OPEN ACCESS

Journal of Excellence in Natural Science Education
Vol. 1 No. 1. December 2025, pp. 44-54

DOI. XX.XXXXX/jense.vxix.xxx

Research Article

THE EFFECT OF DISCOVERY LEARNING ASSISTED BY VIRTUAL REALITY ON THE VISUAL SPATIAL ABILITY OF JUNIOR HIGH SCHOOL STUDENTS LEARNING RESPIRATORY SYSTEM MATERIAL

Umun Nur Zakiyatul Miskiyah[1], Laifa Rahmawati[2]
[1] Yogyakarta State University, Indonesia
[2] Yogyakarta State University, Indonesia

Corresponding Author:

Umun Nur Zakiyatul Miskiyah,
Department of Science Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University.
Jl. Colombo No.1, Karangmalang, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281
Email: umunnur.2021@student.uny.ac.id

Article Info
Received: 7-11-2025
Revised: 21-11-2025
Accepted: 11-12-2025
Online Version: 16-12-2025

Abstract
This study aims to examine the differences and effects of using Virtual Reality (VR) in science learning on junior high school students' visual–spatial abilities. The research employed a quantitative approach with a quasi-experimental nonequivalent control group design. The sample consisted of two eighth-grade classes at a public junior high school, with Class VIII F as the experimental group and Class VIII E as the control group. The research instruments included validated pretest–posttest questions and observation sheets to assess the implementation of learning. Data were analyzed using the Independent Sample t-test and Cohen's d effect size. The results showed a significant difference between the experimental and control groups ($p < 0.05$), with higher visual–spatial ability scores in the group that learned using VR. The effect size value ($d = 0.6604$) indicates a moderate effect of VR-assisted discovery learning. The novelty of this study lies in the integration of immersive VR technology within a discovery learning model to enhance students' mental visualization of abstract science concepts, suggesting that VR has the potential to serve as an effective and engaging instructional innovation in science education.

Keywords: DL, Virtual Reality, Visual Spatial Ability.

Journal Homepage https://jurnal.educatech.id/index.php/jense
How to cite: Miskiyah, U. N. Z., & Rahmawati, L. (2025). The Effect of Discovery Learning Assisted by Virtual Reality on the Visual Spatial Ability of Junior High School Students Learning Respiratory System Material. *Journal of Excellence in Natural Science Education 1*(1), 44–54.
Published by: Indonesia Cakap Digital

INTRODUCTION

Technological developments have become a promising alternative in developing effective, efficient, and superior learning media (Dika et al., 2018). The teaching and learning process, which was previously dominated by conventional methods, is now shifting to more modern and interactive methods. One innovation in the field of education that is attracting increasing attention is the use of virtual reality (VR) technology. According to Herlangga (2016), the use of VR can encourage student activity in the learning process, making it suitable for increasing interest in learning. This technology integrates digital elements with data from the real world and is able to adapt to the environment directly, as well as being accessible via mobile devices. In this rapidly developing digital era, the world of education is required to adapt to various technological innovations in order to improve the quality of the learning process.

Advances in information and communication technology have opened up great opportunities in creating learning media that is not only interesting but also capable of addressing the challenges in understanding complex concepts. One of the main challenges in teaching science at the junior high school level is the students' limited ability to understand abstract material, such as the human respiratory system. To overcome this, the use of technology-based learning media has become an urgent necessity to make the learning process more effective and meaningful. Interviews with teachers at SMP Negeri 16 Yogyakarta showed that students' spatial visual abilities in this subject matter are still not optimal.

In the context of this research, visual spatial ability is defined as a student's ability to understand, process, and manipulate visual information related to the structure and relationships between parts in three-dimensional space. The operational definition of visual-spatial ability refers to the ability to imagine organ structures, understand spatial relationships between parts of the respiratory system, and visualize transformations or rotations of biological objects (Lohman, 1996; McGee, 1979; Hegarty & Waller, 2005). This indicates the need to improve the quality of learning, among others by utilizing digital media that can visualize concepts more realistically. VR is one of the media that has the potential to be used for virtual experience-based learning, with the support of various platforms such as Unity, Cardboard, Millea Lab, and others (Kristiansen & Lauridsen, 2025). This technology is seen as an effective solution to overcome learning challenges in the real world and has been recognized as an important breakthrough in education (Sun, Lin, & Wang, 2010), as it has the potential to improve student learning retention (Chou, 2017).

