ISSN 2355-4185(p), 2548-8546(e)
DOI: 10.24815/jdm.v9i2.26839

The Effect of Interactive Multimedia-Based Learning on Students' Mathematical Critical Thinking Ability in the Course of Structure Algebra

Lilis Marina Angraini[1*], Nurmaliza[2]

[1,2]Mathematics Education, Islamic University of Riau, Pekanbaru, Indonesia
[*]Email: *lilismarina@edu.uir.ac.id*

Received: 8 July 2022; Revised: 27 September 2022; Accepted: 29 October 2022

Abstract. *The critical thinking ability is fundamental in learning mathematics so it must be possessed by students as prospective teachers. In fact, the students' mathematical critical thinking ability is still relatively low. In this case, one of the causes is the change in learning system from face-to-face to online learning. One effort that can be done to overcome this issue is to apply interactive multimedia-based learning. Current research was further conducted in this matter, aiming to improve students' mathematical critical thinking ability through interactive multimedia-based learning to support online learning. This quantitative research (quasi-experimental) was carried out by involving prospective mathematics teacher students enrolling in the algebraic structure course in 2021/2022 at Universitas Islam Riau (UIR) as the experimental class and prospective mathematics teacher students at Universitas Pasir Pengaraian (UPP) as the control class. The data were further collected through a mathematical critical thinking ability test which were further analyzed through statistical tests. Based on the results of the t-test, there was an increase in students' mathematical critical thinking ability who received a learning process using interactive multimedia.*

Keywords*: mathematical critical thinking, interactive multimedia, online learning, structure algebra*

Introduction

Critical thinking ability is very important for the students to meet of the demands of 21st century learning which requires students to have 4C skills including critical thinking, creative, collaboration, and communication skills (Aizikovitsh-Udi & Cheng, 2015; Maričić & Špijunović, 2015; Miller & Topple, 2020; Sustekova, Kubiatko, & Usak, 2019). This statement is further reinforced by the recommendations from Committee on the Undergraduated Program in Mathematics that each subject in mathematics should be composed of activities that can help students developing their analysis, critical reasoning, problem solving, and communication skills as well as acquiring mathematics with habits of mind (Hariyani & Mz, 2018; Karakoc, 2016; Welch, Hieb, & Graham, 2015). In other words, critical thinking skill is a fundamental skill in learning mathematics that always needs improvement. Furthermore, the importance of critical thinking is related to the process of making something original (Ahonen & Kinnunen, 2015; Changwong, Sukkamart, & Sisan, 2018; Dumitru, 2019;), in this case is concerning the exploration of dynamic nature of attentional focusing (Dixon, 2017; Fajari, Sarwanto, & Chumdari, 2020; Toner & Moran, 2016). Therefore, critical thinking ability needs to be trained in the learning process because it can provide opportunities to learn through discovery, help

students understand and apply concepts in their daily life, complete problems, give opinions, and be a good and well-educated human being in future professions (Wulandari, 2018; Facione, 2013). Hence, it is important for students to have critical thinking ability.

The results of previous study (Miatun & Khusna, 2020a; Pearce, Bruun, Skinner, & Lopez-Mohler, 2013; Salemeh & Etchells, 2016) showed that students' mathematics critical thinking skill was low. Meanwhile, Ariawan and Zetriuslita (2021) reported that the critical thinking skill of the students with cognitive styles independent field was categorized as very critical, while the critical thinking skill of students with cognitive style dependent field was categorized as sufficient. Furthermore, another study conducted by Widodo, Santia, and Jatmiko (2019) discovered that only 2 students from 24 students had high critical thinking ability. Safrida, Ambarwati, Adawiyah, and Albirri (2018) then added through their research involving 30 university students, only 23.33% of students started to think critically and less than 25% of students were able to meet the five indicators of critical thinking skill. These research results show that it is necessary to improve students' critical thinking skill, especially student teacher candidates considering that prospective teacher students will have the task of developing students' critical thinking ability (Miatun & Khusna, 2020b).

