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Machine Design and Development of CoreXY FDM 3D Printer for Learning

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ABSTRACT

This research aims to design and develop CoreXY FDM 3D Printer that can be optimized for learning purposes. By detailing aspects of design, hardware, and software, this research is expected to make a significant contribution in improving the quality of learning. Research using the Research and Development method, carried out based on the Machine Learning System Development model with stages in the form of Problem Understanding, Data Handling, Model Building, and Model Monitoring. The results showed that the lowest average depreciation value in the 3D printer developed was smaller than the 3D Printer machine from the previous study. The best print quality was produced in experiment number 3 where the print results were almost flat and smooth. So that the best print parameters are produced at a layer thickness of 0.1 mm and a print speed of 60 mm / minute. Blackbox Test results show that all components of the 3D printer machine have been able to function properly. The results of the user trial questionnaire showed that the average value of all aspects received a value of 3.55 from a range of values 1-4, indicating that this machine is very good to be used as a medium in the learning process. Comparison of FDM CoreXY 3D Print printing process time after development shows shorter print time than FDM CoreXY 3D Printer machine before development.

1. Introduction

The development of technology has increased very rapidly along with the times. The development of this technology is directly proportional to the development of modern human civilization. Technology that exists today helps humans in carrying out all daily activities, especially in the industrial sector. The industrial sector in this era of disruption entered the industry 4.0 sector where the industry continues to experience rapid development, especially in manufacturing, the design of a product becomes very important. In order to ensure the stability of the industry in market competition and product development, the industry needs devices with a high degree of precision and fast manufacturing capabilities[1]. This aims to simplify the production process, especially in making prototypes. Therefore, many industries apply the use of CNC (Computer Numerical Control) machines in their production operations. The development of CNC machining has been remarkable, given its ability to make complex, precise, accurate products easily and efficiently, even in large quantities[2]. One of the technological implementations of CNC development is three-dimensional printing (3D printing).

Three-dimensional printing (3D printing) has become a major focal point in the development of manufacturing technology, bringing revolutionary impacts on various sectors, including Education.

In this context, the design and development of CoreXY Fused Deposition Modeling (FDM) 3D Printer becomes an important aspect that supports innovation and learning in the Education environment.The design and development of CoreXY FDM 3D Printer has its own positive side in the context of learning. Its ability to print objects with high speed and high accuracy makes it an ideal instrument for illustrating product design concepts and manufacturing processes to learners. The use of 3D printers also allows one to prototype tools during the research and development process. This helps to reduce research and development costs.

3D Printer is one of the latest breakthrough innovations in the world of technology in accordance with the industrial era 4.0. A 3D printer is a desktop computer fabrication or additive manufacturing tool used for the prototyping process of creating tangible objects from 3D designs. Recent research shows that 3D printer technology has seen significant advances in recent decades, changing the paradigm of manufacturing processes and creativity. previous research results have stated that 3D printer technology has significantly advanced in recent decades, transforming manufacturing processes and creativity paradigms[3]. Generally, making a prototype takes a long time because it involves a series of stages, starting from design design to the finishing stage. Therefore, the conventional process of prototyping requires a lot of manual work and takes significant time in prototype production[4].

The use of 3D printing technology in education has become a positive trend, opening up new opportunities to bring students closer to design and manufacturing concepts. The operational principle of a 3D printer is similar to that of a 2D printer, where objects are built through the stacking of a number of layers, with each layer printed on top of the previous layer. With the advancement of its features, 3D printers have the ability to produce solid objects of diverse shapes and sizes[5]. CoreXY FDM 3D Printer, has a unique and efficient working principle that uses a coordinate system of two motors, located on two sides of the machine. These motors are controlled separately and work simultaneously to drive the nozzle on the X and Y axes[6]. With a different mechanism to other FDM printers, CoreXY 3D printers offer the potential to improve the quality of the learning experience, particularly in developing technical skills relevant to the industry in the future[7].

This research focuses on the design and development of a CoreXY Fused Deposition Modeling (FDM) 3D Printer optimized for learning purposes. CoreXY 3D printers' ability to print objects with high speed and accuracy makes them ideal instruments for illustrating product design concepts and manufacturing processes to learners. Additionally, 3D printers enable the prototyping of tools during the research and development process, thereby reducing research and development costs.

The development model serves as a guide to determine the necessary steps in the development process of a product to conform to the set goals. This development procedure is designed to help address the complexity of people's needs for the product, so that problems can be effectively addressed. There are four stages implemented by researchers to solve these problems. (1) Problem Understanding, (2) Data Handling, (3) Model Building; and (4) Model Monitoring [8].

