Jurnal Inovasi Teknologi Pendidikan
Volume 10, No.1 March 2023 (33-42)
Online: http://journal.uny.ac.id/index.php/jitp

Design of air conditioner (AC) system simulator on cars to improve student competence

Nuzul Hidayat*, Ambiyar, Wakhinuddin, Muslim, Wawan Purwanto
Universitas Negeri Padang, Indonesia.
* Corresponding Author. E-mail: nuzulhidayat@ft.unp.ac.id

ARTICLE INFO

Article History
Received:
16 December 2022;
Revised:
15 February 2023;
Accepted:
28 February 2023;
Available online:
09 March 2023.

Keywords
Air conditioner;
competency; simulator.

ABSTRACT

The purpose of this study is to design a simulator for a car air conditioning system as a learning medium, so that the learning objectives can be achieved properly and in accordance with the expected competencies. This design uses an electric motor drive to drive the AC system compressor so that it is easier to operate and does not produce air pollution and is made with a design that can be moved easily by having sturdy wheels. The electric motor is also equipped with an inverter that can adjust the rotation of the motor as in the conditions of a real car engine. This research model uses Research and Development, which includes the stages: problem analysis, seeking information, designing a model, validating the design, evaluating the model, testing the model, revising the model, wider testing, finalizing the design. The results obtained are the creation of an AC simulator that has been validated by experts in terms of media and material in the very feasible category, then from the user side with 25 respondents giving a value in the very feasible category for use in learning. The increase in competency occurred by 23.90% with a comparison of the pretest value with the posttest value.

How to cite:
Hidayat, N., Ambiyar , A., Wakhinuddin, W., Muslim, M., Purwanto, W. (2023). Design of air conditioner (AC) system simulator on cars to improve student competence. *Jurnal Inovasi Teknologi Pendidikan, 10*(1), 33-42. doi: https://doi.org/10.21831/jitp.v10i1.55758

INTRODUCTION

The air conditioning system (AC) has the function of adjusting temperature, keeping the air clean, maintaining air humidity and circulating air in the vehicle cabin. On the other hand, the use of the air conditioning system in a car aims to stabilize the temperature in the car so that the cabin conditions are comfortable for passengers and drivers. Furthermore, use also has the function of removing condensation on the windshield when it rains. The working principle of the air conditioning (AC) system in vehicles, especially cars, has several processes, namely the cooling step by reducing the amount of water vapor by going through the process of increasing the temperature and adding the amount of water vapor. However, in areas with hot air, an air conditioner (AC) is only used to lower the temperature and reduce the amount of water vapor. On the other hand, the air conditioning (AC) system also produces conditions where a person is comfortable or uses it, under all circumstances. The air conditioning (AC) system is usually

integrated with the existing car control system, which already uses sensors and systems based on electronic systems and utilizes computer control which is commonly referred to as ECU control and Air Conditioning System (Arif et al., 2017).

The results of research on making air conditioner (AC) simulators for cars can increase motivation in learning practicum (Suranegara et al., 2014). From research, information was obtained that learning achievement using simulators had good learning outcomes compared to learning outcomes using only modules (Syahyuniar et al., 2018). Development of an air conditioner (AC) simulator regarding damage analysis to the electrical system in the simulator (Hafizah, 2017). Development of an air conditioner (AC) simulator for cars with CFD (Computational Fluid Dynamics) analysis, the results obtained by simulation have almost the same value when compared to the simulator, so it is very possible for the simulator to be developed because it has the same information when the results are compared with the experiment (Kitada et al., 2000). Research has been conducted on the manufacture of a car air conditioner (AC) simulator with a straight fin condenser type which is commonly used with single-phase electric motor drives with a series circuit that only produces 2 HP of power and that can be done with a moderate rotation in this simulator, the simulator can work well and the result is that the car's AC system can work properly (Wiharsa, 2018).

The development and manufacture of a 3-phase induction motor and inverter ATV312 electric motor simulator for 3-phase motors will be better because the measurement of the COP (coefficient of performance) of the compressor rotation is between 1500rpm-2000rpm because the power generated is sufficient to operate the car's air conditioning (AC) system (Andrizal & Arif, 2017). Furthermore, it is also easier to operate and understand the concept and calculation of the COP (Coefficient of Performance) because it is equipped with a pressure gauge and thermocouple for every change in refrigerant temperature and pressure which will be developed digitally.