According to Paradesa (2015), the level of students' mathematical critical thinking skills at university was generally categorized as low. Based on the indicators of mathematical critical thinking skills, students at university were lacking and very lacking in meeting the indicators of the ability to identify, formulate problems into mathematical models, deduce with principles, and provide further explanations. Furthermore, Wibowo and Sutarni (2020) revealed that among the students who participated in the Group Algebra Structure course through the Higher Order Thinking Skills (HOTS), only 7.5% who had a very critical thinking level is still 7.5%. Ismail & Bempah (2018) also reported that the critical thinking skill of mathematics students participating in the calculus I course on limit functions material was classified as moderate. This was obtained based on the description of the characteristics of the mathematical critical thinking ability of the subject in each predicate, where it was found that students were generally only able to fulfill some of the critical thinking indicators or have not been able to meet all of the critical thinking indicators.

In this case, one of the efforts to improve students' mathematical critical thinking ability is to apply a learning process that uses interactive multimedia-based teaching materials. Learning mathematics using learning media has an important role because it can concrete abstract mathematical material and help students understand difficult material verbally (Palupi, 2020; Yuliati, Saputra, & Yonanda, 2020). The use of interactive learning media that is not limited by space and time makes students more interested, thus building their motivation to learn, the

material will be easy to understand, and the teaching methods become more varied (Prasojo, Mukminin, Habibi, Marzulina, Sirozi, & Harto, 2018). In addition, students' critical thinking skill can be improved through learning process using interactive multimedia-based teaching materials as well (Yulianto & Juniawan, 2022).

The application of interactive multimedia to improve students' mathematical critical thinking skill is seen in the Algebraic Structure course. Algebraic Structure is one of the courses that contains abstract concepts which often make the students find difficulties to learn it. Lecturers as professional educators are expected to be able to direct students to understand the concepts contained in the Algebraic Structure course to be more interesting and meaningful. Interactive multimedia is one of the media that provides great benefits in learning (Ilyasa & Dwiningsih, 2020; Mumtaha & Khoiri, 2019; Nazar, Zulfadli, Oktarina, & Puspita, 2020). Interactive multimedia is a multimedia that is equipped with a controller that can be operated by the user so that the user can choose something he wants for the next process. In addition, the use of interactive multimedia is not limited by space and time so that it provides its own learning motivation for students (Anggraeni, Sulton, & Sulthoni, 2019; Atibrata, Nugroho, & Azmi, 2019; Ferry & Kamil, 2019; Istigfar, Wijaya, & Nurmila, 2018; Prasojo, et al., 2018; Riyanto & Susilawati, 2019; Sadikin & Hakim, 2019; Wilsa, 2019).

The development and use of media in the learning process is for the fluency of the learning process itself (Kusmanagara, Marisa, & Wijaya, 2018; Muhaimin, Habibi, Mukminin, Saudagar, Pratama, Wahyuni, Sadikin, & Indrayana, 2019; Mukmin & Primasatya, 2020, Sadikin & Hakim, 2019; Sadikin, Johari, & Suryani, 2020; Sembiring, Wahyuni, & Anurogo, 2018). Several studies have reported that the use of interactive multimedia is effective to help students understand scientific information easier through visual explanations of information.

The potential of interactive multimedia as a medium in learning mathematics is so great. Through appropriate software, multimedia can be an effective tool in helping mathematics learning. Learning that involves interactive multimedia designed with deep thought in mind can bring many things, for example, it can display dynamically connected repetitive presentations, which are not possible for silent media such as books or whiteboards. Some applications of multimedia also have the ability to display the learning process in an attractive, interactive, and dynamic visual display (Eryilmaz, 2015).

Furthermore, the use of multimedia has several advantages, one of them is that this media allows students to learn independently and conduct experiment with various options, provides immediate feedback, provides control during learning, and teaches gradual material weights. The use of interactive multimedia will support learning because it can help improving students' understanding in constructing mental mathematics on a concept. The innovation in this research

is interactive multimedia-based teaching materials that contain materials, examples and practice questions that are arranged based on the indicators to be achieved in order to develop the students' mathematical critical thinking skill. This study was further conducted aiming to improve the students' mathematical critical thinking skill through interactive multimedia-based learning materials to support online learning.

Method

This research was carried out through experimental method in order to find the effect of treatments applied. In this case, the design used was a quasi-experimental non-equivalent control group, because the research respondents involved were not randomly selected, but the researchers randomized the existing class. In addition, this research also looks at the effect of the learning process as a whole.

Additionally, this research was conducted on students majoring in Mathematics Education who were taking the algebraic structure course for the 2021/2022 academic year at 2 universities, namely Universitas Islam Riau (UIR) and Universitas Pasir Pengaraian (UPP). The two groups empirically had similarities such as the same age, the same semester, and the same previous material learnt (Introduction to Basic Mathematics and Linear Algebra). In this case, both UIR and UPP had established collaborations (partners) in the field of research.

