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DESIGNING ARM ROBOT BASED ON INTERNET OF THINGS AS A LEARNING MEDIA

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ABSTRACT

Technology is evolving rapidly push the manufacturing industries to achieve an optimal production, among of them is using automated machines to convenience their production. To synergize with those evolution, the education system also needs to evolve to make sure that the educational material contains follow the trends of automation and increase the level of understanding about technological developments. Based on a survey given to Industrial Engineering students at Diponegoro University who were studying the Integrated Manufacturing System courses the class said that automation tools are very important in processes in industry, but their understanding about the description of the automation in the industrial world have a different understanding level, their level of understanding was 35%. understand, 35% quite understand and 30% do not understand. Therefore, the researcher designed a learning media based on student requirement and Curricullum of Intregated Manufacturing System Subjects to support an understanding of automation learning, especially Industrial Robotics. The learning Media use the Engineering Design Process method, to obtain a teaching tool that is in accordance with existing requirements, its called Arm Manipulator Robot whose using Internet of Things to do material handling work. This tool is handling with a rate of accuracy 74%, which is classified as very feasible as a learning media.

KEYWORDS: Engineering Design Process, Arm Manipulator, Internet of Things, Learning Media.

INTRODUCTION

The development of industrial technology has increased the achievement of optimal production, one of which is the use of automation tools. To synergize with industrial technology, a qualified and aligned workforce is needed so that in the world of education it is very important to align learning materials with technological developments. Providing education about industrial robotics and the internet of things can give an idea of how close it is to our daily lives. Among the various automation tools, there are robots that can help handle and organize materials so that they can easily monitor and manage, as well as reduce production costs.

The Industrial Engineering Department of Diponegoro University studies and mentions the importance of automation in several subjects such as the Internet of Things (IoT), Manufacturing Process, Integrated Manufacturing System, and Lean Manufacture. However, in the survey given, it was found that understanding of student lecture material was still at a different level which consist of 35%. understand, 35% quite understand and 30% do not understand. According to [1], the use of robots really helps the learning process and absorption of material for children, where out of 295 participants there are 71% agreeing that robots help the learning process, 87% of participants stated that the use of modern methods in learning-based robotics has a positive effect. Therefore, it is intended to make a learning media for the Integrated Manufacturing System course that students can use in practicing and observing directly a prototype of a arm robot found in industry which has almost have the same use, facilitating understanding of industrial robotics and students can make or Design your own tool based on existing product.

2. METHOD

The results of field studies and literature studies obtained problems in students' understanding of industrial robotic material in the Integrated Manufacturing System course at the Department of Industrial Engineering, Diponegoro University, students already know about industrial robotics but cannot describe its form, function, and design. To help with this problem, the researchers designed an IoT-based robotic arm trainer. The purpose of this research is to design an Internet of Things-based robotic arm trainer as a learning media, and to create an Internet of Things-based robotic arm trainer for the Integrated Manufacturing System course. This study uses the steps of the Engineering Design Process method discovered by [2], to solve a problem for consumers by creating a real product with a specific purpose.

3. RESULT AND DISCUSSION

Needs and Market Analysis

• Need Statements

According to the questionnaire given to Diponegoro University Industrial Engineering students who were studying the Integrated Manufacturing System course, all students thought that automatic work tools in industry were important, but their understanding of automation in the industrial world, their level of understanding was 35%. understand, 35% quite understand and 30% do not understand. So that at least 65% of students are not good at understanding automation in the industrial world, even though Industrial Engineering students should know the role of automation technology that is currently developing. According to [3] globally, it is recorded that 53% of manufacturers are willing to apply automation technology to their business processes or systems. This proves that in the advancement of industrial technology, the majority of companies are aware of the role of automation in their business processes. So the researchers concluded that a tool, method was needed to help students understand automation in industrial technology.

● Market Analysis

According to [2] it is divided into several, namely:

a. Define the problem

Based on the need statement, it is known that tools, methods or methods are needed to help students understand automation in industrial technology. [4] states learning media is a process of personality development with the help of materials or media, which helps to interact with the media, development of creativity, communication skills, critical thinking, stating perceptions, interpretations, analyzing and evaluating media texts, and teaching using technological media. Automation has basic ideas such as using certain electricity or mechanics, having a "brain" core control system, and increasing productivity so that user needs are obtained, namely a mechanical or electrical device, which has a control system (brain) that can help with a job that can help student understanding of industrial robotics.

