25 (2), 2024, 569-581

Jurnal Pendidikan MIPA

e-ISSN: 2685-5488 | p-ISSN: 1411-2531

http://jurnal.fkip.unila.ac.id/index.php/jpmipa/

Wordwall Interaction Media Development to Increase Mathematical Connection and Visual Thinking of Junior High School Students

Muhammad Allegra Prima Aristya Putra, Baiduri, & Zukhrufurrohmah*

Department of Mathematics Education, University of Muhammadiyah Malang, Indonesia

Abstract: In today's digital era, optimizing the use of technology in education has become a primary focus for enhancing the quality of learning. One potential innovation in this area is the use of interactive media in the teaching and learning process, which not only increases students' interest but also deepens their understanding of concepts and mathematical skills. This study aims to develop an interactive learning media based on Wordwall that can improve mathematical connection abilities and visual thinking skills among junior high school students. This research is a development study (R&D) following the ADDIE research method, which begins with the analysis phase, followed by the design phase, the development phase, the implementation phase, and concludes with the evaluation phase. The study was conducted in the even semester of the 2023/2024 academic year, involving eighth-grade students as research subjects. The research instruments used include media validation sheets, student response questionnaires, and tests of mathematical connection abilities and visual thinking skills. The results indicate that the Wordwall-based learning media has very high validity, with a validation score of 95.2%. The tests of mathematical connection abilities and visual thinking skills show that this media can improve students' mathematical connection abilities at a moderate level, with an N-Gain value of 0.419, and enhance visual thinking skills at a low level, with an N-Gain value of 0.241. Additionally, this media was also rated as highly practical, with a practicality score of 88.8%. Overall, this Wordwall-based learning media is valid, effective, and practical, making it recommended for use in teaching to improve students' mathematical connection abilities and, to a lesser extent, their visual thinking skills.

Keywords: interactive media, Wordwall, mathematical connections, visual thinking.

▪ INTRODUCTION

Mathematics is crucial in education since it closely relates to analytical and logical reasoning (Moussa & Saali, 2022). This subject includes various topics, ranging from simple to advanced concepts, which are integrated among one another and are significant to achieve in-depth understanding (Khairunnisak et al., 2020). Mathematics learning invites students to improve their critical and logical thinking (Liu et al., 2024), essential in understanding mathematical concepts and solving problems in daily life (Pratiwi & Widjajanti, 2020). The correlation among various concepts in mathematics, such as theory and application, enables students to view a more comprehensive and in-depth understanding of topics and makes them master the material comprehensively (Rafiepour & Faramarzpour, 2023). Therefore, mathematical fluency not only provides knowledge but also trains students' way of thinking towards subjects and making rational decisions.

According to Dudung & Oktaviani (2020), the indicator of mathematical connection is feasible in three aspects. The first aspect is the ability to connect different mathematical concepts in one topic and among different topics. The second is correlating different mathematical concepts with actual conditions apart from academic context, such as daily life or other practical applications. The third is using mathematical concepts in different contexts, such as science and technology, demonstrating flexibility and

Zukhrufurrohmah
*Email: zukhrufurrohmah@umm.ac.id

DOI: http://dx.doi.org/10.23960/jpmipa/v25i2.pp569-581
Received: 02 August 2024
Accepted: 20 August 2024
Published: 17 September 2024

interdisciplinary thinking. These indicators are essential to ensure that students master the theories and can apply them in different contexts to produce an in-depth understanding and better problem-solving skills (Loka Son, 2022).

Mathematical connection has long become a significant issue in education (de Gamboa, Badillo, & Font, 2023; Hatisaru, 2024). Mathematical connection is the ability to correlate one concept with another, one concept with another subject, and also with daily life (Azizah, Ulya, & Wanabuliandari, 2022; Purwanti, Mardiyana, & Indriati, 2021). This ability also uses data collection, analysis, and interpretation skills, such as in statistics (Rahmanti, Hobri, & Oktavianingtyas, 2018). Mathematical connection is a fundamental skill that represents several mathematical concepts applied to develop other subjects and solutions in daily life (Loka Son, 2022). Students' ability to apply this skill is significant during learning as it helps the subject develop mathematical skills faster (Kenedi, Helsa, Ariani, & Zainil, 2019). Nevertheless, some students still need help solving a particular problem that requires connecting mathematical concepts and other subjects (de Gamboa, Badillo, & Font, 2023; Wahyuni, Rusdi, & Huda, 2021)