Furthermore, the research subjects involved were 32 students from two classes, namely the experimental class and the control class. In this case, the experimental class received interactive multimedia-based teaching materials, while the control class received teaching materials on the form of student worksheets (SW). The student worksheets used in the control class was also arranged according to the stages that must be achieved in critical thinking skill. The difference between the two learning methods is that the experimental class used interactive multimedia which was structured by paying attention to the stages of critical thinking, while the control class used SW which had the same content and exercises, but the stages in the SW also referred to aspects of critical thinking that must be achieved by the students. In addition, the SW was also structured as attractively as possible by considering the problems that have been experienced by students.

This study was conducted for one semester, where the students received learning with interactive and conventional multimedia for 14 meetings. In this case, the interactive multimedia teaching materials were designed for 14 meetings (all algebraic structure course materials are studied for one semester) and also designed interactively with several menu options such as: learning objectives menu, material menu, sample question menu, practice menu, and quiz menu. The practice and quiz menus are connected to the Quizizz application, making it easier for

lecturers to make detailed and objective assessments. This interactive multimedia teaching material has also been previously validated by two lecturers who taught multimedia learning mathematics at UIR's mathematics education study program and 1 lecturer who taught educational technology applications at UPP. Since the design of interactive multimedia teaching materials was equipped with several menus and connected to the Quizizz application for practice and quizzes, it was expected that this media could create a more interesting learning atmosphere. Therefore, the mathematical critical thinking skills of the students who received interactive multimedia learning were better than students who received conventional learning as a whole.

Furthermore, research data of the current research were collected using tests. The test was given in the form of questions about critical thinking skills. Before use, the test was first validated by experts and then analyzed through t-test. Prior to the t-test, the data were tested for prerequisites, in this case, to ensure that the data met the normality and homogeneity tests. In this case, Kolmogorov-Smirnov test was used to check the data normality and Levene's test was used to check the data homogeneity.

The test instrument used in this study contained four questions and has met the elements of validity and reliability. In this case, the validation test was carried out based on the results of expert considerations. The expert was two lecturers of mathematics education study program at UIR and one lecturer of mathematics education study program at UPP. The result of the reliability test obtained score of 0.67 which was categorized as medium. Thus, the research instrument was concluded as to have sufficient correlation to meet the level of consistency of an instrument.

Results and Discussion

The critical thinking skill is fundamental to learn mathematics and always needs improvement. In this case, it is also necessary to train the critical thinking skill because it can provide opportunities to learn through discovery, help students understand and apply the concepts in daily life, solve problems, give opinions, as well as become a good and well-educated human being in future professions (Wulandari, 2018).

Data on Initial Mathematical Ability (IMA) were collected and analyzed to determine the students' initial mathematical ability before this research was carried out. Initial mathematical ability was obtained from the score of the prerequisite courses (Introduction to Basic Mathematics). In this case, in order to obtain an overview of the students' initial mathematical abilities, the data were analyzed descriptively to obtain the mean score, standard deviation value, minimum score, and maximum score. The summary of the results of descriptive analysis of students' initial mathematical ability data based on previous learning outcomes is presented in the Table 1 as follow.

Table 1. Description of students' IMA data

Descriptive Statistic	Experiment	Control
N	16	16
Mean	81.02	81.85
SD	6.12	6.16
Maximum	100	100
Minimum	60	62

Based on the Table 1, it can be seen that the description of the initial mathematical skill of the control class is better than the experimental class, although there was not much difference. In this case, the researcher chose the group of students who had a mean score of 80.02 as the experimental class, because the researcher wanted to increase the mean score of the experimental class (the group that received interactive multimedia learning) so that it could be higher than the mean score of the control class (the group that received conventional learning) as a whole.

Furthermore, the equivalence test of the initial mathematical abilities of the two learning groups was carried out using t test. In this case, the results of the normality test using the Kolmogorov-Smirnov test of the experimental class students' initial mathematical ability data were 0.45, while the control class obtained 0.41. Meanwhile, the results of the homogeneity test using Levene test of the initial mathematical ability data variance of the two learning groups obtained 0.23. Furthermore, the results of the equivalence test of the initial mathematical ability data was 0.38. This indicates that there was no difference in the mean score of initial mathematical ability between students who received interactive multimedia learning and students who received conventional learning.