Learning in tertiary institutions is an organization that develops knowledge including cognitive, affective, and psychomotor aspects. In cognitive learning, such as learning based on technology and technological capabilities, this must be synchronized with the industry, which is better known as link and match, so that learning is in line with industry needs (Siregar & Simatupang, 2020).

At this time learning is not running as it should and seems to be ignored and only provides conventional learning. The implementation of learning which is mostly carried out in educational institutions still uses a lot of learning methods with lectures or demonstrations which are then carried out with practical implementation in workshops or workshops. Limitations of learning media, especially in practical learning, are the main obstacles in achieving learning objectives, especially simulator media in learning. Other obstacles in learning are the occurrence of misconceptions about the working principle of the air conditioning system in cars which makes learning objectives difficult to achieve.

Air conditioning technology course, hereinafter abbreviated as TPU, is a compulsory subject for students of the Department of Automotive Engineering, Faculty of Engineering, Padang State University with a load of 2 practical credits and 1 theoretical credit. Air Conditioning Technology is a course that covers learning and skills including: about cooling steps, psychrometric diagrams, COP (coefficient of performance), refrigerant, components and parts contained in a vehicle's air conditioner (AC) also includes periodic maintenance, inspection of components, steps to repair and testing of the air conditioner (UNP, 2017).

This course consists of two methods, namely in theory 1 credit (50 minutes) and in practice 2 credits (200 minutes). During the theory lectures there were no serious obstacles to be encountered because for theory the facilities and infrastructure were sufficient. On the other hand, in practice, there are many obstacles encountered, especially in the equipment for TPU practice, which is very minimal. The condition of the practical equipment for TPU is not in good condition because the practical training for TPU is combined with the Automotive Electronics Electrical Practice (LEO) in one engine stand. The use of this engine stand alternates with different lecture semesters. If the engine stand is used in the LEO recovery, then it is certain that the AC system will be damaged or cannot be used directly during lectures or must be repaired again so that the air conditioning (AC) system can work. Conditions like this take quite a long time on average 60 minutes. Another

problem is that the installed air conditioner (AC) system uses a car engine that is old and difficult to start and barely even starts. If the engine cannot be turned on, it is certain that lectures cannot be continued with the main material because time is taken up to repair the car engine (Hidayat et al., 2017).

The level of understanding considered complete by students can be seen from the achievement of learning objectives, including skills in carrying out practical learning activities. Practice must be carried out on an ongoing basis and can result in comprehensive motor skills. Students can practice by carrying out activities that lead to learning objectives that can make their skills develop and carry out activities in the form of demonstrations and simulations. Implementation of practical activities gives opportunities to students to be better and more effective in carrying out learning activities. In addition to maximizing learning activities that are carried out practically, there are several stages, namely the preparatory steps in practical activities, then the implementation of the practice itself.

Figure 1. The condition of the air conditioner (AC) practicum equipment which was heavily damaged and produced pollution during practical activities

From the problems described above, to see the changes that occur in the car air conditioner (AC) system to increase its efficiency in implementing learning both in terms of competence achievements and in the operation of the air conditioning system, it is necessary to develop a car air conditioner (AC) simulator separately from the car engine to make it easier to understand the concept and how the air conditioner (AC) works.

To drive the compressor in the AC air conditioner system, it is assisted by using an electric motor with an inverter which is easier to operate and easier to maintain. The development of this simulator can help students understand concepts and achieve competency in learning car air conditioning (AC) systems in Air Conditioning Technology (TPU) lectures.

METHOD

In this study using the research and development method, namely research with development. Development research is a process that can be used to develop and validate a product produced in the field of education in accordance with the study (Borg & Gall, 1983). Development research is a process that can be used to develop and validate a product produced in the field of education in accordance with the study (Borg & Gall, 1983). Research implementation is fundamental in research preparation including determining the results of the research to be carried out, designing research implementation procedures, preparing supporting materials such as materials and materials in the implementation of lectures and preparing subject matter related to media and semester learning plans. The stages carried out are: (1) preparing the design of the air conditioner (AC) simulator, by studying the basic principles of the air conditioner (AC) system, to develop including manufacturing plans, assembling from the simulator and the learning model to be used; (2) validating the air conditioner (AC) simulator, validating it by media experts, then validating the testing of the tool by testing it from the perspective of the workings and working principles of the air conditioner (AC), and testing the use of the AC simulator in learning or in the field.

