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Virtual Reality-based Virtual Lab Product Development in Developing Students' Spatial Abilities Using the Van Hiele Theory Approach

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Abstract

In learning during the current pandemic, there are many problems, one of which students cannot meet face to face on campus, one of the learning problems that often occurs is learning geometry in universities, geometry is a scourge lesson before the pandemic both at Universitas PGRI Semarang and other private universities so far, students are required to use a compass and ruler in making flat shapes and building spaces so they have to face to face with the lecturer, but now it can't because it is still online, therefore it is necessary to make learning media that aims to help students sketch flat shapes and build spaces virtually with practice making it online with a van hiele theory approach, so that the resulting product is truly capable of elaborating between technology, the right learning approach and the content of lecture materials on an ongoing basis, then a virtual media lab for geometry courses is created that is able to display material virtually and practice making material designs virtually with the van hiele theory approach, the research method used using the ADDIE R & D model (Analysis, Design, Develop, Implementation and Evaluation), the result of this study is a virtual geometry lab application with van Hiele theory that is valid according to material and media experts with an average score of 93 and 95 can be used as an online geometry learning media solution. at Universitas PGRI Semarang, for student responses below 40% very agree, 59% agree and 1% disagree using virtual lab geometry it is was able to improve students' spatial abilities, Results The effectiveness of the media after being tested in the experimental class obtained an N-gain value of 0.39 which was better than the control class which only obtained an N-gain value of 0.02, then a virtual media lab for geometry courses is created that is able to display material virtually and practice making material designs virtually with a van hiele theory approach.The five steps in van Hile's theory have been well implemented consisting of (1) Visualization level, (2) Analysis level, (3) Abstraction level, (4) Formal deduction level, (5) Rigor level.

Keywords: development, Virtual Lab, Geometry, van hiele theory, spatial abilities.

Introduction

The learning media in question is virtual reality-based virtual reality-based geometry lab media that is well packaged and follows the times. Domestically, there are already virtual labs for science lessons which show that mobile virtual reality can improve students' analytical skills in studying physics material (Triatmaja & Khairudin, 2018), then using virtual reality packaged in the form of games can improve student motivation and learning outcomes in learning biology (Zhang et al., 2018). , then it was shown that virtual reality-based virtual labs were able to improve the cognition of kindergarten children in Bali in learning a variety of fish for children (Kusuma et al., 2018) , : then the effect of the application of van Hiele's learning theory on student learning outcomes on the material properties of flat shapes has increased cognitive value above the minimum completeness criteria (Zheng et al., 2015)., then there is a significant influence in the application of van Hiele's theory on the ability to understand students' mathematical concepts on cube and block material because by collaborating with augmented reality mobile media, it makes students more interested and enthusiastic in following geometry learning by releasing three-dimensional reality (Buchori et al., 2017). In overcoming the problem of understanding Universitas PGRI Semarang students in understanding geometry material, this has been linked in the research center and community services Universitas PGRI Semarang research strategic plan related to the prototype of professional development of educators and education personnel in the digital era with a focus on improving the ability of lecturers to present learning in class in an interesting and fun way,

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Literature review

Virtual Laboratory

A learning experience that might not be practical in a physical classroom (Budiman & Rosmiati, 2020). and processes in real contexts. All students can be involved in the whole process, unlike in a physical laboratory where only a few students can carry out a similar process like lecturers (Junedi, 2017)

Virtual Reality

Examples of virtual reality applications used today are in the military field. Virtual reality is used to simulate war drills, parachute training simulations, and so on. Where the use of this technology can save more costs and time compared to conventional methods (Pratiwi et al., 2020).