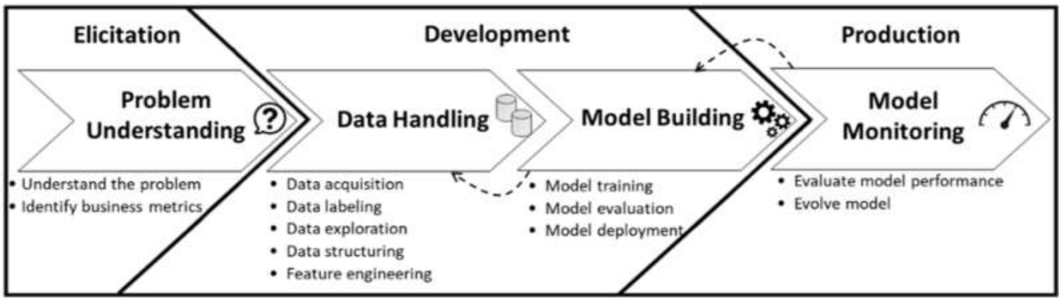

Fig. 1. Machine Learning System Development process steps.

2. Method

Research conducted using Research and Development methods. During the limited trial phase, the FDM CoreXY 3D Printer was introduced and its usage demonstrated to students enrolled in courses related to 3D printing technology. Specifically, students from the Mechatronics Engineering Education program, who had completed the CNC Technology Practice course, were involved in this study. A total of 35 students from the 2021 cohort participated as respondents, providing valuable feedback on the printer's functionality and effectiveness in an educational setting. This research was carried out based on the Machine Learning System Development model: (1) Problem Understanding, (2) Data Handling , (3) Model Building ; and (4) Model Monitoring [8]. The stages of the development model are as follows:

2.1. Understanding the Problem

Existing problems from the environment or community can be analyzed to then find solutions and map the most appropriate targets. The main problem that exists today is the development of FDM-based custom 3D printing machines that currently exist is still limited, especially in aesthetics and improving the quality of print results carried out. Understanding the problem is carried out to identify the development components and the process of improving the quality of print results needed in a custom FDM-based 3D Printer to print goods with PLA materials so as to accommodate the needs in the community. The purpose of this process is to find out the development of aesthetic aspects in the form of what shape and layout of a 3D Printer that is attractive and has maximum performance in printing using various types of PLA filaments.

2.2. Data Handling

Data handling is carried out by researchers to find out what data is needed to meet the research objectives. This data can be the result of previously existing research. Data from FDM-based custom 3D printing machines that have been developed previously are taken and then reviewed and developed to obtain a new, more optimal design. To start handling data, developers perform several tasks, such as data acquisition, data exploration, data structuring, and feature engineering. The previous 3D printing machine design is in the picture below.

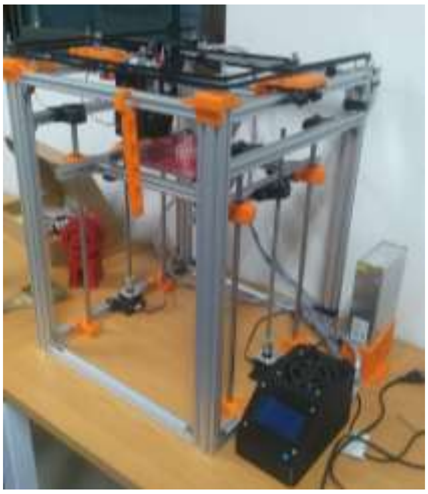

Fig. 2. Design custom 3d print FDM CoreXY from previous research.

2.3. Model Creation

This stage researchers carry out the process of developing tools / models of machines and conducting basic testing. The development of the design process involves the creation of a custom Fused Deposition Modeling (FDM) 3D Printer, which includes both hardware and software components, as well as additional instruments to enhance the printing outcomes as required by the preliminary phase. It is anticipated that the outcomes of this 3D printer design, demonstrated through various applications, will fulfill the diverse requirements of the printing process for multiple uses. The results of the design implementation from the previous study are shown in figure 2. Pre-made designs still require development in terms of aesthetics and improvement of the results of the process so as to produce attractive shapes, easy to use and identify the most suitable parameters in printing with the maximum quality of results. The design and model of the previous machine were again researched to obtain maximum results. Furthermore, at this stage, a mechanical manufacturing and assembly process will also be carried out to get more optimal 3D printing machine results.

The model fabrication phase is conducted by constructing a 3D Printer, which begins with the assembly of mechanical and electronic components. This is followed by the installation and integration of software with the electronic components. Adjustments are also made to the software to enable communication with the pre-prepared hardware, allowing it to process designs using PLA filament for printing pre-designed models. Furthermore, the validation of the completed 3D print is performed during this phase. Expert validation is conducted by specialists and academics whose expertise aligns with the research objectives.

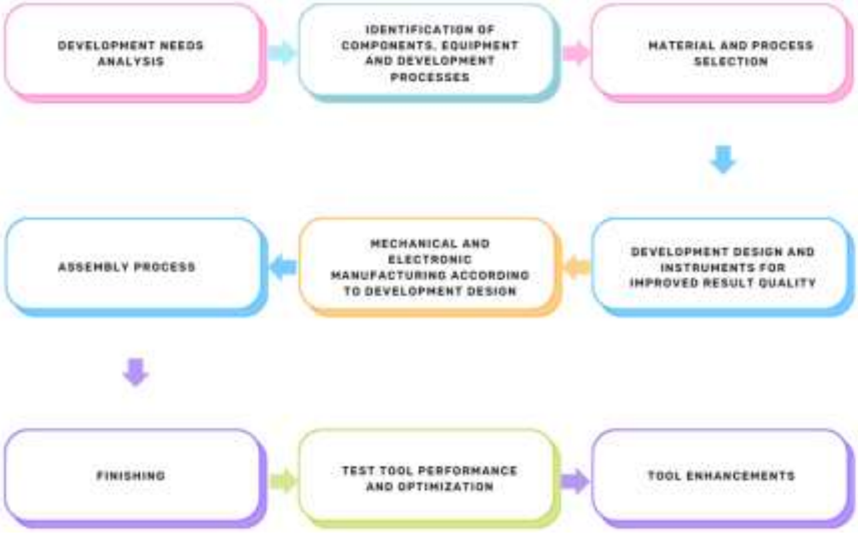

Fig. 3. FDM-based 3D Printer Development Process.