In line with this, the discovery learning model proposed by Bruner (in Emetembun, 1986) and Budiningsih (2005) emphasizes the importance of students' active role in discovering concepts or knowledge themselves through intuitive thinking processes. This model is highly suitable for integration with VR technology, as both require active student involvement and exploration. Although various studies have shown that technology-based media can improve visual spatial abilities, research on the effectiveness of VR, particularly the milea Lab application, in teaching the respiratory system at the junior high school level is still very limited. Therefore, it is important to explore and test the effectiveness of more interactive and engaging learning media, such as Android-based VR through the Milea Lab application. This study aims to measure the extent to which the use of VR can influence students' visual spatial abilities in respiratory system material. It is hoped that with the use of VR, students can be more actively involved in learning, understand the material better, and develop a positive scientific attitude.

RESEARCH METHOD

Research Design

This study employed a quantitative research approach using a quasi-experimental design with a nonequivalent control group design. Two classes were involved as research samples, with class VIII F serving as the experimental group and class VIII E as the control group. The samples were selected using purposive sampling to ensure suitability for the treatment and research objectives. The experimental class received treatment through Discovery Learning assisted by virtual reality (VR) media, whereas the control class used the Discovery Learning method supported by PowerPoint. Both groups were given a pretest before the treatment to measure initial ability and a posttest afterward to assess changes in spatial visual abilities, allowing comparisons between the two learning approaches.

Table 1. Nonequivalent Control Group Design Research Design

Group	Pretest	Treatment	Posttest
Experimental	O_1	X_1	O_2
Control	O_3	X_2	O_4

Table 1 presents the Nonequivalent Control Group Design used in this study. This quasi-experimental design involves two groups—a treatment (experimental) group and a comparison (control) group—without random assignment of individual students. Both groups received a pretest (O_1 and O_3) before the intervention and a posttest (O_2 and O_4) afterward. The experimental group received the treatment in the form of VR-based learning using the Milea Lab application (X_1), while the control group was taught using the conventional discovery learning model (X_2). By comparing the pretest and posttest results of both groups, this design allows the researcher to evaluate the effect of the VR intervention on students' visual–spatial ability.

The research was carried out at SMP Negeri 16 Yogyakarta during the 2024/2025 academic year. All data collection activities—including treatment implementation, pretests, posttests, and observations—were conducted in the classrooms where regular learning activities normally took place. This ensured that the research process occurred in a natural school environment and maintained the ecological validity of the instructional interventions.

Research Target/Subject

The subjects of this study were eighth-grade students at SMP Negeri 16 Yogyakarta. Two classes were selected as the research sample using purposive sampling, with class VIII F assigned as the experimental class and class VIII E as the control class. This sampling technique was used because both classes met the required criteria for implementing Discovery Learning and VR-based learning activities. The students in each class participated in the learning process, pretests, posttests, and observations related to spatial visual ability development.

Research Procedure

The research procedure began with administering a pretest to both the experimental and control groups to measure students' initial spatial visual abilities. Afterward, the experimental group received learning using the Discovery Learning model assisted by virtual reality media, while the control group received Discovery Learning assisted by PowerPoint presentations.

During each learning session, observers recorded the implementation of learning activities using observation sheets. After the treatment sessions were completed, a posttest was administered to both groups to measure improvement and compare outcomes. This sequence enabled the researcher to determine whether virtual reality–assisted Discovery Learning had a significant effect compared to conventional Discovery Learning using PowerPoint.

Instruments, and Data Collection Techniques

The instruments used in this study consisted of pretest and posttest sheets to measure students' spatial visual abilities, along with learning implementation observation sheets. The pretest was conducted before learning to assess initial abilities, while the posttest was given afterward to evaluate learning outcomes. Spatial visual ability indicators assessed in the test included imagination, conceptualization, problem solving, and pattern finding. The observation sheet was used to assess the implementation of learning activities through observer scoring during the sessions. All instruments underwent validity and reliability testing using SPSS, resulting in 25 valid multiple-choice questions for use in the tests. Data collection consisted of test administration, classroom observations, and documentation of learning implementation.