Geometry

Geometry is a science that discusses the relationship between points, lines, angles, planes and shapes of space. Geometry is a branch of mathematics that studies the ins and outs of flat shapes and spatial shapes (Atiaturrahmaniah & Ibrahim, 2017). The understanding of geometry is arranged in stages starting from the simplest things and is an element that is considered to have become everyone's understanding (primitive element) is called the basic notion, leading to elements that require boundaries/definitions by using the definition of the base, then axioms/postulates are compiled, namely the basic assumptions that are agreed upon are correct and do not need to be proven, based on the existing axioms/postulates and definitions, a theorem/formula/ proposition is compiled which is a provisional assumption that must be verified deductively (Nuraini & Ganda, 2021). Literature review of no more than 1000 words by stating the state of the art and roadmap in the field being researched/ technology being developed. The presentation of the road map can be in the form of a chart in the form of an image. Sources of relevant primary literature/references and by prioritizing research results in the latest scientific journals and/or patents.

Van Hiele's Theory

Two figures of mathematics education from the Netherlands, namely Pierre van Hiele and his wife, Dina van Hiele-Geldof, in 1957 to 1959 proposed a theory regarding a theory of the developmental process that students go through in studying geometry (Pattiiha, 2020) .In the theory they put forward, they argue that in studying geometry, students experience the development of thinking skills by going through the following levels. (1) Visualization level, (2) Analysis level, (3) Abstraction level, (4) Formal deduction level, (5) Rigor level This level is also called metamathematical level (Nugroho, 2021).

Spatial Abilities

The concept of spatial thinking is quite interesting to discuss considering that many previous studies found that students found it difficult to understand geometric objects or figures. Spatial thinking is a collection of cognitive skills, which consists of a combination of three elements, namely spatial concepts, representational tools, and reasoning processes (Ismail et al., 2016) .Spatial learning outcomes are a concept in spatial thinking. spatial learning outcomes can be grouped into three categories, namely: (1) spatial perception, (2) mental rotation, and (3) spatial visualization (Ballotti et al., 2010) .cognitive is a thinking process, namely the individual's ability to connect, assess , and considering an event or events Coyne et al., 2018) .By having cognitive abilities, children use their thinking tools to observe, relate, assess, and consider an event or events in order to solve problems as effectively and efficiently as possible in achieving goals. The more stimulation the child gets when interacting with the environment, the faster his thought function will develop (Oh & Bailenson, 2017).

Methodology

Method

This research uses Research and Development (R&D) research. development research is a research method used to produce certain products, and to test the effectiveness of these products (Nersesian et al., 2019). This development research uses the ADDIE model which consists of five stages, namely Analysis, Design, Development, Implementation and Evaluation.

Research Design

The ADDIE model is a research design used in this study, which consists of five stages, namely Analysis, Design, Development, Implementation and Evaluation, these five steps are carried out regularly and systematically

Population and Sample/ Study Group/Participants

The population in this study were students of the Mathematics Education study program at the University of PGRI Semarang, who were taken respectively two experimental classes and a control class.

Data Collection Tools

The research data was obtained by using a questionnaire response validation of material experts, learning media experts and user responses, then continued with tests in the form of pretest and posttest to determine students' spatial abilities, then N Gain test to determine the improvement of process skills and cognitive learning outcomes between before and after studying at Universitas PGRI Semarang.

Data Collection

The data collected was taken using a google form related to the validation of material experts and learning media experts, then the student response questionnaire was also carried out using the google form, while the pretest and posttest were carried out in writing and scanned results were sent via email to be assessed in detail.

Data Analysis

For the analysis of the results of the acquisition of research data processed using a Likert scale related to user responses and expert validation, then for the results of students' spatial abilities using the average score and N Gain test to determine improving the ability of process skills and cognitive learning outcomes of students.

Results and Discussion

Results

In this study, the Virtual Lab Geometry product was produced using the parallel material developed using the ADDIE model. The product development results are described in detail according to the ADDIE development procedure as follows:

Analysis

At this stage of analysis, an analysis related to the problems of learning geometry at Universitas PGRI Semarang in the Mathematics Education study program has been carried out which shows that 60 percent of students are still weak in understanding geometry material, especially those related to flat and spatial shapes, their cognitive and spatial abilities are still below 70. Based on the results of the initial pretest, then the students said that during the 2020-2021 pandemic, 90% of Universitas PGRI Semarang students really needed learning media that were able to improve their knowledge and spatial abilities related to geometry material, especially parallelism.