Furthermore, in order to analyze the effect of using interactive multimedia on students' mathematical critical thinking ability, a parametric test was further carried out. In order to obtain an overview of the quality of mathematical critical thinking ability of the two groups of students, the data were analyzed descriptively. The Table 2 below is a data description of students' mathematical critical thinking ability.

Table 2. Data description of students' mathematical critical thinking skill

Descriptive Statistic	Experiment	Control
N	16	16
Mean	63.43	45.31
SD	26.69	22.76
Maximum	100	75
Minimum	15	15

Based on the description presented in Table 2 above, the experimental class students had a higher mean score of mathematical critical thinking skill that the control class students. The following is the result of data processing students' mathematical critical thinking ability.

Table 3. Normality test

Class	p-value
Experiment	0.117
Control	0.134

Based on Table 3, the experimental class p-value was 0.117 > 0.05 and the control class p-value was 0.134 > 0.05. Hence, it can be concluded that the mathematical critical thinking skill of experimental class students and control class students were normally distributed at a significant level = 0.05.

Furthermore, the results of the homogeneity test are obtained as follows:

Table 4. Homogeneity test

Levene Statistic	df	p-value
0.629	26	0.434

Based on table 4 above, the p-value obtained was 0.434 > 0.05, indicating that the two learning groups had a homogeneous variance.

Furthermore, the results of the t-test were obtained as follows:

Table 5. T-test

T-test	p-value
Learning	0.024

Based on table 5, it was obtained that the p-value was 0.001 < 0.05, indicating interactive multimedia affected the students' mathematical critical thinking skill. In this case, the mathematical critical thinking skill of students who received interactive multimedia based-learning was better than students who received conventional learning.

The results showed that interactive multimedia-based teaching materials were able to facilitate students to learn online. Although the learning was done online, there was an improvement on students' mathematical critical thinking ability who received interactive multimedia based learning compared to conventional learning. These results are in accordance with previous findings (Abdulah, Mustadi, & Fitriani, 2021; Syawaludin, & Rintayati, 2019), which have indicated that interactive multimedia based teaching materials had advantages for learning. The use of interactive multimedia in learning mathematics indeed has an important role because it can concrete the abstract mathematical material and help students understand difficult material verbally (Palupi, 2020).

The following figure is a documentation of the implementation of learning using interactive multimedia-based teaching materials.

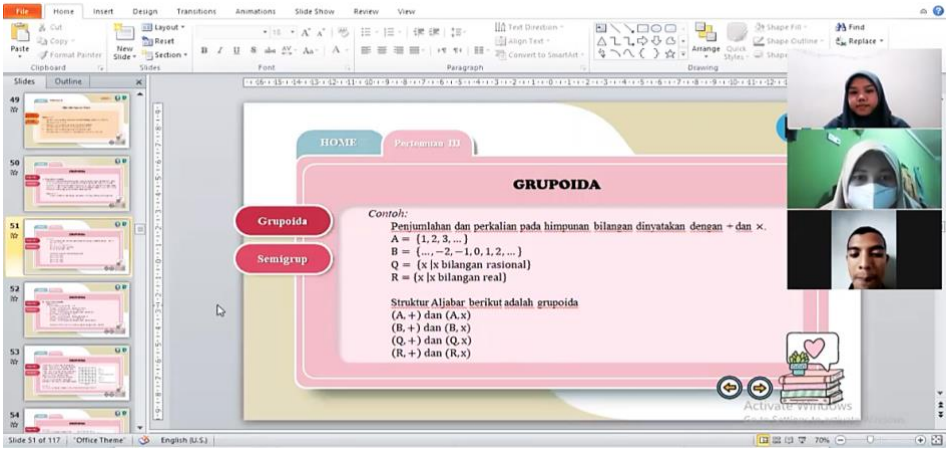

Figure 1. The learning process of experimental class

The Figure 1 shows the learning process that was carried out using interactive multimedia-based teaching materials. During the learning process, there were several students who were enthusiastic in participating when practice questions were given. They answered the practice questions in turn. The figure above is one display of interactive multimedia-based teaching materials that contains: (1) prerequisite materials that aim to stimulate students' initial ability; (2) core material that aimed at inculcating the concepts that must be learned; and (3) practice questions that aim to apply the concept ability they learned that day. Meanwhile, some of the buttons in the display above are: (1) back button to go back to the previous material that was provided so that students who forgot the concepts they were learning could immediately open the material quickly; (2) home button, which functions to determine what meeting materials they would study aiming to make it easier for students who have high ability to learn faster than students who have medium and low ability, thereby minimizing the boredom they experience; and (3) practice button, that is directly connected to Quizizz, so that students could do exercises such as playing games, so that their boredom disappear and is replaced with curiosity and enthusiasm to complete the practice questions and thus they could reach the finish point.

