difficulty perceiving objects from a certain point of view and understanding the relationship between these objects in a particular space. These difficulties affect students' spatial abilities and require special handling in the form of learning-oriented to the learning process, not learning outcomes. The learning process itself can be determined by information systems such as the basis of cybernetic theory and supported by information technology-based interactive learning media. Therefore, this study aims to develop augmented reality media based on cybernetic learning theory to stimulate valid and practical spatial abilities of deaf students. The research and development model carried out in this study is the Borg and Gall model, which has systematic and descriptive steps for practical problems in teaching through applied research. Researchers collected data through validation questionnaires and student response questionnaires. Data analysis was carried out qualitatively and quantitatively. The augmented reality media developed here can be said to meet the criteria of validity and practicality based on the results of the product feasibility test. This media has also proven to be a solution in helping teachers to stimulate the spatial abilities of deaf students through a meaningful learning process determined by a technology-assisted information system.

Keywords: Augmented Reality, Cybernetic, Spatial Abilities

INTRODUCTION

Geometry is a branch of mathematics in which learning basic concepts is better known to students through informal knowledge with the object of play than other mathematics branches (Andriyani & Juniati, 2020). According to Hwang et al. (2009), implementing the concept of learning geometry uses a lot of physical models, especially concepts related to measuring length, surface area, and volume. However, geometric concepts are also taught without the need to see the physical form of geometric shapes so students must be able to construct these shapes in their minds by using a particular ability called spatial ability (Arifin, et al., 2020).

Spatial ability is a student's capacity to recognize and describe objects/patterns received by the brain (Jayantika et al., 2013). In detail, Linn & Petersen (1985) and Lohman (1993) also argue that spatial ability is a mental process when students perceive, store, remember, create, change visual images and communicate spatial shapes. Therefore, a person's spatial ability will show his ability to understand the perspective of space and dimensions (Achdiyat & Utomo, 2018). Furthermore, Achdiyat & Utomo (2018) explain that spatial abilities require left-right understanding, perspective understanding, geometric shapes, connecting spatial concepts with numbers, and the ability to transform from visual images mentally. In line with this, according to Rynhart (2012), the spatial ability will generate, store, retrieve and transform three-dimensional images, so they are well structured. Meanwhile, geometry problems are often encountered in school mathematics learning, which is difficult for students to solve because solving these problems requires spatial ability.

The emergence of geometric problem-solving difficulties that require spatial ability is closely related to the low achievement of these abilities in learning. This low achievement because spatial abilities require left-right understanding, perspective understanding, geometric shapes, an association of spatial concepts with numbers, and the ability to mentally transform from visual images (Achdiyat & Utomo, 2018). With good spatial conceptualization, students will find it easier to understand concepts and solve mathematical problems, especially problems related to the creation of shape imagination in students' minds as well as in the form of three-dimensional objects, as well as the problem when imagining geometric object position experiencing a geometric transformation to then accurately predict the actual shape from a certain point of view (Gunur et al., 2019).

The spatial ability of students in Indonesia is still relatively low. This fact can be seen from the results of research related to the low spatial ability of students, which has implications for their geometry learning achievement, such as Arcat's research (2014) on the low spatial ability of junior high school students due to the abstract characteristics of geometry that require visualization; research by Mulyadi et al. (2015) and Siswanto (2016) about the low spatial ability of students due to lack of imagination in visualizing the components of shapes and errors in transforming them; Hutagalung & Harahap (2018) and Siswanto & Kusumah (2017) research on the problem of the low spatial geometry ability of students because the geometry learning model is still conventional; and research by Usman et al. (2020) about the low spatial ability of students which causes difficulties in learning geometry.

The low spatial ability, which has implications for difficulty in learning geometry for most students, also occurs in students with special needs, such as the deaf, who still have hearing and communication limitations, but still have a sense of sight (Buliali et al., 2021). These physiological abnormalities certainly affect the success of knowledge achievement in learning geometry for deaf students, which are mostly slower than students in general. In contrast, students' success in learning can be determined by internal factors that come from the students themselves and external factors such as teacher learning strategies. Therefore, it is not enough to lecture to instill concepts in geometry learning with an expository method. But, teachers must combine several learning strategies, such as the use of technology in the learning process in the classroom, so that students be assisted in obtaining visualization of geometric material and not only receive theoretical knowledge.