Design

Product designs are arranged based on the needs and achievement of learning objectives, namely making applications Virtual Geometry Lab which focuses on alignment material with virtual reality technology, the explanation regarding Alignment becomes clearer so it is hoped that students' geometric spatial abilities will be better than using other conventional media, in making this virtual geometry lab design it starts with designing in Corel Draw, then create animations with Unity 3D, Blender software and Vuforia Development, after the application design product is finished, a focus group discussion is held regarding the appearance of the design and the depth of the material displayed, namely alignment, the results of the focus group discussion show that students need to be given practice to determine the position of alignment so that they better understand mathematical concepts.

Development

In this development stage, the framework that has been designed is realized so as to produce a product that can be implemented. At the stage of developing the Geometry Virtual Lab media, it is made according to the Alignment material, after the android-based media is complete, it is validated by media experts and material experts by the validator to get input and evaluate according to the input given by the validator. Furthermore, the Virtual Reality-based media is revised according to the input given by the validator to improve the product. In this development stage, a virtual geometry lab product has been produced that has been adapted to the results of a focus group discussion between lecturers and students which includes the design of virtual geometry lab media and the depth of the geometry material taken.

The Geometry Virtual Lab product was validated by media experts with the following results: (1) the appearance of this virtual geometry lab product is suitable as a virtual supplement for geometry course material, (2) color gradations related to geometric alignment material can be understood virtually and attractively, (3) the virtual geometry lab application is interesting for lectures because quizzes are displayed with interesting animations, (4) the menus in the virtual geometry lab application can be used in a fun, easy and fun way, (5) the product can relate these congruent and parallel

Fig. 1: Virtual Lab Geometry product about alignment material

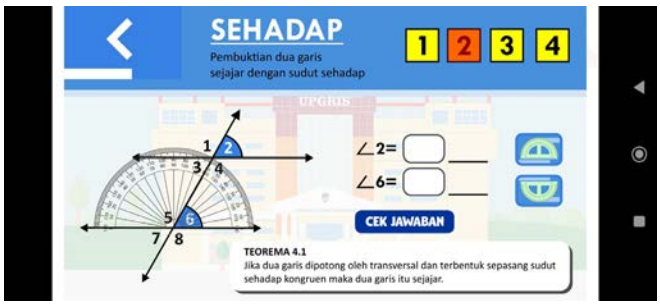

Fig. 2: Material display with Virtual Lab Geometry about alignment material

materials with students' spatial skills with 3D objects, (6) existing questions need to be related to the context of the latest alignment problems, (7) virtual geometry lab applications can be applied properly and in accordance with Indonesia's national qualifications framework material,(8) students can solve questions about geometric parallelism sequentially and interestingly, (9) users will have no difficulty in operating this virtual geometry lab application product, (10) this application is able to increase student learning motivation, from the validation results it is shown that the average The result of the learning media expert's assessment is 93, which indicates that the virtual geometry lab product in terms of the feasibility of the geometry virtual lab product design is very suitable for use in learning. From the validation results it is shown that the average result of the learning media expert's assessment is 93, which indicates that the virtual geometry lab product in terms of the feasibility of the geometry virtual lab product design is very suitable for use in learning. From the validation results it is shown that the average result of the learning media expert's assessment is 93, which indicates that the virtual geometry lab product in terms of the feasibility of the geometry virtual lab product design is very suitable for use in learning.