2.4. Model Monitoring

The model/tool of the 3D printer is continuously monitored in the production environment to obtain performance data from the machine. Since new data is fed into machines in production environments, researchers have continuously monitored the performance of 3D printers. This stage can also be carried out various forms of validation of the product to achieve the expected goals. The evaluation results of this product can be a benchmark for product propagation. Here are the stages for the development of a 3D printer machine.

Fig. 4. FDM-based Custom 3D Printer Machine Development Model.

Monitoring of the model is implemented to derive enhancements from the executions made previously. This includes the refinement of mechanical and electronic components, software, standard operating procedures (SOPs), and user manuals. The primary objective of this research is to design a device in the form of a custom Fused Deposition Modeling (FDM)-based 3D Printer and to deploy it for printing items as required, using optimal parameter settings to achieve superior printing results. The result of this research are expected to be beneficial for both the academic program and the general public in enhancing skills and productivity, particularly in the areas of design, installation, programming, and control of a 3D Printer, as well as its application in the printing of design models.

3. Results and Discussion

The research findings indicate that the developed CoreXY 3D printer has the lowest average shrinkage value in the X-axis direction at -0.1600, which is smaller than the previous study's 3D printer. The best print quality was achieved in experiment number 3, with a layer thickness of 0.1 mm and a print speed of 60 mm/min. The discussion highlights the repeated testing to ensure the method's suitability. User trial results show that the machine is highly suitable for use in the learning process, with an average rating of 3.55 out of 4. Additionally, the developed machine's printing time is shorter compared to the pre-development machine.

This research uses Research and Development method conducted by Nascimento. There are 4 stages carried out to solve problems, especially related to machine development: (1) Problem Understanding, (2) Data Handling, (3) Model Building; and (4) Model Monitoring [8]. Each stage is detailed to provide a comprehensive approach to developing and optimizing the CoreXY 3D printer.

3.1. Stage of Understanding the Problem

As professionals in the industry continue to increase the use of 3D printing machines, this technology is becoming an ever-evolving part of everyday life. The education world has realized this and incorporated 3D printing into the curriculum, but extensive integration in additive manufacturing into educational programs will depend on greater awareness of the many benefits of 3D printing for Education [9]. Currently, there are still many traditional educations relying on rote memorization of reading materials in the learning process. 3D printing offers a way for learners to truly connect with the subject matter by physically manipulating print-ready teaching aids or by designing the tools themselves.

In a 3D Printer learning activity, Formlabs delivers a project-based course, culminating in students designing, modeling, and printing tools in 3D. The students are able to solve problems and use CAD skills to develop solutions, then bring their ideas to life with a 3D printer. The most preferred aspect of learning is the ability to manifest physical objects in the mind into something tangible that can be held or touched through 3D printing technology. Through 3D printing technology, teachers and students can have the ability to replace damaged equipment or components and replace them with new ones. The manufacturing process can also be introduced through this 3D printing technology so that students have the ability to implement their ideas from designs that have been made on computers through CAD software.

The types of 3D printer machines used in the field of Education consist of Fused Deposition Modeling (FDM) 3D Printers, Stereolithography (SLA) 3D Printers and Selective Laser Sintering (SLS) 3D Printers. FDM is the most common type of 3D printer used in education. FDM 3D printers create components by melting and extruding thermoplastic filaments, which are then arranged layer by layer by the printer nozzle in the manufacturing area. Its advantages lie in its scalability and affordability, as well as the nature of the technology, making it an easy-to-understand concept. The disadvantages of FDM are the quality of the surface finish and low precision which causes problems. Lower part quality and a narrower range of materials are what makes the applications that FDM printers can support limited, especially in research environments or at the higher education level. SLA 3D Printers generally have a high price, but now manufacturers are starting to make affordable types of SLA printers so as to make this technology accessible in the educational environment and prove its reliability and high professional quality, this printer has also become a reliable tool in every educator's device. SLA printers are versatile and suitable for a wide range of applications, due to their excellent surface finish, wide choice of materials, and precise accuracy [9]. Because the material used is a resin liquid, so the treatment of materials in the printing process also needs to be considered, such as should not be exposed to sunlight, should not be exposed to the skin. UV resins contain irritants that can be harmful to humans, as well as pollutants that can be harmful to the environment and other living species. The chemical properties of liquid photopolymers make them toxic if ingested and also have the potential to cause irritation (to the skin and eyes) and allergens to the skin as well as the emergence of harmful fumes. In addition, resins are also harmful to aquatic life [9]. Of the various dangers caused, then for the field of Education, the type of SLA printer is less recommended. SLA printers are the most expensive of the three main types of plastic 3D printing technology. The technology uses a high-power laser to selectively sinter small powder particles in the form of the desired file cross-section, then repeat the process layer by layer[9]. From the results of the analysis of the type of 3D printer for learning above, FDM 3D Printer is the most suitable type of printer for use in learning. These selection considerations are based on low price, easy process and variety of materials widely available on the market. After selecting the type of printer, then the printer design is carried out along with the analysis of material needs.