Apart from mathematical connection skills, visual thinking is also significant (Albert, Mihai, & Mudure-Iacob, 2022; U. Sholihah et al, 2019). Visual thinking is one method of enabling students to learn mathematics more efficiently (Ummu Sholihah & Asyhar, 2018; Sitompul, Surya, & Sinaga, 2020). This skill shows the ability to interpret, process, visualize, or transform information from various graphs, images, or other forms that help to communicate the information (Arini & Surya, 2017). Visual thinking includes converting mathematical concepts into graphs, figures, diagrams, and vice versa (Hrp, Surya, & Mulyono, 2021). Visual thinking also involves data representation in graphs and diagrams, as in statistics (Jannah, 2018). This skill is fundamental for students while learning mathematics, and it can become a significant asset and provide meaningful insights into mathematical concepts (Sholihah, Nusantara, Sa'dijah, & Susanto, 2019). Visual thinking stimulates the mental ability to use visual action, such as recognizing similarities and differences between visual objects in written and oral form Apart from the essential meaning of visual thinking for students, (Juandi & Priatna, 2018; Sholihah & Maryono, 2020), research by Sholihah & Maryono (2020) shows that some students still need to meet the visual thinking indicators.

Mathematical connection and visual thinking issues can be due to inadequate learning media; for example, the learning only uses textbooks; thus, students cannot interact or receive quick feedback on their mistakes and problems, which might hamper the learning process (Azizah, Ulya, & Wanabuliandari, 2022). Therefore, students need interactive learning media to solve these issues, enabling them to pay attention to the material and actively interact during the lesson (Harsiwi & Arini, 2020). Interactive learning media can reduce boredom and create a more attractive, practical, and fun process (Novita & Harahap, 2020). Learning media is a two-way application/ software/ product with its users designed to offer interactive learning in 3D, graphics, audio, and animation to create interaction (Atmazaki, Ramadhan, & Indriyani, 2023; Sahronih, Purwanto, & Sumantri, 2020). Compared to conventional media, interactive media enables teachers to use technology in learning, which aligns with world advancement and makes the material more attractive and fun; students can achieve a more comprehensive understanding, experience real-situ Proposal Skema Layanan Penerjemahan Gratis untuk Dosen Universitasation learning, and have enthusiasm toward material presented in class

(Rasmani et al., 2023). Media yang interaktif lebih efektif daripada media konvensional Interactive media is more effective than conventional media (Damarwan & Khairudin, 2017) and can direct students to a more active learning activity (Yanti, Anggraini, & Darwanto, 2019). Interactive media must encourage students to be more curious and enjoy learning (Yanti, Anggraini, & Darwanto, 2019; Yunarti, Loviana, & Safaatin, 2022). Wordwall is an innovative learning media application for educators (Arsini, Santosa, & Marsakawati, 2022). Wordwall consists of game templates that can create interaction during the learning process (Amri & Sukmaningrum, 2023; Nenohai et al., 2022). Wordwall is available online and accessible through the website; therefore, students can access it through Android and computers without needing to install the application. This media offers interactive games such as Word Search, Hangman (word guessing) and Bingo (using words or phrases relevant to the learning topic which can increase teacher engagement in the learning process, particularly in mathematics (Akbar & Hadi, 2023). Wordwall enables teachers to create learning content rich in figures, graphs, and other visual elements to help students understand visual thinking concepts involving information processing and understanding through figures, diagrams, or other visual representations, which is fundamental in mathematics (Nasution, 2020).

Several previous studies have learned about interactive learning media in the context of mathematics education. For example, studies by Faatin & Rusnilawati (2022) and Ilahi, Sudiana, Nindiasari, Sultan, & Tirtayasa (2022) show that interactive learning media such as Wordwall can increase students' thinking skills and motivation, consequently reducing mathematical anxiety. Another study by Nissa & Renoningtyas (2021) also supports the effectiveness of Wordwall to increase students' interest and participation in learning mathematics. Nevertheless, despite exploring the Wordwall benefit in various aspects of learning mathematics, studies have yet to be focused on evaluating the Wordwall effect on students' mathematical connection and visual thinking.

The novelty of this research lies in its specific focus on Wordwall interactive media to increase mathematical connection and visual thinking for junior high school students. This research also fills the gap in the existing literature by investigating two significant aspects of mathematical learning: mathematical connection and visual thinking. Although several studies have investigated motivation, interest, and mathematical anxiety, there have not been any reviews of Wordwall and its potential to develop these two essential skills. Therefore, this research offers an in-depth and specific approach by filling in the existing literature gap.

▪ METHOD

Participants

This research is developmental research, a process to develop or improve a product, commonly known as Research and Design (R&D) using the A.D.D.I.E. model, which consists of five stages: analysis, design, development, implementation and evaluation (Rahman, Faisal, & Tho, 2023). This research took place in a private junior high school in Batu City that consisted of 26 students in 8th grade during the event semester.