Meanwhile, based on the results of material expert validation, the following results were obtained: (1) this virtual geometry lab product is suitable as a virtual supplement of geometry course material, (2) concepts related to this geometric alignment material can be understood virtually, (3) virtual applications the geometry lab is interesting to use in other courses, (4) the menus in the virtual geometry lab application can be used in a fun and fun way, (5) this geometry alignment material can be related to students' spatial skills, (6) the questions existing needs to be related to the context of the latest congruence and alignment problems, (7) this virtual geometry lab application can be applied properly and in accordance with the IQF material, (8) students can solve questions about parallelism sequentially,(9) there is no difficulty in operating this virtual geometry lab application product, (10) the Geometry Virtual Lab application is able to improve students' cognitive abilities, based on the expert assessment of geometry learning materials shows that the material presented in this virtual geometry lab media is very feasible to be applied in eye learning geometry lectures with an average value of 95, meaning that the geometry material presented is very suitable for use in learning.based on the expert's assessment of geometry learning material, it shows that the material presented in this virtual geometry lab is very feasible to be applied in learning geometry courses with an average value of 95, meaning that the geometry material presented is very suitable for use in learning.based on the expert's assessment of geometry learning material, it shows that the material presented in this virtual geometry lab is very feasible to be applied in learning geometry courses with an average value of 95, meaning that the geometry material presented is very suitable for use in learning.

Implementation

At this implementation stage, students of the mathematics education study program from the Universitas PGRI Semarang use the Virtual Lab Geometry product in the Geometry lecture learning material for parallelism by first installing the virtual application for the geometry lab for congruence material then taking a pretest before learning geometry and post-testing after participating in learning using the Virtual Lab Geometry, the implementation of the research was carried out face-to-face with practical students using VR glasses with the virtual lab geometry application.

Based on the student response questionnaire, it was shown that the average number who stated that they were happy and very happy using the virtual geometry lab application was 40% very agree, 59% agree and 1% disagree using virtual lab geometry. after practicing using the geometry lab virtual learning media for six meetings on alignment material the data was obtained, then a virtual media lab for geometry courses is created that is able to display material virtually

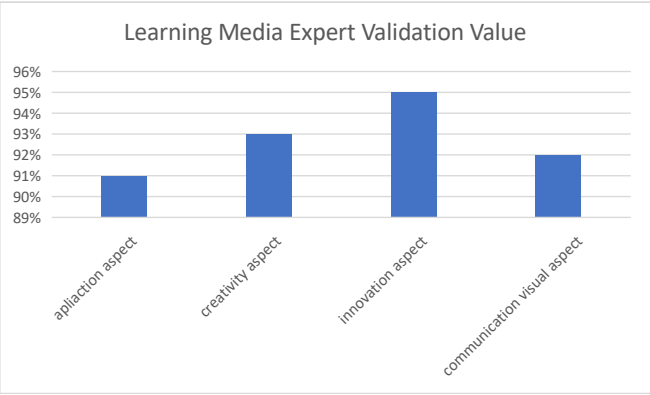

Fig. 3: The results of the validation of learning media experts on virtual geometry lab products

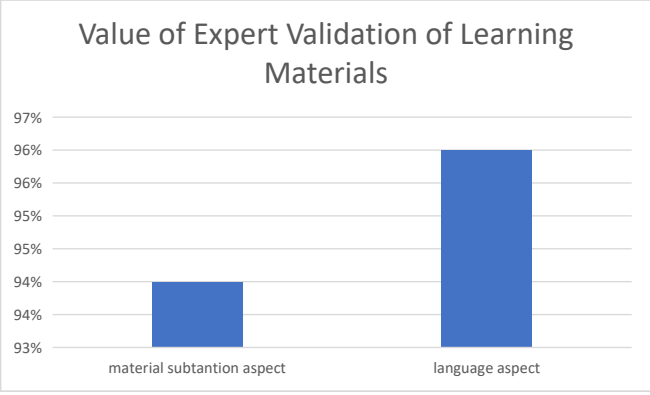

Fig. 4: The results of the expert validation of learning materials on the depth of the virtual geometry lab product material

Fig. 5: Implementation of Geometry Virtual Lab Products in parallel at Universitas PGRI Semarang

