DEVELOPMENT OF ANDROID-BASED INTERACTIVE MULTIMEDIA TO ENHANCE CRITICAL THINKING SKILLS IN LEARNING MATTER

RESEARCH PAPER

Submitted as Requirement to Obtain Degree of Sarjana Pendidikan in International Program on Science Education (IPSE) Study Program

Arranged by:
Salma Almira Hamdani
NIM 1604576

INTERNATIONAL PROGRAM ON SCIENCE EDUCATION
FACULTY OF MATHEMATICS AND SCIENCE EDUCATION
UNIVERSITAS PENDIDIKAN INDONESIA
2021
DEVELOPMENT OF ANDROID-BASED INTERACTIVE MULTIMEDIA TO ENHANCE CRITICAL THINKING SKILLS IN LEARNING MATTER

Oleh:
Salma Almira Hamdani

Skripsi ini diajukan untuk memenuhi salah satu syarat memperoleh gelar Sarjana Pendidikan pada Program Studi International Program on Science Education (IPSE) Fakultas Pendidikan Matematika dan Ilmu Pengetahuan Alam

© Salma Almira Hamdani
Universitas Pendidikan Indonesia
April 2021

Hak Cipta Dilindungi Undang-Undang
Skripsi ini tidak boleh diperbanyak seluruhnya atau sebagian.
Dengan dicetak ulang, difotokopi, atau cara lainnya tanpa izin dari penulis.
APPROVAL SHEET

SALMA ALMIRA HAMDANI

DEVELOPMENT OF ANDROID-BASED INTERACTIVE MULTIMEDIA TO ENHANCE CRITICAL THINKING SKILLS IN LEARNING MATTER

Approved and confirmed by:

Supervisor I

Dr. Eka Cahya Prima, S.Pd., M.T.
NIP. 199006262014041001

Supervisor II

Rika Rafikah Agustin, M.Pd
NIP. 198308032012122001

Head of International Program on Science Education Study Program

Dr. Eka Cahya Prima, S.Pd., M.T.
NIP. 199006262014041001
DECLARATION

I do hereby declare that every aspect was written in this research paper entitled “Development of Android-Based Interactive Multimedia to Enhance Critical Thinking Skills in Learning Matter” genuinely results of my original idea, efforts, and works. The theories, finding of experts, opinions, and others contained in this paper have been quoted or referenced based on scientific code from UPI and following scientific ethics that applies in scholarly society. This declaration is created truthfully and consciously. When an infringement towards scientific ethics subsequently is found or if there is a claim of any others towards the authenticity of this research paper, hence I am willing to be responsible and accept academic sanctions correspond to the rules.

Bandung, April 2021

Declarant,

Salma Almira Hamdani
NIM. 1604576
DEVELOPMENT OF ANDROID-BASED INTERACTIVE MULTIMEDIA TO ENHANCE CRITICAL THINKING SKILLS IN LEARNING MATTER

Salma Almira Hamdani

International Program on Science Education
Universitas Pendidikan Indonesia

ABSTRACT

The development of science and technology in the 21st Century requires students to develop critical thinking skills. However, according to the PISA test, the scores obtained by Indonesian students are relatively low. It indirectly indicates that students’ critical thinking skills are still in the low category. Interactive multimedia is one of the learning media that can enhance critical thinking skills because it facilitates student-centered learning. This research aims to develop android-based interactive multimedia to enhance critical thinking skills in learning matter. This study used a developmental research method consisting of analysis, design, development, implementation, validation, evaluation, and one group pretest-posttest to analyze the impact of the interactive multimedia on students’ critical thinking skills. The subject was 30 students of Private Junior High School in Bandung Barat. The instruments used were expert’s judgment rubric, students’ questionnaire, and objective test used for pretest and posttest. The average score of experts’ validations using the V index is 0.863, which is classified as valid. And then, there are 89.23% of students gave a positive response toward the application. Based on the analysis result, the N-Gain score is 0.52 which is categorized as a medium improvement. It means that there is a significant difference in students’ critical thinking skills with medium improvement. The indicator with the highest improvement is an explanation with 0.55. This result shows that the application is valid and ready to be used in the learning process.