Research Design and Procedures

The five developmental stages using the A.D.D.I.E model are 1) analysis involving the needs found in the field. The researcher conducted requirement analysis through

observation; 2) the design stage, which shows the planning of Wordwall interactive learning media design to increase mathematical connection and visual thinking of students; 3) the developmental stage, where the researcher developed Wordwall according to the material and objective to deliver in class. The media underwent a validation process by one mathematics teacher and one mathematics education lecturer, which became the revision base; 4) implementation stage: valid Wordwall media underwent a test in a private junior high school at Batu city, East Java; 5) evaluation stage: assessing the success and effectivity of the media in increasing mathematical connection and visual thinking. This stage also assessed the validity and practicality of Wordwall in the learning process.

Instrument

This research utilized test and non-test instruments: a student response questionnaire and a test sheet. The test lasted 40 minutes in two meetings: pre-test and post-test for Wordwall-based interactive media. The researchers developed pre-test and post-test items validated by the validator. The test items were different sentences and problems but included similar indicators and levels of difficulty. Each item of the test represents more than one indicator of mathematical connection and visual thinking. Problem 1 tested the mathematical connection skill with its indicator and the visual thinking skill with the indicator of searching and observing. In contrast, number 2 tested the mathematical connection skill with mathematical connection in real life and mathematical connection in daily life and the visual thinking skill with an indicator of imagining and narrating. At the same time, the student response questionnaire was used for data collection purposes, providing a set of questions to respondents. This questionnaire is an adaptation of valid research from Sudarsono (2021). The questionnaire consisted of five aspects: media design, media application, ease of media, mathematical connection skill, and visual thinking skill, all of which had three questions.

Data Analysis

The data analysis technique applied in this research was data validity and practicality using the Likert scale, which transform qualitative to quantitative using scoring. According to Wiyono, Baiduri, & Zukhrufurrohmah (2023) the Likert scale consists of four categories: very valid/ very practical, valid/ practical, less valid/ less practical, and invalid/ not practical. The data come in different categories based on the percentage achieved from the media analysis being developed, as shown by the Likert scale criteria in Table 1.

Table 1. Assessment criteria

Achievement percentage (%)	Validity	Practicality
$76\% < P \leq 100\%$	Very valid	Very practical
$51\% < P \leq 75\%$	Valid	Practical
$26\% < P \leq 50\%$	Less valid	Less practical
$P \leq 25\%$	Invalid	Impractical

Effectivity data analysis is feasible based on the mathematical connection and visual thinking skills test results, which aligns with research by (Sudarsono, 2021) which states that learning media effectiveness is the result of pre-test and post-test. Further, to

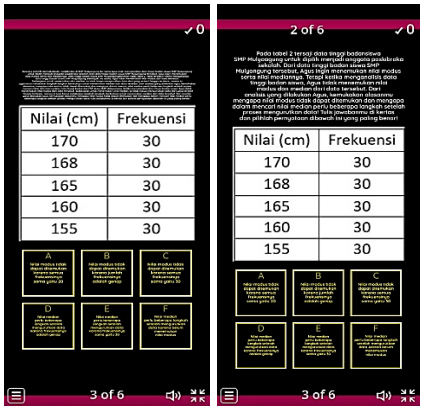
identify the success rate of critical thinking and problem-solving skills, the research used the n-Gain formula. The increase before and after using comic media refers to the n-Gain formula. The effectiveness of comic media based on its categories refers to the n-Gain result. According to Wiyono, Baiduri, & Zukhrufurrohmah (2023) N-Gain ≥ 0.7 refers to the high category, $0.3 \leq$ N-Gain <0.7 refers to the moderate, and N-Gain < 0.3 refers to the low category.

▪ RESULT AND DISSCUSSION

This research and development produced a valid, practical, and compelling interactive media: Wordwall. The analysis stage was based on observation at a private junior high school in Batu City. The results of the analysis became a reference for developing Wordwall as a learning media. The observation showed that 8th-grade students did not use interactive learning media frequently, such as Wordwall; instead, they used PPT, workbooks, and L.K.P.D., which was less attractive for students. Additionally, researchers identified several students who needed help connecting mathematical concepts and processing information based on visual forms such as diagrams or tables. Therefore, researchers assume that developing interactive learning media such as Wordwall can significantly increase students' mathematical connection and visual thinking skills.