Data Analysis Technique

Data analysis included several stages. First, percentage analysis was used to interpret the learning implementation data by calculating percentages of observer scores during instructional activities. The results were interpreted according to predetermined categories. Prerequisite tests, including normality and homogeneity tests, were conducted using the Shapiro–Wilk method because the sample size exceeded 50 students. Data were considered normally distributed and homogeneous when the significance value (Sig. 2-tailed) was greater than 0.05. After meeting prerequisite criteria, hypothesis testing was conducted using the Independent Sample T-Test through IBM SPSS Statistics 30 to determine differences in spatial visual abilities between the experimental and control groups. To determine the magnitude of the effect of VR-assisted learning, Cohen's effect size was calculated using Cohen's formula. The interpretation of the effect size followed Cohen's guidelines Cohen et al. (2018:746).

RESULTS AND DISCUSSION

Learning Implementation

The implementation of learning activities in this study was measured using observation sheets filled out by an observer during the teaching and learning process based on the criteria listed on each observation sheet, both for the experimental class and the control class. The results of the implementation of learning in the experimental class using the discovery learning model assisted by virtual reality media and the control class using the discovery learning model assisted by PowerPoint media are presented in Table 2.

Table 2. Learning Implementation Results

Class	Average %	Criteria
Experiment	98	Very Good
Control	100	Very Good

Based on Table 2, it shows that the implementation of learning in the experimental class and control class was very good. In the experimental class that used the *discovery learning* model assisted by *virtual reality* media, the average score was 98%, and in the experimental class that used the *discovery learning* model assisted by PowerPoint, the average score was

100%. This shows that the learning activities during the study went very well and were in accordance with the syntax in the teaching module that had been prepared as a research instrument.

Pre-test and Post-test Data on Spatial Visual Ability

The pre-test and post-test questions in this study consisted of 25 multiple-choice questions covering material on the human respiratory system. The points obtained for the students' visual spatial abilities are presented in Table 3.

Table 3. Pre-test and Post-test Results of Visual Spatial Ability

Aspect	Control	Experimental
N Valid	32	32
Pre-test Average	55	56
Post-test Average	74	85
Difference between Pre-test and Post-test	19	29

Table 3 shows that the average *pre-test* scores achieved by the experimental class were higher than those of the control class. Similarly, the average *post-test* scores achieved by the experimental class were also higher than those of the control class. The difference between the average *pre-test* and *post-test* scores in the experimental class is higher than that in the control class. The difference between the average pre-test and post-test scores in the experimental class is 10 points greater than the difference between the average pre-test and post-test scores in the control class.

Pre-test and post-test questions were used to measure students' initial knowledge before being given treatment and their final knowledge after being given treatment. The visual spatial ability indicators studied were imagination, conceptualization, problem solving, and pattern finding, in accordance with the *pre-test* and *post-test* questions related to visual spatial abilities used in this study. Each indicator was analyzed by calculating the number of student scores on each indicator, then calculating the total number of scores in one class on that indicator, and then calculating the average by dividing the number of items in the indicator. The results of the spatial visual ability scores are presented in Table 4.

Table 4. Average Score of Visual Spatial Ability Indicators

No.	Aspect	Control	Experimental
1	Imagining	19.27	20.31
2	Conceptualization	17.19	22.66
3	Problem Solving	19.79	21.61
4	Pattern Search	18.23	20.57
	Maximum Average	6.20	7.10

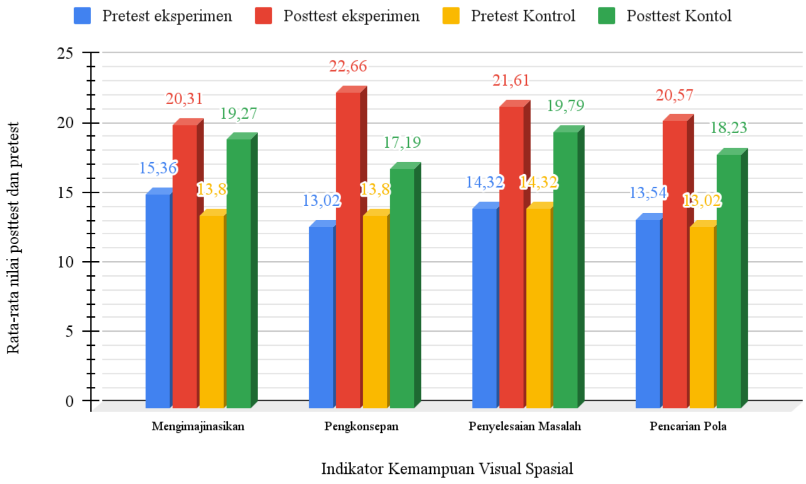

Figure 1. Graph of the average pretest and posttest scores for spatial visual ability