3.2. Data Handling

a. Pre-existing 3D printer machine dimension data.

Previous research has produced CoreXY FDM 3D Printer machines with specifications; Machine Dimensions (W x W x H) = 44 cm x 44 cm x 59 cm, Bed Dimensions (W x D) = 20 cm x 20 cm, Print Dimensions (W x W x H) = 20 cm x 20 cm x 35 cm, Bed using ordinary glass, Bed temperature <1000C, Frame material using silver aluminum profile, and Filament diameter 1.75 mm

b. The printed data uses PLA filaments from previous 3D printer machines.

The printing process uses 3D Print previously by printing the Calibration Cube obtained from the UltiMeker Thingiverse website. The design of the Calibration Cube can be seen in figure 6.

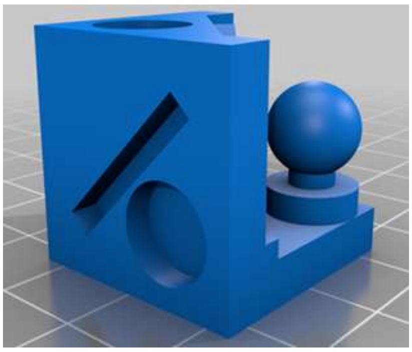

Fig. 5. Calibration Cube.

The printing process is carried out with nozzle temperature printing parameters of 2100C and bed temperature of 600C, infill of 40%. The results of printing using PLA filament from the previous 3D printer machine are presented in the table as follows:

Table 1. Accuracy data of printing results using PLA filaments using previous 3D printers

No	Nozzle Size	layer thickness (mm)	Print Speed (mm/menit)	Design Size(mm)			Result Size (mm)			Print Time (Minutes)	Shrinkage			Average
				X	Y	Z	X	Y	Z		Shrinkage X	Shrinkage Y	Shrinkage Z	
1	Nozzle 0.4	0,1	40	25	25	25	25.47	25.08	26.31	142’	-1.8800	-0.3200	-5.2400	-2.4800
2		0,1	50	25	25	25	24.93	25.01	26.11	147’	0.2800	-0.0400	-4.4400	-1.4000
3		0,1	60	25	25	25	25.16	25.38	25.98	141’	-0.6400	-1.5200	-3.9200	-2.0267
4		0,2	40	25	25	25	25.21	25.31	25.77	83’	-0.8400	-1.2400	-3.0800	-1.7200
5		0,2	50	25	25	25	25.13	25.45	25.96	76’	-0.5200	-1.8000	-3.8400	-2.0533
6		0,2	60	25	25	25	25.19	25.74	25.88	74’	-0.7600	-2.9600	-3.5200	-2.4133
7		0,32	40	25	25	25	25.12	25.43	25.95	57’	-0.4800	-1.7200	-3.8000	-2.0000
8		0,32	50	25	25	25	25.11	25.65	25.93	52’	-0.4400	-2.6000	-3.7200	-2.2533
9		0,32	60	25	25	25	25.31	25.72	26	50’	-1.2400	-2.8800	-4.0000	-2.7067
Average											-0.7244	-1.6756	-3.9511	

Text The quality of the print using PLA filament is reviewed from the various parameters depicted in figure 7. The best quality was produced on experiment number 5 where the prints were almost flat and smooth. So that the best print parameters are produced at a layer thickness of 0.2 mm and a print speed of 50 mm / minute.