Combining learning strategies organized by utilizing technology with information processing will be more effective (Indrawati in Trianto (2010)). This strategy is because learning with information processing emphasizes how a person thinks and imagines and how it impacts on ways of processing information (Siswanto & Kusumah, 2017). One of the things included in this information processing learning is cybernetic learning (Salim & Maryati, 2017). In cybernetic learning, the teacher helps students achieve their learning goals effectively by enabling the elements of cognition, especially the mind element, to understand external stimuli through the information processing process.

In processing information systems to facilitate the delivery of material, especially geometry, that requires visualization, supporting learning media is needed so that teachers can manage their learning classes well. To help the learning process, teachers need to develop a learning media that can encourage students to be more interactive and fun and also motivate students to play an active and independent role (Salim & Maryati, 2017). In this case, augmented reality technology can be used as a choice to facilitate interactive learning media for deaf and deaf students through visual illustrations (Buliali et al., 2022). With augmented reality, students' perceptions of reality become more prosperous so that objects that were initially difficult to imagine become visualized in real terms. Therefore, this study aims to develop augmented reality media based on cybernetic learning theory to stimulate valid and practical spatial abilities of deaf students, especially the concept of a plane solid figure.

METHOD

This research is included in research and development using the Borg and Gall model, which has systematic and descriptive steps for practical problems in teaching. This research procedure refers to the development stage of the Borg and Gall model (Gall et al., 2003), which consists of four stages: the preliminary form of product development stage, the preliminary field testing stage, the main product revision stage, and the main field testing stage. Because this research is a follow-up study, the research and information gathering stages, as well as the planning stage, have been carried out by researchers conducting preliminary research related to needs analysis in the previous year. Meanwhile, operational product revisions, operational field trials, final product revisions, and the socialization and implementation stages cannot be carried out due to restrictions on school activities during the Covid pandemic and time constraints.

The research subjects involved in this study were 17 deaf students at SLB Negeri 2 Bantul, Yogyakarta. The research instrument consisted of an instrument for assessing the validity and practicality of learning media. The instruments to evaluate the validity of learning media experts consist of 15 questions regarding presentation, display, and compatibility aspects. The instruments for assessing the validity of educational experts consist of 13 questions regarding aspects of the appropriateness of content and language. The practicality assessment instrument consists of 8 questions regarding effectiveness, interaction, efficiency, and creativity (Zahroni, 2019). The validity and practicality assessment instrument uses a Likert scale with five answer choices.

In this study, responses, comments, and suggestions given by validators and students will be analyzed qualitatively and used as a reference for making improvements to the product. While the results of the validity assessment from media experts and material experts and the results of practicality assessments from students will be processed from qualitative data using a Likert scale into percentages with the percentage formula adapted from (Arikunto & Jabar, 2009).

$$Percentage = \frac{Answer\ frequency}{number\ of\ respondents} \times 100\%$$

The percentage of the assessment is then interpreted into the product assessment criteria as presented in Table 1.

Table 1. Criteria for Assessment of Development Products

Achievement rate	Qualification	Information
91%-100%	Very Good	*No revision*
81%-90%	Good	*No revision*
71%-80%	Enough	*Revision*
61%-70%	Deficient	*Revision*
0%-60%	Very Deficient	*Revision*

Both the validity criteria and the product's practicality are obtained if the average score of the questionnaire assessment results meets the minimum criteria of 'good'.

RESULT AND DISCUSSION

Result(S)

1. Develop Preliminary Form of Product stage

At this stage, the researcher designs learning media based on the results of the needs analysis carried out in the research and information collecting stage and the planning stage in the previous year. Learning media that had previously been designed by starting with making a flowchart about the application to be developed. The application developed based on the flowchart that has been made cannot stand alone so that the learning media developed consists of three components, namely the augmented reality application as the application, and the Guidebook as a guide for teachers. Then the design of the learning media is realized in development.