[1] stated that the use of robots can improve learning, 87% agree that using modern technology can help learning need. spesifically [5] stated that the use of iArm, a robotic arm used for learning, can improve understanding of computational thinking based on five aspects, namely creative thinking, critical thinking, problem-solving thinking, algorithmic thinking, and cooperative thinking. A robotic arm is an automation tool that is shaped like a human arm with a degree of freedom (DOF) according to its design use. [6] Meanwhile, according to [7], a robotic arm is formed from three basic parts, namely the manipulator (mechanical structure), actuator and control system. According to [8], the core movement of a robot is the brain or the control system that is often used is the microcontroller. This makes it easy for researchers to determine that the microcontroller is a suitable control system for the basis of design. This can help that the role of robots as learning aids to support understanding of presentations conveyed only through videos, robots can be included in a learning system that alludes to the efficiency of the manufacturing process.

b. Develop a strategy

The design in this study provides a composition and input to the product to match the existing trends. In user need, it is found that students need to better understand industrial robotic courses, according to [9] learning media that can be used on several topics, so that the design of tools, methods, or methods that are made can be used in a number of subject topics, as well as simple and durable, made from inexpensive materials, and easy to store. The use of robots in the majority of industries is as a tool to carry out material handling processes, but can also do welding, cutting and others. So that the manipulator arm type robot was chosen because what can be used is in accordance with the type of end-of-effector that is set, and more types of robots besides that can move freely by adjusting the use of the degree of freedom. With a

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more compact form, the robot arm is simple in shape, easy to store and use, as well as materials and manufacturing methods that can utilize 3D printer tools found in the Production Systems Laboratory, as well as parts that can be searched for in online stores and are affordable in the range of Rp 40,000 – 100,000, according to Graduate Learning Outcomes (CPL) number 6, namely being able to design an integrated system by taking into account economic factors, in which case the researcher intends to be able to provide an economic picture of how much it costs to make an industrial clone robotics that are in actual manufacturing.

[10] companies are starting to be interested in the use of the Internet of Things, so that the use of IoT can be used as an element in designing tools, ways, or methods to increase learning understanding.

As a support for the existing literature study, the researcher gave a questionnaire to Undip Industrial Engineering students studying the Integrated Systems course, some of the following questions:

- Is the implementation of the IoT application suitable and applied to Industrial Engineering department facilities?
- Have you ever used a microcontroller?
- Do you know a simple tool that uses a microcontroller to operate?
- Do you have an interest in creating a simple tool system using a microcontroller?
- Based on industrial robotic material in manufacturing systems courses, do you need visual aids in understanding the material provided?

From these questions, it was found that 85.7% of students thought that the application of IoT was very suitable for use at Undip Industrial Engineering Department facilities, 81.25% of them did not know, and were familiar with microcontrollers, so the design of this product was in accordance with research purposes or as a demonstration learning about Industrial Robotics. Even so, in the next point questionnaire, 50% of them knew that there was a simple tool with a microcontroller as a means of operation, but these examples were items that they often encountered, such as robots, children's toys. In the next point of the questionnaire, 56.25% of students have the desire to try to make a simple tool using a microcontroller, with a further point that 93.75% of Industrial Engineering students need a tool visual aids or learning media to provide a deeper understanding of Industrial Robotic material. So that some of these points are in accordance with the background and purpose of this research that Undip Industrial Engineering students need a teaching aid or learning media to better understand the material.