Keywords: Students’ Critical Thinking Skills, Android, Interactive Multimedia, Matter.
ABSTRAK

Perkembangan sains dan teknologi pada abad ke 21 menuntut siswa untuk mengembangkan keterampilan berpikir kritis. Namun, mengacu pada tes yang dilakukan oleh PISA, skor pada kategori sains yang didapat oleh siswa Indonesia tergolong rendah. Hal tersebut secara tidak langsung menunjukkan bahwa keterampilan berpikir siswa Indonesia masih dalam kategori rendah. Multimedia interaktif merupakan salah satu media pembelajaran yang dapat digunakan untuk meningkatkan keterampilan berpikir kritis karena memfasilitasi pembelajaran yang berpusat pada siswa. Penelitian ini bertujuan untuk mengembangkan multimedia interaktif berbasis Android untuk meningkatkan keterampilan berpikir kritis dalam pembelajaran zat. Penelitian ini menggunakan metode pengembangan yang terdiri dari analisis, desain, penegmbangan, implementasi, validasi, evaluasi, dan pretest-posttest satu kelompok untuk menganalisis pengaruh aplikasi terhadap keterampilan berpikir kritis siswa. Subjek penelitian ini adalah 30 siswa SMP di Bandung Barat. Instrumen yang digunakan adalah rubrik penilaian ahli, angket siswa, dan tes objektif yang digunakan untuk pretest dan posttest. Hasil rata-rata validasi ahli dengan menggunakan indeks V adalah 0.863 dan tergolong valid. Kemudian, ada 89.23% siswa yang memberikan respon positif terhadap aplikasi tersebut. Berdasarkan hasil analisis diperoleh, nilai N-Gain sebesar 0.52 yang dikategorikan sebagai peningkatan sedang. Hal itu menunjukkan terdapat perbedaan yang signifikan pada kemampuan berpikir kritis siswa dengan peningkatan sedang. Indikator berpikir kritis dengan peningkatan paling tinggi adalah penjelasan dengan nilai sebesar 0.55. Hasil ini menunjukkan bahwa aplikasi sudah valid dan siap digunakan dalam proses pembelajaran.

Kata Kunci: Keterampilan Berpikir Kritis Siswa, Multimedia berbasis Android, Zat.
# List of Contents

COVER .................................................................................................................
APPROVAL SHEET ............................................................................................ i
DECLARATION .................................................................................................. ii
AKNOWLEDGEMENTS .............................................................................. iii
ABSTRACT ......................................................................................................... v
List of Contents ............................................................................................... vii
List of Tables ................................................................................................... ix
List of Figures .................................................................................................. x
List of Appendices ........................................................................................... xi

CHAPTER I ........................................................................................................ 1
1.1 Background ................................................................................................. 1
1.2 Research Problem ....................................................................................... 5
1.3 Research Question ....................................................................................... 5
1.4 Limitation of Problem .................................................................................. 5
1.5 Research Objective ...................................................................................... 6
1.6 Research Benefit .......................................................................................... 6
1.7 The Organization of Research Paper ........................................................ 7

CHAPTER II ...................................................................................................... 8
LITERATURE REVIEW ................................................................................... 8
2.1 Interactive Multimedia ............................................................................... 8
2.2 Mobile Application ...................................................................................... 9
2.3 Android Application ................................................................................... 10
2.3 Articulate Storyline 3 .................................................................................. 11
2.4 Critical Thinking ........................................................................................ 17

CHAPTER III .................................................................................................. 19
RESEARCH METHODOLOGY ......................................................................... 29
3.1 Research Method ......................................................................................... 29
3.2 Research Design .......................................................................................... 29
3.3 Population and Sample .............................................................................. 30
3.4 Operational Definition ............................................................................... 30
3.5 Assumption ................................................................................................. 31
3.6 Hypothesis ................................................................................................. 31
3.7 Research Instrument ................................................................................. 31

vii
3.8 Data Processing Technique ........................................ 38
3.9 Research Procedure ................................................ 40
CHAPTER IV ........................................................................ 43
RESULT AND DISCUSSION .................................................. 43
4.1 The Development of Android-based Interactive Multimedia ...... 43
4.2 The Experts’ Judgment Towards Android-based Interactive
Multimedia ........................................................................... 60
4.3 The Implementation of Android-based Interactive Multimedia...
65
4.4 Students’ Respond after Implementing Android-Based Interactive
Multimedia as Learning Media .............................................. 66
4.5 Students’ Critical Thinking Skills ........................................ 71
CHAPTER V ........................................................................ 81
CONCLUSION, IMPLICATIONS AND RECOMMENDATIONS ........ 81
5.1 Conclusion ........................................................................ 81
5.2 Implications ...................................................................... 81
5.3 Recommendations ............................................................. 82
REFERENCES ........................................................................ 83
APPENDICES ......................................................................... 88
List of Tables