To help students' spatial imagery, the learning media displays digital elements that can visualize these geometric abstract materials using markerless augmented reality (AR) technology. This markerless AR technology tracks real objects around students as marker objects, thus the media displays animated geometric objects in real-time. Designing of learning media into application prototypes is carried out by Java programming language and openJL es, so the application can be implemented on Android. Furthermore, learning media in this form of application can be used without internet connection access (offline).

2. Preliminary field testing stage

This stage began with an assessment of the feasibility of the product in terms of the substance of material and media design by the validator. Three validators carried out the feasibility assessment of each material and media product with relevant expertise in learning materials, learning media and practitioners. The assessment of the validity of the learning material by the validators is presented in Table 2.

Table 2. Product validation results by material experts

	Total Score	Category
Validator-1	84	*Very Good*
Validator-2	79	*Good*
Validator-3	83	*Very Good*
Total average	**82**	**Very Good**

In Table 2, it is known that the average value of the three material expert validators is 82, which means that the augmented reality media developed has met the very valid criteria in terms of the construction of material content so that it is feasible to be used as a learning medium. In contrast, the results of the assessment of the validity of the media by the validator are presented in Table 3.

Table 3. Product validation results by media experts

	Total Score	Category
Validator-1	98	*Very Good*
Validator-2	102	*Good*
Validator-3	107	*Very Good*
Total average	**102**	**Very Good**

Table 3 above shows that the average value of the three media expert validators is 102, which means that this augmented reality media has met the very valid criteria in terms of media so that it is feasible to be used as a learning medium. The results of the validator's assessment, both in terms of material and media, indicate that the product has met the validity of a development product. In addition to validation by experts, the researcher also tested the product on a limited basis with two students for advice.

3. Main product revision stage

The product that has been validated is then revised according to suggestions from experts and student suggestions in a limited field test. The revision includes the size of the letters and the color of the writing that accompanies the illustration of the appearance of the flat side space. In addition, researchers must also add an instruction menu that contains an explanation of how to scan 3-dimensional objects and open 3-dimensional webs.

4. Main field testing stage

After the product was revised, the researcher tested the product in the main field. The test is carried out by implementing the product on a broader learning scale for 7 (seven) meetings. At the end of the meeting, the researcher gave a questionnaire that students had to fill out regarding their responses as users of the product developed in this study. The average score of the assessment/student response to the use of this product is 85.71, which means that the student's assessment of the product is included in the very good category. Thus, the product developed in this study can be said to have met the practicality of product development and is suitable for use as a medium for learning mathematics.

Discussion(s)

Based on the results of the validation and main field tests above, it can be seen that the augmented reality media developed in this study is feasible regarding the validity and practicality of a learning media. Deaf students respond very well to the use of this media in learning the concept of a plane solid figure that has been difficult for them to imagine the space. Augmented reality media visualization helps students stimulate their spatial abilities to the concept of a plane solid figure that is abstract.

Augmented reality media in this study is used to support learning activities in visualizing the space of a plane solid figure, not only in theory but also given direct experience through computational practice-oriented to cybernetic learning theory related to information system processing to facilitate the delivery of learning material to students. This is in line with the nature of learning management based on cybernetic learning theory, which leads to the teacher's efforts to help achieve student learning goals effectively by enabling students' cognitive elements to understand external stimuli (i.e., real motorcycle taxis being explored) through processing-information and transfers-learning in a real-life environment (Rachmad, 2011; Thobrani & Mustafa, 2012).