The second stage is the design of learning media. This stage started by selecting the media, which was a Wordwall interactive game. The game used a "gameshow quiz" template, which offers a fun way to test students' skills in a form similar to a television quiz. The main feature of this game is multiple-choice problems, where the researchers have added precise figures and items that can increase the students' mathematical connections and visual thinking skills. With the timer feature, the test creator can determine the time limit for each question, which adds challenge and speed elements to the game. The point and scoreboard scheme enables the test creator to give points for the correct answer, time spent answering, and the student's ranking. Therefore, this game can boost the students' engagement in learning. There are also bonus and double rounds as variations and elements of the game for extra points and challenges.

The third stage was development, related to the media development process from design and instrument production to assessing mathematical connections and visual thinking skills. A mathematics education lecturer and a mathematics teacher would validate the media and instruments. After validation, researchers revived the media based on suggestions and comments before implementing it with students. Researchers developed word wall-based media to help students' mathematical connection and visual thinking skills using seven questions based on the indicators to assess. During the development stage, media validation includes the media and content aspects. Media validation involved two validators. The validation aims to ensure that the media design, layout, and functionality meet the standard and are effectively applicable. In contrast, content validation aims to ensure that the content is accurate, relevant, and aligned with learning objectives. Media validation was done by testing the media and scoring it according to the indicators provided in the questionnaire. The validators' suggestions became the basis for revising the media before testing it on students. Validators also measured the text readability. Researchers also completed the revision, as illustrated in Figure 1.



(a) (b)

Figure 1. Question page, (a) before and (b) after revision

In Figure 1, the question appears small due to its overlength display. After the revision, the media underwent another validation. The final result from the validator's assessment, which included presentation, engagement, facilitation of mathematical connection skills, and facilitation of visual thinking skills, achieved 95.2%, indicating that the question meets the Very Valid criteria.

Content validation resulted from assessing the content's accuracy, relevancy, and suitability with learning objectives based on indicators provided in the questionnaire. Validators suggested revising the material before students tested it, which included adjusting the content for middle school students.

Based on the average assessment of two validators, The final result of this assessment, which included aspects such as learning, content, ease of mathematical connection skills, and facilitation of visual thinking skills, achieved a score of 95%, which states that Wordwall media is available for test if it meets the valid criteria.

The fourth stage of this research is the implementation stage. During this phase, the researchers conducted a thorough trial of the validated pre-test and post-test questions with students. The questions met the validity criteria set by the validators with a score of 97.4%. This stage aims to assess the effectiveness and reliability of the test instruments, ensure that the instruments accurately measure mathematical connection skills and visual thinking, and provide valuable data for the research. Based on test result data, the comparison of students who meet each indicator of mathematical connections is as in Figure 2.

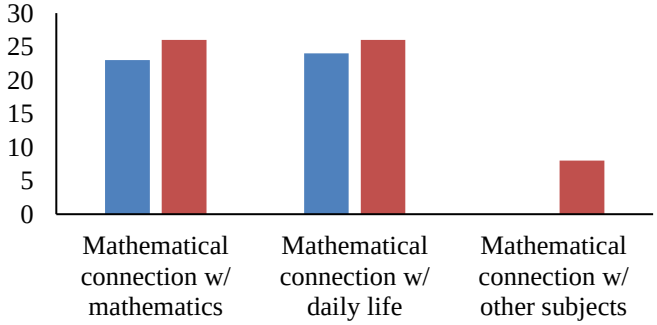


Figure 2 Pre-test and post-test comparison of mathematical connection indicators

There was an insignificant improvement regarding the first and second indicators. In contrast, the third indicator showed a significant increase because, during the pre-test, no students met the criterion of 'mathematical connection with other disciplines' (in this indicator, the researchers integrated mathematical connections with the science subject on the topic of uniform linear motion). This finding indicates an improvement in mathematical connection skills, consistent with the research by Juandi & Priatna (2018); Junedi & Sari (2020) which state that interactive media can help enhance students' mathematical connection abilities. Based on the test result, the number of students who meet each indicator of visual thinking skill is as in Figure 3

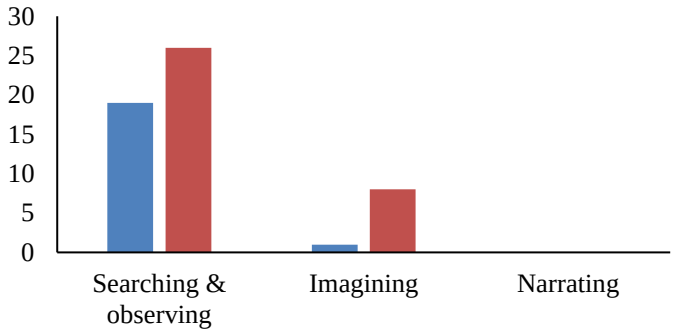


Figure 3 Pre-test and post-test comparison of visual thinking indicators

Improvement is feasible regarding the first and second indicators, although it is not significant. However, for the third indicator, students still needed to meet the criterion, as during both the pre-test and post-test, students still needed to satisfy the 'narration' criterion. This finding indicates an improvement in visual thinking skills, but not significantly, consistent with the research by Sholihah & Maryono, (2020); Tegas & Warmi (2019) which states that many students still need to meet the visual thinking criteria.