Table 2.1 Framework of Mobile Application ..............................................................10
Table 2.2 Critical Thinking Aspects based on Facione’s Indicator .................................18
Table 2.3 The Analysis of Core and Basic Competence of Matter .................................19
Table 2.4 The Characteristics of Metal and Non-Metal ...............................................23
Table 2.5 Compound and Its Element ...........................................................................23
Table 3.1 One Group Pretest Postest Design ................................................................29
Table 3.2 Research Instrument .......................................................................................32
Table 3.3 The Indicator and Aspects of Expert’s Judgement ...........................................32
Table 3.4 Likert Scale for Student’s Questionnaire .......................................................33
Table 3.5 The Distribution of Test Item ..........................................................................34
Table 3.6 Interpretation of Validity Score ........................................................................35
Table 3.7 Interpretation of Reliability Score ...................................................................35
Table 3.8 Interpretation of Difficulty Level .................................................................36
Table 3.9 Interpretation of Discriminating Power .........................................................37
Table 3.10 Test Items Analysis Result ...........................................................................37
Table 3.11 The Interpretation of N-Gain Score ...............................................................39
Table 4.1 Hardware Necessity Specifications .................................................................44
Table 4.2 Storyboard of Application Interface ...............................................................46
Table 4.3 Recapitulations of Expert’s Judgement ............................................................61
Table 4.4 Application Improvement ................................................................................64
Table 4.5 Student’s Respond towards Interactive Multimedia ........................................66
Table 4.6 Test of Homogeneity of Variances ................................................................72
Table 4.7 Test of Normality ...........................................................................................72
Table 4.8 Rank of Wilcoxon .........................................................................................73
Table 4.10 Descriptive Statistic of Student’s Critical Thinking Skills ...............................74
List of Figures

Figure 2.1 The interface of Articulate Storyline 3 ......................................................... 12
Figure 2.2 The interface of story view ............................................................... 13
Figure 2.3 The interface of scene and slide ....................................................... 13
Figure 2.4 Slide layer ........................................................................... 14
Figure 2.5 Interactive button ................................................................ 14
Figure 2.6 Trigger feature in Articulate Storyline 3 .................................. 15
Figure 2.7 Freeform question type ............................................................ 16
Figure 2.8 Graded Question type ............................................................... 16
Figure 2.9 Survey Question type ................................................................. 16
Figure 2.10 Result of question ................................................................. 17
Figure 2.11 Red and blue litmus ................................................................. 17
Figure 3.1 Flowchart of interactive multimedia ........................................... 42
Figure 4.1 Flowchart of interactive multimedia ........................................... 45
Figure 4.2 The flow of media content .......................................................... 47
Figure 4.3 Story View of Articulate Storyline 3 ............................................. 48
Figure 4.4 Even sheet of sub-chapter 1 ....................................................... 49
Figure 4.5 Even sheet of sub-chapter 2 ....................................................... 49
Figure 4.6 Even sheet of sub-chapter 3 ....................................................... 49
Figure 4.7 Even sheet of sub-chapter 1 ....................................................... 50
Figure 4.8 The Interface of Website 2 Apk Builder Pro 4.0 ......................... 50
Figure 4.9 The First Page during Animation ................................................. 51
Figure 4.10 The interface of First Page after the Animation .......................... 51
Figure 4.11 The Interface of Loading Page ................................................. 52
Figure 4.12 The interface of choosing character and input name ................ 52
Figure 4.13 The Interface of Welcoming Page ............................................. 53
Figure 4.14 The Interface of Main Menu ...................................................... 53
Figure 4.15 The Interface of Learning Material Menu ................................ 54
Figure 4.16 The example of pop up information ....................................... 54
Figure 4.17 Pop up Information ................................................................ 55
Figure 4.18 The Example of Multiple Quiz ................................................. 55
Figure 4.19 The Interface of “Pick Many” Game .......................................... 56
Figure 4.20 The example of game instruction .............................................. 56
Figure 4.21 The Interface of Drag and Drop game ...................................... 57
Figure 4.22 The Interface of drag and Drop Game ....................................... 57
Figure 4.23 The Interface of Matching quiz ............................................... 57
Figure 4.24 The Interface of Appreciation page ........................................... 58
Figure 4.25 The Interface of Appreciation page ........................................... 58
Figure 4.26 Average Score of Interactive Multimedia Aspect .................... 62
Figure 4.27 Students’ questionnaire result .................................................. 68
Figure 4.28 The Average Percentage of Students’ Respond ......................... 68
Figure 4.29 Recapitulation pretest and posttest scores for each critical thinking aspect... 76
Figure 4.30 N-Gain Score of Critical Thinking Aspect ............................... 77
List of Appendices