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c. Organize and check the information gathered

Summarizing from the previous steps, the researcher makes a list of customer needs and analysis in table 1 Customer Requirements Need that has been obtained can be seen in Table 2 which developed into requirements divided into two groups namely wish (W) and demand (D), demand is the desire of the user, meanwhile wish is the development of desire by researchers based on literature studies and discussion. Then from Table 2 a grouping requirement was made based existing types. The grouping is divided into four types, namely performance, safety, appearance, and learning purposes that can be seen in Table 3

Table 1: Resume of Need and Market Analysis

Need Statement	- tools, methods to understand industrial robotics - otomation base		
Market Research	Product	Product Names	Arm Robot as a learning media for Industrial Robotic Topic
	Product	Product Features	- Material Handling - Using Microcontroller - Simple shape and not easily broken - Easy to store and moveable - Use in different topics - Expedite the learning process
	Industry	Trends	- use automation for processes in the industry - use a single control center system setup - use the robot principle for iterative processes
	Market Information	Market Report	- 85.7% of students understand the importance of automation - student needs for tools or learning media for industrial robotic material by 93.75%
		Target Market	Industrial Engineering Student Laboratory connected to Industrial Robotics
		Demographics	- Active college students - Students of the internet of think, manufacturingsystem, manufacturing process, introduction to industrial engineering, lean manufacturing system
	Customer Trends	- Internet of Things - Robotic Design - Using 3D Printer	

Table 2: Requirement Wish and Demand

Requirement	Demand (D) or wish (W)	Importance (1-10)
Usefull for material handling process	D	10
Use Microcontroller	D	10
Use in different topics	D	10
Expedite learning process	D	10
Robots can perform repetitive processes	D	10
Use 3D Printing	D	10
Based on Internet of Think	D	10
Easy to operate	D	10
Made form light and strong material	D	10
Move otomatically	D	10
Easy to store	D	10
Appropriate to tools use in the industry	D	10
Sistem design appropriate with technical specification	W	8
Applicable	W	7
Can choose right resources	W	7
Use tools that already in market	W	7
Apply basic concept	W	9
Use 4 to 6 Degree of Freedom	W	8
Low Maintenance	W	7
Wireless	W	7
Use motor drive	W	7
Maximal Dimention 50 x 50 x 50 cm	W	6
things that are gripped are not easily released	W	7
Move in order	W	7
orders can be stored and the robot can move itself according to the stored orders	W	5
Maximal weight 150 grams	W	6
Maximal lift dimension 6 x 6 x 6 cm	W	6
Use 5 volt power source (low watt)	W	4
Portable	W	7
Easy to assembly	W	5
Not harm to user	W	8
There is a stop program	W	3
Start immediately	W	2
Interesting design	W	3
Every part and function understandable	W	8

Table 2 divided into three columns, in the first columns a list of requirements is presented that is needed to design the product to be made, in the second columns the demand or wish table is a table used to define existing requirements that demand is a need or a direct user request, while wish is a requirement that is

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the desire of the researcher to build and support the product to suit its purpose and use. In the third columns is the importance table, in this table the researcher can determine the weight of each importance value listed, for demand type requirements because they come from the user's wishes directly, then they are given a weight of 10 which means maximum, while for the wish type the weight will be given a value according to the discussion from the researcher with the supervisor.

The requirements are built based on literacy studies on the use of teaching aids based on suitability in curriculum for integrated manufacturing systems, industrial robotics, Internet of Things, as well as elements of teaching aids. For example, several points regarding the use of teaching aids based on suitability in curriculum, namely designing a system in accordance with technical standards, ease of application in learning, and explaining the objectives in selecting resources, then based on industrial robotic elements, namely, using 4-6 degrees of freedom, motor propulsion, grip strength, precise movement, use of start and stop buttons to facilitate operation are taken based on the opinion of [11]. Based on the topic Internet of Things, several requirements were built such as wireless, and the save command according to input, while on the topic of teaching aids based on the opinion of [12], requirements were built such as tool dimensions, low maintenance, portable, not injuring the user, easy assembled, as well as the user's understanding of the tool itself.