Based on the posttest results obtained, students who were learning using the interactive multimedia-based teaching materials were able to fulfill the following stages: 1) Clarification, where the students could understand the questions given, write down the information they know from the questions, and write down what the questions ask; 2) Assessment, where the students could provide examples for the variables in the problem, mention the formula that will be used to solve the problem, and assess relevant concepts or ideas to solve the problem; 3) Conclusion, where the students could write the steps for solving the problem in a coherent and correct manner, mentions the steps that have been found to solve the problem, and be able to reach a conclusion

from the problem; and 4) Strategy, where students could solve problems coherently and correctly and explain the problem solving strategies that have been found well.

During the learning process, students showed their enthusiasm in participating when there were practice questions given by the lecturer. They took turns offering to answer the exercise. The experimental class used interactive multimedia which was arranged based on the stages of critical thinking, while the control class used students' worksheets whose content and exercises remain the same, but the stages in the students' worksheets also referred to aspects of critical thinking that must be achieved by students. The students' worksheets were also arranged as attractively as possible by considering the problems that have been experienced by students. The students' worksheets contain prerequisite material that aims to stimulate the initial ability of students in the control class; core material that aims to inculcate the concepts that must be learned, and practice questions that aim to apply the concept skills they learned that day. In this case, the content of the material and exercises remains the same and the only difference is the use of media.

Based on the answers to the post-test, students who received interactive multimedia-based teaching materials were able to understand the questions given, write down the information they knew from the questions, and write down what the questions ask, indicated by their ability in taking any member of Group G. In addition, students could also provide an example for the variables that exist in the problem, mention the formula that will be used to solve the problem, and assess relevant concepts or ideas to solve the problem, indicated by their ability to show (G, *) groups by fulfilling the closed axiom, associative, identity and inverse. Furthermore, the students could write down the steps to solve the problem in a coherent and correct manner, mention the steps that have been found to solve the problem, and were able to reach conclusions from the problem, proven by their ability to prove the axioms of closure, associative, identity and inverse. Students could also solve the questions in a coherent and correct manner as well as explain the problem solving strategies that have been found well, indicated by their abilities to sequence the steps that must be met to prove (G, *) the group, namely first proving the axiom of closure, then proving the associative axiom, proving the identity axiom, and proving the inverse axiom, so that if the four axioms are fulfilled it can be concluded that (G, *) group.

Conclusion

Although learning using interactive multimedia has a better influence on students' mathematical critical thinking skill in the algebraic structure course, a much better results in the future is expected so that it is hoped that the time planning in learning process is carefully regulated by further researchers, considering that many unexpected things can appear in learning

activities. In addition, the use of interactive multimedia cannot replace direct interaction between lecturers and students and it also requires an internet connection and large bandwidth.

Based on the results of research and discussion, it can be concluded that there is an improvement in students' mathematical critical thinking skill who receive learning using interactive multimedia-based teaching materials compared to students who receive conventional learning. Furthermore, the effect of interactive multimedia-based learning on mathematical critical thinking skills also needs to be seen based on the initial mathematical ability. In other aspects, it is realized that students' mathematical ability can also distinguish students' mathematical critical thinking skills themselves. In this case, students who have good mathematical ability tends to show a good level of critical thinking ability, and vice versa.

In this case, initial mathematical knowledge needs to be considered in this study, because initial mathematical abilities are considered to be a determining factor in distinguishing mathematical critical thinking skills. The acquisition of initial mathematical abilities describes how the relationships between the improvement and achievement of students' mathematical critical thinking ability is found in each existing learning process, with the levels of each student's prior mathematical knowledge test. Then it is also necessary to look at the interaction between the learning used and the prior mathematical knowledge to increase students' mathematical critical thinking skills. This means that it is necessary to see whether the learning factor and the prior mathematical knowledge factor together have a significant effect on increasing students' mathematical critical thinking skills.