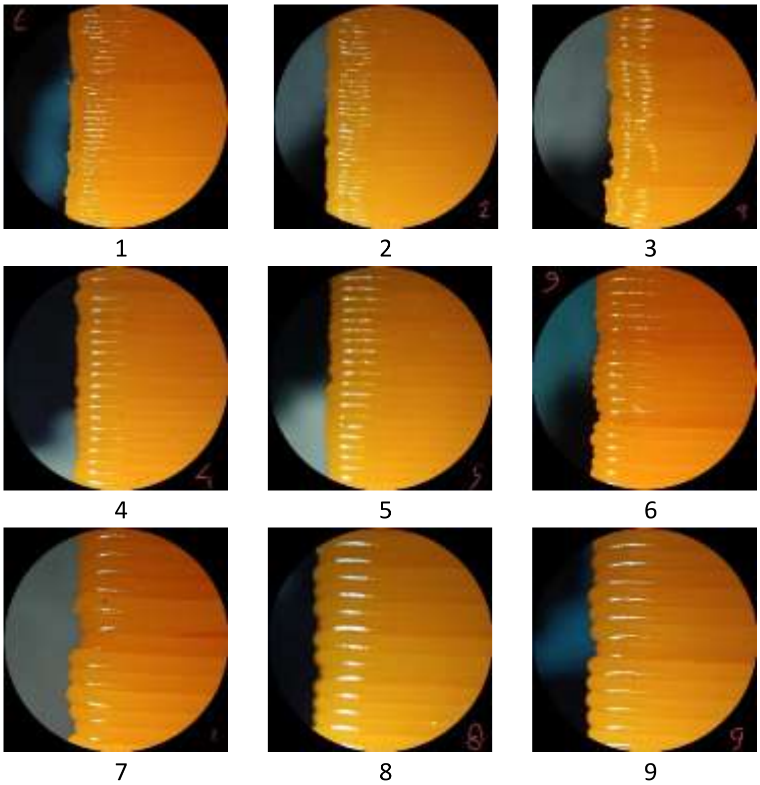

Fig. 6. Quality of 3D Print with PLA Filament using 3D printer before development.

3.3. Model Building

The workflow in using the CoreXY FDM Printer 3D machine begins with designing a model to be printed using 3-dimensional design software. Software that can be used in the process of designing 3-dimensional objects such as Autodesk Inventor, MasterCAM, SolidWoks and the like. The software will produce 3-dimensional files in the form of files with .stl (stereolithography) format. The .stl file will be obtained by the slicer software so that the resulting 3-dimensional design will be cut into layers that will be worked on in the printing process. The slicer software used in this study is Ultimaker CURA. The result of the process from the Ultimaker CURA software is in the form of a .gcode file. This .gcode file will then be run by the 3D Printer machine to print the 3-dimensional design. The flow of the printing process using the CoreXY FDM Printer 3D engine can be seen in figure 5.

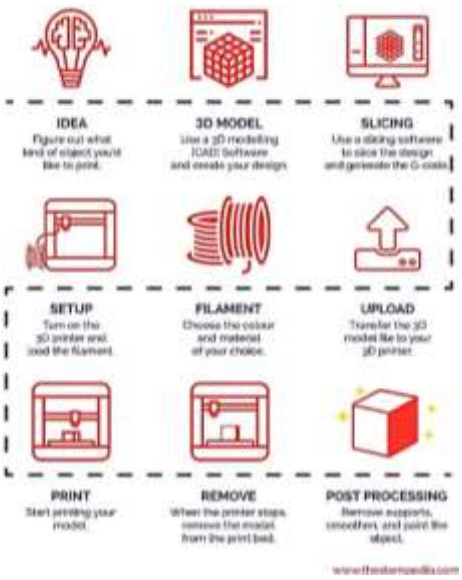

Fig. 7. Printing process flow using FDM Printer 3D machine [11]

Figure The design design of the FDM 3D printer to be made in the form of mechanical and electronic design is shown in figure 9.

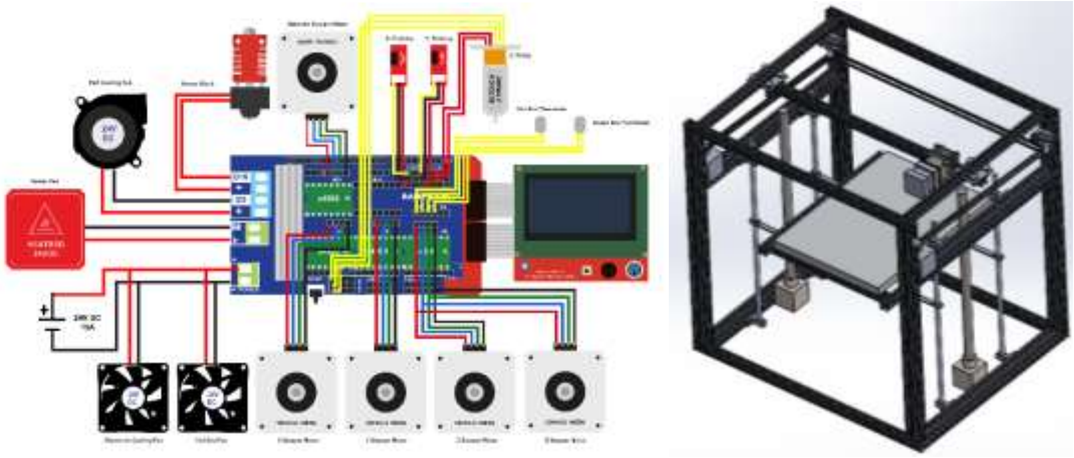

Fig. 8. Electronic Design and Mechanical FDM 3D Printer

Labels From the electronic and mechanical design that has been designed, it can be identified the material requirements for the manufacture of FDM 3D printers. So as to produce a prototype of the results of the implementation of mechanical design as follows:

Fig. 9. Mechanics of a 3D Print Machine

The print areas of mechanical and electronic assembly results are as follows:

