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Design and Development of Inductive Sensor Trainer Based on Arduino and IDE 1.8.19 Software

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ABSTRACT

Sensor and Transducer is one of the subjects that must be followed by students of the Automotive Engineering Department, Faculty of Engineering, Padang State University, which weighs 2 credits. In accordance with the RPS for the Sensor and Transducer Course, there are several types of sensors that are the subject of study, one of which is an inductive sensor. Inductive sensor applications are applied in the automotive world such as Crankshaft Position Sensor (CKP), Camshaft Position Sensor (CMP), Vilocity Sensor. To make it easier to understand each sensor applied in the automotive world, students are required to master the basic concepts of the inductive sensor. One of the ways to increase student competence in the field of inductive sensors is the use of teaching aids during the learning process. Inductive sensor learning media in the Laboratory at the Automotive Engineering Department still uses analog processors, to support the development of digital technology today, so the authors provide an alternative by making teaching aids in the form of an Arduino-based Inductive Sensor Trainer and use IDE 1.8.19 software. This study uses the Research and Development (R&D) method which consists of Define, Design, Development, and Desseminate. The assembled inductive sensor trainer was tested for accuracy, and repeatibility test as well as feasibility test from media experts and users. The results of the research on the product trials carried out, obtained an accuracy level of 96.21%, the sensor output has linearity, the repeatibility test is obtained with an average of 0.1%. The level of product feasibility from Media Experts, is 94.68% and 96.23% from Respondents. So it can be concluded that the Inductive Sensor Trainer is very suitable to be used as a learning medium.

1. INTRODUCTION

[1] Sensors and transducers are one of the courses that must be followed by students majoring in Automotive Engineering, Faculty of Engineering, Padang State University which weighs 2 credits (Semester Credit Units). This course studies the basic concepts and applications of various types of sensors used in the automotive industry. [2] Inductive sensors are widely used and applied in automotive, for example in Cranckshaft Position Sensor (CKP), Camshaft Position Sensor (CMP), vilocity (speed). Inductive sensors are also applied as metal detectors that we can find at airports, malls and when entering hotels. Although inductive sensors have often been encountered by students, conceptually, working principles and to make students creative in producing innovative products using inductive sensors the tendency is still low, this is because the basic concepts of inductive sensors have not been fully understood by students.

The ability of students to master the teaching material is determined by internal and external factors [3]. One of the external factors that affect student learning outcomes is the use of learning media during the teaching and learning process. There are 2 types of inductive sensor learning media in the Automotive Engineering Department laboratory, namely the PNP type and the NPN type. Inductive sensor media is assembled using an analog processor [4][5]. The output terminal of the sensor is connected to the relay, then the NO relay switch terminal is connected to the load (Lamps and Speakers).

The weakness of this media is, the inductive sensor output results must be displayed using an external voltmeter, the media is not equipped with clear information which is the input, processing and output groups. The weakness of students so far is that they lack mastery of the components that are incorporated as input, processing and output in a system, so that a simpler learning media is needed and can provide information that makes it easier for students to master competencies in the inductive sensor field.

Revolution 4.0 also requires students to master digital technology, so learning media is needed that processes inductive sensor output data using a digital processor. This tool is designed using the Arduino UNO Microprocessor. [8] The choice of this microprocessor is because it is easy to operate and the algorithm used is also not difficult for students to learn. IDE 1.8.19 Language Programming is an abbreviation of Integrated Development Environment, or simply an integrated environment used for development. It is called an environment because it is through this software that Arduino is programmed to perform the functions embedded through programming syntax. Arduino uses its own programming language that resembles C language. The Arduino programming language (Sketch) has been changed to make it easier for beginners to program from the original language. Before being sold to the market, the Arduino microcontroller IC has been implanted with a program called Bootlader which functions as an intermediary between the Arduino compiler and the microcontroller.

2. RESEARCH METHOD

The type of research used is research and development [9], research and development methods can be interpreted as a scientific way to research, design, produce and test the validity of the products that have been produced. The same definition is also put forward by research and development is a research approach to produce new products or improve existing products. Research and development is a method for producing certain products or improving existing products and testing the effectiveness of these products. The research development model used is the 4-D type consisting of four stages, namely Define, Design, Develop, and Disseminate to the Design of Arduino-Based Inductive Sensor Trainer Trainer as Learning Media.