The fifth stage is evaluation. At this stage, the researchers evaluated the Wordwall media developed to enhance students' mathematical connections and visual thinking skills. They analyzed the data obtained from students based on the results of pre-test and post-test scores processed using N-Gain and student response questionnaires.

Based on the effectiveness test of the Wordwall media for improving students' mathematical connection skills, the results showed that the average pre-test score increased from 15.667 to 20 in the post-test, with an N-Gain value of 0.419, which falls into the moderate category. As for the mathematical connection skills indicators, the first indicator, 'mathematical connection with mathematics,' and the second indicator, 'mathematical connection with real life,' demonstrated significant improvement, with high N-Gain values. However, the third indicator, 'mathematical connection with other disciplines,' showed less significant improvement, thus falling into the low category. These results indicate that Wordwall is effective in improving certain aspects of mathematical connection skills, particularly mathematical connections with mathematics and real-life applications, but less effective in improving connections with other disciplines. Wordwall proves effective due to its capability to facilitate repetitive practice and evaluation, which helps students strengthen connections between mathematical

concepts. Through various interactive activities, students can relate mathematical concepts to real-life situations or to other concepts within mathematics itself. The flexibility provided by Wordwall also allows for more targeted teaching based on individual student needs, making it easier for them to understand and connect various mathematical concepts. Overall, Wordwall creates an environment that significantly supports the development of mathematical connection skills.

Based on the effectiveness test of the Wordwall media for improving students' visual thinking skills, the results showed that the average pre-test score increased from 6.667 to 11.33 in the post-test, with an N-Gain value of 0.241, which falls into the low category. The first indicator of visual thinking skills is 'searching and observing,' which showed significant improvement with a high N-Gain value. However, the second indicator, 'imagining,' and the third indicator, 'narrating,' demonstrated less significant improvement, thus falling into the low category. These results indicate that Wordwall is effective in enhancing specific visual thinking skills, particularly searching and observing, but less effective in improving imagining and narrating skills. Wordwall effectively improves visual thinking skills due to its ability to present material in an interactive and engaging manner. Features such as quizzes and puzzles enable students to visualize concepts more deeply. Additionally, Wordwall uses various visual representations, such as images, diagrams, and graphs, which help students build connections between the concepts being learned and relevant visual representations. The flexibility in learning offered by Wordwall allows the material to be delivered according to student's needs and learning styles, ultimately making the learning process more effective. Repetitive activities and evaluations also help reinforce understanding and improve students' visual thinking skills.

Based on the questionnaire responses from using the Wordwall media by 26 students, the testing results showed that the average percentage score across various aspects reached 91.54%, which falls into the category of highly practical. The 'design' aspect received a percentage of 92.26%, while the 'usability' aspect achieved 92.85%. The 'ease of use' aspect showed a percentage of 90.17%. The 'mathematical connection skills' and 'visual thinking skills' aspects had percentages of 90.77% and 91.66%, respectively. These results indicate that the Wordwall media is in the "highly practical" category. This finding is consistent with development research conducted by Azizah, Ulya, & Wanabuliandari, 2022; Mulyana & Taufan (2020); Sudarsono (2021) which states that interactive media such as Wordwall is efficient and can be measured based on responses to the tested media.

▪ CONCLUSION

The conclusion of the development research of interactive Wordwall-based media to enhance mathematical connection and visual thinking skills is that the results of the product development for Wordwall-based learning media demonstrate the following: question validation at 97.4% (Very Valid), media expert validation at 95.2% (Very Valid), material expert validation at 95% (Very Valid), and student response questionnaire validation at 88.8% (Very Valid). The N-Gain result for mathematical connection skills scored 0.419, in the 'moderate' category, while visual thinking skills scored 0.241, placing it in the 'low' category. The Wordwall-based learning media is categorized as 'highly practical' with a percentage of 91.54%. Therefore, the Wordwall-

based interactive media is valid, effective, and practical for teaching. Further, the researchers expect that the results of this development research can become the foundation for improving other mathematical skills, particularly in visual thinking, which is still in the low category.

▪ REFERENCES

Akbar, H. F., & Hadi, M. S. (2023). *Pengaruh penggunaan media pembelajaran wordwall terhadap minat dan hasil belajar siswa* [the effect of using wordwall learning media on student interest and learning outcomes]. Community Development Journal, 4(2), 1653–1660.

