PalArch's Journal of Archaeology of Egypt / Egyptology

INTERACTIVE MULTIMEDIA DEVELOPMENT ENGINE MANAGEMENT SYSTEM (EMS) USING THE ADDIE MODEL

Marji [1], Komarudin [2], Eddy Sutadji [3], Widiyanti [4]

[1234]State University of Malang, Indonesia

Corresponding Email: [2]komarrakha.1@gmail.com

Marji, Komarudin, Eddy Sutadji, Widiyanti. Interactive Multimedia Development Engine Management System (Ems) Using The Addie Model-- Palarch's Journal Of Archaeology Of Egypt/Egyptology 17(4), 609-629. ISSN 1567-214x

Keywords : Addie, Prior Knowledge, Problem Solving , Interactive Multimedia

ABSTRACT

This study aims to produce an interactive multimedia engine management system to improve prior knowledge and problem solving abilities as well as to test the effectiveness of the interactive multimedia being developed. Prior knowledge (reading electrical wiring) which is the basis for any learning process in the automotive field. Problem solving ability is the final result in the engineering field which is indispensable in the industrial era4.0. The development of interactive multimedia in this study uses the ADDIE model. The ADDIE model was chosen because of the superiority of this model in every process, there is an evaluation process that is always linked in every development process. The trial subjects in this study were 38 students in the automotive sector at Malang State University. The data collected is quantitative data. Quantitative data were analyzed using the independent sample t test . The results showed that interactive multimedia can improve prior knowledge and problem solving abilities .

INTRODUCTION

The main problem in teaching engineering is visualization. Visualization is very useful to help students understand how abstract electrical components and fields work (Banerjee et al., 2015). Visualization is obtained through media or multimedia intermediaries, by using multimedia, students get personal experience which is the basis for forming visualization (Mohler, 1998; Osman & Lee, 2013; Nicholson, 1995). Multimedia is a technology that combines various forms of media. Multimedia is part of the media (Amir, Hasanah, & Musthofa, 2018;; Ramesh, 2005; Kalyuga, 2009). Seeing this condition, multimedia is the best media when compared to other media. One form of multimedia is interactive multimedia is a combination of educational communication, visual science, and

computer science (Mohler et al., 2001). The use of interactive words means that the multimedia used must be able to interact with its users, for example if the user changes the variables in interactive multimedia, there will be a change in response to it (Deliyannis, 2012). Interactive multimedia is used to describe areas of scientific research that support expression or communication through various media (Chachil et al., 2015). Interactive multimedia in learning can be more effective if it is supported by scientific learning designs. In fact Interactive multimedia has long been used since technology and informatics emerged (Ivers & Barron, 2002; Collins et al., 1997). Learning using multimedia is computer-based learning. According to d Lu & Cheng (2012); Al-hariri & Al-hattami (2017); Deniz & Cakir (2006); Manalu & Sitompul (2017) state that computer-based learning increases the effectiveness of the learning process. Interactive multimedia is a form of utilizing computer technology. The use of technology in the form of multimedia in any type is an effort to ease the cognitive load (Meysun Hamdi & Thair Hamtini, 2016; Tabbers & Koeijer, 2010). Multimedia is an embodiment of technology that can be used regardless of the learning model (Ivers & Barron, 2002; Kirsh, 1997). Learning using multimedia is a teaching effort in overcoming students' incomprehension (Sitompul & Fadilla, 2018). Research (Campanella et al., 2009) state that the use of interactive multimedia in learning will make it easier for students to understand the material content . Multimedia is a forum for raising awareness of the abilities of students (Raaff et al., 2014). Maor's research (2000); (Claudet, 2002) states that multimedia development encourages teachers to understand the needs of students and the conditioning of the environment or situation. Two things that need to be considered when designing multimedia are the design and ability of the media to convey information (Kumpulainen & Salovaara, 2001). Moreno & Mayer (2007) state there are five principles of media / multimedia design: (1) integrated activities; (2) reflection; (3) feedback; (4) control; and (5) pre-training.

The condition of the media in education is still far from ideal, because: 1) the media in education is 100% in the form of an engine stand , so it cannot be used in theoretical classes. Mastery of theory is very influential in the engineering field; 2) the existing media cannot describe the concept well, so it is not able to help students to visualize phenomena; 3) the existing media are 90% over 10 years old, so they are not updated; 4) media in schools and campuses is not equipped with electrical wiring ; and 5) the existing media in schools and campuses are not equipped with tutorials in the form of books or videos, manual books and jobsheets, so that the media is not rich with information and is not interactive.

Interactive multimedia or interactive media has several benefits, including: (1) it has an influence on the effectiveness of learning (Al-Safadi, 2016); (2) minimizing errors in manufacturing (Manalu & Sitompul, 2017); (3) increasing the competence of students (Samsudduha, Masugiono, & Supraptono, 2013a; Samsudduha, Masugiono, & Supraptono, 2013b); (4) maintaining the motivation of students (Chachil et al., 2015); (5) encouraging active students (Fui-Theng LEOW & Mai NEO, 2014); (6) bridging basic concepts into real knowledge (TK & Neo, 2010); (7) The application of multimedia provides satisfaction when attending

lessons (Chu et al., 2019; (8) encourages teachers to always be creative in changing teaching methods to improve student achievement (Manalu & Sitompul, 2017; Tsung, 2010); learning effectiveness (Hsiao, Tiao, & Chen, 2016; Zhou & Yadav, 2017; Wing, So, Chen, Wan, & Chen, 2019; (Jr et al., 2011); (10) increase the independence of students, maintain discipline towards goals even without much teacher intervention (Mayer, 2001; Manurung & Panggabean, 2018; Bodemer & Ploetzner, 2005; and (Oh et al., 2016)); (11) Interactive media makes it easier to teach basic concepts (Khan & Masood, 2015); (12) helping students have basic knowledge or basic concepts (Sukiyasa, 2013); (13) improving prior knowledge and problem solving (Mukhadis, 2020).