Table 3: Requirement Grouping

Performance	Appearance	Safety	Learning Purpose
Usefull for material handling process	Use 5-volt power source (low watt)	Use 4 to 6 Degree of Freedom	Sistem design appropriate with technical specification
Use Microcontroller	Not harm to user	Made form light and strong material	Applicable
Robots can perform repetitive processes		Wireless	Can choose right resources
Based on Internet of Think		Maximal Dimention 50 x 50 x 50 cm	Use tools that already in market
things that are gripped are not easily released		Interesting design	Use in different topics
Maximal lift dimension 6 x 6 x 6 cm		Portable	Apply basic concept
Use motor drive			
Move otomatically			
Move in order			
orders can be stored and the robot can move itself according to the stored orders			
Maximal weight 150 grams			
Easy to operate			

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There is a stop program			
Start immediately			
Every part and function understandable			
Low Maintenance			

After the requirements were grouped in the table
3 above, an objective tree was formed and diagram that can be seen in Figure 1

Defining Functions

In this sub-chapter a function will be designed for the product to be designed. Function is a relationship between input and output in a design, more clearly that at this stage the researcher describes what the object design will do to fulfill the design objectives can be seen at Figure 2

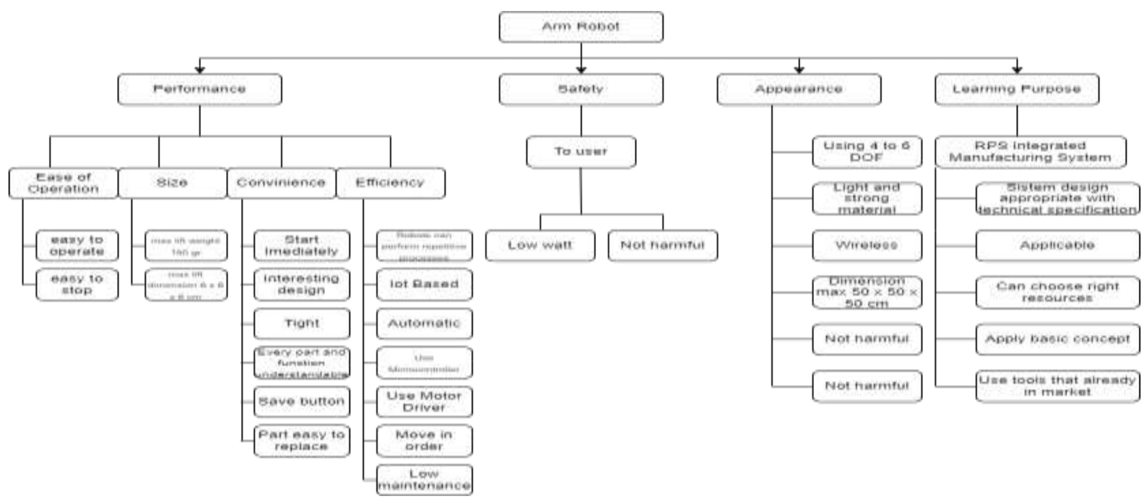

Figure 1: Objective tree diagram

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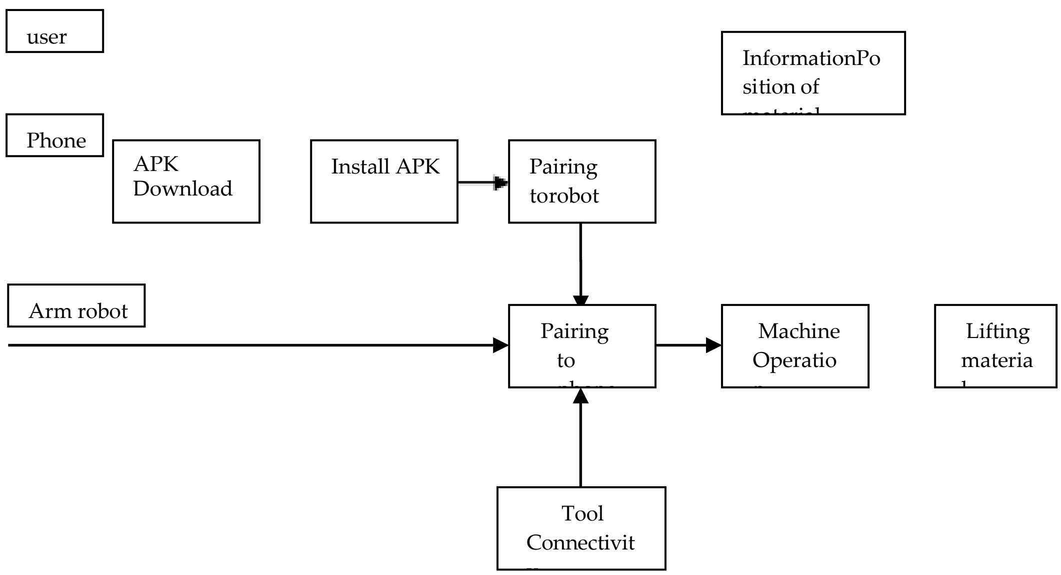

