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CAD-BASED 3D PRINTING EDUCATION TO ENHANCE THE COMPETENCE OF VOCATIONAL STUDENTS OF SMK BABAT LAMONGAN

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ABSTRAK

Teknologi manufaktur dalam 3D printing menjadi semakin penting bagi siswa sekolah kejuruan untuk bersaing dalam kompetensi desain dan manufaktur. Keterlibatan 3D printing dalam kursus pelatihan kejuruan dan program pendidikan memberikan banyak manfaat bagi siswa dan mempersiapkan mereka untuk profesi teknis di berbagai industri. Pelatihan ini bertujuan untuk meningkatkan kompetensi lulusan SMK di bidang manufaktur modern khususnya 3D printing. Siswa dapat menyelami model dunia nyata dari persamaan matematika yang kompleks, grafik, dan rekayasa melalui 3D printing. Hal ini memungkinkan siswa yang mengalami kesulitan dalam memvisualisasikan konsep-konsep tersebut untuk memahaminya dengan lebih mudah. Kegiatan ini berupa pelatihan dengan metode ceramah, penugasan dan praktek. Hasil evaluasi kegiatan pelatihan 3D Printing ini mendapat respon positif. Mayoritas siswa SMK sebagai peserta menyatakan materi pelatihan disampaikan dengan sistematika yang jelas dan narasumber mampu menyampaikan materi dengan jelas dan runtut sehingga dapat disimpulkan bahwa kegiatan ini berhasil.

Kata kunci: 3D printing, siswa vokasi, CAD

ABSTRACT

Manufacturing technology in 3D printing is becoming increasingly important for vocational school students to compete in design and manufacturing competencies. The involvement of 3D printing in vocational training courses and educational programs provides many benefits to students and prepares them for technical professions in various industries. This training aims to increase the competency of vocational school graduates in the field of modern manufacturing, especially 3D printing. Students can dive into real-world models of complex mathematical equations, graphics, and engineering through 3D printing. This allows students who have difficulty visualizing these concepts to understand them more easily. This activity takes the form of training using lecture, assignment and practice methods. The evaluation results of this 3D Printing training activity received a positive response. The majority of vocational school students as participants stated that the training material was delivered in a clear systematic manner and the resource person was able to convey the material clearly and coherently so it could be concluded that this activity was successful.

Key word: 3D Printing, vocational students, CAD

INTRODUCTION

In the world of education, especially the world of education in Vocational High Schools, the most emphasised thing for graduates is competence in the field of competence according to their expertise. Along with the development of science and technology, especially in the industrial world, it is appropriate for students to be equipped with competencies that can support them to compete in the industrial world, especially the manufacturing industry. Prototyping technology has now developed rapidly. Almost all medium and large manufacturing companies use rapid prototyping in the prototyping process. To be able to work well in the machining industry, which is increasingly sophisticated as time progresses, it is necessary to master CAD and Rapid Prototyping competencies, and this is due to the ability of CAD software that is very complex and able to make a design quickly when compared to using manual drawings (Fanuc, 2010;Feeler, 2002; MST, 2005)).

Factors for the low acquisition of student learning outcomes in the competence of operating CAD software and rapid prototyping include the learning process that has not been able to take place as it should, the ratio of machines to the number of ineffective machines, namely 1: 15 to 17 students, or even many SMKs that do not yet have rapid prototyping machines (3D Printing). In addition, it is also due to the lack of learning resources or learning materials that support and can be studied by students at home.

The above problems indicate that the learning process for 3D printing competence still needs to be improved and easier to understand by students. In connection with this, CAD software training is needed to implement 3D Printing to improve the quality of SMK graduates. In this community service proposal, the target for 3D Printing training is SMK Muhammadiyah 5 Babat. The training is conducted by sending students periodically by SMK Muhammadiyah 5 Babat to the Surabaya State Shipbuilding Polytechnic Campus. This training is expected to increase the knowledge, skills, and insights of SMK students in 3D Printing.

THEORETICAL FRAMEWORK

3D PRINTING

A 3D printer is a printing device capable of producing three-dimensional objects that can be seen, held, and have volume. Creating a three-dimensional solid object from a digital file involves building a 3D model layer by layer (Karuniawan et al, 2019; Putri et al, 2022).

3D printer, also known as Additive Layer Manufacturing, creates three-dimensional solid objects from a digital design that can be seen, held, and in volume. 3D printing is accomplished through an additive process in which successive layers of raw materials are used to construct an object. 3D printing can print models and takes a short time to create a product, but it has the drawbacks of low product strength and limited dimensions (Karuniawan et al, 2022; Rachman et al., 2021). A digital 3D model must be obtained by scanning a set of 3D models/objects or drawing using 3D design software such as AutoCAD, 3DsMax, SketchUp, and others to create an object.

PLA (Poly Lactic Acid) Filament

PLA is a plastic polymer made from biodegradable materials, such as corn, tapioca, or processed sugar cane. Because it is made from biodegradable materials, PLA is environmentally friendly. This PLA is what makes this material gain more and more popularity. PLA can produce substantial and elegant molds (Setiawan et al., 2018).