Appendix A. Research Instrument ................................................................. 89
Appendix B Media Design ............................................................................. 147
Appendix C Instructional Tools ................................................................. 160
Appendix D Recapitulation of Data Results .................................................. 174
Appendix E. Permission Letter .................................................................... 179
REFERENCES

Adipat, B., & Zhang, D. (2005). Interface design for mobile applications. *Association for Information Systems - 11th Americas Conference on Information Systems, AMCIS 2005: A Conference on a Human Scale*, 3, 1157–1166.

Adrizal, M., & Pahlifi, D. M. (2020). The use of android media in improving students’ motivation in learning sports physiology. In *Journal of Physics: Conference Series* (Vol. 1440, No. 1, p. 012075). IOP Publishing.

Ahmar, A. S., & Rahman, A. (2017). Development of teaching material using an Android. *Global Journal of Engineering Education, 19*(1), 72–76.

Ambarwati, D., & Suyatna, A. (2018). Interactive design for self-study and developing students’ critical thinking skills in electromagnetic radiation topic. *Journal of Physics: Conference Series, 948*(1).

Amir, M. F., Hasanah, F. N., & Musthofa, H. (2018). Interactive multimedia based mathematics problem solving to develop students’ reasoning. *International Journal of Engineering and Technology(UAE), 7*(2.14 Special Issue 14), 272–276.

Ananda, L., Fahirrozi, F., & Simanihuruk, L. (2020). *Development of Interactive Multimedia–Based Science Teaching Materials*.

Ayob, N. Z. B., Hussin, A. R. C., & Dahlan, H. M. (2009). Three layers design guideline for mobile application. *Proceedings - 2009 International Conference on Information Management and Engineering, ICIME 2009*, 427–431.

Bailin, S. (2002). *Critical Thinking and Science Education*. 361–375.

Barros, R. S. M. de, Hidalgo, J. I. G., & Cabral, D. R. de L. (2018). Wilcoxon Rank Sum Test Drift Detector. *Neurocomputing, 275*, 1954–1963.

Bidin, S., & Abu, A. (2013). Adoption and application of mobile learning in the education industry. *Procedia - Social and Behavioral Sciences, 90*(InCULT 2012), 720–729.

Cairncross, S., & Mannion, M. (2001). Interactive multimedia and learning: Realizing the benefits. *Innovations in Education and Teaching International, 38*(2), 156–164.

Creswell, John W. 2015. *Penelitian Kualitatif dan Desain Riset*. Yogyakarta: Pustaka Pelajar.

Dalle, J., Hadi, S., Baharuddin, & Hayati, N. (2017). The development of interactive multimedia learning pyramid and prism for junior high school using macromedia authorware. *Turkish Online Journal of Educational Technology, 2017*(Special Issue 2017), 714–721.

Dilmaç, S. (2020). Students’ Opinions about the Distance Education to Art and Design Courses in the Pandemic Process. *World Journal of Education, 10*(3), 113.

Djamas, D., & Padang, U. N. (2018). *Development of Interactive Multimedia Learning Materials for Improving Critical Thinking Skills*. 14(4), 66–84.