Figure 2: Functional Structure Learning Media

Specifications are important in achieving design suitability, at this stage the researcher adds clarification to existing requirements, and this is the stage before the researcher actually determines a solution that can be realized. In accordance with the objective tree that has been made, the list of specifications is at table 4 as follows:

Table 4: Specification list

Specification	**Value**
Dimension	Max 50 x 50 x 50 cm
Weight	< 3 kg
Cost of Production	< Rp 1000000
Number of Parts	< 20 pcs
People able to use	13 to 25 years old
Weight that can be lifted	< 40 gr
Weight dimension	<= 6 x 6 x 6 cm
Lift range	40 cm
Grip Power	Medium
Move Smoothness	Medium
Precision	Medium
Degree of freedom	4 to 6
Power Input	5 – 9 V
Life time	Depend on power input (use batteries or

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	electrify)
Maintenance	< 2 twice a month
Maintenance cost	< 200000 annually
Colour variation of part	➢ 2 colour
Approximately time to assembly	3 days
Pairing range	< 1.5 meter
Connectivity strength	Easy to connect
Robot response	Medium
Harmful to user	Low / not significant

After determining the existing specifications, to determine the relationship between user requests and specifications and then accurately translating them into units of value, the researchers used the Quality Function Deployment method, supported by the House of Quality (HOQ) method. The following is the HoQ of the design of the robotic teaching aid.