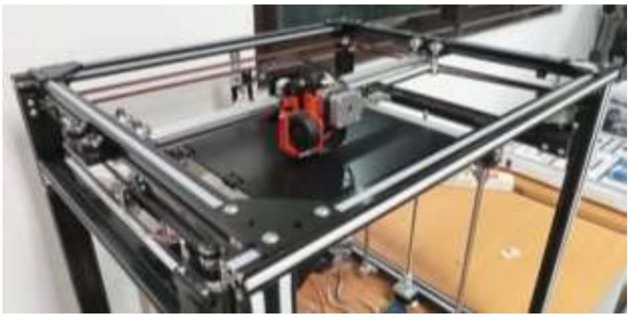

Fig. 10. CoreXY Custom 3D Print Machine Print Area

The CoreXY FDM 3D Printer engine results of the development process can be seen in Figure 12

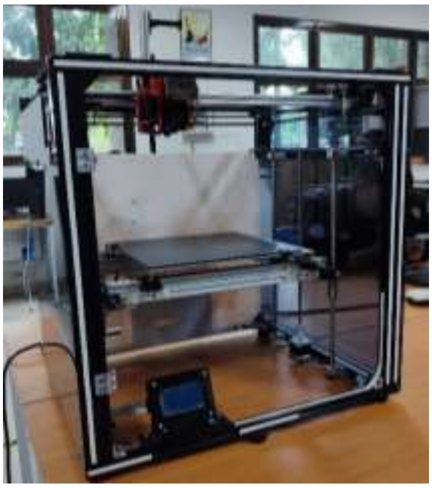

Fig. 11. FDM 3D Printer Machine developed

The 2023 research has resulted in various development of parts of the CoreXY type FDM 3D Printer machine with specification improvements; Machine dimensions P x L xH = 60 cm x 49 cm x 70 cm, Bed dimensions P x L = 33 cm x 33 cm, Print dimensions P x L x H = 30 cm x 25 cm x 30 cm, Bed material: Tempered glass, Bed temp < 80°C, Hot end temp <285°C, Frame material a combination of black and silver aluminum (majority black), Filament diameter = 1.75 mm, Movement system: CoreXY, Motor driver: drv8825, Max print speed: 100mm/s, Max acceleration: 8000mm/s², and Leveling mode: auto bed leveling with BL Touch.

After the FDM CoreXY 3D Printer machine has been assembled, then a function test of each component in the machine is carried out. The function test results are presented in the black box test results table in table 2.

Table 2. Blackbox Test Results

No.	Types of Testing	Functionality	
		Yes	No
1	Turn on the 3D Printer	V	
2	Home Settings of X, Y, Z axis	V	
3	X-axis movement settings	V	
4	Y-axis movement settings	V	
5	Z-axis movement settings	V	
6	Start Printing button	V	
7	Printing percentage indicator	V	
8	Print estimation time indicator	V	
9	Temperature information Hot End and actual Hot Bed	V	
10	Target Hot End and Hot Bed temperature information	V	
11	Finish printing button	V	
12	Turn Off the 3D Printer	V	

3.4. Model Monitoring

Times The printing process using the FDM 3D Printer machine after development was also carried out with nozzle temperature printing parameters of 2100C and bed temperature of 600C, infill of 40%. The results of printing using PLA filament from 3D printer machines after development are presented in table 3.

Table 3. Data on the accuracy of 3D Print results Development Results

No	Nozzle Size	layer thickness (mm)	Print Speed (mm/menit)	Design Size(mm)			Yield Size (mm)			Print Time (Minutes)	Shrinkage			Average
				X	Y	Z	X	Y	Z		Shrinkage X	Shrinkage Y	Shrinkage Z	
1	Nozzle 0.4	0,1	40	25	25	25	24.99	25.11	24.94	91'	0.0400	-0.4400	0.2400	-0.0533
2		0,1	50	25	25	25	25.01	25.14	25	82'	-0.0400	-0.5600	0.0000	-0.2000
3		0,1	60	25	25	25	25.03	25.06	25.05	76'	-0.1200	-0.2400	-0.2000	-0.1867
4		0,2	40	25	25	25	24.99	25.29	25.4	51'	0.0400	-1.1600	-1.6000	-0.9067
5		0,2	50	25	25	25	25.03	25.1	25.18	47'	-0.1200	-0.4000	-0.7200	-0.4133
6		0,2	60	25	25	25	25.1	25.12	25.1	43'	-0.4000	-0.4800	-0.4000	-0.4267

7	0,32	40	25	25	25	25.01	25.46	24.93	36'	-0.0400	-1.8400	0.2800	-0.5333
8	0,32	50	25	25	25	25.1	25.33	25.73	33'	-0.4000	-1.3200	-2.9200	-1.5467
9	0,32	60	25	25	25	25.1	25.2	24.7	33'	-0.4000	-0.8000	1.2000	0.0000
Average										-0.1600	-0.8044	-0.4578	

The quality of prints using PLA filaments using 3D FDM CoreXY printers resulting from the development process is reviewed from various parameters shown in Figure 15. The best quality was produced in experiment number 3 where the print was almost flat and smooth. So that the best print parameters are produced at a layer thickness of 0.1 mm and a print speed of 60 mm / minute.