Djamas, D., & Ramli, R. (2019, April). Learning model based on discovery learning equipped with interactive multimedia teaching materials assisted by games to improve critical thinking skills of high school students. In *Journal of Physics: Conference Series* (Vol. 1185, No. 1, p. 012054). IOP Publishing.

Dutta, S., & Smita, M. K. (2020). The Impact of COVID-19 Pandemic on Tertiary
Education in Bangladesh: Students’ Perspectives. *Open Journal of Social Sciences, 08*(09), 53–68.

Kocakoyun, S., & Bicen, H. (2017). Development and Evaluation of Educational Android Application. *Cypriot Journal of Educational Sciences, 12*(2), 58-68.

Escudero, E. B., Reyna, N. L., & Morales, M. R. (2000). The Level of Difficulty and Discrimination Power of the Basic Knowledge and Skills Examination (EXHCOBA). *Revista Electrónica de Investigación Educativa, 2*(1), 1–16.

Facione, P. A. (2015). *Permission to Reprint for Non-Commercial Uses Critical Thinking: What It Is and Why It Counts.* 1–30. www.insightassessment.com

Fajar, C., Safii, M., & Andajani, K. (2021). *Video-Based Android Application Development as an Educational Facility for E-Journal Users at the Library of Universitas Negeri Malang.* 514(Icoship 2020), 14–18.

Fraenkel, J. R., Wallen, N.E., & Hyun, H.H. (2012). *How to Design and Evaluate Research in Education.* New York: Mc Graw-Hill.

Hamimi, L., & Sari, R. (2020). *The Development Of Proof Teaching Materials For High School Students.* 488(Aisteel), 113–119.

Hardani, H., Medica, P., Husada, F., Andriani, H., Sukmana, D. J., Mada, U. G., & Fardani, R. (2020). *Buku Metode Penelitian Kualitatif & Kuantitatif* Hautala, J., Baker, D. L., Keurulainen, A., Ronimus, M., Richardson, U., & Cole, R. (2018). Early science learning with a virtual tutor through multimedia explanations and feedback on spoken questions. *Educational Technology Research and Development, 66*(2), 403–428.

Huang, C. (2005). *Designing high-quality interactive multimedia learning modules.* 29, 223–233.

Jeno, L. M., Grytnes, J., & Vandvik, V. (2017). The effect of a mobile-application tool on biology students’ motivation and achievement in species identification: A Self-Determination Theory perspective. *Computers & Education*

KEMENDIKBUD RI. (2016). Permendikbud RI Nomor 20 Tahun 2016. *Journal of Chemical Information and Modeling, 53*(9), 1689–1699.

Kimberlin, C. L., & Winterstein, A. G. (2008). Validity and reliability of measurement instruments used in research. *American Journal of Health-System Pharmacy, 65*(23), 2276–2284.

Kotevsk, Z., & Tasevsk, I. (2017). Evaluating the Potentials of Educational Systems to Advance Implementing Multimedia Technologies. *International Journal of Modern Education and Computer Science, 9*(1), 26–35.

Kurniawan, B. R., Shodiqin, M. I., Saputri, D. E., Kholifah, M. N., & Affriyenni, Y. (2020). Development of android-based assessment to improve student’s concept acquisition on vector topics. *AIP Conference Proceedings, 2215*(April).

Kusumoto, Y. (2018). Enhancing critical thinking through active learning. *Language Learning in Higher Education, 8*(1), 45–63.

Lanka, S., Education, D., & Project, M. (n.d.). *Designing Interface for Interactive Multimedia:*

Larson, L. C., & Miller, T. N. (2012). *CENTURY SKILLS: Prepare Students for October 2014.*

Leacock, T. L., Nesbit, J. C., Journal, S., Leacock, T. L., & Nesbit, J. C. (2017). *International Forum of Educational Technology & Society A Framework for Evaluating the Quality of Multimedia Learning Resources Published by:*
International Forum of Educational Technology & Society Stable URL: http://www.jstor.org/stable/jeductechsoci.1.10(2), 44–59.

Learning, M. (2016). The role of mobile learning on the learning environment shifting at high school in Indonesia Dwi Sulisworo * and Moh Toifur. 10(3).