Experts who will be involved in this validation test are: experts in charge of the teaching and learning process, experts in charge of the working principles of air conditioners (AC). The implementation carried out by experts is by carrying out model focused group discussion (FGD) activities. In this study, the object to be studied is the air conditioner (AC) simulator and the model in a learning approach that can be designed and implemented when learning about air conditioners (AC). Namely attitude at work, performance, which is guided by the criteria in learning Air Conditioning Technology Data collection in this study, used measuring instruments including: distribution of questionnaires, interview sheets, and observation sheets.

Data analysis techniques used are qualitative and quantitative. For quantitative, it comes from a questionnaire about whether the resulting simulator is feasible or not, based on the opinions of experts and students. The formula used to calculate the average value is:

$$\bar{x} = 1/n\ (x1+x2+\cdots+xn) \quad (1)$$

Description:

$\bar{x}$ = Average value
xi = the value of the i sample
n = number of samples

From the average value obtained from the instrument then interpreted. From the interpretation of the data, it can be determined the level of failure of the AC simulator that has been made which can be seen in table 1 which is an interpretation of quantitative to qualitative data (Mardapi, 2017).

Table 1. Eligibility categories

No	Score	Eligibility Category
1	$x \geq \bar{x} + 1.SB_x$	Very worth it
2	$x \geq \bar{x} + 1.SB_x > x \geq \bar{x}$	worthy
3	$\bar{x} > x \geq \bar{x} - 1.SB_x$	Not feasible
4	$x < \bar{x} - 1.SB_x$	Very unworthy

Description:

$\bar{x}$ = Average overall score in one class = (1/2). (Maximum score + Minimum score)
SB_x = Standard deviation of the overall score in one class = (1/6) .(Maximum score - Minimum score)
x = score achieved (Mardapi, 2017)

RESULTS AND DISCUSSION

Result

Based on the targets and steps in the research, there are several steps that must be taken, namely the first step is to design a simulator by making a frame design and layout and the position of placing components that are right and proportional (Aditya, 2020). The second step is to proceed to the process of preparing materials and making simulators that refer to the learning objectives and competencies that must be achieved after learning. After making it, it is continued with designing learning which includes modules and usage procedures and steps in learning.

The design of the air conditioner (AC) simulator, has dimensions of Length x Width x Height which is 0.8 m x 1.2 m x 1.2 m using hollow steel 40mm x 40mm with a thickness of 2mm as the main frame. And supported by hollow iron 20mm x 20mm 1.2mm thick as a supporting bone. Place for mounting components using 5mm thick acrylic. The design looks like in Figure 2.