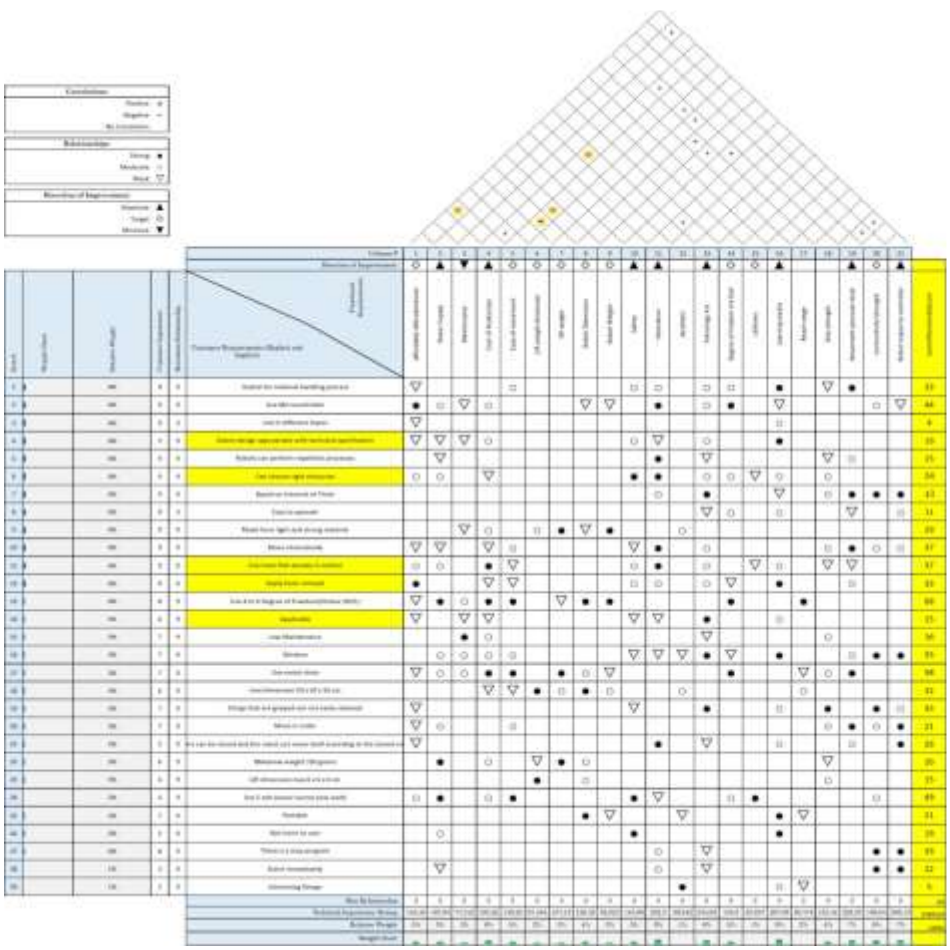

Figure 3: House of Quality

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After unit value being determined researchers determine the real concept of user wishes, by searching for a possible concepts and combinations to form an automation prop that exists, Table 5 is a morphological learning media design chart

Table 5: Morphological learning media

Specification	Option 1	Option 2	Option 3
Degree of Freedom	4	5	6
Dimension	30 x 30 x 30 cm	40 x 40 x 40 cm	50 x 50 x 50 cm
Motor	Servo motor	Stepper motor	Linear Hidraulic
Microcontroller	Arduino Uno	Raspberry	
Pairing Device	Blue tooth	Wifi ESP 32	
Board Circuit	Breadboard	PCB Board	
End Effector	Gripper	Vacuum	Magnetic Device

In the series of morphological charts that are made, a combination of various designs can be searched, then the researcher can evaluate the existing designs to determine which design meets the requirements that have been made. Researchers use a decision matrix to evaluate which design is in accordance with the requirements that have been made. Using the Weighting Factor obtained from the value of the relative weight in making the House of Quality. In the early stages, after determining the weight factor of the requirements, an importance rating was given based on the subjectivity of the researcher and supervisor. The Arm Robot can be assembled based on several combinations of suitable designs, this includes the number of degrees of freedom (DoF), the use of actuators or robot drives, and the determination of the end of effector according to the purpose, in this case it is found that learning media are useful as a tool in material handling process. The value of the design criteria is then carried out calculation, by multiplying the weighted factor (WF) and rating factor (RF) will then determine the value of the weighted rating factor (RWF). The highest RWF value will be used as design.

The decision matrix is divided into four alternative groups that is robot body arm, microcontroller, board assembly, and connectivity devices, this alternative group is decided because of all four combinations of the selected alternative can be used as a design. The following is decision matrix teaching aids

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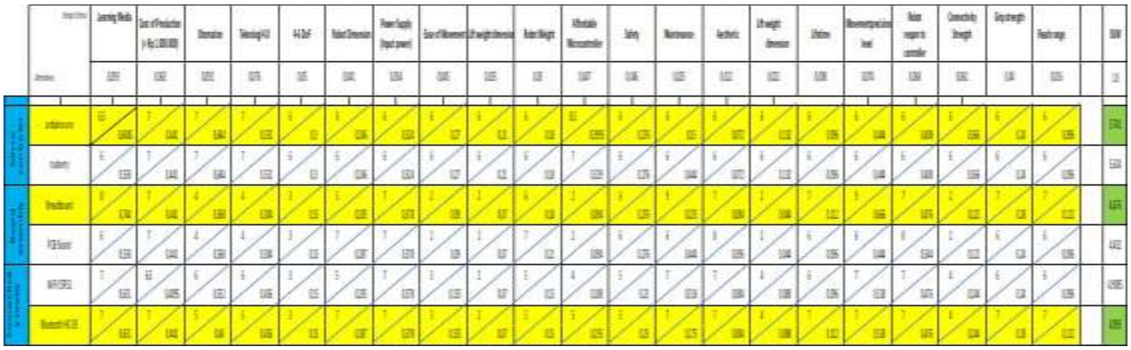

Figure 3: Decision Matrix

Researchers make a modification to some parts of the body on the robot, this is due to the capabilities of the motor servo which drops when lifting object at a certain weight, so that moment lifting robot objects stuck or has a difficulty moving. Therefore, researchers decided to change some parts of the robotic arm become lighter part. And there is also a replacement of the gripper arm robot design in order to add more dimensions of objects gripped and gripper or claw movement more stable, so that objects are not easy fell when grabbed. Researchers change two parts namely Arm 2 and Gripper.