Interactive multimedia, which is an effort to improve visualization skills in the field of engineering, is an urgent need, as an effort to improve the quality of graduates. This research is a multimedia engine management system (EMS) development and research activity which aims to produce interactive multimedia products that can be used in learning activities in the S1 automotive education study program, Malang State University. The use of interactive multimedia EMS is an effort to improve prior knowledge (reading electrical wiring) and the problem solving ability of students in automotive education undergraduate study programs. The development of EMS in this study uses the ADDIE model, the existing model is chosen because this model has several advantages: 1)interdependent , each component of the ADDIE model is interrelated; 2) synergistic , each part of ADDIE influences each other; 3) dynamic , each process / step can change according to the input from the previous process; 4) cybernetic , each process / step in the ADDIE model is to organize, guide, automate, replicate, and prevent failure of the entire process; 5) systematic , the ADDIE model development, all designs have been completely planned for each process / step (Branch, 2009).

Product development is implemented in two groups, namely the prototype test group of 38 taken from the automotive training class and the final product test group of 40 people taken from the automotive education study program. The effectiveness of development products is measured by providing a test divided into pretest and posttest on two competencies, namely problem solving. The test results were analyzed using the T test. The results of the T test analysis were used as a basis for determining unique trial subjects. The experimental subjects were then interviewed to find out their critical-thinking abilities , and presentation skills .

In essence, this research aims to produce EMS products that can improve prior knowledge (reading electrical wiring) and problem solving (critical-thinking, creativity, and presentation skills).

METHODS

This study uses the ADDIE development model. The ADDIE model was chosen because this model has several advantages, including: 1) interdependent , in the ADDIE model each component is interrelated so that any changes in other components will affect other components, as illustrated in Figure

2; 2) synergistic , each part of ADDIE is a big thing and influences each other; 3) dynamic , each process / step can change according to the input from the previous process; 4) cybernetic , each process / step in the ADDIE model is to organize, guide, automate, replicate, and prevent failure of the entire process; 5)systematic , the ADDIE model development, all designs have been completely planned for each process / step (Branch, 2009).

The ADDIE development model is the result of refinement of the IPO development model (input, process, output). The input stage in the IPO model is a step to identify variables through data and information. The process stage is the stage of finding ways to produce a product or procedure. At this stage it does not only contain the development process but also the implementation process. The output stage is a description of all development processes from start to finish.

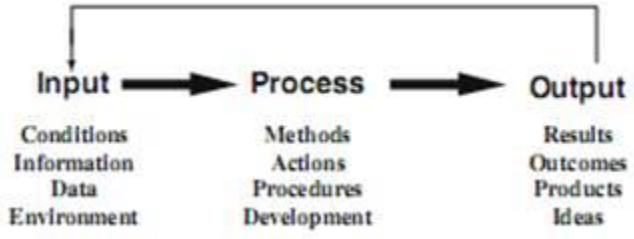

Figure 1 IPO Model Development

Researchers chose the ADDIE model because the relationship between the components of the ADDIE model development is one of the advantages of this model not only as a development cycle, but each component is another component. This development model always pays attention to the suitability of any other component changes as depicted in Figure 2. Researchers hope that the product has advantages in terms of renewability.

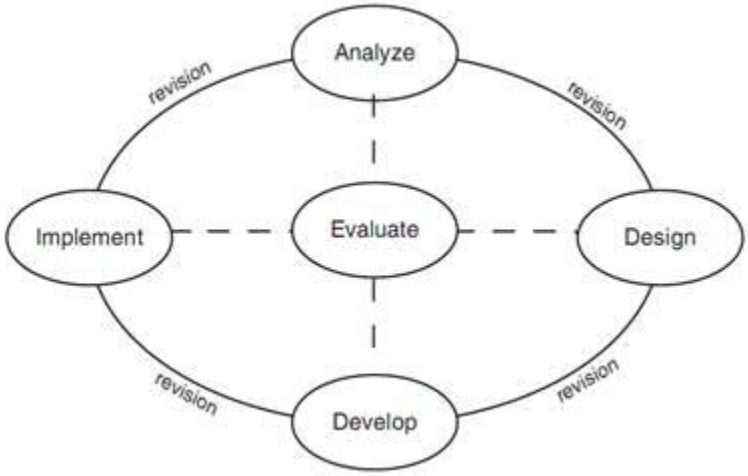

Figure 2 ADDIE Development Model (Branch, 2009)

Evaluation in ADDIE is intended to strengthen a product or procedure. The evaluation procedure is carried out in each ADDIE step to make sure all steps have a level of validity. Any revisions to planned instructions must be substantiated by empirical evidence obtained during the formative evaluation, thereby increasing the validity of the entire process. Evaluation is done using quantitative and qualitative. ADDIE is a validation process because it verifies all products and procedures related to development.

Research Procedure

ANALYSIS

In this study the analysis was carried out in several aspects: 1) analysis of the media on campus by looking at the quantity and quality aspects; 2) student satisfaction analysis; 3) goal attainment, the achievement aspect can be seen from 2 points of view, namely the point of view of the teacher and the point of view of students.

DESIGN

Media design is designed to be interactive multimedia so that participants can interact with multimedia. Multimedia design is based on the results of an analysis of the needs and conditions that exist in the population. In the design process, the researcher asked for input from automotive experts and field experts so that the multimedia form was in accordance with the teaching needs of the theory class.

DEVELOPMENT

This phase depends on the first two phases, namely the analysis and design phases. The development of interactive multimedia in this study uses materials that are widely used in vehicles that are dominant in Indonesia. The dimensions of the multimedia engine management system are made with attention to ease of operation, the ability to convey information and the ease of moving from class to class.

IMPLEMENTATION

This phase is about turning our plans into action. The implementation in this study is divided into two, namely: 1) implementation in a limited sample, in this study automotive training was selected. The results of this study determine the next design. If the results are not significant in this research, the prototype must be improved, so that the ideal prototype is obtained; 2) implementation on the actual sample. The results of previous research will then be implemented in the automotive department of Malang State University. At the beginning the researcher chose the sample to be used, followed by the researcher providing an explanation of how to use interactive multimedia, then giving the subject the opportunity to try to use interactive multimedia when they practiced the researcher making observations.posttest . The posttest results were analyzed by using the independent

sample t test . Furthermore, the researcher conducted interviews with unique experimental subjects, which were the results of observations.

The implementation was carried out in the automotive department class with 38 participants. The implementation procedure is shown in **Figure 3**.