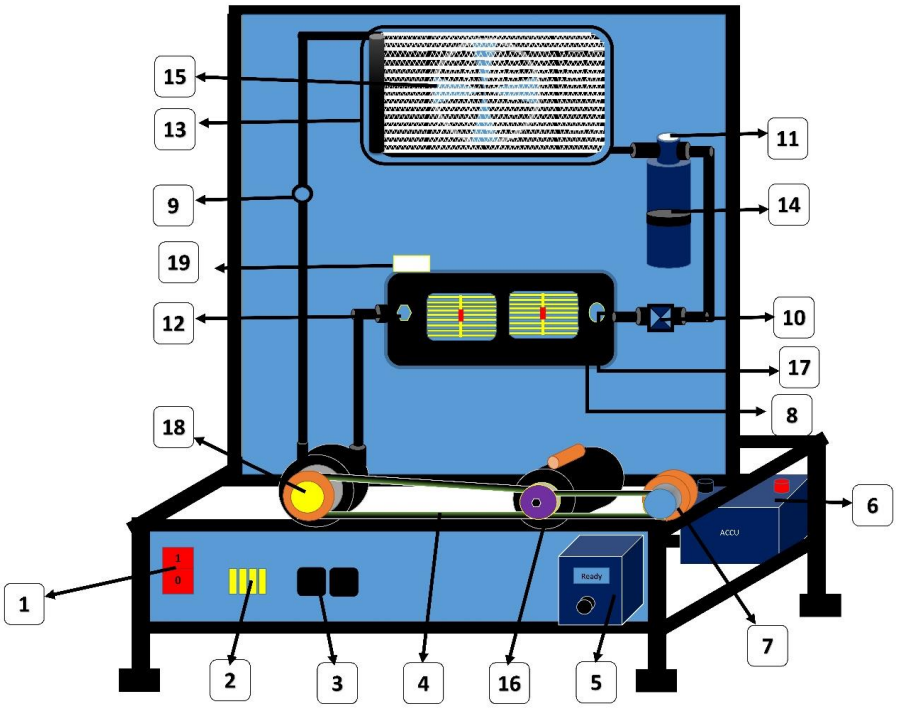

Figure 2. Design of an air conditioner (AC) simulator with an electric motor drive Information

Explanation of the components of these products can be reviewed in Table 2 which displays the component names, specifications, and quantities. The embodiment of this product design can be seen in Figure 3.

Table 2. Specifications for the components of the air conditioner simulator (AC).

No	Component name	Specifications	Amount
1	*Main switch*	5 terminals	1
2	*Fuse*	20 Amperes	4
3	*Relays*	4 feet	4
4	V-belts	Type B	2
5	*inverters*	*ATV312HU22N4*	1
6	Step down transformers	12V 45 Amperes	1
7	evaporators	Pipe and fin type	1
8	*Dual pressure switches*	Minimum 1.5 kg/cm ^{2} - Max 15 kg/cm ^{2}	1
9	*expansion valve*	*thermostatic expansion valve*	1
10	Lookout glass	*Transparent glass*	1
11	blower switch	5 terminals	1
12	Condenser	*straight fin flat tube*	1
13	*Receiver drier*	*Dryer type*	1
14	Cooling fan	*Electric dynamo*	1
15	*Electric motors*	*Three-phase induction motor 3 HP/2.2Kw*	1
16	*Thermostats*	Mechanical models	1
17	AC compressor	*Wobble plates*	1
18	blower resistance	prisoner	1

Figure 3. Ready-to-install simulator support frame and simulator

The feasibility value of the media seen from the appearance and how to use the media. The results can be seen in Table 3.

Table 3. Results Validation Media Aspect

No.	Respondents	Score	Category
1.	Validators 1	39	Very Worthy
2.	Validators 2	37	Very Worthy
3.	Validators 3	38	Very Worthy
Average Score		38	Very Worthy

From table 2 for the scores given by experts, an average score is obtained with a value of 38. The average value is x≥30, which means it is included in the very feasible category. For more details, we can see in the form of a diagram in Figure 4.

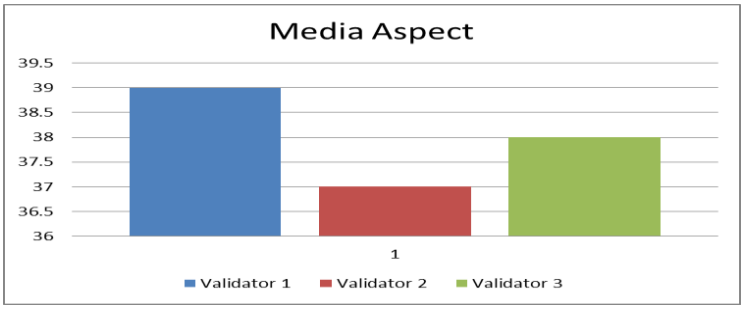

Figure 4. Value validation by media experts

For the feasibility value seen from the material side, namely the compatibility between the media and the material taught in learning Air Conditioning Technology can be seen in Table 4.

Table 4. Results Validation Aspect Material

No.	Respondents	Score	Category
1.	Validators 1	37	Very Worthy
2.	Validators 2	38	Very Worthy
3.	Validators 3	39	Very Worthy
Average Score		38	Very Worthy

In table 3 the values given by the testers obtained an average value of 38. This value is in the range x≥33, so the level of feasibility is in the very decent category. For more details can be seen in the diagram in Figure 5.