Lee, H., Parsons, D., Kwon, G., Kim, J., Petrova, K., Jeong, E., & Ryu, H. (2016). Computers & Education Cooperation begins: Encouraging critical thinking skills through cooperative reciprocity using a mobile learning game. Computers & Education, 97, 97–115.

lewis. R. Aiken. (1985). Three Coefficients For Analyzing The Reliability And Validity Of Ratings. Educational and Psychological Measurement, 45, 131–141.

Ma, L., Gu, L., & Wang, J. (2014). Research and development of mobile application for android platform. International Journal of Multimedia and Ubiquitous Engineering, 9(4), 187–198.

Mahfudz, A. Z., & Billah, A. (2020). The development of android-based learning media on vibrations and waves topic for junior high school students. Journal of Physics: Conference Series, 1567(4), 3–9.

Mishra, P., Pandey, C. M., Singh, U., Gupta, A., Sahu, C., & Keshri, A. (2019). Descriptive statistics and normality tests for statistical data. Annals of Cardiac Anaesthesia, 22(1), 67–72.

Niemi, H. M., & Kousa, P. (2020). A Case Study of Students’ and Teachers’ Perceptions in a Finnish High School during the COVID Pandemic. International Journal of Technology in Education and Science, 4(4), 352–369.

Nivethika, M., Vithiya, I., Ananthashika, S., & Deegalla, S. (2013). Personalized and adaptive user interface framework for mobile application. Proceedings of the 2013 International Conference on Advances in Computing, Communications and Informatics, ICACCI 2013, 1913–1918.

Nordin, N., Amin, M., & Yunus, M. (2010). Mobile Learning Framework for Lifelong Learning, 7(C), 130–138.

Nugraha, M. G., Kaniawati, I., Rusdiana, D., & Kirana, K. H. (2017). Combination of inquiry learning model and computer simulation to improve mastery concept and the correlation with critical thinking skills (CTS) combination of Inquiry Learning Model and Computer Simulation to Improve Mastery Concept and the Correlation. 070008(2016).

Nurdiyah, L. (2019). Effect of interactive multimedia based on PBL on critical thinking ability and science literacy VII junior school student at kupang. 6th ICRIEMS Proceedings, 2011, 1–8.

OECD. (2019). PISA 2018 insights and interpretations. OECD Publishing, 64. https://www.oecd.org/pisa/PISA 2018 Insights and Interpretations FINAL PDF.pdf

Orr, K. L., Golas, K. C., & Yao, K. (1994). Storyboard development for interactive multimedia training. Journal of Interactive Instruction Development, 6(3), 18-31.

Ozdamlı, F., & Cavus, N. (2011). Basic elements and characteristics of mobile learning. Procedia - Social and Behavioral Sciences, 28, 937–942.

Parsons, D., & Cranshaw, M. (2007). A Design Requirements Framework for Mobile Learning Environments, 2(4), 1–8.

Perolat, J., Couso, I., Loquin, K., & Strauss, O. (2015). Generalizing the Wilcoxon
rank-sum test for interval data. *International Journal of Approximate Reasoning*, 56(PA), 108–121.

Prameswari, S. W., Suharno, S., & Sarwanto, S. (2018). Inculcate Critical Thinking Skills in Primary Schools. *Social, Humanities, and Educational Studies (SHEs): Conference Series, 1*(1), 742–750.

Rachmadullah, R., Zulela, M. S., & Syarif Sumantri, M. (2019). Computer-based interactive multimedia: A study on the effectiveness of integrative thematic learning in elementary schools. *Journal of Physics: Conference Series, 1175*(1), 0–6.

Rahayu, D. M., Roesminingsih, M. V., -, H., & Subroto, W. T. (2019). "The Use of Interactive Multimedia to Improve Critical Thinking Skills of Primary School Students". *International Journal of Scientific and Research Publications (IJSRP), 9*(4), p8821.

Rahmawati, L., Labibah, U. N., & Kuswanto, H. (2020). The implementation of android-based physics learning media integrated with landslide disaster education to improve critical thinking ability and disaster preparedness. *Journal of Physics: Conference Series, 1440*(1).

Reich, J., Buttimer, C., Coleman, D., Colwell, R., Faruqi, F., & Larke, L. (2020). *What’s lost*. https://osf.io/2fjtc/.