Acknowledgement

This research is supported by the Ministry of Education, Culture, Research and Technology and the Education Fund Management Institute through the 2021 Scientific Research Program Funding

References

Abdulah, A., Mustadi, A., & Fitriani, W. (2021). PBL-based interactive multimedia in improving critical thinking skills. *JPI (Jurnal Pendidikan Indonesia)*, *10*(1), 136-144. https://doi.org/10.23887/jpi-undiksha.v10i1.25521

Atibrata, T. G., Nugroho, W., & Azmi, U. (2019). Multimedia interaktif pembelajaran bahasa inggris materi “expressions” pada siswa sekolah menengah pertama. *LingTera*, 6(2), 172-181.

Ahonen, A. K., & Kinnunen, P. (2015). How do students value the importance of twenty-first century skills?. *Scandinavian Journal of Educational Research*, *59*(4), 395–412. https://doi.org/10.1080/00313831.2014.904423

Aizikovitsh-Udi, E., & Cheng, D. (2015). Developing critical thinking skills from dispositions to abilities: mathematics education from early childhood to high school. *Creative Education, 06*(04), 455–462. https://doi.org/10.4236/ce.2015.64045

Anggraeni, R. D., Sulton, S., & Sulthoni, S. (2019). Pengaruh multimedia tutorial terhadap hasil belajar bahasa indonesia. *Jurnal Kajian Teknologi Pendidikan 2*(2), 96-101.

Ariawan, R., & Zetriuslita. (2021). Kemampuan berpikir kritis matematis mahasiswa ditinjau dari gaya kognitif (studi kasus pada mata kuliah persamaan differensial). *Jurnal Cendekia: Jurnal Pendidikan Matematika*, *05*(02), 1410–1426.

Changwong, K., Sukkamart, A., & Sisan, B. (2018). Critical thinking skill development: analysis of a new learning management model for thai high schools. *Journal of International Studies*, *11*(2), 37–48.

Dumitru, D. (2019). Creating meaning. the importance of arts, humanities and culture for critical thinking development. *Studies in Higher Education*, *44*(5), 870–879. https://doi.org/10.1080/03075079.2019.1586345

Dixon, P. A. (2017). Extensive listening, teacher proficiency and 21 st century skills: Interview with Dr Willy A. Renandya. *RELC Journa*l, *48*(1), 153–158. https://doi.org/10.1177/0033688217695658

Eryilmaz, S. (2015). E-learning as a teaching strategy actively used in FATIH project. *European Journal of Educational Research*, *4*(1), 38–47. https://doi.org/10.12973/eu-jer.4.1.38

Facione, P. A. (2013). Critical thinking: What it is and why it counts. *Insight Assessment*, 1-23. Measured Reasons and The California Academic Press. https://www.nyack.edu/files/CT_What_Why_2013.pdf

Ferry, D., & Kamil, D. (2019). Peningkatan hasil belajar biologi siswa melalui penerapan media video animasi tiga dimensi (3D). *Pedagogi Hayati*, 3(2), 1-11.

Fajari, L. E., Sarwanto, S., & Chumdari, C. (2020). Improving elementary school's critical thinking skills through three different learning media viewed from learning styles. *Journal of E-Learningg and Knowledge Society*, *16*(1), 55–64. https://doi.org/10.20368/1971-8829/1135193

Hariyani, M., & Mz, Z. A. (2018). Peningkatan kemampuan penalaran matematis mahasiswa pendidikan guru madrasah ibtidaiyah melalui concept attainment model. *JMIE: Journal of Madrasah Ibtidaiyah Education*, *2*(1), 119–130.

Ilyasa, D. G., & Dwiningsih, K. (2020). Model multimedia interaktif berbasis unity untuk meningkatkan hasil belajar ikatan ION. *Jurnal Inovasi Pendidikan Kimia,* 14(2), 2572-2584.

Ismail, S., & Bempah, H. O. (2018). Analisis kemampuan berpikir kritis matematika mahasiswa jurusan pendidikan matematika pada mata kuliah kalkulus I materi limit fungsi. *Jurnal Entropi*, *13*(1), 7-13.

Istigfar, A. M., Wijaya, M., & Nurmila, N. (2018). Pengaruh multimedia ncesoft flipbook maker pada materi pembelajaran pengendalian gulma terhadap motivasi dan hasil belajar siswa kelas XI ATPH SMK negeri 1 Bone-Bone. *Jurnal Pendidikan Teknologi Pertanian, 4*, 66-78.