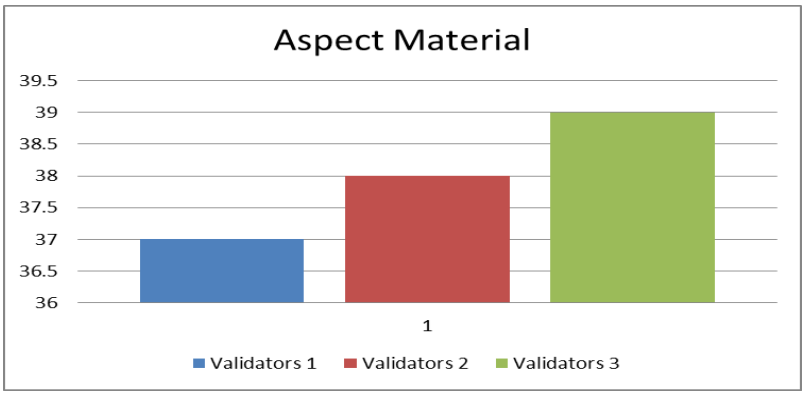

Figure 5. Value validation by material experts

For the feasibility value obtained from users which is based on the contribution of the media in helping to achieve learning objectives and understanding of material from the Air Conditioning Technology course with 23 respondents can be seen in Table 5.

Table 5. Results Validation Aspect Material

Respondents	Score	Category
1	31	Very Worthy
2	36	Very Worthy
3	32	Very Worthy
4	34	Very Worthy
5	36	Very Worthy
6	37	Very Worthy
7	35	Very Worthy
8	35	Very Worthy
9	36	Very Worthy
10	34	Very Worthy
11	38	Very Worthy
12	37	Very Worthy
13	34	Very Worthy
14	36	Very Worthy
15	32	Very Worthy
16	34	Very Worthy
17	34	Very Worthy
18	31	Very Worthy
19	34	Very Worthy
20	36	Very Worthy
21	30	Very Worthy
22	34	Very Worthy
23	32	Very Worthy
Average Score	34.26	Very Worthy

From Table 5 the values obtained from users with an average of 34.26, this value is included in the range of scores x ≥ 30 with a feasibility value from the media side and helps in learning in the very feasible category, to be more clearly displayed in the form of a diagram in the Figure 6.

From media validation data and material from both experts and users in line with the increase in student competence after learning using a media simulator, this is evidenced by learning outcomes compared between pretest and posttest. Overall, students experienced an increase in competence from 23 respondents.

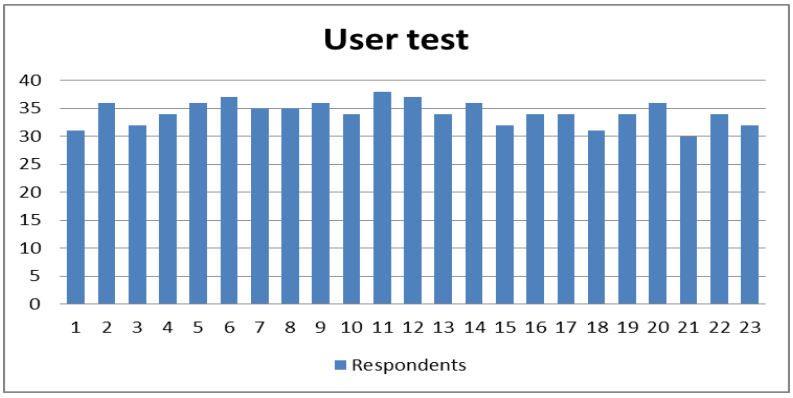

Figure 6. Validation value by media and material users

There is an increase in the value of learning in the Air Conditioning Technology course from the pretest score when compared to the posttest score. The average pretest score of 63.35 increases to 83.09 or if in percentage, which is with a value of 23.90%, this result proves that he use of media simulators can improve student competence well in the Air Conditioning Engineering course.

Discussion

The use of simulators in the implementation of learning in Air Conditioning Technology courses has been properly and carefully reviewed and assessed. Furthermore, the level of effectiveness in learning activities obtained increases rapidly and significantly. From making and using this simulator in learning, it can increase the competence of students when doing practical learning (Jiantoro, 2014).