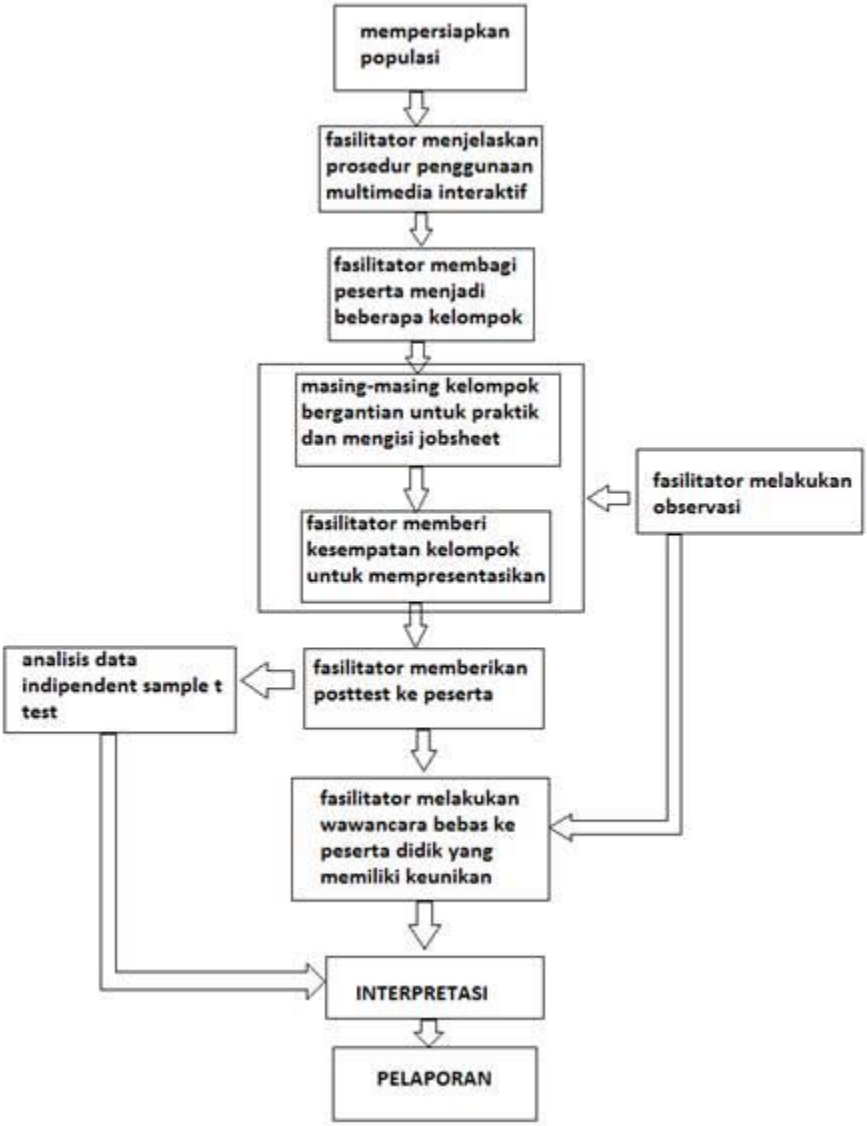

Figure 3. Interactive Multimedia Implementation Procedure

The quantitative data were analyzed using the independent sample t test , then the results of the analysis were interpreted as the final results of the study.

EVALUATION

The last process in the ADDIE model is the Evaluation phase. Researchers talk about evaluation, researchers talk about two types of evaluation, namely formative evaluation and summative evaluation. First, formative evaluation is an ongoing

process during the ADDIE model implementation process. There are two basic processes for formative evaluation, namely small group evaluation and field trials

Interactive multimedia effectiveness test used one group pretest posttest design . The research design is shown in **Figure 3.**

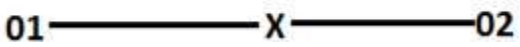

Figure 4. Research design

Information
O1 = Pre-test , carried out before treatment, the purpose of which is to find out knowledge before using interactive multimedia.
X = Treat, start by providing an explanation of the material and how to use interactive multimedia.
O2 = Post-test , carried out after students use interactive multimedia, the goal is to obtain interactive multimedia effectiveness.

FINDINGS AND DISCUSSION

Findings

Needs analysis

The observation results obtained: (1) the number of media on campus is still far from ideal, in practicum activities the number of groups still consists of 4-5 people. The effectiveness of learning depends on the number of media used during practical activities. (2) student satisfaction analysis, from the results of free interviews with students it was revealed that the existing media were not in accordance with the needs; 3) goal attainment, the achievement aspect can be seen from 2 points of view, namely the point of view of the teacher and the point of view of students. The point of view of the teacher tends to be relatively achievable because courses are taught by more than one teacher. The point of view of students, seeing the second point of the learning process is unsatisfactory.

Design

The media on campus and at Pusdik are still in the form of an engine stand which is less able to describe the concept. The absence of completeness in the form of electrical wiring makes it difficult for students in the learning process. Media design is still in the form of an engine stand so that it is less rich in information, with existing designs learning objectives have been achieved.

Evaluation

The Influence of Multimedia on Prior Knowledge

Learning using interactive multimedia in this study is to improve prior knowledge and problem solving abilities . Statistically, in this study there is an increase in prior knowledge as illustrated in **Table 1**.

Table 1 Independent Samples Test										
Levene's Test for Equality of Variances				t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Prior Knowledge Results	Equal variances assumed	2,411	.125	-6,186	74	.000	-15,631	2,526	-20,666	-10,596
	Equal variances not assumed			-6,186	71,323	.000	-15,631	2,526	-20,669	-10,593

Table 1 shows the results of the F test of 2,411 with a significance of 0.125, which means that the significance is greater than 0.05, so it is said that the independent t test of the group is significant. The results of the t test for equality of mean on the equal variances assumed line , the sig (2 tailed) column obtained a significance value of 0.00, meaning that the significance value is less than 0.05 so it can be concluded that there is a difference between the pretest results and the posttest prior ability. knowledge

Effect of Interactive Multimedia on Problem Solving Ability

Learning by using multimedia interactive influence on problem solving ability as the results in **Table 2**

Table 2 Independent Samples Test

Levene's Test for Equality of Variances				t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Results of Problem Solving	Equal variances assumed	.496	.483	-3.97	74	.000	-10.60	2,670	-15.92	-5.29
	Equal variances not assumed			-3.97	73.29	.000	-10.60	2.67	-15.92	-5.27

Table 2 illustrates the F test value of 0.496 with a significance of 0.483 meaning that the significance is greater than 0.05, so that the F test results are significant, which means the group test is significant. The significance of the t-test for Equality of Means is 0.00, so the significance is smaller than 0.00, which means that there is a significant difference in the results of the pretest and posttest test problem solving.