Based on Table 4 and Figure 1, the average scores for each indicator of spatial visual ability can be seen for both the control and experimental groups. Overall, there was an increase in the average scores for each indicator of spatial visual ability in both classes after the treatment. However, a more significant increase occurred in the experimental group, with a total difference in the average before and after treatment of 28.92, while for the control class, the total difference after treatment was 19.54. Overall, the average score of the experimental class was higher than that of the control class.

Independent Sample T-Test

In this study, hypothesis testing used the Independent Sample t-test analysis technique to determine differences and test the effect size to determine the magnitude of the effect. The following is the analysis that has been carried out.

Hypothesis testing with the Independent Sample T-Test was conducted using the SPSS program at a significance level of 0.05. The data was considered different if the significance (2-tailed) was < 0.005, then H0 was rejected. The data tested using the *Independent Sample T-Test* analysis technique was the *post-test* scores of the experimental and control classes.

Table 5. Results of the Independent Sample T-Test

Visual Ability Spatial	Sig. (2-tailed)	Criteria	Description
Post-test experimental class and control class	0.005	Sig. (2-tailed) < 0.05	There is a significant difference

Based on Table 5, the results of *the Independent sample T-test* of the post-test scores for the experimental class and the control class show a Sig (2-tailed) value of < 0.05, which means that H1 is accepted and H0 is rejected, indicating that there is a difference in the use of *virtual reality* media and PowerPoint on the spatial visual abilities of eighth-grade junior high school students in the respiratory system material.

Effect Size Test

The *effect size* test results were used to find the value of the difference between the independent variable, which was *virtual reality-based* learning media, and the dependent variable, which was spatial visual ability. The results of the effect size test analysis for the experimental class and the control class are presented in Table 6.

Table 6. Effect Size Test Results

Spatial Visual Ability	Results	Cohen's Criteria	Description
Post-test experimental class	0.6604	0.9 d 0.2	Moderate

Based on Table 6, the results of the *effect size* analysis using *Cohen's* formula obtained a value of 0.6604 for the spatial visual ability variable. The effect size analysis results obtained, when adjusted to Cohen's value interpretation criteria, show that the value for the spatial visual ability variable falls into the moderate category. This means that the use *of virtual reality*-assisted learning media has a moderate influence on the spatial visual ability of eighth-grade junior high school students in the respiratory system material.

This study shows that the use of *a discovery learning* model assisted by *virtual reality* media in the experimental class yielded better results than the use of PowerPoint media in the control class. This is in line with the theory that students learn more effectively when they are actively involved in discovering concepts themselves, rather than just passively receiving information. Rosdiana et al. (2017) emphasize that *discovery learning* is a learning approach that emphasizes the active role of students in constructing knowledge through the process of exploration. In its implementation, students are divided into several groups to make observations and complete Student Worksheets (LKPD) based on their observations. This encourages critical thinking, group interaction, and direct engagement with the teaching material.

The use of *virtual reality* media provides an immersive learning experience, where students can see, feel, and manipulate virtual objects as if they were in a real environment. This technology facilitates *experiential learning*, which is very effective in helping students understand abstract concepts, such as the working mechanisms of respiratory organs, air movement pathways, and the relationships between structures in the respiratory system. Herlangga (2016) and Chou (2017) state that VR can increase student engagement, learning retention, and spatial thinking skills through interactive visual presentations that cannot be achieved with two-dimensional media such as PowerPoint. The following is an illustration of students' enthusiasm in using *virtual reality* media.

Figure 2. Students' enthusiasm in using virtual reality media

The spatial visual ability that is the focus of this study is the ability of students to understand visual and spatial information, including imagining, creating, and understanding spatial relationships, both real and abstract. Dadang (2007) states that children with visual spatial intelligence tend to be able to think visually, creatively, and show interest in fields such as fine arts, design, architecture, and animation. They are also able to imagine shapes in two or three dimensions and understand spatial patterns in depth. According to Haas (2003), visual spatial abilities can be identified through four indicators, namely: 1) imagination, which is the ability to imagine two- or three-dimensional shapes. 2) conceptualization, which is the ability to understand and analyze the relationships between objects in space, 3) problem solving, which is the ability to solve problems related to shapes and space, and 4) pattern recognition, which is the ability to recognize patterns in space.