Steps in improving so that learning objectives are achieved by using the right simulator and having compatibility with the components in the real car or vehicle. The simulator is a medium and is also a determinant of achieving learning objectives properly and maximally. Simulator is a media that has very important elements, namely physical hardware and non-physical software, namely learning modules and job sheets and the hardware is an air conditioner (AC) simulator. The air conditioner (AC) simulator is one of the learning media that is used to speed up and make it easier for students to understand and master competence.

On the other hand, simulators are designed with the aim of achieving the same learning objectives and according to standards, then active and participatory learning and better efficiency of learning duration. The level of effectiveness in using media in learning cannot be separated from how to plan the steps in its use. Some of the things that should be of concern are among them the objectives of learning the state of the student and the tools that support these activities as well as the time allotted for the activity and the ability of the teacher to provide understanding and information. In this case, using a simulator is expected to fulfill all these requirements. Then the simulator is designed and developed regularly and structured so that it can solve problems in learning. The making of the simulator in this study has a scope that refers to compulsory courses concerning the development of mandatory competencies for a student.

So the development of this simulator is in accordance with the actual conditions contained in the car, both in terms of how it works, principles, components and problem solving in the air conditioner (AC) system. a product that has exactly the same conditions as the realistic and interactive original. In education, simulators are media that are used in learning whose concepts and forms have quite large similarities in theory and practice learning. The simulator is also a unit that has a resemblance to the original object both in terms of dimensions and size as well as in its function in a system (Nasrullah & Illahi, 2020).

The making and designing of this simulator is the main attraction for students, where the existence of a simulator makes students more interested and easier to understand the concept and workings of a fairly complex air conditioner (AC) system. Furthermore, in learning the lecturer acts as a companion and only directs and students can gather information from teaching modules and job sheets that have been adapted to the learning topic. In learning, learning-oriented simulators can

be applied which can develop abilities in skills, factual skills that are in accordance with reality, then learning based on concepts. In developing learning, air conditioning technology by utilizing simulators can improve 4 competency elements, namely: (1) factual knowledge; (2) conceptual knowledge; (3) procedural knowledge; and (4) metacognitive knowledge (Kalay, 2015). Factual knowledge is basic knowledge that is utilized in knowing and understanding basic knowledge. Knowledge can be signs, symbols that have a relationship with real and concrete learning, which can provide the necessary information. Conceptual knowledge, including competencies that lead to correlations between components and other components in broader and more complex terms. Procedural knowledge, including about how to understand how to do something, can be approached with inquiry that is developing skills. Metacognitive knowledge is knowledge related to competence and cognitive knowledge in a broad sense and the ability to understand one (Andrizal et al., 2020). The learning model developed should be related to living conditions related to the world of work and the industrial world as well as the characteristic conditions of life in society which can assist in forming professional competencies as teaching staff in secondary schools according to their respective majors. Furthermore, the development of an air conditioner (AC) simulator can also avoid misconceptions from students in learning Air Conditioning Technology in the future and so on.

CONCLUSION

After carrying out the development, design and manufacture of the air conditioner (AC) simulator, several things can be concluded, namely the manufacture of the simulator has a very feasible category from media experts in terms of media design and also has a very decent value. From users giving value to material aspects, it gives a very decent rating. To increase the value of competence can be seen in the pretest and posttest scores there is a significant increase in value. For further development, several things are of concern, namely the installation of component positions and how components work because several components must be installed neatly and systematically according to how they work so that it makes it easier for students to understand learning concepts related to air conditioning (AC) systems. For further developments that can be developed is in the form of digital instruments in understanding and diagnosing damage so that learning is not only an increase in competence about air conditioners (AC) but also an understanding of the use of tools in maintenance and repair of AC systems that are better and newest.