DISCUSSION

Analysis

Media is an important component in learning to increase knowledge and problem solving, from the research results that on campus media coverage is very lacking. According to (Manurung, 2014) the failure in teaching knowledge on campus and in educational educational institutions is due to the absence of media during the learning process. The failure in teaching knowledge in general is due to several causes, among others: (1) lack of understanding of concepts; (2) the absence

of relevant phenomena during learning; (3) lack of relevant media in the learning process; (4) lack of proper process in learning (Murtadlo, 2019).

Design

Based on the findings in the field, the authors discussed with the teaching team on campus and discussed with automotive and media experts so that the researchers decided to design multimedia as shown in **Figure 5**.

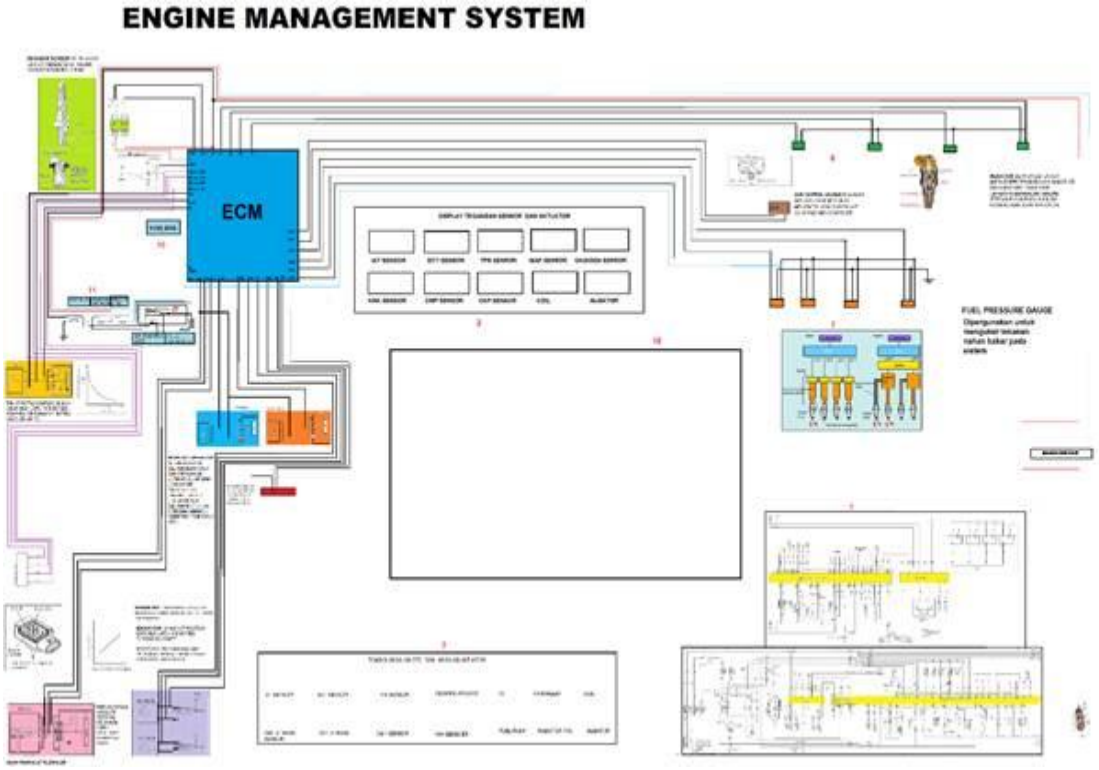

Figure 5. Engine Management System Layout

Layout engine management system, namely: 1) ems wiring diagram, this section describes the engine management system electrical layout that can be used to determine damage; 2) monitor the voltage and resistance of the actuator sensors, useful for showing the voltage and resistance of the sensors and actuators, any changes in the condition of the engine management system can be interpreted by paying attention to changes in voltage; 3) trouble switch , used to cause problems; 4) layoutthe location of the components and the connection of the sensor, module and actuator, which is used to describe the location of the component and the relationship between the sensor and the module and the relationship between the actuator and the module; 5) component name, provides an overview of the component name; 6) the location of the components in the vehicle, describing the location of the components in the vehicle; 7) ignition simulation, describes the working ignition; 8) simulation of spraying, useful for describing to participants the

form of spraying; 9) combination meter , used to show engine speed; 10) fuse , informing the effect of fuse when it is problematic; 11) relay , informs the function and effect when the relay is removed; 12) Laptop / scan tool, displays the condition of the engine management systemby displaying engine condition data; 13) LCD projector , to make it easier for participants / teachers to display the data displayed by the laptop.

Development

Based on the design that has been discussed with various parties, the authors developed multimedia as shown in **Figure 6.**