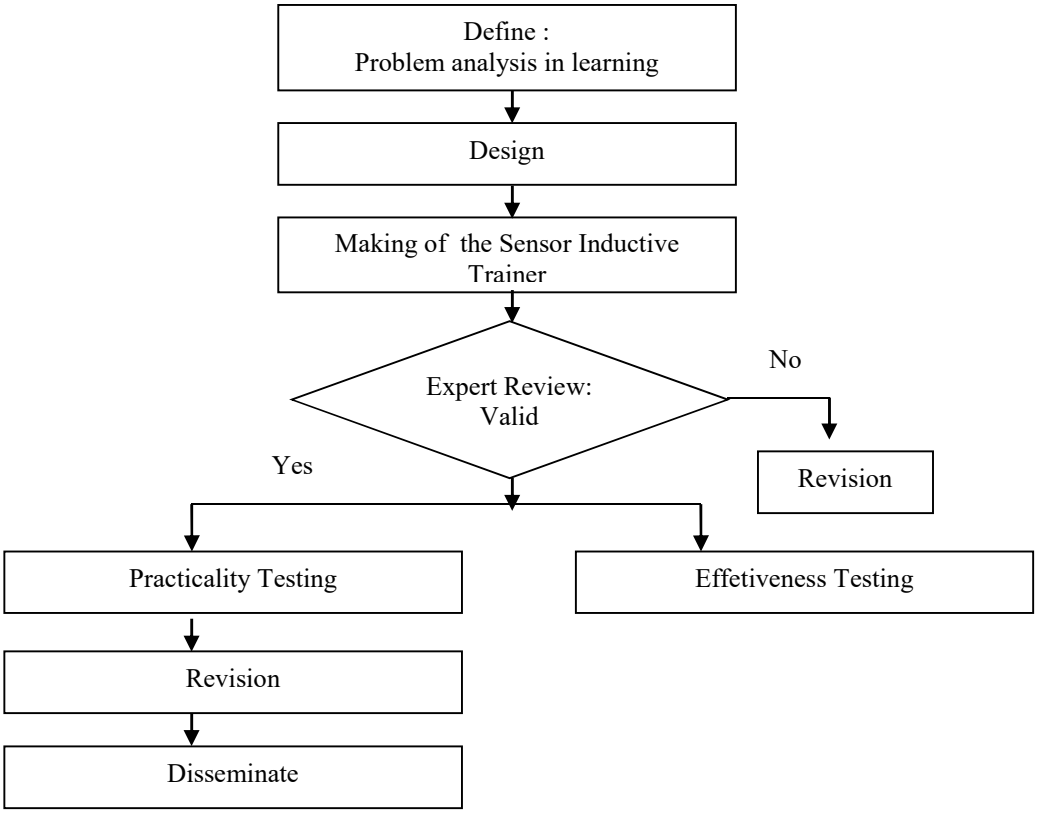

Figure 1. 4-D Development Model

The theoretical validation of the tool is carried out through the Accuracy Test, and the Repeatability Test. The accuracy test is used to determine the deviation of the inaccuracy of the sensor input and output data which is designed with theoretical study analysis and the data sheet of the PNP Inductive Sensor with the code PR12-4AC and the NPN type with the code LJ12A3-4-Z/BX used. The inaccuracy of the designed tool does not exceed 5%.

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The repeatability test is used to see the difference in input and output data when repeated tests are carried out. A good tool will produce a repeatability test result of 0, meaning that there can be no difference in input and output data even though the test is carried out repeatedly. The standard set from the design of the inductive sensor trainer is that it does not have a difference of more than 5% when repeatability tests are carried out, if these standards are not met then revisions and improvements will be made to the inductive sensor traner.

Validation by media experts to see the feasibility level of the Inductive Sensor trainer as a learning medium. Aspects that are considered feasible or not refer to the research as shown in Table 1.

Table. 1 Grid of Validity Instruments by Media Experts

Aspect	Indicator	Amount Item
Media Design	1. Applicative Functions 2. Color combination 3. Component Layout 4. Clarity of information displayed	16
Media Operation	Operation of the Inductive Sensor Trainer as a Learning Media	15
Media Benefits	1. Media benefits for lectures 2. Media benefits for students	14

The level of eligibility by users is also carried out, by demonstrating the Inductive Sensor trainer to 30 students who have passed the Sensor and Transducer course scores. Aspects seen from the user perspective can be seen in Table 2.

Table. 2 User Validity Instrument Grid

Aspek	Indikator	Amount Item
Media Design	Content of material	8
Media Operation	Operation of the Inductive Sensor Trainer as a Learning Media	20
Media benefits	Media benefits for students	9

The feasibility of the inductive sensor trainer is based on the table as shown in Table 3.