An important focus in cybernetic theory-based learning is the use of technology in the learning process to obtain fast and precise information so that students' spatial abilities are increased, and teachers' creativity can be encouraged through information technology-based learning. The usefulness of augmented reality media accommodates teachers' creativity in integrating technology in education and increases students' understanding of geometric concepts through visual illustrations of geometric object models around them. The student response questionnaire results show that the student's positive response is because, in its implementation, this media can activate students in learning. From the various statements used in assessing student responses, it appears that the majority of students' answers are happy to use augmented reality interactive media in learning, interested in following the next geometry lesson, and clearly understand the concept of a plane solid figure visualized by augmented reality technology, and feel uncomfortable. Students also aren't bored from getting hands-on experience by exploring objects around them with this media's usefulness. Thus, learning becomes more effective, and this can't be separated from the role of the teacher in preparing and designing learning according to the characteristics and needs of students. In this case, the teacher is the party who best understands all the potential in the school environment, the suitability of the learning strategies used, and the competencies/abilities that need to be provided to students. On the other hand, to face the challenges of the 21st century, teachers must have digital skills and creative thinking other than skills in leadership, communication, emotional intelligence, entrepreneurship, global citizenship, team working, and problem-solving. Because in this era of society 5.0, teachers must be driving teachers who can initiate change in their students, take action without being prompted and continue to innovate in meaningful learning.

The positive response of students regarding understanding abstract geometric concepts assisted by visualization of augmented reality technology shows the usefulness of augmented reality media in illustrating geometric objects from various points of view (projection relations), geometric objects in space (spatial relations), also distance conversion which has been difficult to students imagine. This condition shows that using augmented reality media has positive implications in stimulating students' spatial abilities when learning the material for a plane solid figure material. Several research results support this, ie. Nasution et al. (2016) and Sugiarni et al. (2018) about positive changes in students' spatial abilities after using learning media.

CONCLUSSION

The augmented reality media based on the cybernetic learning theory developed in this study has met the valid and practical criteria. The validity of augmented reality media is shown by the results of assessments from media experts and material experts with very valid categories. The practicality of augmented reality media is seen in the positive student responses to learning using the media. These results indicate that the developed augmented reality media can be used to support the improvement of students' spatial abilities in learning geometry. This means that augmented reality media can be used as an alternative to teaching geometry based on cybernetic learning theory, especially the concept of a plane solid figure. The researcher hopes that there will be further research that will look at the effectiveness of this media in improving students' spatial abilities or further development in spatial geometry learning for deaf students who have limited vocabulary and knowledge as an implication of their disability.

REFERENCES

Achdiyat, M., & Utomo, R. (2018). Kecerdasan visual-spasial, kemampuan numerik, dan prestasi belajar matematika. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 7*(3), 234–245.

Andriyani, & Juniati, D. (2020). Learning the relation between quadrilateral using geometry’s puzzle for blind students. *Journal of Physics: Conference Series*, *1470*(1). https://doi.org/10.1088/1742-6596/1470/1/012029

Arcat. (2014). Peningkatan Kemampuan Spasial Siswa SMP Melalui Model Kooperatif STAD berbantuan WINGEOM. *Jurnal Ilmiah Edu Research*, *3*(1), 68–73.

Arifin, A.M., Pujiastuti, H., & Sudiana, R. (2020). Pengembangan Media Pembelajaran STEM dengan Augmented Reality untuk Meningkatkan Kemampuan Spasial Matematis Siswa. *Jurnal Riset Pendidikan Matematika*, *7*(1), 59–73.

Arikunto, S., & Jabar, C. S. A. (2009). *Evaluasi program pendidikan (2nd ed.)*. Bumi Aksara.

Buliali, J.L., Andriyani, Pramudya, Y. (2021). Innovative Learning Model with Augmented Reality Technology for Hearing Impairment Students. *Ilkogretim Online - Elementary Education Online*, *20*(1), 663–673.

Buliali, J. L., Andriyani, & Pramudya, Y. (2022). Development of Interactive Media with Augmented Reality for Prospective Solution Quota-Friendly Learning and Physical Limitation in the Pandemic Era. *Mathematics Teaching Research Journal*, *14*(1), 5–40.

Gall, M. D., Gall, J. P., & Borg, W. R. (2003). Educational research: an introduction (7 ed.). *New York: Pearson Education Inc.*

Gunur, B., Lanur, D. A. L., & Raga, P. (2019). Hubungan kemampuan numerik dan kemampuan spasial terhadap kemampuan komunikasi matematis siswa. *PYTHAGORAS: Jurnal Pendidikan Matematika*, *14*(2), 224–232.