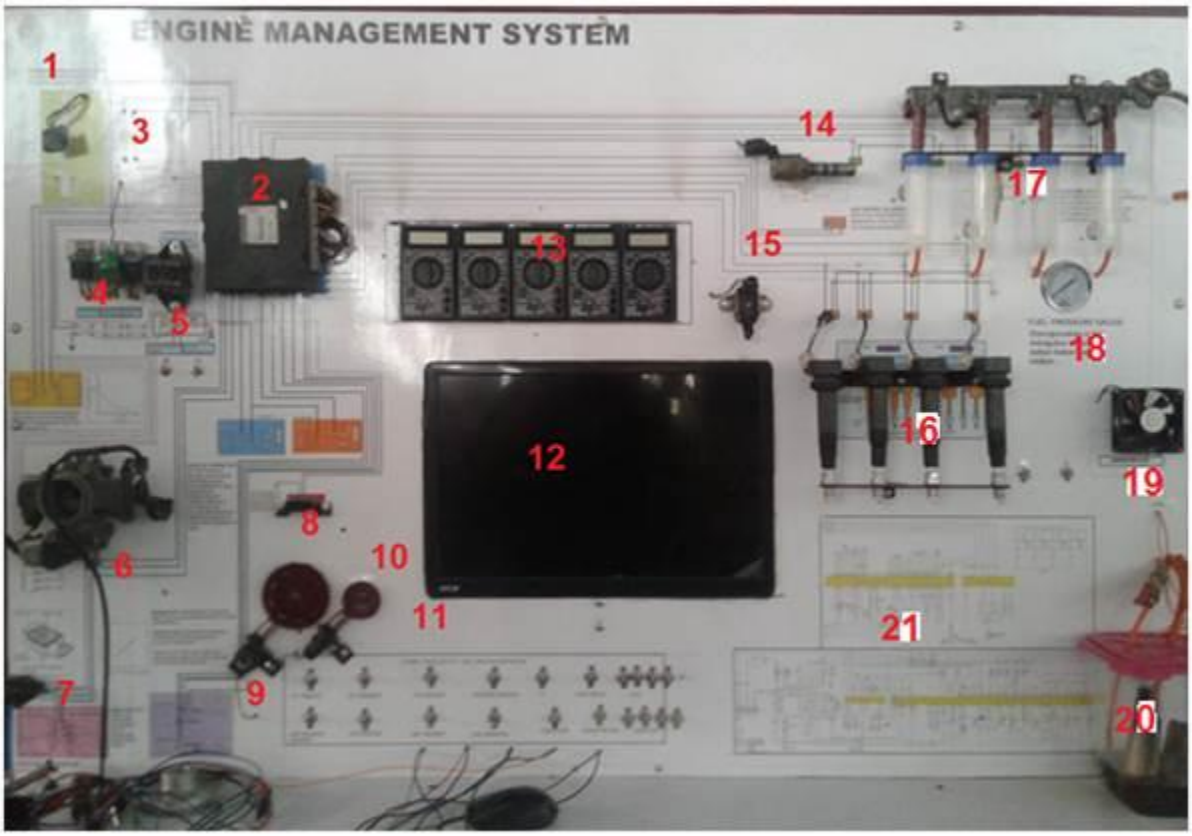

Figure 6 Multimedia Development Results

Multimedia interactive layout: (1) oxygen sensor with wiring and points for measuring voltage; (2) ECM and wiring along with points measuring stress; (3) knock sensors, electrical wiring and points for measuring voltage and sensor resistance; (4) relay-engine management system; (5) engine management system fuses; (6) throttle body and components; (7) absolute pressure manifold along with electrical wiring and measuring point; (8) data link connector; (9) crankshaft position sensor, electrical wiring; (10) camshaft position sensor, electrical wiring, point for measuring voltage, engine resistance; (11) switch actuator sensor simulation; (12) monitor to see machine condition; (13) multitester for measuring

the voltage and resistance of sensors and injectors; (14) oil control valve (OCV) of variable valve timing (VVT); (15) EVAP canister purge; (16) ignition coil along with electrical wiring and measuring points; (17) injectors, spraying volume measuring devices, electrical wiring and measuring points; (18) fuel pressure gauge; (19) radiator fan; (20) fuel pump; (21) electrical wiring.

Evaluation

The Influence of Multimedia on Prior Knowledge

The results of this study indicate that there is an effect of interactive multimedia on prior knowledge in line with the research of Song, Kalet, & Plass (2015); Teoh & Neo; (2007); (Yang, 2018) stated that multimedia has a direct impact on prior knowledge . The main reason multimedia affects prior knowledge is because multimedia is a combination of several media so that it is rich in information. Another study that supports this research is the research of Kalyuga (2009) which states that there are differences in prior knowledge when using multimedia. Other studies that agree with this research are the research of Kalyuga, (2013); Rias, (2008) states the ability of prior knowledgeincreased after implementing multimedia. Every student has different abilities even though they use multimedia (Chiu, 2016). Research (Amadieu et al., 2009) states that providing comprehensive information has an impact on the ability of prior knowledge . Multimedia in this study has comprehensive information. Learning activities are the process of transferring knowledge , there needs to be a minimum capital that students must have, namely prior knowledge . Multimedia is used in building prior knowledge in course places (Bennett & Brennan, 1993). According to (Bodemer & Ploetzner, 2005) using interactive visualization can reduce ability deficienciesprior knowledge . Visualization is the main key in providing deep understanding to students in the engineering field, the use of multimedia in this study is an effort to help students visualize the material.

Effect of Interactive Multimedia on Problem Solving Ability

The results of this study indicate that there is an effect of interactive multimedia on problem solving ability In line with research (Melander, Bowden, 2019; Sazali, Alias, Razally, & Yamin, 2010 ;Manurung & Mihardi, 2018; Neo et al, 2009; Zaid et al., 2013;Tudor, 2013)) states that multimedia is based on computers have an influence on knowledge and problem solving abilities . In line with the research (Mannheimer & Amy, 2011) states that the problem solving ability of students increases when using video media when learning, in this study video is also used to help participants improve their problem solving skills . The use of multimedia helps students to visualize events / phenomena. As stated (Korakakis et al., 2012) that using multimedia helps students to visualize phenomena. This research is a problem-based learning. The results show that interactive multimedia which is designed with problem based has an effect on increasing problem solving abilities . In line with the research of Hoffman & Ritchie (1997), it is stated

that the use of multimedia in problem-based learning can help students solve problems. Development of problem solving abilitiesis done by designing problem-based learning.

Problem-based learning or better known as problem based learning (PBL) will be effective in achieving its goals by utilizing multimedia (Mcalpine & Clements, 2017). Akinsola's research (2014) states that using multimedia provides comprehensive instructions so that it can guarantee the achievement of educational goals, this study uses multimedia which is a combination of several systems used in one interactive multimedia that can provide comprehensive information. Problem solving activities require comprehensive information so that it is a problem solving processcan be done precisely and quickly. Quality education is measured from the learning outcomes of students, one of the components of learning outcomes is problem solving, self-efficacy (Zheng et al., 2006). The results of this study are in line with the research of Ryan et al., (2016) which illustrates that there is a strong relationship between interactive multimedia and the ability to understand problem solving instructions . Melander Bowden (2019) argues that digital learning has an effect on problem solving , in this study it is digital learning that affects problem solving abilities . According to (Banerjee et al., 2015) that By using multimedia, it is obtained the achievement of higher cognitive abilities and an increase in statistical problem solving abilities.

The interactive multimedia design engine management system is tailored to the needs of teaching in the theory class. Samsudduha, Masugiono, & Supraptono (2013) and Neo et al (2009) the use of teaching media when theory helps teachers convey learning goals and objectives, makes it easier to understand how to work and troubleshoot starter motors. According to (Widjanarko, 2014) Based on the results of his research that there was an increase in student learning outcomes after using the wiring indicated by the LED, so that students could easily identify troubleshooting.Research (Zheng et al., 2009) states that using multimedia facilitates problem solving abilities . Multimedia helps students to be actively involved in the problem solving process because it is related to real material and real life situations.