Karakoc, M. (2016). The significance of critical thinking ability in terms of education. *International Journal of Humanities and Social Science Invention*, *6*(7), 81–84. http://www.ijhssnet.com/journals/Vol_6_No_7_July_2016/10.pdf

Kusmanagara, Y, Marisa, F., & Wijaya, I. D. (2018). Membangun aplikasi multimedia interaktif dengan model tutorial sebagai sarana pembelajaran bahasa kanton. *JIMP (Jurnal Informatika Merdeka Pasuruan)*, 3(2), 1-8.

Maričić, S., & Špijunović, K. (2015). Developing critical thinking in elementary mathematics education through a suitable selection of content and overall student performance. *Procedia-Social and Behavioral Sciences, 180*, 653–659. https://doi.org/10.1016/j.sbspro.2015.02.174

Miller, S. E., & Topple, T. A. (2020). Thinking and thinking about thinking: A qualitative study of learning in a process-centric teaching model. *Journal of Social Work Education*, *56*(1), 115–130. https://doi.org/10.1080/10437797.2019.1648224

Miatun, A., & Khusna, H. (2020a). Kemampuan berpikir kritis matematis berdasarkan disposisi matematis. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika*, *9*(2), 269–278. https://doi.org/10.24127/ajpm.v9i2.2703

Miatun, A., & Khusna, H. (2020b). Pengaruh geogebra online berbasis scaffolding dan tingkat self regulate learning terhadap kemampuan berpikir kritis. *Pythagoras: Jurnal Pendidikan Matematika*, *15*(2), 124–136. https://doi.org/10.21831/pg.v15i2.34499

Mumtaha, H. A & Khoiri, H. A. (2019). Analisis dampak perkembangan revolusi industri 4.0 dan society 5.0 pada perilaku masyarakat ekonomi (e-commerce). *Jurnal Pilar Teknologi: Jurnal Ilmiah Ilmu Ilmu Teknik, 4*(2), 55-60.

Muhaimin, M, Habibi, A., Mukminin, A., Saudagar, F., Pratama, R., Wahyuni, S., Sadikin, A., & Indrayana, B. (2019). A sequential explanatory investigation of TPACK: indonesian science teachers' survey and perspective. *Journal of Technology and Science Education,* 9(3), 269-281.

Mukmin, B. A & Primasatya, N. (2020). Pengembangan multimedia interaktif macromedia flash berbasis K-13 sebagai inovasi pembelajaran tematik untuk siswa sekolah dasar. *Jurnal Pendidikan Dasar Nusantara,* 5(2), 221-226.

Nazar, M., Zulfadli, Z., Oktarina, A., & Puspita, K. (2020). Pengembangan aplikasi pembelajaran interaktif berbasis android untuk membantu mahasiswa dalam mempelajari materi larutan elektrolit dan nonelektrolit. *Jurnal Pendidikan Sains Indonesia (Indonesian Journal of Science Education), 8*(1), 39-54.

Palupi, A. N. (2020). Use of manipulative media as a stimulation of ability to understand the concept of early children's age. *Early Childhood Research Journal (ECRJ)*, *3*(2), 41–57. https://doi.org/10.23917/ecrj.v3i2.11414

Paradesa, R. (2015). Kemampuan berpikir kritis matematis mahasiswa melalui pendekatan konstuktivisme pada materi matematika keuangan. *Jurnal Pendidikan Matematika JPM RAFA, 1*(2), 306-326.

Pearce, D. L., Bruun, F., Skinner, K., & Lopez-Mohler, C. (2013). What teachers say about student difficulties solving mathematical word problems in grades 2-5. *International Electronic Journal of Mathematics Education*, *8*(1), 3–19.

Prasojo, L. D., Mukminin, A., Habibi, A., Marzulina, L., Sirozi, M., & Harto, K. (2018). Learning to teach in a digital age: ICT integration and EFL student teachers' teaching practices. *Teaching English with Technology*, *18*(3), 18–32. http://www.tewtjournal.orghttp//www.tewtjournal.org

Riyanto, R & Susilawati, L. (2019). Penerapan media aurora animasi 3D maker untuk meningkatkan hasil belajar kognitif mahasiswa biologi IKIP Budi Utomo Malang. *Edubiotik: Jurnal Pendidikan Biologi dan Terapan,* 4(1), 52-57.