Albert, C. N., Mihai, M., & Mudure-Iacob, I. (2022). Visual thinking strategies—theory and applied areas of insertion. Sustainability (Switzerland), 14(12). https://doi.org/10.3390/su14127195

Amri, F., & Sukmaningrum, R. (2023). Implementation of wordwall as a learning media to improve students' writing skill. International Journal of Multidisciplinary Approach Research and Science, 1(03), 495–502. https://doi.org/10.59653/ijmars.v1i03.255

Arini, L., & Surya, E. (2017). An analysis of realistic mathematic approach effectiveness to improve students' visual thinking ability. Article in International Journal Of Advance Research And Innovative, 3(2), 3726–3730. Retrieved from www.ijariie.com

Arsini, N. N., Santosa, M. H., & Marsakawati, N. P. E. (2022). Hospitality school students' perception on the use of wordwall to enrich students' work-ready vocabulary mastery. Elsya : Journal of English Language Studies, 4(2), 124–130. https://doi.org/10.31849/elsya.v4i2.8732

Atmazaki, Ramadhan, S., & Indriyani, V. (2023). Dialogic-interactive media in online learning: effectiveness in speaking skills. Turkish Online Journal of Distance Education, 24(4), 95–112. https://doi.org/10.17718/tojde.1146195

Azizah, N., Ulya, H., & Wanabuliandari, S. (2022). *Pengembangan media pembelajaran aperska berbasis kemampuan koneksi matematis siswa smp kelas vii* [development of aperska learning media based on the mathematical connection ability of class vii middle school students]. Jurnal Pendidikan Matematika, 10(2), 199–214. https://doi.org/10.20527/edumat.v10i2.11322

Damarwan, E. S., & Khairudin, Moh. (2017). Development of an interactive learning media to improve competencies. Atlantis Press. https://doi.org/10.2991/ictvt-17.2017.5

de Gamboa, G., Badillo, E., & Font, V. (2023). Meaning and structure of mathematical connections in the classroom. Canadian Journal of Science, Mathematics and Technology Education, 23(2), 241–261. https://doi.org/10.1007/s42330-023-00281-2

Faatin, N., & Rusnilawati. (2022). *Pengembangan media digital wordwall ditinjau dari kemampuan berfikir tingkat tinggi materi operasi bilangan kelas vi* [development of digital wordwall media judging from high level thinking abilities class vi number operations material]. Jurnal Teknologi Pendidilan, 10. https://doi.org/10.31800/jtp.kw

Harsiwi, U. B., & Arini, L. D. D. (2020). *Pengaruh pembelajaran menggunakan media pembelajaran interaktif terhadap hasil belajar siswa di sekolah dasar* [the effect of learning using interactive learning media on student learning outcomes in elementary schools]. Jurnal Basicedu, 4(4), 1104–1113. https://doi.org/10.31004/basicedu.v4i4.505

Hatisaru, V. (2024). Mathematical connections–a growing construct. International Journal of Mathematical Education in Science and Technology, Vol. 55, pp. 585–589. Taylor and Francis Ltd. https://doi.org/10.1080/0020739X.2023.2283346

Hrp, H. T., Surya, E., & Mulyono. (2021). Analysis of students' visual mathematical thinking ability improvement using model learning contextual teaching and learning. 440–448. Atlantis Press SARL.

Ilahi, K. A., Sudiana, R., Nindiasari, H., Sultan, U., & Tirtayasa, A. (2022). *Pengembangan media pembelajaran interaktif berbasis wordwall untuk mengurangi kecemasan matematika* [development of wordwall-based interactive learning media to reduce mathematics anxiety]. WILANGAN, 3(4). https://doi.org/https://dx.doi.org/10.56704/jirpm.v3i4.14303

Imanulhaq, R., & Prastowo, A. (2022). Edugame wordwall : *inovasi pembelajaran matematika di madrasah ibtidaiyah* [edugame wordwall: mathematics learning innovation at madrasah ibtidaiyah]. Jurnal Pedagogos : Jurnal Pendidikan STKIP Bima, 4(1). https://doi.org/10.33627/gg.v4i1.639

Jannah, M. (2018). *Perbandingan pembelajaran visual thinking dengan metode quick on the draw dan metode numbered head together (NHT) terhadap kemampuan representasi matematis siswa kelas VIII MTSN tinambung kabupaten polewali mandar* [comparison of visual thinking learning using the quick on the draw method and the numbered head together (NHT) method on the mathematical representation ability of class VIII MTSN tinambung students, polewali mandar regency].