CONCLUSION

Interactive multimedia which is a means of helping students visualize phenomics. This study shows that using interactive multimedia has an effect on increasing prior knowledge , which is the basic scheme in learning. This study also shows that interactive multimedia can help students improve their problem solving skills .

ACKNOWLEDGMENTS

Thanks to: (1) the supervisor who has guided so that this dissertation can be completed; (2) LP2UM institutions that have financed the dissertation; (3) Pusdiklat Suzuki Um; (4) S1 Automotive education.

REFERENCE

Akinsola, M. K. 2014. Effects Of Mnemonic And Prior Knowledge Instructional Strategies On Students ' Achievement In Mathematics. *International Journal of Education and Research* ,*2* (7), 675–688. http://ir.library.ui.edu.ng/bitstream/123456789/102/1/file.pdf

Al-hariri, M. T., & Al-hattami, A. A. 2017. Impact of students ' use of technology on their learning achievements in physiology courses at the University of Dammam. *Journal of Taibah University Medical Sciences*, *12*(1), 82–85. https://doi.org/10.1016/j.jtumed.2016.07.004

Al-Safadi, L. 2016. The Effects of Real-Time Interactive Multimedia Teleradiology System. *BioMed Research International*, *2016*, 1–9. https://doi.org/10.1155/2016/4126841

Amadieu, F., Tricot, A., & Mariné, C. 2009. Interacting With Computers Interaction Between Prior Knowledge And Concept-Map Structure On Hypertext Comprehension , coherence of reading orders and disorientation. *Interacting With Computers*, 1–10. https://doi.org/10.1016/j.intcom.2009.07.001

Amir, M. F., Hasanah, F. N., & Musthofa, H. 2018. Interactive Multimedia Based Mathematics Problem Solving to Develop Student s ' Reasoning, *International Journal of Engineering & Technology 7*(2018), 272–276. https://www.researchgate.net/publication/331962139

Banerjee, G., Murthy, S., & Iyer, S. (2015). Effect of active learning using program visualization in technology-constrained college classrooms. *Research and Practice in Technology Enhanced Learning*, *10*(1). https://doi.org/10.1186/s41039-015-0014-0

Bennett, S. J., & Brennan, M. J. 1993. Interactive Multimedia Learning In Physics. *Australian Journal of Educational Technology*, (Online), 12(1). https://ajet.org.au/index.php/AJET/article/download/2031/976/

Bingimlas, K. A. (2009). Barriers to the Successful Integration of ICT in Teaching and Learning Environments : A Review. *Eurasia Journal of Mathematics, Science & Technology Education 5*(3), 235–245. https://www.ejmste.com/article

Bodemer, D., & Ploetzner, R. 2005. Supporting Learning With Interactive Multimedia Through Active Integration Of Representations. Instructional Science 33: 73–95 https://doi.org/10.1007/s11251-004-7685-z

Branch, R. 2009.*Instruction Design : The ADDIE Approach*. USA. Sringer.

Campanella, M., Leonardi, R., & Migliorati, P. 2009. Interactive Visualization Of Video Content And Associated Description For Semantic Annotation. *Signal, Image and Video Processing*, *3*(2), 183–196. https://doi.org/10.1007/s11760-008-0071-6

Chachil, K., Engkamat, A., Sarkawi, A., & Shuib, A. R. A. 2015. Interactive Multimedia-based Mobile Application for Learning Iban Language (I-MMAPS for Learning Iban Language). *Procedia - Social and Behavioral Sciences*, *167*, 267–273. https://doi.org/10.1016/j.sbspro.2014.12.673

Chiu, T. K. F. 2016. Effects of Prior Knowledge on Mathematics Different Order Thinking Skills in Mobile Multimedia Environments, *Mobile Learning Design*. 373–386. https://doi.org/10.1007/978-981-10-0027-0

Chu, T., Wang, J., Lin, H., Lee, H., Lin, C., & Chieh, L. 2019. Multimedia-Assisted Instruction On Pain Assessment Learning Of New Nurses : A Quasi-Experimental Study, *BMC Medical Education*. 19:68 1–8. https://www.researchgate.net/publication/331508449.

Claudet, J. 2002. Integrating School Leadership Knowledge and Practice Using Multimedia Technology : Linking National Standards , Assessment , and Professional Development. *Journal of Personnel Evaluation in Education* 16 1, 20-43. https://link.springer.com/article/10.1023/A:1019935809057

Collins, J., Hammond, M., & Wellington, J. 1997. *Teaching and learning with multimedia*. USA: Routledge

Deliyannis, I. 2012. *Interactive Multimedia*. Croatia. InTech

Deniz, H., & Cakir, H. 2006. Design principles for computer-assisted instruction in histology education: An exploratory study. *Journal of Science Education and Technology*, *15*(5–6), 399–408. https://doi.org/10.1007/s10956-006-9031-5

Fui-Theng Leow, & Mai Neo. 2014. Interactive Multimedia Learning: Innovating Classroom Education in a Malaysian University. *Turkish Online Journal of Educational Technology*, *13*(2), 99–110. https://files.eric.ed.gov/fulltext/EJ1022913.pdf

Hoffman, B. O. B., & Ritchie, D. 1997. Using Multimedia To Overcome The Problems With Problem Based Learning. *Instructional Science* 25: 97–115. https://link.springer.com/article/10.1023/A:1002967414942

Hsiao, C., Tiao, M., & Chen, C. (2016). Using Interactive Multimedia E-Books For Learning Blood Cell Morphology In Pediatric Hematology. *BMC Medical Education*, 1–8. https://doi.org/10.1186/s12909-016-0816-9

Ivers, K. S., & Barron, A. E. 2002. *Multimedia Projects in Education: Designing, Producing, and Assessing.* USA. Libraries Unlimited Teacher Ideas Press.

Jr, A. R. S., Cavanaugh, C., & Moore, W. A. 2011. Instructional multimedia : An investigation of student and instructor attitudes and student study behavior, *BMC Medical Education*, 11(38) :5–7. http://www.biomedcentral.com/1472-6920/11/38

Kalyuga, S. 2009. *Managing Cognitive Load in Adaptive Multimedia Learning*. New York. IGI Global.