Table 1: Student responses to the use of virtual geometry lab

Response to Use of Virtual Geometry Lab	*Very agree*	*agree*	*disagree*	*Very diasgree*
I can restate a geometric concept to answer a problem virtually	34%	66%	0%	0%
I can understand a concept related to material geometry virtually	36%	64%	0%	0%
I'm interested in using the virtual geometry lab application	48%	52%	0%	0%
I can see and use the menus in the virtual geometry lab application in a fun and enjoyable way	52%	48%	0%	0%
I can relate the geometry material in the virtual lab media with students' spatial skills	34%	62%	4%	0%
I try to solve problems related to geometry properly and correctly	48%	52%	0%	0%
I can apply geometric formulas well and according to the application.	28%	72%	0%	0%
I can solve questions about geometry in order.	32%	66%	2%	0%
I'm sure it's not difficult to operate this virtual geometry lab application product	36%	60%	4%	0%
This application is able to improve the cognitive abilities of students	52%	48%	0%	0%
	40%	59%	1%	

and practice making material designs virtually with a van hiele theory approach students experience the development of thinking skills by going through the following levels. (1) Visualization level, at the visualization stage students have paid attention to alignment material by using the virtual geometry lab application by measuring the angles that are applied by measuring in real time on each worksheet, (2) Analysis level, at the analysis level level students are asked to analyze the position of lines and angles on two parallel lines divided by one line which causes there to be several kinds of angles so students look for angle equations that have the same angle size (3) Abstraction level, at the abstraction level stage students are asked to answer quickly and precisely regarding the position of angles and lines both facing angles, inside and outside opposite angles then the position of two lines crossing, parallel or coincident, (4) Formal deduction level, at the Formal deduction level stage students are able to deduce the position of angles and lines correctly either by using the virtual geometry lab application or in the usual way with a ruler and arc in determining the size of the angle, (5) Rigor level, at the rigor level stage, students reason formally in mathematical systems and can analyze the consequences of manipulating axioms and definitions related to the position of lines and angles precisely regarding the position of lines and angles either with the application of virtual media lab geometry or without an application. after a limited test was carried out in the mathematics education study program at the PGRI University in Semarang can results the effectiveness of the media after being tested in the experimental class obtained an N-gain value of 0.39 which was better than the control class which only obtained an N-gain value of 0.02.

Discussion

At the research development stage with the ADDIE model, the following things have been significantly produced:

At the analysis stage, it was known that as many as 60 percent of students of the Mathematics Education study program at Universitas PGRI Semarang were still weak in mastering geometry material, especially congruence and parallelism material, this was because the majority during the pandemic could not practice virtually, then analysis of the relevant solution was made by media. which is able to improve students' practical skills in geometry material, with students being able to directly practice virtually during a

pandemic, one of which is by using interesting virtual reality-based media and is able to improve students' spatial abilities, this is corroborated by (Sulistyowati & Rachman, 2017) who showed that by virtual lab in biology learning is able to increase students' motivation and learning experience, then (Suharjana, 2015) .Explaining that learning with virtual labs by combining e-learning makes students more interested in participating in learning, strengthened by (Lumbantoruan, 2019) .who shows that virtual reality-based online learning makes it easier for students to understand learning material.

At the design stage, a virtual geometry lab learning media design has been made that can be installed on all android smartphones, the geometry lab virtual media design presents geometry course material which includes flat and spaced material that is packaged well and attractively with color gradations and animations capable of attracting students' cognitive and spatial abilities by practicing using them, (Hadi, 2019).explained that using a physics virtual laboratory made students have more critical behavior in analyzing a problem, then (Alpian & Anggoro, 2020).explained that in virtual reality-based chemistry learning is able to improve students' creative abilities in combining chemicals that have been tested in the laboratory, then (Drummond & Fischhoff, 2017)explains that virtual-based learning and conventional learning have very clear differences in efficiency in understanding students' understanding of a learning material.

