A Web-Based Aircraft Maintenance Learning Media to Support Learning Process in Aerospace Engineering Education during the COVID-19 Pandemic

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***Abstract*— The COVID-19 pandemic has raised significant challenges for the higher education community worldwide. Students in aerospace engineering need a learning method that can give them more experiments. An interactive learning media is needed using software to make it easier to deliver materials, for example, on aircraft maintenance materials. In aircraft maintenance, there is a section on studying aircraft damage types that require more understanding because decision-making is quite difficult and needs to be calculated precisely according to the symptoms experienced. Based on these problems, this study aimed to build web-based aircraft maintenance learning media to support the learning process in aerospace engineering education during the COVID-19 pandemic. This learning media is made a web-based because it can be accessed by students online to support the online learning process, especially during this pandemic. Based on the system comparison test results, it can be concluded that this learning media for aircraft engine failure identification can produce solutions that match the proper conditions. This media also supports online learning because web-based media can access the internet anytime and anywhere. Moreover, this learning media can be used by students to study independently.**

Keywords—aircraft damage identification, aerospace engineering, web-based learning media, COVID-19 pandemic

I. Introduction

The COVID-19 outbreak has impacts on various sectors around the world, particularly the education sector. Apart from aims to solve this COVID-19 problem, the state needs to continue maintaining the learning process's stability and sustainability [1]. The COVID-19 pandemic has raised significant challenges for the higher education community worldwide [2]. Challenges appear in universities that have aerospace engineering majors, which require a lot of practice. Students in aerospace engineering need a learning method that can give them more experiments. For example, lecturers can apply problem-based learning methods. Using this method, students can identify problems, investigate solutions, and design complex systems that integrate aerospace engineering fundamentals [3].

A project-based learning method is also needed to make students more experienced [4], [5]. Moreover, a technique such as challenge-based learning is also required to enhance student motivation and improve the lecturer-student relationship and the overall learning process [6]. Motivation is an essential factor in academic performance. In aerospace engineering education, it is incredibly necessary due to the subject's difficulty, so it is critical to use specific instruments to allow aerospace engineering lecturers to understand how their students' motivation works [7]. However, these methods are not easy to apply in the learning process during this pandemic, namely online learning.

The development of communication and information technology changed educational paradigms [8]. It has influenced learning processes and methods, which today has supported the online learning system. It led to a transformation and innovation in current online learning methods, one of which is in the field of aviation. Learning media using interactive media or computers as a learning tool plays an essential role in the learning process [9]. An interactive learning media is needed using software to make it easier to deliver materials, for example, on aircraft maintenance materials. An interactive learning media, such as multimedia, also can be used by students to study independently [10].

In aircraft maintenance, there is a section on studying aircraft damage types that require more understanding because decision-making is quite difficult and needs to be calculated precisely according to the symptoms experienced. Based on these problems, this study aimed to build web-based aircraft maintenance learning media to support the learning process in aerospace engineering education during the COVID-19 pandemic. This learning media is made a web-based because it can be accessed by students online to support the online learning process, especially during this pandemic. Moreover, this learning media can aid students to study independently.

II. Literature Review

Research with the same domain has been conducted by several researchers before. Knowledge-based systems have become necessary media for organizational learning. Several researchers have conducted a study on the use of knowledge-based systems to support the learning process. Hung et al., in 2014 [11], developed a dynamic expert system to aid the comfort of information retrieval and the performance of learning. The results show that the participants intend to adopt this system with a 95% chance of achieving above-average satisfaction. In 2017 [12], Paive et al. explained the development intelligent tutorial system to emphasize mathematical concepts. The results showed a significant improvement in student performance and engagement.

Ruiz et al., in 2018 [13], applied micro-flip and micro collaborative learning with sophomore aerospace engineering students. This study shows that adaptation is fast and easy. The student perception of the model's usefulness is based more on the methodology than on either course content or the tutors participating in the experience. Moraño-Fernandez et al., in 2018 [14], also applied micro-flip teaching with e-learning resources in aerospace engineering mathematics. Using this technique, students experience increased grades and subject understanding.