The final design obtained will be tested for accuracy using three tubes with a diameter of 7 cm and a height of each tube, namely Tube A 5 cm, Tube B 10 cm and Tube C 15 cm. The test results were obtained as follows.

Table 6: Test Results for the Arm Robot

Trial Number	Tube A	Tube B	Tube C	Precise Percentage
1	Precise	Not Precise	Precise	100%
2	Precise	Not Precise	Precise	67.5%
3	Precise	Precise	Not Precise	67.5%
4	Precise	Precise	Precise	100%
5	Precise	Not Precise	Precise	67.5%
6	Not Precise	Precise	Precise	67.5%
7	Precise	Precise	Not Precise	67.5%
8	Precise	Precise	Precise	100%
9	Precise	Not Precise	Not Precise	33.33%
10	Not Precise	Precise	Precise	67.5%
Presentase	80%	60%	70%	
Average				74%

Based on these tests, the Arduino robot arm has an average level of accuracy of 74%, whereas in research conducted by Imam Faisal (2016) the graphical User Interface-based object selector robot manipulator tool in related aspects of the device has an average value of 78.126% with 75% of students stated that the tool was very feasible to use as a learning medium. So, the conclusion is that with the accuracy of the level of accuracy or performance of an instrument with a value of ≥60% it can be said to be very feasible as a learning medium.

REFERENCES

[1] Yousif, J. H., Al-Hosini, M., Al-Sheyadi, S., Al-Ofui, A., & Al-Syehadi, M. (2018). Questionnaire of Using Humanoid Robotfor Teaching and Learning Kids. International Journal of Computatuion and Applied Sciences IJOCAAS, Vol.2, 2.

[2] Yosef, H., & Tamer, S. (2011). Engineering Design Process. Stamford: Global Engineering.

[3] Shobur, M., Alfatiyah, R., Dahniar, T., &Supriyadi, E. (2021). Sistem Produksi LEAN. Tangerang Selatan: UNPAM PRESS.

[4] Federov, A. (2008). *On Media Education.* Moscow: ICOS UNESCO IFAP.

[5] Zeng, C.; Zhou, H.; Ye, W.; Gu, X. iArm: Design an Educational Robotic Arm Kit forInspiring Students' Computational Thinking. Sensors 2022, 22, 2957. https:// doi.org/10.3390/s22082957

[6] Afin. (2018). Rancangan dan Analisis Kinematika pada Manipulator Robot Lengan Mentor dengan Pengolahan Citra Kamera. *Universitas GadjahMada*.

[7] Yulianto, A., & Ramadan. E. (2015). Sistem Kendali Robot Manipulator Pemindah Barang dengan Umpan Balik Visual. *Jurnal Ilmiah Mikrotek, 1(2)*, 1-8.

[8] Faisal, I. (2016). Pengembangan Media Pembelajaran Robotika Menggunakaan Robot Manipulator Penyeleksi Benda BerbasisGraphical User Interface. *E-Journal Universitas Negeri Yogyakarta*, *Vol.6, No.6*, 452-458.

[9] Dihan, N. (2022, September 4).*KONSEP ROBOT INDUSTRI*. FromTeknik Elektronika Industri SMKNegeri 1 Ampelgading: http://www.elinsmkamga.com/2017/11/konsep-robot-industri.html

[10] Bi, Z. & Xu, Li & Wang, Chengen. (2014). Internet of Things for Enterprise Systems of Modern Manufacturing. Industrial Informatics, IEEE Transactions on. 10. 1537-1546. 10.1109/TII.2014.2300338.

[11] Shobur, M., Alfatiyah, R., Dahniar, T., & Supriyadi, E. (2021). *Sistem Produksi LEAN*. Tangerang Selatan:UNPAM PRESS.

*[12]*Rusman, Kurniawan, D., & Riyani, C.(2011). *Pengembangan Berbasis Teknologi Informasi dan Komunikasi :Mengembangkan Profisionalisme*