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Table. 3 User Validity Instrument Grid

Number	Scorein Prosen (%)	Qualifying Category
1	90% - 100%	Very Worthy
2	80% - 89%	Worthy
3	65% - 79%	Decent enough
4	55% - 64%	less worthy
5	0% - 54%	Not feasible

3. RESULTS AND DISCUSSION

3.1. Product Design

The product is designed using 2 concepts, namely the display design of the Inductive Sensor Trainer and the schematic design of the circuit. Inductive Sensor Trainer has designed by autoCAD software. The design of the trainer pays attention to the layout of the components, the wiring connection and the mix and match of attractive trainer colors to make the student interisting to learn.

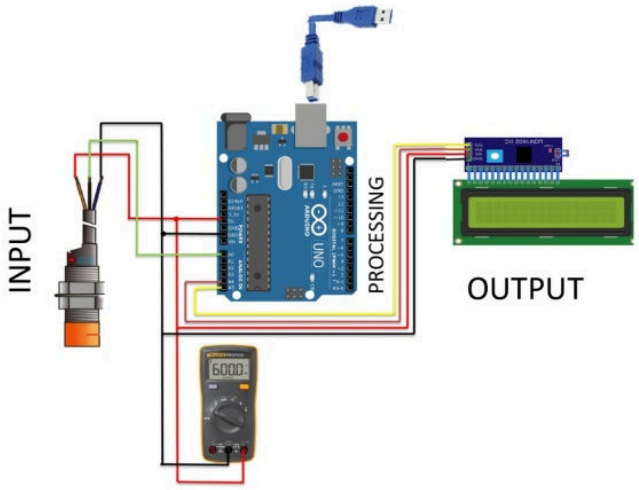

Figure 1. Inductive Sensor Trainer Network Scheme

The inductive sensor is an input in the assembly of the Inductive Sensor Trainer system. The inductive sensor consists of 3 terminals, 2 terminals are used for working sensor resources and one terminal is used as an inductive sensor output which is connected to A0 from the Arduino UNO Microprocessor. [11] Arduino UNO microprocessor is used to digitally process sensor output data. The advantage of digitally processing data is that

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system changes can be made by simply changing the software without having to make any hardware changes. The output of the trainer uses an LCD, with an LCD every change in input and output data from the inductive sensor can be seen directly by students without having to use an external voltmeter. To facilitate the connection of the LCD terminal with Arduino UNO, a 12C LCD module is used, the A4 and A5 Arduino UNO terminals are connected to the SDA and SCL 12C LCD terminals. All VCC and GND terminals of all components and modules involved are integrated into a voltage source for each component/module used. The assembled inductive sensor media uses a display concept as shown in show figure 2.

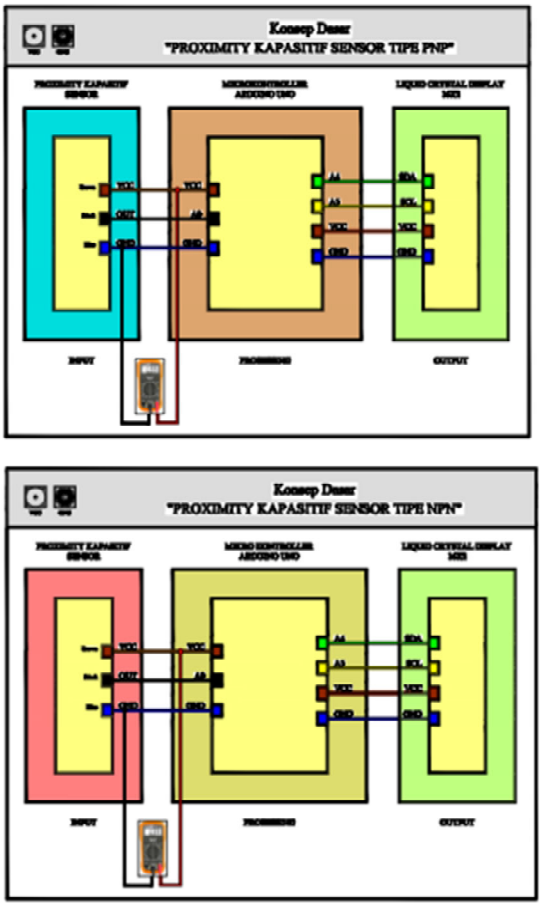

Figure 2. Design Housing Inductive Trainer

The display uses 3 separate color groups, which show the Input (orange), Processing (yellow) and Output (pink) groups. The colors to make student easy to different part of part on Inductive Sensor Trainer. In the input section, an inductive sensor is installed. Any changes in data detected and generated by the inductive sensor will be processed by the

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Processing Unit (second color group) and input and output data will be displayed on the LCD (third color group).