Dalkilic, in 2017 [15], developed an e-learning training model in aircraft maintenance technician training to improving aircraft safety and reliability. This training model overcomes the disadvantages of traditional face to face training models. White et al., in 2017, [16] described the implementation of flight simulators to support the teaching process in the aerospace engineering program. This technique allows students to study flight dynamics and control problems through physics-based models and perform real-time piloted simulations experiments.

III. Methodology

A. Aircraft Damage Problem Analysis

Determining engine failure is the main task in airline repair control [17], which is quite tricky and a lot to consider with the various symptoms that exist. It often makes it difficult for students to understand the material in finding the exact cause of damage. The right learning media can analyze the damage quickly and precisely, and it is easy to know when studying the types of aircraft damage.

B. Learning Media Design Analysis

The learning media for the identification process guides the student learning process in reasoning about a condition based on the available knowledge base, which can be identified using the forward chaining method of reasoning. A forward-chaining system's operation starts by inserting known facts into working memory and then lowering the new facts based on the premise rules that match known facts. This process is continued until it reaches a goal, or there are no longer premise rules that match the known facts. Defining the structure of data control rules written in the format of "If-Then" and given several rules to distinguish each other's rules [18]. This learning media displays information on any damage that occurs in the aircraft engine. A solution is made to make it easier to solve aircraft engine damage, especially for testing data using samples of military-type aircraft engines, namely Bravo AS202.

C. Data Requirements Analysis

Table I shows the analysis of the data requirements on learning media for the damage identification process. Tables II and III deliver the data requirements for symptoms and types of damage use a Bravo AS202 aircraft type sample. The attribute table or symptoms of damage occurred in the Bravo AS202 aircraft engine. In testing using this Web-based learning media, there were 16 symptoms of the damage, while there were nine types of damage. This learning media also displays information about solutions to machine failures that have been identified. The solution to engine failure on the test aircraft, namely Bravo AS202, can be seen in Table IV.

TABLE I. Data Requirements Analysis

No.	Type of Data	Information
1	Text	Symptoms and damage data
2	Image	Photo and Background
3	Document	Damage Reports and Solutions

TABLE II. Symptoms of Aircraft Engine Damage

Code	Symptoms Name	Question
001	The CHT indicator shows red	What causes the CHT indicator to light red?
002	The oil pressure indicator shows red.	What causes the oil pressure indicator to show red?
003	The oil temperature indicator shows red	What is the cause of the oil temperature indicator showing red?
004	Detonation	What is the cause of the Detonation?
005	*The chip detector doesn't work.*	What is the cause of the chip detector not functioning?
006	Imperfect lubrication.	What is the cause of imperfect lubrication?
007	Imperfect movement	What causes imperfect movement?
008	*Oil pressure too high*	What causes the oil pressure is too high?
009	*Oil pressure too low*	What causes the oil pressure is too low?
010	Exhaust bolt and loose manifold	What are the causes of loose exhaust and manifold bolts?
011	All indicators are limited	What are the causes of all indicators being limited?
012	Engine sound is different	What causes different engine sounds to occur?
013	Aircraft speed is reduced	What causes the plane's speed to decrease?
014	Lack of lubrication	What causes the lack of lubrication?
015	Loose Shaft	What causes loose shaft to occur?
016	Oil is not suitable	What happens if the oil doesn't match?