Based on the *pretest* results, it can be seen that the average spatial visual ability scores between the experimental class and the control class were relatively comparable, indicating that both groups had similar initial abilities. However, after the treatment, the posttest scores showed a significant increase in the experimental class compared to the control class. This shows that the use of *virtual reality* technology in *discovery learning-based* learning can actually provide a more in-depth and contextual learning experience, thereby improving students' visual spatial abilities.

The improvement in spatial visual abilities was more specific in each indicator, namely in the first indicator, imagining, which consisted of three questions aimed at measuring students' ability to imagine the shape and structure of an object in space. The results showed that the score increase in the experimental class was 4.95, while in the control class it was slightly higher, at 5.47. This indicates that the use of *virtual reality* media did not have a significant additional impact compared to PowerPoint on this indicator. According to Libranti et al. (2015), the characteristics of the ability to imagine in visual spatial include understanding perspective, translation, reflection, or rotation, as well as the ability to visualize changes in the position and orientation of objects. Students with this ability find it easier to understand material with the help of pictures or diagrams than verbal explanations because they can internalize information through visual imagination.

The second indicator is conceptualization, which measures students' ability to understand and conceptualize information visually. The increase in scores in the experimental class reached 9.64, much higher than the control class, which only increased by 3.39. These results show that Virtual Reality media is more effective in helping students build a strong conceptual understanding. Libranti et al. (2015) stated that students with high spatial visual abilities are able to connect facts and build conceptual frameworks to understand the core of a problem, even if they have difficulty memorizing formulas. In this context, the use of VR helps students understand concepts not only theoretically but also through concrete visual experiences.

The third indicator is problem solving, which measures students' ability to use spatial visual skills to solve problems. The score increase in the experimental class was 7.29, while in the control class it was 5.47. These results indicate that *virtual reality* media can strengthen the spatial understanding needed to solve problems. According to Libranti et al. (2015), students with high visual spatial problem-solving abilities are able to understand a problem from various perspectives and produce more than one solution approach. The application of VR-assisted *discovery learning* is very relevant in this case, especially in the *data processing* and *generalization* stages. In the *data processing* stage, students process data from observations, interviews, or experiments through organization, classification, and numerical analysis. This stage trains analytical thinking skills to evaluate data before drawing conclusions. Hosan (2014:289) states that this process provides an opportunity for students to verify and organize information logically.

The last indicator is pattern recognition, which is the ability of students to recognize and find patterns in spatial structures. The improvement in the experimental class reached 7.03, while the control class only reached 5.21. Although the difference is not too big, this data shows that the use *of virtual reality* provides an advantage in helping students identify patterns visually. Libranti et al. (2015) explain that students with this ability are able to find regularities in spatial problems and use these patterns to solve problems. The application of VR-assisted *discovery learning* supports the development of this ability through data collection and data processing syntax.

Thus, the results of this study confirm that the combination of the *discovery learning* model and *virtual reality* media can be an effective learning strategy to improve students' spatial visual abilities, especially in understanding abstract and complex materials such as the human respiratory system. This innovation can be widely adopted as an alternative to interactive, innovative digital learning media that meets the demands of 21st-century education.

CONCLUSION

Based on the results of the analysis and discussion, it can be concluded that *the discovery learning* model assisted by *virtual reality* media has a significant difference and a high impact on students' spatial visual abilities. This impact is evidenced by a 2-tailed Significance Value of < 0.05 in the *independent sample t-test* and a Cohen's *effect size* test value that falls into the high category.

Recommendations for future researchers include conducting studies with larger samples and over longer periods of time in order to obtain more generalized and in-depth results, as well as adding more diverse evaluation instruments, such as interviews or direct observation, to gain a deeper understanding of how *virtual reality* affects students' understanding and skills.