Hutagalung, A., & Harahap, M. S. (2018). Peningkatan Kemampuan Spasial Siswa Melalui Penggunaan Model Auditory Intellectually Repetition (Air) Di Smp Negeri 1 Pinangsori. *Jurnal MathEdu*, *1*(1), 15–23.

Hwang, W.-Y., Su, J.-H., Huang, Y.-M., & Dong, J.-J. (2009). A study of multi-representation of geometry problem solving with virtual manipulatives and whiteboard system. *Journal of Educational Technology & Society*, *12*(3), 229–247.

Jayantika, N. T., Ardana, I. M., & Sudiarta, P. (2013). Kontribusi bakat numerik, kecerdasan spasial, dan kecerdasan logis matematis terhadap prestasi belajar matematika siswa SD Negeri diKabupaten Buleleng. *Jurnal Jurusan Pendidikan Matematika Ganesha*, *2*(1), 1–12.

Linn, M., & Petersen, A. (1985). Emergence and characterization of sex differences in spatial ability: a meta-analysis. *Child Development*, *56*(6), 1479–1498.

Lohman, D. F. (1993). Spatial Ability and G. *Paper Presented at the First Spearman Seminar*.

Mulyadi, Riyadi, & Subanti, S. (2015). Analisis Kesalahan Dalam Menyelesaikan Soal Cerita Pada Materi Luas Permukaan Bangun Ruang Berdasarkan Newman’S Error Analysis (Nea) Ditinjau Dari Kemampuan Spasial. *Jurnal Elektronik Pembeljaran Matematika*, *3*(4), 370–382.

Nasution, S. H., Anwar, L., & Sudirman, & S. (2016). Pengembangan media pembelajaran untuk mendukung kemampuan penalaran spasial siswa pada topik dimensi tiga kelas X. *Jurnal Keguruan Dan Ilmu Pendidikan*, *4*(2), 903–913.

Rachmad, E. (2011). *Aplikasi Teori Belajar Sibernetik.*

Rynhart, P. (2012). *Importance.of Spatial Skill*. diakses: http://proactiveplay.com/importance-ofspatial-skills/ (25-09- 2020)

Salim, S., & Maryati, E. (2017). Pengembangan Perangkat Pembelajaran Matematika Melalui Teori Pembelajaran Sibernetik Berbantuan Software Derive. *Jurnal Riset Pendidikan Matematika*, *4*(2), 229–238.

Siswanto, R. D. (2016). Asosiasi Antara Kemampuan Geometri Spasial Dengan Kemampuan Berpikir Kreatif Matematis Siswa. *KALAMATIKA: Jurnal Pendidikan Matematika*, *1*(2), 141–146.

Siswanto, R. D., & Kusumah, Y. . (2017). Peningkatan Kemampuan Geometri Spasial Siswa Smp Melalui Pembelajaran Inkuiri Terbimbing Berbantuan Geogebra. *Jurnal Penelitian Dan Pembelajaran Matematika*, *10*(1), 42–51.

Sugiarni, R., Alghifari, E., & Ifanda, A. R. (2018). Meningkatkan kemampuan spasial matematis siswa dengan model pembelajaran problem based learning berbantuan geogebra. *Kalamatika: Jurnal Pendidikan Matematika*, *3*(1), 93–102.

Thobrani, M., & Mustafa, A. (2012). *Belajar & Pembelajaran.* Ar-Ruzz Media.

Trianto. (2010). *Mendesain Model Pembelajaran Inovatif-Progresif*. Kencana Prenada Media Group.

Usman, A., Fauzi, A., Karnasih, I., & Mujib, A. (2020). Kemampuan Spasial Siswamelalui Model Pembelajaran Berbasis Masalah Berbantuan Alat Peraga Berbahan Pipet. *Transformasi: Jurnal Pendidikan Matematika Dan Matematika*, *2*(2), 321–330.

Zahroni, A. (2019). Pengembangan mobile learningmenggunakan adobe flash pada pelajaran narrative text di SMP eLKISI Mojokerto. *Nidhomul Haq: Jurnal Manajemen Pendidikan Islam*, *4*(1), 90–103.