REFERENCES

Aditya, A. (2020). *Rancang Bangun Simulator Sistem Air Conditioning Mobil Type Single Blower Program Vokasi* [Universitas Muhammadiyah Yogyakarta]. https://etd.umy.ac.id/id/eprint/1635/

Andrizal, A., & Arif, A. (2017). Pengembangan media pembelajaran interaktif pada sistem E-Learning universitas negeri padang. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *17*(2), 1–10. https://doi.org/10.24036/invotek.v17i2.75

Andrizal, Saputra, H. D., Setiawan, D., & Setiawan, M. Y. (2020). Percangan dan pembuatan simulator sistem pengkondisian udara mobil jenis orifice tube dengan fluida pendingin R134a. *MOTIVECTION: Journal of Mechanical, Electrical and Industrial Engineering*, *2*(3), 21–30. https://doi.org/10.46574/motivection.v2i3.68

Arif, A., Hidayat, N., & Setiawan, M. Y. (2017). Pengaruh pengaturan waktu injeksi dan durasi injeksi terhadap brake mean effective pressure dan thermal efficiency pada mesin diesel dual fuel. *INVOTEK: Jurnal Inovasi Vokasional Dan Teknologi*, *17*(2), 67–74. https://doi.org/10.24036/invotek.v17i2.73

Borg, & Gall. (1983). *Educational research: An introduction*. Longman.

Hafizah, N. (2017). Rancang bangun simulator trouble shooting sistem kelistrikan AC mobil. *Ekp*, *13*(3), 1576–1580.

Hidayat, N., Sugiarto, T., & Yuvenda, D. (2017). Optimization of effectiveness in radiator straight fin type with flat tube angle variation. *International Conference of Applied Science on Engineering, Business, Linguistics and Information Technology (ICo-ASCNITech)*, *1*, 384–389. http://repository.unp.ac.id/21969/

Jiantoro, A. (2014). *Kajian dan modifikasi struktur mekanik mesin simulator Cnc AC servo system* [Institut Teknologi Sepuluh Nopember Surabaya]. https://repository.its.ac.id/478/3/2111030055-Non_Degree.pdf

Kalay, A. G. (2015). *Perawatan dan perbaikan sistem air conditioner pada mobil daihatsu taruna* [Politeknik Negeri Manado]. https://docplayer.info/30428308-Perawatan-dan-perbaikan-sistem-air-conditioner-pada-mobil-daihatsu-taruna.html

Kitada, M., Asano, H., Kanbara, M., & Akaike, S. (2000). Development of automotive air conditioning system basic performance simulator: CFD technique development. *JSAE Review*, *21*(1), 91–96. https://doi.org/10.1016/S0389-4304(99)00077-6

Mardapi, D. (2017). Pengukuran, penilaian dan evaluasi pendidikan. In *Parama Publishing.* (Vol. 2). Parama Publishing.

Nasrullah, H., & Illahi, S. R. (2020). Pengujian arus pada simulator sistem kelistrikan air conditioner (AC). *AEEJ : Journal of Automotive Engineering and Vocational Education*, *1*(2), 93–100. https://doi.org/https://doi.org/10.24036/aeej.v1i2.32

Siregar, W. D., & Simatupang, L. (2020). Pengaruh model pembelajaran PBL terhadap aktivitas belajar dan hasil delajar siswa pada materi asam basa. *Jurnal Inovasi Pembelajaran Kimia*, *2*(2), 91–96. https://doi.org/10.24114/jipk.v2i2.19571

Suranegara, G. M., Abdullah, A. G., & Saputra, W. S. (2014). Tantangan pendidikan teknologi kejuruan dalam era global. *Prosiding Konvensi Nasional Asosiasi Pendidikan Teknologi Dan Kejuruan (APTEKINDO) Ke 7 FPTK Universitas Pendidikan Indonesia, Bandung, 13 Sd.14 November 2014*, *1*(1), 254–262. https://rp2u.unsyiah.ac.id/index.php/welcome/prosesDownload/3061/5

Syahyuniar, R., Ningsih, Y., & Kurniawan, R. D. (2018). Perancangan sistem kerja simulator AC (Air Conditioner) mobil. *Jurnal Elemen*, *5*(1), 20–27. https://doi.org/10.34128/je.v5i1.71

UNP. (2017). *Struktur kurikulum pendidikan teknik otomotif (S1)*. Universitas Negeri Padang. http://otomotif.ft.unp.ac.id/struktur-kurikulum/

Wiharsa, R. A. (2018). *Karakteristik sistem AC mobil pada putaran car AC characteristics using 1400 rpm compressor rotation* [Sanata Dharma University]. https://repository.usd.ac.id/26995/