TABLE III. Types Of Aircraft Engine Damage

ID Damage	Damage Name	Solution
K001	Corrosion in the Pistons	Piston cleaning to remove corrosion.
K002	The crankshaft is loose	Tighten Crankshaft
K003	Cracked valve key	Key valve substitution
K004	Cracked piston component	Replacement of piston components
K005	Loosening of the Connecting Rod component	Tighten the connecting rod components
K006	Relay valve	Replacement of relay valve
K007	Dirty hose oil	clean Hose oil
K008	Exhaust	Replacement of packing or gaskets
K009	Leaking	Replacement of packing or gaskets

TABLE IV. Fault Identification Solutions

ID Damage	Damage Name	Symptoms	Solution
K001	Cracked Pistons	Frequent friction in the piston cylinder	Piston Replacement
K002	Relay valve	Lack of lubrication	Increase or decrease the washer on the relay valve

K003	Connecting Rod Movement	Movement on the piston is not perfect	Tightening the connecting rod
K004	Corrosion to the piston	Frequent friction in the piston-cylinder and lack of lubrication	Piston Replacement
K005	The oil hose is leaking	Less lubrication	Oil hose replacement
K006	*The valve key is damaged*	Incomplete fuel mixture causes corrosion	Key valve
K007	Exhaust	Detonation or explosion occurred	Replacement of packing or gaskets
K008	Leaking	Detonation or explosion occurred	Replacement of packing or gaskets
K009	*The crankshaft is loose*	Loosening of the crankshaft	Fasten the Crankshaft

D. Knowledge Base Analysis of Machine Damage Identification in Learning Media

According to the symptoms of damage written in Table I, a rule is created in the form of a knowledge base to identify engine failure in the AS202 Bravo aircraft sample. Table V shows the knowledge base. The knowledge base is used to store the domain knowledge represented in the form of rules required for prediction [19], which is, in this case, is aircraft damage.

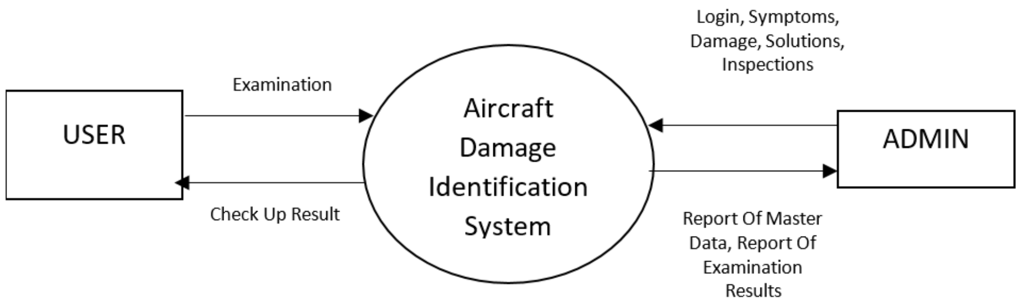


Fig. 1. Context diagram of aircraft engine damage learning media

TABLE V. KNOWLEDGE BASE

1	**IF** Pistons is **c**racked **AND** *The chip detector doesn't work* **THAN** Plug replacement on the piston
2	**IF** Pistons is **c**racked **AND** all indicators exceed the limitations **THAN** Plug replacement on the piston
3	**IF** Pistons is **c**racked **AND** Engine sound is different **THAN** Plug replacement on the piston
4	**IF** Crankshaft is loose **AND** Less lubrication **THAN** Tighten the crankshaft
5	**IF** Crankshaft is loose **AND** Oil is not suitable **THAN** Tighten the crankshaft
6	**IF** Leaking **AND** occurs Detonation **AND** Exhaust bolt and loose manifold **THAN** replacement of exhaust packing and packing manifold or replacement of gaskets
7	**IF** Key valve is **c**racked **AND** Poor lubrication **THAN** Replace the key valve
8	**IF** Key valve is **c**racked **AND** Oil temperature shows max / red **AND** Poor lubrication Poor lubrication **THAN** Replace the key valve
9	**IF** Exhaust **AND** occurs Detonation **THAN** replacement of exhaust packing and packing manifold or replacement of gaskets
10	**IF** Connecting Rod is loose **AND** imperfect movements **THAN** Tighten the Connecting Rod
11	**IF** Connecting Rod is loose **AND** imperfect movements **AND** shaft is loose **THAN** Fasten the Connecting Rod
12	**IF** Pistons Corrosion **AND** aircraft speed is reduced **THAN** Replace the Piston
13	**IF** Pistons Corrosion **AND** CHT shows max / red **AND** aircraft speed is reduced **THAN S**ubstitute the Piston
14	**IF** Relay valve **AND** Oil pressure too high **THAN** Relay valve washers need to be reduced
15	**IF** Relay valve **AND** Oil pressure too low **THAN** Relay valve washers need to be added
16	**IF** *The oil hose is leaking* **AND** *imperfect of oil pressure* **THAN** Replace the Hose oil