3.2. Development

The assembled sensor inductive trainer produces a display as shown in Figure 3.

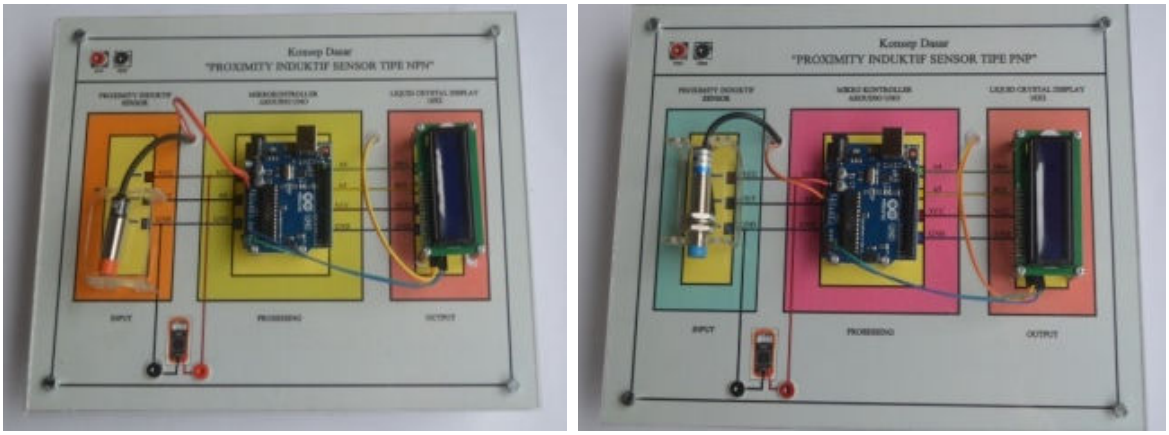

Figure 3. Trainer Inductive Sensor

PNP type inductive sensor, when an object made of metal is brought close to the sensor with a distance of 0-4mm, the sensor output voltage is ON/High (1), whereas if the non-metal or metal material is more than 4mm apart, the sensor output condition is in OFF/Low (0). Unlike the NPN type inductive sensor, when an object made of metal is brought to a distance of 0-4mm from the sensor, the sensor output condition is OFF/Low (0), while for non-metal and metal materials with a sensing distance of more than 4mm, the the inductive sensor output will be ON/ High (1).

The assembled inductive sensor trainer has previously been tested for accuracy and repeatability. The accuracy test refers to the PNP PR12-4AC and NPN LJ12A3-4-Z/BX model inductive sensor data sheets. From the data sheet, it is explained that these two inductive sensors have a sensing distance response of 0-4mm for metal materials. Emphasis is placed on the accuracy test to compare the input and output data displayed on the inductive sensor trainer LCD screen with a ruler and voltmeter. This can be seen from table 4 below:

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Table 4. Data of Inductive Trainer Sensor Type PNP

Object	Detectable Distance (0– 10 mm)	Voltage	Condition
Metal (pliers, bolts, scissors, wrench)	0 mm	4,16 v	ON
	1 mm	4,16 v	ON
	2 mm	4,16 v	ON
	3 mm	4,16 v	ON
	4 mm	4,16 v	ON
	5 mm	0.00 v	OFF
	6 mm	0.00 v	OFF
	7 mm	0.00 v	OFF
	8 mm	0.00 v	OFF
	9 mm	0.00 v	OFF
	10 mm	0.00 v	OFF
(Non Metal) Plastic, paper, body	0 mm	0.00 v	OFF
	1 mm	0.00 v	OFF
	2 mm	0.00 v	OFF
	3 mm	0.00 v	OFF
	4 mm	0.00 v	OFF
	5 mm	0.00 v	OFF
	6 mm	0.00 v	OFF
	7 mm	0.00 v	OFF
	8 mm	0.00 v	OFF
	9 mm	0.00 v	OFF
	10 mm	0.00 v	OFF

Inductive Sensor of PNP type, in this trainer have code PR12-4AC. Following the data sheet PR12-4AC, the inductive sensor will be respond if the the metal or conductor around the sensor with 0 to 4mm. in the range distance, Inductive sensor produce magnetic field and the the voltage output wil the same and the voltage source. But if the sensing distance more 4mm, the output inductive sensor will be zero, like as when the matrial isolator and semiconductor near from sensor, the voltage output inductive sensor still zero too.