Juandi, D., & Priatna, N. (2018). Discovery learning model with geogebra assisted for improvement mathematical visual thinking ability. Journal of Physics: Conference Series, 1013(1). Institute of Physics Publishing. https://doi.org/10.1088/1742-6596/1013/1/012209

Junedi, B., & Sari, E. P. (2020). *Penggunaan multimedia pembelajaran interaktif terhadap kemampuan koneksi matematis siswa kelas XI MIPA SMA* [use of interactive learning multimedia on the mathematical connection ability of class XI MIPA SMA Students]. PRISMA, 9(1), 87–97. https://doi.org/http://dx.doi.org/10.35194/jp.v9i1.915

Kenedi, A. K., Helsa, Y., Ariani, Y., & Zainil, M. (2019). Mathematical connection of elementary scholl students to solve mathematical problems. Journal on Mathematics Education, 10(1), 69–80. https://doi.org/https://doi.org/10.22342/JME.10.1.5416.69-80

Khairunnisak, C., Hasbi, M., Mustika, A., & Elizar, E. (2020). Students' mathematical connection ability in the learning employing contextual teaching and learning. Journal of Physics: Conference Series, 1460(1). Institute of Physics Publishing. https://doi.org/10.1088/1742-6596/1460/1/012028

Liu, J., Liu, Z., Wang, C., Xu, Y., Chen, J., & Cheng, Y. (2024). K-12 students' higher-order thinking skills: Conceptualization, components, and evaluation indicators.

Thinking Skills and Creativity, 52, 101551. https://doi.org/10.1016/j.tsc.2024.101551

Loka Son, A. (2022). The students' abilities on mathematical connections: a comparative study based on learning models intervention. Mathematics Teaching-Research Journal (MTRJ), 14(2), 72–87.

Moussa, N. M., & Saali, T. (2022). Factors affecting attitude toward learning mathematics: a case of higher education institutions in the gulf region. SAGE Open, 12(3). https://doi.org/10.1177/21582440221123023

Mulyana, D., & Taufan, M. (2020). *Pengembangan media pembelajaran online terhadap kemampuan koneksi matematis mahasiswa.* Jurnal Ilmiah Pendidikan Matematika p, 8(2), 239–248. https://doi.org/10.31941/delta.v8i2.1076

Nasution, N. K. (2020). *Meningkatkan kemampuan visual thinking siswa dalam pemecahan masalah matematika* [improving students' visual thinking abilities in solving mathematical problems]. Article in Mathematics Education Research Journal. Retrieved from https://www.researchgate.net/publication/341768957

Nenohai, J. A., Rokhim, D. A., Agustina, N. I., & Munzil, M. (2022). Development of gamification-based wordwall game platform on reaction rate materials. Orbital, 14(2), 116–122. https://doi.org/10.17807/orbital.v14i2.16206

Nissa, S. F., & Renoningtyas, N. (2021). *Penggunaan media pembelajaran wordwall untuk meningkatkan minat dan motivasi belajar siswa pada pembelajaran tematik di sekolah dasar* [using wordwall learning media to increase student interest and motivation in thematic learning in elementary schools]. Edukatif : Jurnal Ilmu Pendidikan, 3(5), 2854–2860. https://doi.org/10.31004/edukatif.v3i5.880

Novita, R., & Harahap, S. Z. (2020). *Pengembangan media pembelajaran interaktif pada mata pelajaran sistem komputer di SMK* [development of interactive learning media in computer systems subjects in vocational schools]. 8(1). https://doi.org/http://dx.doi.org/10.36987/informatika.v8i1.1532

Parisa, M., Arcana, N., Susetyo, A., & Krida, S. (2023). *Pengembangan kuis dan game edukasi menggunakan wordwall pada pembelajaran daring pertidaksamaan nilai mutlak bentuk linier* [development of quizzes and educational games using wordwall in online learning absolute value inequalities in linear form]. Jurnal Theorems (The Original Reasearch Of Mathematics), 7(2). https://doi.org/http://dx.doi.org/10.31949/th.v7i2.4351

Pratiwi, S. A., & Widjajanti, D. B. (2020). Contextual problem in mathematical problem solving: Core ability in Realistic Mathematics Education. Journal of Physics: Conference Series, 1613(1). https://doi.org/10.1088/1742-6596/1613/1/012018

Purwanti, Mardiyana, & Indriati, D. (2021). The development of interactive multimedia based on mathematics to increase the mathematical connection ability in probability learning. IOP Conference Series: Earth and Environmental Science, 1808(1). IOP Publishing Ltd. https://doi.org/10.1088/1742-6596/1808/1/012047

Rafiepour, A., & Faramarzpour, N. (2023). Investigation of the mathematical connection's ability of 9th grade students. Journal on Mathematics Education, 14(2). https://doi.org/10.22342/jme.v14i2.pp339-352

Rahman, M. A., Faisal, R. R., & Tho, C. (2023). The effectiveness of augmented reality using flash card in education to learn simple english words as a secondary language.