Richey, R. C. (1994). Developmental Research: The Definition and Scope. 1994 *National Convention of Teh Association Fr Educational Communications and Technology*, 714–720. http://files.eric.ed.gov/fulltext/ED373753.pdf

Richey, R. C., & Klein, J. D. (2005). Developmental research methods: Creating knowledge from instructional design and development practice. *Journal of Computing in Higher Education, 16*(2), 23–38.

Ridlo, I. A. (2017). Pedoman Pembuatan Flowchart. *Academia.Edu*, 14. https://www.academia.edu/34767055/Pedoman_Pembuatan_Flowchart

Room, B., & Mercure, G. (2017). *AISTEEL 2017*. 2(December).

Rusmansyah, Yuanita, L., Ibrahim, M., Isnawati, Rizkiana, F., & Kusuma, A. E. (2020). Effect of scientific critical thinking model to train critical thinking skills and student self efficacy. *Journal of Physics: Conference Series, 1422*(1).

Saputra, M. R. D., & Kuswanto, H. (2019). The effectiveness of Physics Mobile Learning (PML) with HomboBatu theme to improve the ability of diagram representation and critical thinking of senior high school students. *International Journal of Instruction, 12*(2), 471–490.

Saputri, D. Y., & Indriayu, M. (2018). Need Assessment of Interactive Multimedia Based on Game in Elementary School: A Challenge into Learning in 21st Century. 1–8.

Sari, S., Aryana, D. M., Subarkah, C. Z., & Ramdhani, M. A. (2018). Multimedia Based on Scientific Approach for Periodic System of Element. *IOP Conference Series: Materials Science and Engineering, 288*(1).

Selamat, I. N. (2018). Students ’ Critical Thinking Skills in Chemistry Learning Using Local Culture-Based 7E Learning Cycle Model. *11*(2), 399–412.

Salkind, N. J. (2012). *EXPLORING RESEARCH EIGHT EDITION* (8th ed.). United States of America: Pearson Education

Sookoo-Singh, N., & Boisselle, L. N. (2018). How Does The “Flipped Classroom Model” Impact On Student Motivation And Academic Achievement In A
Chemistry Classroom? *Science Education International, 29*(4), 201–2012.  
Sumardi, L., Rohman, A., & Wahyudiati, D. (2020). Does the teaching and learning process in primary schools correspond to the characteristics of the 21st century learning? *International Journal of Instruction, 13*(3), 357–370.  
Sya’ Bandari, Y., Firman, H., & Rusyati, L. (2018). The validation of science virtual test to assess 7th grade students’ critical thinking on matter and heat topic (SVT-MH). *Journal of Physics: Conference Series, 1013*(1).  
Syawaludin, A., Gunarhadi, & 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.  
Thesis, A. (2010). *Contextual android education. December.*  
Utami, B., Saputro, S., Masykuri, M., & Widoretno, S. (2017). Critical thinking skills profile of high school students in learning chemistry. *I(2), 124–130.*  
Villasenor Alva, J. A., & Estrada, E. G. (2009). A generalization of Shapiro-Wilk’s test for multivariate normality. *Communications in Statistics - Theory and Methods, 38*(11), 1870–1883.  
Walker, L. (2011). My teacher is an android: Engaging learners through an android application. *ASCILITE 2011 - The Australasian Society for Computers in Learning in Tertiary Education, 1270–1274.*  
Widodo, W., Sudibyo, E., Suryanti, Sari, D. A. P., Inzanah, & Setiawan, B. (2020). The effectiveness of gadget-based interactive multimedia in improving generation z’s scientific literacy. *Jurnal Pendidikan IPA Indonesia, 9*(2), 248–256.  
Yang, Y. C., & Chang, C. (2013). Computers & Education Empowering students through digital game authorship : Enhancing concentration , critical thinking , and academic achievement. *Computers & Education, 68*, 334–344.  
Yuniarti, A., Yeni, L. F., & Yokhebed. (2017). Development of Virtual Laboratory Based on Interactive Multimedia on Planting and Painting Bacteria. *Journal of Physics: Conference Series, 895*(1).  
Yustiqvar, M., Gunawan, G., & Hadisaputra, S. (2019). Green Chemistry Based Interactive Multimedia on Acid-Base Concept. *Journal of Physics: Conference Series, 1364*, 012006.