Kalyuga, S. 2013. Effects of learner prior knowledge and working memory limitations on multimedia learning. *Procedia - Social and Behavioral Sciences*, *83*(1965), 25–29. https://doi.org/10.1016/j.sbspro.2013.06.005

Khan, F. M. A., & Masood, M. 2015. The Effectiveness of an Interactive Multimedia Courseware with Cooperative Mastery Approach in Enhancing Higher Order Thinking Skills in Learning Cellular Respiration. *Procedia - Social and Behavioral Sciences*, *176*, 977–984. https://doi.org/10.1016/j.sbspro.2015.01.567

Kirsh, D. 1997. Interactivity And Multimedia Interfaces. *Instructional Science* (25) :79–96. https://link.springer.com/article/10.1023/A:1002915430871

T. K., K. N., & Neo, M. (2010). Interactive multimedia education: Using Authorware as an instructional tool to enhance teaching and learning in the Malaysian classroom. *Digital Education Review*, *5*(5), 80–94. https://revistes.ub.edu/index.php/IEM/article/view/11744/14554

Korakakis, G., Boudouvis, A., Palyvos, J., & Pavlatou, E. A. 2012. Social And The Impact Of 3D Visualization Types In Instructional Multimedia Applications For Teaching Science, *Procedia - Social and Behavioral Sciences* 31: 145 – 149 . https://doi.org/10.1016/j.sbspro.2011.12.032

Kumpulainen, K., & Salovaara, H. 2001. The Nature Of Students ' Sociocognitive Activity In Handling And Processing Multimedia-Based Science Material In A Small Group, *Instructional Science* 29: 481–515. https://link.springer.com/article/10.1023/A:1012272119868

Lu, C.-H., & Cheng, S.-F. 2012. Applying Computer-based Technology to Instruction for the Effectiveness of Teaching and Learning, ARPN Journal of Science and Technology *2*(10), 1013–1017. Retrieved from http://www.ejournalofscience.org

Manalu, D. R., & Sitompul, D. R. P. 2017. Developing Learning Media Of

Teaching Of 8051 Microprocessor In Data Retrieval To Support The ALFHE. *Internetworking Indonesia Journal*, *9*(1), 89–92. https://www.researchgate.net/publication/316253865

Mannheimer, J., & Amy, Z. 2011. The Use of Video Cases in a Multimedia Learning Environment for Facilitating High School Students ' Inquiry into a Problem from Varying Perspectives, *J Sci Educ Technol* 20:715–728 . https://doi.org/10.1007/s10956-010-9264-1

Manurung, S. R., & Mihardi, S. (2018). Improved Problem-Solving Ability after using Interactive Multimedia in Teaching of Ideal Gas, *Indian Journal of Science and Technology*, 11(36). https://doi.org/10.17485/ijst/2018/v11i36/

Manurung, S. (2014). Contribution of Formal Thinking Ability on The Concept Mastery of Kinematics. *Proceeding: The First International Seminar on Trends in Science and Science Education*, *2*, 461–469. http://digilib.unimed.ac.id/24605/.

Manurung, S. (2019). Improving Students' Thinking Ability In Physics Using Interactivemultimedia Based Problem Solving . *Cakrawala Pendidikan Islam*. *38*(3), 398–410. https://doi.org/10.21831/cp.v38i3.26411

Manurung, S. R., & Panggabean, D. D. (2014). Development Of Learning Tool Of Physics Based On Interactive Multimedia Charged On " Problem Solving " (Mmi-Ps) To Increase Problem Solving Ability For Prospective Teachers, (c), 177–180. http://digilib.unimed.ac.id/27761/

Maor, D. 2000. A Teacher Professional Development Program On Using A Constructivist Multimedia Learning Environment, *Learning Environments Research* 2: 307–330. https://link.springer.com/article/10.1023/A:1009915305353

Mayer, R. E. 2005. *Multimedia Learning The Cambridge Handbook of Multimedia Learning Edited*. New York: Cambridge University Press.

Mayer, R. E. 1999. Multimedia Aids To Problem-Solving Transfer. *International Journal of Educational Research*, (Online), 31 : 611-623. https://www.sciencedirect.com/science/article/pii/S0883035599000270

Mcalpine, I., & Clements, R. 2001. Problem Based Learning In The Design Of A Multimedia Project, *Australian Journal of Educational Technology17*(2), 115–130. https://www.semanticscholar.org/paper/Problem-based-learning-in-the-design-of-a-project-McAlpine-Clements/269433aa9c13e4dd1fc7c798816a22147dc0e835

Melander Bowden, H. 2019. Problem-solving in collaborative game design practices: epistemic stance, affect, and engagement. *Learning, Media and Technology*, *9884*. https://doi.org/10.1080/17439884.2018.1563106

Meysun Hamdi, & Thair Hamtini. 2001. Designing an effective e-content development framework for the enhancement of learning programming. *International Journal of Emerging Technologies in Learning*, *11*(4), 131–141. https://doi.org/10.3991/ijet.v11i04.5574

Mohler, J. L. 1998. Computer Graphics for Multimedia and Hypermedia Development, *Journal of Computing in Higher Education Fall*, 10(1),71-88. https://link.springer.com/article/10.1007/BF02946987

Mohler, J. L., Hall, K., & Lafayette, W. 2001. Using Interactive Multimedia Technologies To Improve Student Understanding Of Spatially-Dependent Engineering Concepts, *GraphiCon*, (Online): 292–300. https://www.researchgate.net/publication/228819480.

Moreno, R., & Mayer, R. 2007. Interactive Multimodal Learning Environments, *Educ Psychol Rev* (2007) 19:309–326 . https://doi.org/10.1007/s10648-007-9047-2

Mukhadis, A. & Komarudin. (2020). Interactive Multimedia Engine Management System (Ems) To Improve Prior Knowledge And Problems Solving. 26(1), 52–62.