ACKNOWLEDGMENTS

The author expresses sincere gratitude to the teachers and students at a public junior high school in Yogyakarta for their willingness to take part in this study and for their valuable contributions during data collection. The author also conveys deep appreciation to the supervisor and research group for the guidance, feedback, and constructive suggestions provided throughout the research process. Appreciation is likewise extended to fellow students and all individuals who offered support, whether directly or indirectly, in the implementation and completion of this research.

AUTHOR CONTRIBUTIONS

Author 1: Conceptualization; Investigation; Project administration; Validation; Writing – review and editing; Data curation; Formal analysis; Methodology; Writing – original draft; Resources; Visualization.

Author 2: Validation; Formal analysis; Other contributions; Resources; Supervision.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

REFERENCES

Budiningsih, C.Asri. (2005). *Belajar dan Pembelajaran*. Jakarta: PT. Asdi Mahasatya.

Chou, C.C. (2017). An Analysis of The 3D Video and Interactive Response Approach Effects on The Science Remedial Teaching for Fourth Grade Underachieving Students. *Eurasia Journal of Mathematics, Science and Technology Education*, 13(4), 1059–1073. https://doi.org/10.12973/eurasia.2017.00658a

Dadang, A. (2007). *Mencerdaskan potensi IQ, EQ, dan SQ*. Bandung: Globalindo Universal Multikreasi.

Dika, J., Brata, K. C., & Az-Zahra, H. M. (2018). Evaluasi Usabilitas dan Perbaikan Tampilan Desain Antarmuka Pengguna Situs Web Eventmalang.net dengan Pendekatan Human-Centered Design, WEBUSE, dan Importance-Performance Analysis. *Jurnal Pengembangan Teknologi Informasi Dan Ilmu Komputer*, 2(10), 3655–3663. https://j-ptiik.ub.ac.id/index.php/j-ptiik/article/view/2695

Hegarty, M., & Waller, D. (2005). Individual differences in spatial abilities. *The Cambridge Handbook of Visuospatial Thinking*.

Herlangga, K. (2016). *Virtual reality dan Perkembangannya*. Diakses dari https://www.codepolitan.com/virtual-reality-dan-perkembangannya

Kristiansen, E., & Lauridsen, E. (2025). How is it going? - Virtual Reality used in student counselling - practices and experiences from using VR for personal conversations. *Computers & Education: X Reality*, 7. https://doi.org/10.1016/j.cexr.2025.100119

Lohman, D. F. (1996). Spatial ability and g. *Human Abilities*.

McGee, M. G. (1979). Human spatial abilities: Psychometric studies and environmental, genetic, hormonal, and neurological influences. *Psychological Bulletin*, 86(5), 889–918. https://psycnet.apa.org/record/1979-32746-001

Rosdiana, and Dkk.(2017). Pengaruh Penggunaan Model Discovery Learning Terhadap Efektivitas Dan Hasil Belajar Siswa. *Jurnal Pendidikan: Teori, Penelitian Dan Pengembangan*. Vol 2, no. 8.

Sun, K. T., Lin, C.L. & Wang, S.M. 2010. A 3-D Virtual Reality Model of The Sun and the Moon For E-Learning At Elementary Schools. *International Journal of Science and Mathematics Education*, 8(4), 689–710. https://doi.org/10.1007/s10763-009-9181-z

Uskono, Y. C., Simarmata, J. E., & Mone, F. (2023). Pengembangan Media Pembelajaran Berbasis Lectora Inspire Dengan Model Discovery Learning Untuk Meningkatkan Kemampuan Pemahaman Konsep Siswa. *Jurnal Penelitian Pembelajaran Matematika Sekolah (JP2MS)*, 7(3), 385-394. Diakses dari https://doi.org/10.33369/jp2ms.7.3.385-39418

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education Eighth Edition*.

Anggraini, P. D., & Cahyaka, H. W. (2024). Perbedaan Hasil Belajar Antara Model Pembelajaran STAD dan Model Konvensional Pada Mata Pelajaran Gambar Teknik Kelas X TKP SMK N 2 Surabaya. *Jurnal Kajian Pendidikan Teknik Bangunan (JKPTB)*, 10(2), 53–61.

Librianti, D. L., Sunardi, Sugiarti. (2015). Kecerdasan Visual Spasial dan Logis Matematis dalam Menyelesaikan Masalah Geometri Siswa Kelas VIII A SMP Negeri 10 Jember. *Artikel Ilmiah Mahasiswa,* 1(1). 1-7.