(Khemaswati, 2018) showed that educational games based on virtual augmented reality were able to increase students' motivation and spatial abilities with fun games, then (Lumbantoruan, 2019), explaining that the virtual lab in physics learning makes students understand the structure of the material more deeply and more interestingly, (Zheng et al., 2015).explain that virtual reality is a renewable innovation that makes learning in schools to colleges interesting and interesting. fun for students.

At the implementation stage, in applying the virtual geometry lab product at Universitas PGRI Semarang, students were very enthusiastic about using the virtual geometry lab product because the virtual geometry lab application was able to display interesting objects and forced students to practice measuring angles and parallels in the virtual geometry lab application, (Susanti, 2018). explained that students of the vocational education study program at UTM received internships related to their skills in mastering technology that support their internship practices, one of the media taught is virtual reality which is very much needed in learning geometry and computer-based design science, then (Anugrahana, 2021) also explained the importance of campuses providing students with mastery of virtual reality materials so that they can package learning in an interesting and meaningful way, then (Sugiyono, 2010). explained that the novelty of learning with virtual reality media make students motivated in learning and try to make interesting media supplements in their learning, then (Meltze, 2002). explains that today the world of education cannot be separated from augmented reality and virtual reality, both of which are very supportive of the learning process in the current pandemic era by students are invited to adventure in the virtual world and there is an interesting augmented reality.

Conclusion

Based on the results and discussion, it can be concluded that the development of a virtual geometry lab product is a virtual geometry lab application with a van hiele theory approach that is valid and feasible to use as one of the online learning media solutions at Universitas PGRI Semarang and based on the responses from students of the Geometry Virtual Lab product, they get response positive, then the product of this virtual geometry lab has shown that the experimental class has better learning outcomes than the control class which does not use virtual geometry lab media, then by using van hiele's theoretical approach in learning geometry it really helps students understand the material in a systematic and clear manner supported by using virtual geometry lab media.

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References

Alpian, R., & Anggoro, BS (2020). Analysis of Students' Mathematical Reasoning Based on Van Hiele Theory. Indonesian Journal of Science and Mathematics Education, 3(1), 96-105.

Anugrahana, A. (2021). Analysis of Cognitive Understanding Ability and Difficulty in Learning Mathematics The Concept of "Logic" With Online Learning Models. Scholaria: Journal of Education and Culture, 11(1), 37-46.

Atiaturrahmaniah, A., & Ibrahim, DSM (2017). Development of adobe flash-based learning media with the application of Van Hiele theory. Journal of DIDIKA: Scientific Forum for Basic Education, 3(1), 1-13.

Bellotti, F., Berta, R., & De Gloria, A. (2010). Designing Effective Serious Games: Opportunities and Challenges for Research. International Journal of Emerging Technologies in Learning (IJET), 5(SI3), 22–35.

Buchori, A., Setyosari, P., Dasna, IW, Ulfa, S., Degeng, INS, & Sa'dijah, C. (2017). Effectiveness of direct instruction learning strategy assisted by mobile augmented reality and achievement motivation on students cognitive learning results. Asian Social Science, 13(9), 137-144.

Budiman, H., & Rosmiati, M. (2020). Application of Geogebra Assisted Van Hiele Learning Theory to Improve Students' Mathematical Reasoning Ability. Prism, 9(1), 47-56.

Coyne, L., Takemoto, JK, Parmentier, BL, Merritt, T., & Sharpton, RA (2018). Exploring virtual reality as a platform for distance team-based learning. Currents in Pharmacy Teaching and Learning, 10(10), 1384–1390.

Drummond, C., & Fischhoff, B. (2017). Individuals with greater science literacy and education have more polarized beliefs on controversial science topics. Proceedings of the National Academy of Sciences, 114(36), 9587-9592.

Hadi, AM (2019). Analysis of the Mathematics Learning Process of Children with Special Needs (Abk) in Understanding Flat Shapes Based on Van Hiele Theory at SMPLB BD Bima City. Proceedings of the Syllogism, 1(1).