Table 5. Data of Inductive Trainer Sensor Type NPN

Object	Detectable Distance (0– 10 mm)	Voltage	Condition
Metal (pliers, bolts, scissors, wrench)	0 mm	0,62 v	OFF
	1 mm	0,62 v	OFF
	2 mm	0,62 v	OFF
	3 mm	0,62 v	OFF
	4 mm	0,62 v	OFF
	5 mm	4,38 v	ON
	6 mm	4,38 v	ON
	7 mm	4,38 v	ON
	8 mm	4,38 v	ON
	9 mm	4,38 v	ON
	10 mm	4,38 v	ON
(Non Metal) Plastic, paper, body	0 mm	4,38 v	ON
	1 mm	4,38 v	ON
	2 mm	4,38 v	ON
	3 mm	4,38 v	ON
	4 mm	4,38 v	ON
	5 mm	4,38 v	ON
	6 mm	4,38 v	ON
	7 mm	4,38 v	ON
	8 mm	4,38 v	ON
	9 mm	4,38 v	ON
	10 mm	4,38 v	ON

Inductive Sensor of NPN type, in this trainer have code PR12-4AC. Following the data sheet LJ12A3-4-Z/BX. The sensor will give respond if the conductor material in distance 0 to 4 mm. the principle of the NPN type inductive sensor is reverse to PNP type inductive sensor. It means, when the conductor distace 0 to 4mm from sensor, the voltage output's is zero, but when the conductor material more than 4mm the output voltage from the sensor is the same in input source voltage, like as when the sensor sensing isolator and semiconductor material, output voltage sensor is high.

In this reseach, to make sure the trainer can be used for media learning, some testing have done. To display performace inductive sensor in the system, characteristc dinamic from the sensor must do it. Characteristc dinamic in the reseach are acuuracy repeatability test. The accuracy test resulted in an accuracy rate of 96.21%, meaning that the difference

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between the data displayed on the LCD trainer and the measuring instrument from multimeter as data validity was only 3.79%. it is mean the sensor and the system is correct and valid.

The repeatability test is used to see the sensor input and output data, even though repeated data testing is carried out, it still produces the same data. And based on the repeatability test, the Inductive Sensor Trainer produces a repeatability rate of 99.9%, meaning that there is a 0.1% difference in input and output data even though the data test is repeated.Validity to media experts is done by demonstrating the Inductive Sensor Trainer and providing instrument sheets related to question items regarding the suitability of teaching materials with the media created, ease of operation and the usefulness of Sensors and Transducers Trainers in supporting improving the quality of learning. From the instruments that were circulated, data such as Table 6.

Table 6. Feasibility Results of Each Aspect by Media Experts

Aspect	Percentage of each aspect
Material	92.97%
Operation	98.80%
Benefits	92.28%
Average	94,68%

The feasibility test for users was carried out by demonstrating the Inductive Sensor Trainer and giving instrument sheets to 30 students who had taken the Sensor and Transducer Course. From the respondents, because they already have previous experience so that they are predicted to be able to provide accurate input and data related to the usefulness of the tools made. The results of the feasibility test by users can be seen in Table 7.

Table 7. Feasibility Results of Each Aspect by Users

Aspect	Percentage of each aspect
Material	94.00%
Operation	98.40%
Benefits	96.3%
Average	96,23%

The results of the research on product trials carried out, obtained an accuracy level of 96.21%, repeatibility tests were obtained with an average of 0.1%. The level of product feasibility from Media Experts is 94.68% and from Respondents 96.23%. Based on the accuracy test, repeatability, feasibility test by media experts and users, the sensor inductive trainer was declared suitable for use as a learning medium.

3.3. Disseminate

The Arduino-based inductive sensor trainer is currently still limited to trial use for students who have taken the sensor and transducer course, so that distribution or mass production has not yet been carried out.

4. CONCLUSION

The inductive sensor trainer developed through research and development is suitable for use as a learning medium with an accuracy rate of 96.21%, repeatability test obtained with an average of 0.1%, the validity level of media experts is 94.68% (Very Eligible) , and the feasibility test of the users obtained a validity of 96.23%. (Very Worthy). The data show that inductive sensor trainer Very Worthy to use media learning

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