Procedia Computer Science, 227, 753–761. Elsevier B.V. https://doi.org/10.1016/j.procs.2023.10.580

Rahmanti, S. A., Hobri, & Oktavianingtyas, E. (2018). *Analisis kemampuan koneksi matematis pada pokok bahasa statistika berbabasis lesson study for learning community* [analysis of mathematical connection ability in the basic language of statistics based on lesson study for learning community.].

Rasmani, U. E. E., Wahyuningsih, S., Nurjanah, N. E., Jumiatmoko, J., Widiastuti, Y. K. W., & Agustina, P. (2023). *Multimedia pembelajaran interaktif untuk guru* PAUD [interactive learning multimedia for PAUD teachers]. Jurnal Obsesi : Jurnal Pendidikan Anak Usia Dini, 7(1), 10–16. https://doi.org/10.31004/obsesi.v7i1.3480

Sahronih, S., Purwanto, A., & Sumantri, M. S. (2020). The effect of use interactive learning media environment-based and learning motivation on science learning outcomes. ACM International Conference Proceeding Series, 20–24. https://doi.org/10.1145/3323771.3323797

Sholihah, U., Nusantara, T., Sa'Dijah, C., & Susanto, H. (2019). The ability of students' visual thinking in solving integral problems. Journal of Physics: Conference Series, 1157(3), 1–7. Institute of Physics Publishing. https://doi.org/10.1088/1742-6596/1157/3/032090

Sholihah, Ummu, & Asyhar, B. (2018). The student's visual thinking profile in solving mathematics problems. 74–78. Atlantis Press. https://doi.org/10.2991/incomed-17.2018.16

Sholihah, Ummu, & Maryono, M. (2020). Students' visual thinking ability in solving the integral problem. JRAMathEdu (Journal of Research and Advances in Mathematics Education), 5(2), 175–186. https://doi.org/10.23917/jramathedu.v5i2.10286

Sholihah, Ummu, Nusantara, T., Sa'dijah, C., & Susanto, H. (2019). Solve integral problems in perspective of visual thinking ability. International Journal Of Scientific & Technology Research, 8, 8. Retrieved from www.ijstr.org

Sitompul, M. S. S., Surya, E., & Sinaga, B. (2020). Analysis of student's visual thinking difficulties in learning using pbl models with metacognitive approach. Journal of Education and Practice, 11(21), 8–13. https://doi.org/10.7176/jep/11-21-02

Sudarsono, S. (2021). *Pengembangan media pembelajaran game interaktif berbasis aplikasi web wordwall pada pelajaran matematika materi bilanagn ganjil genap kelas II SD* [development of interactive game learning media based on the wordwall web application in mathematics lessons on odd-even numbers material for class II elementary school].

Surya, E., Sabandar, J., & Kusumah, Y. S. (2013). Improving of junior high school visual thinking representation ability in mathematical problem solving by CTL (Vol. 4).

Tegas, A. S. R. H., & Warmi, A. (2019). *Kemampuan berpikir visual siswa pada materi geometri* [students' visual thinking ability in geometry material]. 1008–1014.

Wahyuni, S., Rusdi, M., & Huda, N. (2021). *Pengembangan lembar kerja peserta didik berbasis core (connecting, organizing, reflecting and extending) untuk meningkatkan kemampuan koneksi matematis pada materi persamaan trigonometri* [development of core-based student worksheets (connecting, organizing, reflecting and extending) to improve mathematical connection ability in trigonometric equations material]. Jurnal Cendekia: Jurnal Pendidikan Matematika, 05(02), 1498–

1511. Retrieved from https://www.j-cup.org/index.php/cendekia/article/view/619/360

Wiyono, C., Baiduri, B., & Zukhrufurrohmah, Z. (2023). Development of an E-pocketbook to develop critical thinking skills and problem-solving ability. JTAM (Jurnal Teori Dan Aplikasi Matematika), 7(4), 1026. https://doi.org/10.31764/jtam.v7i4.16270

Yanti, C., Anggraini, F., & Darwanto. (2019). *Media pembelajaran matematika interaktif dalam upaya menumbuhkan karakter siswa* [interactive mathematics learning media in an effort to develop student character].

Yunarti, Y., Loviana, S., & Safaatin, A. (2022). *Pengembangan media pembelajaran matematika interaktif berbasis adobe flash CS6* [development of interactive mathematics learning media based on adobe flash CS6]. AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11(1), 159. https://doi.org/10.24127/ajpm.v11i1.4459