Ismail, I., Permanasari, A., & Setiawan, W. (2016). The effectiveness of STEM-based virtual labs in improving scientific literacy of students with gender differences. Journal of Science Education Innovation, 2(2), 190-201.

Junedi, B. (2017). Application of Van Hiele's Learning Theory on Geometry in Class VIII. MES: Journal of Mathematics Education and Science, 3(1), 1-7.

Khemaswati, DA (2018). Development of NCTM standard mathematics learning tools with nuances of cognitive load theory for students of class XI (Doctoral dissertation, UIN Sunan Ampel Surabaya).

Kusuma, T. A., Wirawan, I. M. A., & Arthana, I. K. R. (2018). Virtual Reality for Learning Fish Types in Kindergarten, International Journal of Interactive Mobile Technologies (iJIM) Vol. 12, No. 8, 2018.

Lumbantoruan, JH (2019). Geometry Module I (Plat and Space Geometry).

Meltzer, D. E. (2002). The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores. *American journal of physics*, *70*(12), 1259-1268.

Nersesian, E., Spryszynski, A., & Lee, MJ (2019). Integration of Virtual Reality in Secondary STEM Education. 2019 IEEE Integrated STEM Education Conference (ISEC), 83–90.

Nugroho, A. (2021). The effectiveness of virtual laboratories in pharmacy analysis practicum learning for pharmacy students during the covid-19 pandemic. Reflection on Innovative Learning, 3(1).

Nuraini, L., & Ganda, N. (2021). The Effect of the Application of Van Hiele's Learning Theory on Student Learning Outcomes on the Material of Flat Shape Properties. PEDADIDAKTIKA: Scientific Journal of Elementary School Teacher Education, 8(2), 395-403.

Oh, SY, & Bailenson, J. (2017). Virtual and Augmented Reality. In The International Encyclopaedia of Media Effects (pp. 1–16); John Wiley & Sons, Inc.

Pattiiha, S. (2020). The Influence of the Application of Van Hiele Theory on Students' Ability to Understand Mathematical Concepts in Class VIII Cubes and Blocks at MTs Negeri 5 Central Maluku (Doctoral dissertation, IAIN Ambon).

Pratiwi, F., Sugiarti, T., & Hutama, FS (2020). The application of Van Hiele's learning theory to improve student activity and learning outcomes on the subject of square, rectangular, and triangle areas. Widyagogic: Journal of Elementary School Education and Learning, 7(2), 128-138.

Sugiyono (2010). Educational Research Methods (Quantitative, Qualitative, and R&D Approaches). Bandung: Alphabeta

Suharjana, A. (2015). Flat geometry and space. Yogyakarta: Pusat Pengembangan dan Pemberdayaan Pendidik dan Tenaga Kependidikan (P4TK) Matematika.

Sulistyowati, S., & Rachman, A. (2017). Utilization of 3D virtual reality technology in elementary school level mathematics learning. Network Engineering Research Operations, 3(1), 37-44.

Susanti, VD (2018). Analysis of cognitive abilities in problem solving based on logical-mathematical intelligence. JMPM: Journal of Mathematics and Mathematics Education, 3(1), 71-83.

Triatmaja, A. K., & Khairudin, M. (2018). Study on Skill Improvement of Digital Electronics Using Virtual Laboratory with Mobile Virtual Reality. Proceeding of International Conference of Electrical, Electronics, Informatics and Vocational Education, Yogyakarta, Indonesia

Zhang, M., Zhang, Z., Chang, Y., Aziz, E., & Chassapis, C. (2018). Recent Developments in Game-Based Virtual Reality Educational Laboratories Using the Microsoft Kinect. International Journal of Emerging Technologies in Learning. Vol.13(1), 138 - 159.

Zheng, R., Zhang. D. and Yang, G. (2015). Seam the Real with the Virtual: a Review of Augmented Reality. Information Technology and Mechatronics Engineering Conference. Atlantis Press. 7:77-80.