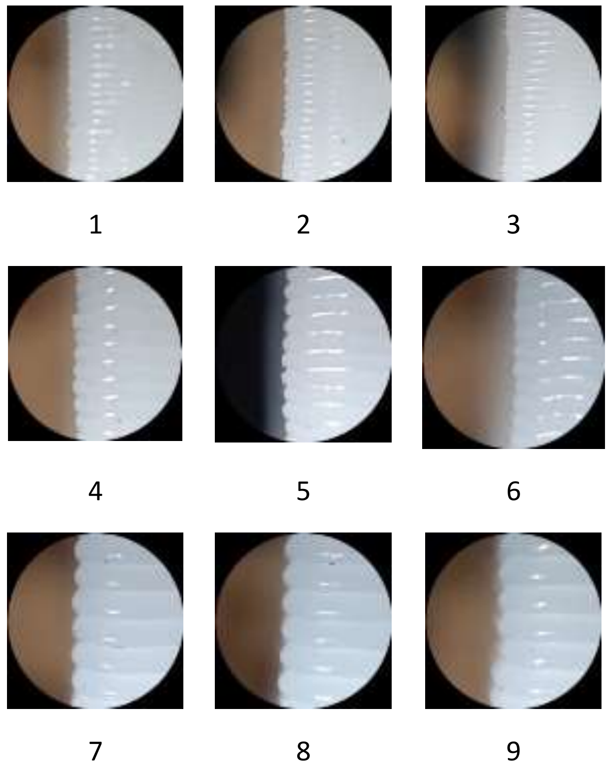

Fig. 12. Quality of 3D Print with PLA Filament using 3D printer after development

In the limited trial process, the use of the FDM CoreXY 3D Printer machine was carried out by presenting and piloting the process of using the FDM CoreXY 3D Printer machine to students who had taken courses related to the use of 3D Printer machines. Courses related to the use of 3D printer machines in the Mechatronics Engineering Education study program are CNC Technology Practice Courses. There are 35 students who are willing to be respondents in this study, consisting of students of the Mechatronics Engineering Education study program, Class of 2021. The results of user trials obtained data from user test questionnaires are presented in Table 4

Table 4. Trial Questionnaire Results

Question	Average score
The parts on a *3D Printer* are not confusing	3.26
3D Print Core XY Based Arduino Mega can be easily operated	3.34
I can do the *slicing* process on the application easily	3.46
The filament *installation process* can be done easily	3.71
The process of removing *the filament* can be done easily	3.69
SDCard reads well on *CoreXY 3D Printers*	3.71
Arduino Mega-Based CoreXY 3D Print helps teachers explain material about using *3D Printers*	3.57
3D Print CoreXY Based on Arduino Mega adds to my competence in understanding *3D Print systems*	3.74
The use of 3D Print CoreXY Based on Arduino Mega increases knowledge related to components in 3D printers	3.63
The use of 3D Print CoreXY Based on Arduino Mega adds knowledge related to various types of 3D printers	3.60
3D Print CoreXY Based on Arduino Mega adds knowledge related to 3D Printer parameter settings	3.57
The use of 3D Print CoreXY Based on Arduino Mega helped me learn material in other courses	3.46

Question	Average score
The use of Arduino Mega-Based CoreXY 3D Print made me more creative and innovative	3.20
The use of Arduino Mega-Based CoreXY 3D Print adds to my learning motivation	3.40
3D Print CoreXY has an interesting shape	3.49
3D Print CoreXY has a neat component layout	3.57
CoreXY 3D Print size according to practicum needs	3.54
3D Print CoreXY has a shape to suit my needs	3.37
The information on the LCD display is easy to understand	3.49
The design and layout of the CoreXY 3D Print component can be easily understood	3.60
The process of releasing printouts can be done easily	3.69
CoreXY 3D Print print quality	3.74

User input regarding the use of the FDM CoreXY 3D Printer machine includes LCD displays to be more user friendly, neatness in wiring, good design, easy maintenance, suitable for facilitating practicum activities that sometimes lack equipment in carrying out the 3D printing process.

The advantages of the FDM CoreXY 3D Printer from development compared to before development are a larger printer size, larger print dimensions so that it is able to print objects larger than the previous 3D printer, hot end temperatures that can reach 2850C can melt materials not only PLA but also able to melt other materials such as ABS and PETG so as to increase the variety of materials that can be processed on the 3D printer machine and system Stronger and aesthetically better mechanics. The mechanical system on the Z-axis on the previous machine used 2 motors to raise and lower the bed from the left and right sides of the printer. While the developed printer uses 1 motor connected together on the left and right threads to raise the bed simultaneously. So that the lack of synchronization that occurs in raising the bed which causes the bed to tilt which results in the print results not being straight up / slightly tilted can be avoided. While the drawback is that the motor on the Z axis will have a higher effort / energy than the previous printer.

Based on the test results, the blackbox test shows that the 3D Printer FDM CoreXY after development has been checked for every step of the printing process. All components can operate properly and as expected, from the process of turning on to turning off the printer.

Comparison of printing process time from the results of the FDM CoreXY 3D Print printing process after development shows a shorter print time compared to the printing process on the FDM CoreXY 3D Printer machine before development. This can be seen from the average difference in printing process time in 9 experiments of 36.67 minutes faster in the printing process using 3D Printer FDM CoreXY after development. The time difference calculation table can be seen in Table 5.