Neo, M., Neo, K. T. K., Tan, H. Y., & Kwok, W. 2009. Problem-solving in a Multimedia Learning Environment : The MILE @ HOME Project. *Social and Behavioral Sciences*, (Online) 64: 26 – 33. https://doi.org/10.1016/j.sbspro.2012.11.004

Nicholson, A. Y. W. 199. Managing The Development And Production Of Interactive Multimedia Courseware In Education. *Australian Journal of Educational Technology*, (Online), 12(1): 36-46. https://pdfs.semanticscholar.org/d4e0/85e431f27645c7be057b5bb0ad7d54d6f106.pdf

Oh, E. G., Yang, Y. L., Sung, J. H., Park, C. G., & Chang, A. M. (2016). Psychometric Properties of Korean Version of Self-Ef fi cacy of Evidence-Based Practice Scale. *Asian Nursing Research*, *10*(3), 207–212. https://doi.org/10.1016/j.anr.2016.05.003

Osman, K., & Lee, T. T. 2014. Impact Of Interactive Multimedia Module With Pedagogical Agents On Students' Understanding And Motivation In The

Learning Of Electrochemistry. *International Journal of Science and Mathematics Education*, (Online) 12, 395–421. https://doi.org/10.1007/s10763-013-9407-y

Paas, F. 1992. Training Strategies for Attaining Transfer of Problem-Solving Skill in Statistics : A Cognitive-Load Approach, (December). *Journal Educational Phychology*, 84(4): 429-434. https://doi.org/10.1037/0022-0663.84.4.429

Raaff, C., Glazebrook, C., & Wharrad, H. 2014. A Systematic Review Of Interactive Multimedia Interventions To Promote Children's Communication With Health Professionals: Implications For Communicating With Overweight Children. *BMC Medical Informatics and Decision Making*, *14*(1), 1–21. https://doi.org/10.1186/1472-6947-14-8

Ramesh, C. 2005. *Interactive Multimedia in Education and trainning.* India: Idea Group Publishing (an

Rias, R. M. 2013. Ascilite Understanding The Role Of Prior Knowledge In A Multimedia Learning Application, Australasian Journal of Educational Technology, *29*(4): 537–548.

Samsudduha, Masugiono, & Supraptono. 2013a. Automotive Science and Education Journal. *Automotive Science and Education Journal*, *2*(2), 63–70. https://journal.unnes.ac.id/sju/index.php/asej

Samsudduha, Masugiono, & Supraptono. 2013b. Automotive Science and Education Journal. *Automotive Science and Education Journal*, *2*(2), 71–76. https://journal.unnes.ac.id/sju/index.php/asej

Sazali, M., Alias, M., Razally, W., & Yamin, S. 2010. The Effect of Using an Interactive Multimedia Courseware within a Collaborative Learning Environment on the Learning of Pre- Algebra Concepts among Pre-University Engineering Students, *Procedia Social and Behavioral Sciences* 8: 571–579. https://doi.org/10.1016/j.sbspro.2010.12.079

Sitompul, D. R. P., & Fadilla, S. D. 2018. An Active Learning Media Of Interfacing Microcontroller 8051 To 4X4 Keypad using MCU 8051 IDE and ASM-51. *ARPN Journal of Engineering and Applied Sciences*, *13*(8), 2987–2992. https://www.researchgate.net/publication/325580811.

Song, H. S., Kalet, A. L., & Plass, J. L. 2015. Interplay Of Prior Knowledge , Self-Regulation And Motivation In Complex Multimedia Learning Environments. *Journal of Computer Assisted learning*, 31–50. https://doi.org/10.1111/jcal.12117

Sukiyasa, K., & Negeri Yogyakarta, U. (2013). Pengaruh Media Animasi Terhadap Hasil Belajar Dan Motivasi Belajar Siswa Materi Sistem Kelistrikan Otomotif Effect Animation Media on Student'S Learning Outcomes and Learning Motivation. *Jurnal Pendidikan Vokasi Jurnal Pendidikan Vokasi*, *3*(1), 126–137. https://journal.uny.ac.id/index.php/jpv/article/view/1588

T. K., K. N., & Neo, M. 2010. Interactive multimedia education: Using Authorware as an instructional tool to enhance teaching and learning in the Malaysian classroom. *Digital Education Review*, *5*(5), 80–94. Retrieved from http://greav.ub.edu/Der/index.php/der/article/viewArticle/56

Tabbers, H. K., & Koeijer, B. De. 2010. Learner Control In Animated Multimedia Instructions, *Instr Sci :* 441–453. https://doi.org/10.1007/s11251-009-9119-4

Teoh, B. S., & Neo, T. 2007. Interactive Multimedia Learning : Students ' Attitudes And Learning Impact In An Animation Course, *The Turkish Online Journal of Educational Technology* *6*(4): 28-37. http://www.tojet.net/articles/v6i4/643.pdf

Tudor, S. L. 2013. The Role of Multimedia Strategies in Educational Process. *Procedia - Social and Behavioral Sciences*, *78*, 682–686. https://doi.org/10.1016/j.sbspro.2013.04.375

Widjanarko, D. 2014. Pemeriksaan Dan Troubleshooting Motor Starter Tipe, *Automotive Science and Education Journal* *3*(2). https://journal.unnes.ac.id/sju/index.php/asej/article/view/7878/5458

Widjanarko, D., Sofyan, H., & Surjono, H. D. 2016. Improving Students' Mastery On Automotive Electrical System Using Automotive Electrical Multimedia. *Research and Evaluation in Education*, *2*(1), 71. https://doi.org/10.21831/reid.v2i1.8219

Wing, W., So, M., Chen, Y., Wan, Z. H., & Chen, Y. 2019. Multimedia e-Learning and Self-Regulated Science Learning : a Study of Primary School Learners ' Experiences and Perceptions. *Journal of Science Education and Technology* https://doi.org/10.1007/s10956-019-09782-y

Yang, Z. 2018. Research on Organization of Mathematics Knowledge in Good Mathematical Cognitive Structure, *14*(1), 291–302. https://doi.org/10.12973/ejmste/78242

Zheng, R., Zhou, B., Journal, S., & Zheng, R. 2006. International Forum of Educational Technology & Society Recency Effect on Problem Solving in Interactive Multimedia Learning Published I*nternational Forum of Educational Technology & Society Stable* 9(2), 107–118. https://www.jstor.org/stable/10.2307/jeductechsoci.9.2.107 L,

Zhou, N., & Yadav, A. (2017). Effects of multimedia story reading and questioning on preschoolers' vocabulary learning, story comprehension and reading engagement. *Educational Technology Research and Development*, *65*(6), 1523–1545. https://doi.org/10.1007/s11423-017-9533-2