E. Context Diagram and Database of Learning Media

In this learning media, there are two types of users. The admin is the teacher or lecturer who manages the entire database of this learning media, such as logging in, inputting master data, and providing reports. Meanwhile, users are students who can only identify the type of damage to an airplane engine. Fig. 1 shows a context diagram of this learning media. Fig. 2 shows the relation between tables identification of aircraft engine damage.

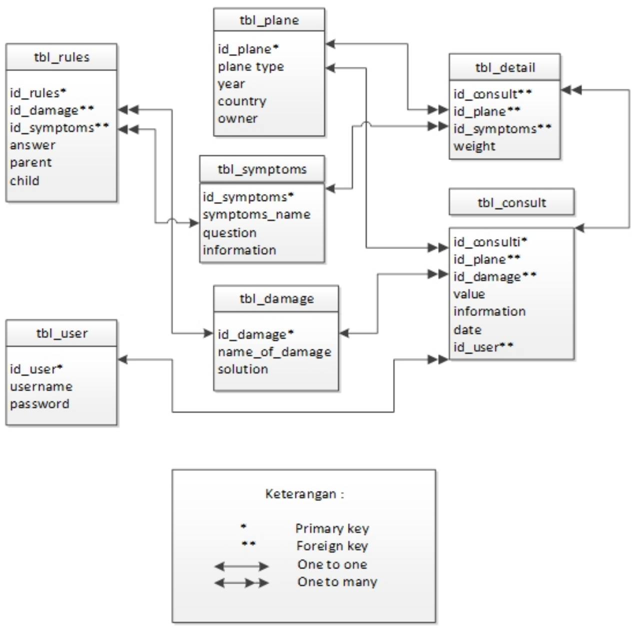


Fig. 2. The relation between tables identification.

Relationships between tables are relationships that occur in a table with other tables that function to regulate the operation of a database used in identifying aircraft engine damage. The lecturer manages data such as aircraft identity, damage symptom data, examination data, examination detail data, and data on the types of damage on the head. Meanwhile, students can only enter aircraft identity, inspection data and receive the inspection report results. Symptom data is a display used to view a list of symptoms, enter symptom data used to diagnose aircraft engine damage, and relate symptom data and solutions to symptoms that occur.

IV. Results And Discussion

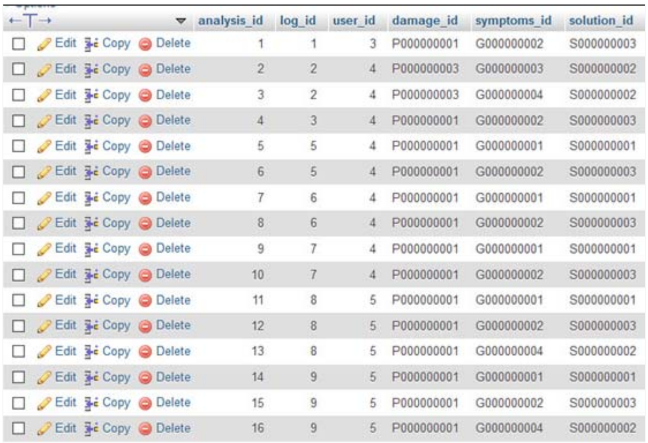
In this section, a learning media has been implemented to identify engine damage to the aircraft based on the model architecture that has been carried out in the previous section. The implementation of this learning media aims to identify engine damage to the aircraft, where the test sample uses a military aircraft type, namely Bravo AS202. We build this web-based learning media by using PHP programming language and MySQL database. Fig. 3 shows the table from the database in MySQL that contains the knowledge base, which corresponds to the knowledge base in Table V. The knowledge base table is used to store the results of analyzing the damage that occurred to the aircraft based on the observed symptoms. Moreover, to the type of damage resulting from the analysis process, there are also informed solutions to overcome the damage. For example, on analysis_id 1 with symptoms_id G000000002, namely "the CHT indicator is red" and damage_id P000000001, namely "Pistons Corrosion" with solution_id S000000003, namely "Bulb Replacement."