Table 5. Printing time difference

Attempt to-	Print Time (minutes)	Print Time (minutes)	Time difference (minutes)
1	142	91	51
2	147	82	65
3	141	76	65
4	83	51	32
5	76	47	29
6	74	43	31
7	57	36	21
8	52	33	19
9	50	33	17
Rata-rata			36.67

4. Conclusion

The development of FDM CoreXY 3D Printer machines has been carried out using Research and Development methods guided by the Machine Learning System Development model. The process of optimizing the performance of the CoreXY FDM 3D Printer machine for learning purposes has been carried out by comparing from prototypes produced by previous studies. In the previous prototype, the lowest average depreciation value was obtained in the X-axis direction of -0.7244 while in the 3D printer development the lowest average depreciation value was obtained in the X-axis direction of -0.1600 smaller than the 3D Printer machine from the previous study. The best print quality was produced in experiment number 3 where the print results were almost flat and smooth. So that the best print parameters are produced at a layer thickness of 0.1 mm and a print speed of 60 mm / minute. Blackbox Test results show that all components of the 3D printer machine have been able to function properly. The results of the user trial questionnaire showed that the average value of all aspects received a value of 3.55 from a range of values 1-4, indicating that this machine is very good to be used as a medium in the learning process. Comparison of printing process time from the results of the FDM CoreXY 3D Print printing process after development shows a shorter print time of 36.67 minutes compared to the printing process on the FDM CoreXY 3D Printer machine before development.

In essence, this research succeeded in developing the CoreXY FDM 3D Printer using an R&D method guided by the Machine Learning System Development model. Performance optimization was carried out by comparing prototypes from previous research. The results show improved print quality and reduced printing time. This machine is very suitable for educational use and is expected to make a significant contribution to improving the learning process.

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References

[1] A. A. Nurul Amri and W. Sumbodo, "Perancangan 3D Printer Tipe Core XY Berbasis Fused Deposition Modeling (FDM) Menggunakan Software Autodesk Inventor 2015," Jurnal Dinamika Vokasional Teknik Mesin, vol. 3, no. 2, pp. 110–115, 2019. Available: https://doi.org/10.21831/dinamika.v3i2.21407

[2] C. F. Soon, M. F. Ramilan, D. Hanafi, W. N. W. Zakaria, S. B. M. Khialdin, H. Isa, and K. S. Tee, "Development of a 3D bio-printer using CoreXY mechanism and syringe-based extrusion," Indonesian Journal of Electrical Engineering and Computer Science, vol. 18, no. 3, pp. 1180–1187, 2020.

[3] Wicaksono RA, Kurniawan E, Syafrianto MK, Suratman RF, Sofyandi MR. Rancang Bangun dan Simulasi 3D Printer Model Cartesian Berbasis Fused Deposition Modelling. Jurnal Engine: Energi, Manufaktur, dan Material [Internet]. 2021 Oct 23 [cited 2024 Jul 2];5(2):53–64. Available from: https://ejournal.up45.ac.id/index.php/Jurnal_ENGINE/article/view/895

[4] R. A. Abdullah, "The Use of 3d Printing on Design Thinking in The Design Process: A Literature Review," Journal of Industrial Product Design Research and Studies, vol. 1, no. 1, p. 9, 2022. Available: https://ejournal.upi.edu/index.php/JIPDRS/article/view/47469.

[5] A. Muhyi, R. Ferdiyanto, K. Rajagukguk, W. S. Sipahutar, and M. F. Arif, "Analisis Sifat Mekanik dari Struktur Seluler yang Difabrikasi dengan Printer 3D," Journal of Science and Applicative Technology, vol. 7, no. 1, p. 1, 2023. Available: https://doi.org/10.35472/jsat.v7i1.370.

[6] E. Idà, F. Nanetti, and G. Mottola, "An alternative parallel mechanism for horizontal positioning of a nozzle in an FDM 3D printer," Machines, vol. 10, no. 7, p. 542, 2022.

[7] CHAYAANK, "Design and Fabrication of FDM 3D printer using core-XY mechanism," Academia.edu, 2021. Available: https://www.academia.edu/83213664/Design_and_Fabrication_of_FDM_3D_printer_using_core_XY_mechanism.

[8] E. de S. Nascimento, I. Ahmed, E. Oliveira, M. P. Palheta, I. Steinmacher, and T. Conte, "Understanding Development Process Of Machine Learning Systems: Challenges And Solutions," International Symposium on Empirical Software Engineering and Measurement, Oct. 11, 2019. Available: https://doi.org/10.1145/3239235.3268927.

[9] Formlabs, "Guide to 3D Printing In Education," Formlabs, 2023. Available: https://formlabs.com/blog/guide-3d-printing-education/

[10] B. O'Neill, "Is UV resin toxic? Risks and safety measures explained," Wevolver, Jun. 16, 2022. Available: https://www.wevolver.com/article/is-uv-resin-toxic-risks-and-safety-measures-explained.

[11] STEMpedia, "3D Printing: What it is, Types, Applications, and Printers," STEMpedia, 2023. Available: https://ai.thestempedia.com/docs/3d-printing/getting-started-with-3d-printing/.