Safrida, L. N., Ambarwati, R., Adawiyah, R., & Albirri, E. R. (2018). Analisis kemampuan berpikir kritis mahasiswa program studi pendidikan matematika. *EDU-MAT: Jurnal Pendidikan Matematika*, *6*(1), 10–16. https://doi.org/10.20527/edumat.v6i1.5095

Salemeh, Z., & Etchells, M. J. (2016). A case study: Sources of difficulties in solving word problems in an international private school. *Electronic International Journal of Education, Arts, and Science, 2*(1), 149–163. Retrieved from http://www.eijeas.com/index.php/EIJEAS/article/view/88

Sustekova, E., Kubiatko, M., & Usak, M. (2019). Validation of critical thinking test on slovak conditions. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(12), em1798. https://doi.org/10.29333/ejmste/112295

Syafril, S., Aini, N. R., Netriwati, Pahrudin, A., Yaumas, N. E., & Engkizar. (2020). Spirit of mathematics critical thinking skills (CTS). *Journal of Physics: Conference Series*, *1467*(1), pp. 012069. https://doi.org/10.1088/1742-6596/1467/1/012069

Syawaludin, A., & Rintayati, P. (2019). Development of augmented reality-based interactive multimedia to improve critical thinking skills in science learning. *International Journal of Instruction*, *12*(4), 331–344. https://doi.org/10.29333/iji.2019.12421a

Sadikin, A., & Hakim, N. (2019). Pengembangan media e-learning interaktif dalam menyongsong revolusi industri 4. *Jurnal Ilmiah Pendidikan Biologi*, *5*(2), 131-138.

Sembiring, E. B., Wahyuni, D., & Anurogo, W. (2018). Multimedia interaktif pengenalan hewan dan tumbuhan langka menggunakan model tutorial. *Journal of Digital Education, Communication, and Arts,* 1(2), 103-112.

Sadikin, A., Johari, A., & Suryani, L. (2020). Pengembangan multimedia interaktif biologi berbasis website dalam menghadapi revolusi industri 4.0. *Edubiotik: Jurnal Pendidikan, Biologi dan Terapan,* 5(1), 18-28.

Toner, J., & Moran, A. (2016). On the importance of critical thinking: A response to wulf's 2015 commentary. *Psychology of Sport and Exercise*, *22*, 339–340.

Widodo, S., Santia, I., & Jatmiko, J. (2019). Analisis kemampuan berpikir kritis mahasiswa pendidikan matematika pada pemecahan masalah analisis real. *Jurnal Pendidikan Matematika Raflesia*, *4*(2), 1–14. https://doi.org/10.24127/ajpm.v8i2.1947

Wulandari, A. Y. R. (2018). Correlation between critical thinking and conceptual understanding of student's learning outcome in mechanics concept. *AIP Conference Proceedings*, *2014*(1), pp. 020028. https://doi.org/10.1063/1.5054432

Welch, K. C., Hieb, J., & Graham, J. (2015). A systematic approach to teaching critical thinking skills to electrical and computer engineering undergraduates. *American Journal of Engineering Education (AJEE)*, *6*(2), 113–124. https://doi.org/10.19030/ajee.v6i2.9506

Wibowo, A., & Sutarni, S. (2020). Analisis kemampuan berpikir kritis matematis mahasiswa melalui soal tipe higher order thinking skills pada mata kuliah struktur aljabar grup program studi pendidikan matematika. Doctoral dissertation, Universitas Muhammadiyah Surakarta. Diakses di: http://eprints.ums.ac.id/82465

Wilsa, A. W. (2019). Perbedaan hasil belajar siswa yang menggunakan multimedia interaktif dengan buku teks dalam pembelajaran biologi di SMA. *Jurnal Mangifera Edu*, *4*(1), 62-70.

Yulianto, D., & Juniawan, E. A. (2022). Pengembangan media pembelajaran interaktif lectora inspire dengan pendekatan saintifik untuk meningkatkan kemampuan berpikir kritis matematis. *Jurnal Penelitian dan Pembelajaran Matematika*, *15*(1), 1-16.

Yuliati, Y., Saputra, D. S., & Yonanda, D. A. (2020). The development of android-based learning media in multiplication concept for the fourth grade of primary school. In *3rd International Conference on Learning Innovation and Quality Education (ICLIQE 2019)*, 576–580. https://doi.org/10.2991/assehr.k.200129.071