Fig. 4 shows the interface of this learning media to identify aircraft engine damage. In this learning media, the first step is done by selecting the type of damage based on the example cases, as shown in Table III. The next step is to choose a symptom, where some initial questions will appear, and then students can examine the damaged aircraft. In the test shown in Fig. 4, the CHT marker shows a red color at the inspection time. It can be concluded that there is interference with CHT. Fig. 5 shows the output results for the damage identification process of this system.

In this web-based learning media, we have tested the damage identification by comparing the system's output with manual calculations. Table VI shows the overall results where this identification learning media was successfully used to identify engine failure in the Bravo AS202 aircraft test sample. Using this web-based learning media, the students can identify aircraft damage. This media can make students understand easier the process of identifying aircraft damage. Students can also directly practice the identification process based on existing symptoms with this web-based learning media. Web-based learning offers the advantage of improved access to education by overcoming distance because this media can be accessed anytime, anywhere, as individuals are increasingly connected 24/7, primarily via mobile devices [20]. Furthermore, distance-learning or online learning is indispensable in a pandemic situation such as COVID-19 [21].

TABLE VI. Testing Results Of The Web-Based Learning Media

No	Input		Output		Result
	Hypothesis	Damage	Manual (Solution)	System (Solution)	
1.	Relay valve	Oil pressure too low	Relay valve washers need to be added	Relay valve washers need to be added	Valid
2.	Relay valve	Oil pressure too high	Relay valve washers need to be reduced	Relay valve washers need to be reduced	Valid
3.	Leaking	Occurs Detonation and Exhaust bolt and loose manifold	Replacement of exhaust packing and packing manifold or replacement of gaskets	Replacement of exhaust packing and packing manifold or replacement of gaskets	Valid
4.	Hose Oil	Oil pressure is not perfect or max	Replace the Hose oil	Replace the Hose oil	Valid
5.	Exhaust	Occurs Detonation	Replacement of exhaust packing and packing manifold or replacement of gaskets	Replacement of exhaust packing and packing manifold or replacement of gaskets	Valid
6.	Corrosion in the Pistons	The CHT indicator shows red/max, reduced aircraft speed	Piston Replacement	Piston Replacement	Valid
7.	Corrosion in the Pistons	Reduced aircraft speed	Piston Replacement	Piston Replacement	Valid
8.	Connecting Rod is loose	Imperfect movements	Fasten the connecting rod	Fasten the connecting rod	Valid
9.	Connecting Rod is loose	Loose Shaft, imperfect movements	Fasten the connecting rod	Fasten the connecting rod	Valid
10.	Key valve	Lack of lubrication	Key valve replacement	Key valve replacement	Valid
11.	Key valve	Oil temperature max / red, lack of lubrication	Key valve replacement	Key valve replacement	Valid
12.	The crankshaft is loose	Lack of lubrication	Tighten the crankshaft	Tighten the crankshaft	Valid
13.	The crankshaft is loose	Oil is not suitable	Tighten the crankshaft	Tighten the crankshaft	Valid
14.	The pistons is cracked	The chip detector does not work	Piston Replacement	Piston Replacement	Valid
15.	The pistons is cracked	All indicators are limited	Piston Replacement	Piston Replacement	Valid
16.	The pistons is cracked	Change in engine sound	Piston Replacement	Piston Replacement	Valid



	analysis_id	log_id	user_id	damage_id	symptoms_id	solution_id
Edit Copy Delete	1	1	3	P000000001	G000000002	S000000003
Edit Copy Delete	2	2	4	P000000003	G000000003	S000000002
Edit Copy Delete	3	2	4	P000000003	G000000004	S000000002
Edit Copy Delete	4	3	4	P000000001	G000000002	S000000003
Edit Copy Delete	5	5	4	P000000001	G000000001	S000000001
Edit Copy Delete	6	5	4	P000000001	G000000002	S000000003
Edit Copy Delete	7	6	4	P000000001	G000000001	S000000001
Edit Copy Delete	8	6	4	P000000001	G000000002	S000000003
Edit Copy Delete	9	7	4	P000000001	G000000001	S000000001
Edit Copy Delete	10	7	4	P000000001	G000000002	S000000003
Edit Copy Delete	11	8	5	P000000001	G000000001	S000000001
Edit Copy Delete	12	8	5	P000000001	G000000002	S000000003
Edit Copy Delete	13	8	5	P000000001	G000000004	S000000002
Edit Copy Delete	14	9	5	P000000001	G000000001	S000000001
Edit Copy Delete	15	9	5	P000000001	G000000002	S000000003
Edit Copy Delete	16	9	5	P000000001	G000000004	S000000002

Fig. 3. Knowledge base table in MySQL database.

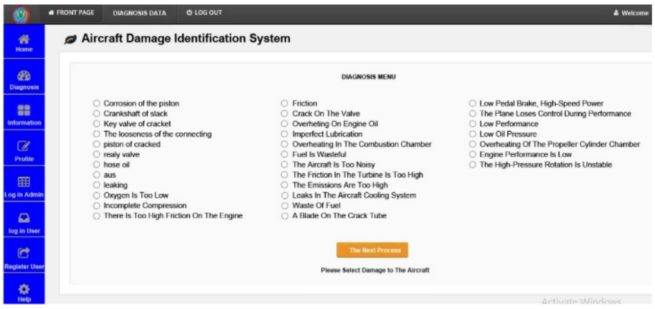


Fig. 4. The interface of aircraft engine damage learning media.

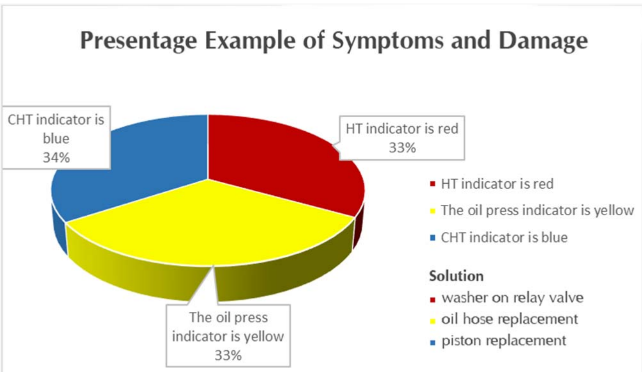


Fig. 5. Interface of output results for the damage identification process.

V. CONCLUSION

This learning media for aircraft engine failure identification with the Bravo AS202 test sample has been successfully built and can make it easier to find solutions for students in dealing with problems that occur in aircraft engines. This web-based learning media is built by using PHP programming language and MySQL database. This learning media can handle problems according to aircraft engines' damage and can provide solutions to the problems experienced. Based on the system comparison test results, it can be concluded that this learning media for aircraft engine failure identification can produce solutions that match the proper conditions. This learning media also supports online learning, especially during the COVID-19 pandemic, because this is a web-based media that can access anytime and anywhere using the internet. Moreover, this learning media can be used by students to study independently.

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