Composites

A *composite* is a material structure composed of two or more macroscopically combined constituents that do not dissolve each other and produce a new material with properties different from the fundamental properties before mixing and surface bonding between each constituent material. The first constituent called the reinforcing phase, while the second constituent, in this case, the surrounding, is called the matrix.

One of the advantages of composite materials is the material's ability to be directed so that its strength can be adjusted only in specific directions that we want. Besides being strong, composites are also lightweight, rigid, corrosion-resistant, and highly resistant to dynamic loads. In addition to having advantages, composites have disadvantages, such as being less elastic

(Setiawan et al., 2018; Sholeh et al., 2018). Furthermore, it is more challenging to form plastically and cannot withstand shock and crash loads.

ADDICTIVE MANUFACTURING

The term "Addictive Manufacturing" effectively encapsulates the fascinating and highly appealing qualities of 3D printing, accurately reflecting the strong attraction associated with this technological advancement. One finds oneself inevitably captivated by the realm of meticulous and sequential construction, which unveils boundless prospects.

The remarkable precision with which 3D printing can transform computer plans into tangible items is considered one of its primary advantages. The addictive quality of this phenomenon has resemblance to the observation of the conversion of abstract ideas into concrete manifestations. The utilisation of 3D printing technology enables individuals to achieve a previously unimaginable degree of customisation and creativity in various domains, including prototype, custom production, and artistic expression (Juniani et al., 2021; Prabowo et al., 2018)

Additive manufacturing exhibits a wide range of applications in many sectors, encompassing aerospace, healthcare, and consumer goods. Within the aerospace industry, experts utilise the technique of 3D printing to fabricate components that possess a combination of low weight and high strength. This enables them to enhance both fuel efficiency and overall performance. The capacity of technology in healthcare to manufacture implants and prosthetics tailored to individual patients demonstrates its potential to transform the field of personalised medicine (Jumandono et al., 2017; Rahman et al., 2020; Setiawan et al., 2023).

Furthermore, the realm of additive manufacturing is characterised by its perpetual evolution. With the advancement of materials science, a wide range of materials, including as metals, polymers, and bio-printable substances, are now available for utilisation in the field of 3D printing. The proliferation of diverse materials serves as a catalyst for the growing enthusiasm among innovators, motivating them to venture into uncharted territories in both design and usefulness.

METHOD

The strategy for implementing this service research uses the applied approach method with students. This method is carried out to channel the main focus according to the service objectives by providing knowledge and understanding through scientific conceptual theories. In contrast, guided training is carried out to focus more on the target object, namely students of SMK Muhammadiyah 5 Babat, with a training system (demonstration and practice). The training was held at the Surabaya State Shipbuilding Polytechnic CNC Laboratory.

The steps of this community service activity include preparation and implementation activities. The preparation activities were carried out with the following steps. First, developing activity planning in the form of training. Next, the team apply for permission and cooperation with SMK Muhammadiyah 5 Babat Lamongan. Third, conducting socialisation with the approach method to provide information related to training activities. Developing a schedule of training activities is very significant to schedule. And the last step is providing training materials through scientific methods such as basic theory, demonstration, guided practice, feedback, and evaluation. The reason for choosing this method is that it is the easiest way for students to understand. The students can dive into real-world models of complex mathematical equations, graphics, and engineering through 3D printing. This allows students who have difficulty visualizing these concepts to understand them more easily.

RESULT AND DISCUSSION

This training activity was carried out on July 26th 2023 at Politeknik Perkapalan Negeri Surabaya in collaboration with SMK 5 Babat Lamongan. This training means to increase the competency of vocational school graduates in the field of modern manufacturing especially in 3D printing. The training lasted for 8 hours starting from 08.00 to 16.00 and was attended by 20 students with 3 accompanying teachers. The event rundown can be seen in the table 1 below:

Table1. Event rundown

Session	Time	Learning Materials

Opening	09.00 - 09.30	Registration
Session 1	09.30-11.00	Utilization of CAD software for 3D printing
Session 2	11.15-12.00	Introduction to 3D printing machines
Break		
Session 3	13.00-15.00	Demonstration of making products using a 3D printing
Session 4	15.00-15.30	Product handover
Session 5	15.30-16.00	Closing

The activity was opened by giving a discourse from a lecturer teaching design and manufacturing engineering regarding the development of addictive manufacturing technology (Figure 1).

Figure 1. Opening Session with Addictive Manufacturing Insight

The market for 3D printing technology continues to increase but there are still few business models available. With the increase in the market demand, business competition will of course increase, so business model development is needed. By paying attention to the conditions above, it is necessary to motivate students to be enthusiastic about participating in the training. Motivation is provided by accompanying teachers (Figure 2). In providing this motivation, it was stated that apart from developing a business model, a concept is also needed that is capable of producing new, innovative and creative values.

Figure 2. Co-Advisor Proposed the Student Motivation in 3D Printing

The next session is explanation about concept and benefit of 3D printing in manufacturing industry (Figure 3). More and more manufacturing companies are embracing the trend of 3D printing. While manufacturing companies often use other tools and machines to convert raw materials into finished products, 3D printers offer several unique benefits. By using a 3D printer, manufacturing companies can customize nearly every aspect of their product. Product designs, of course, are created in computer-aided design (CAD) software. Manufacturing companies can design their products using CAD software, after which they can upload or transfer the CAD file to a 3D printer. It's a simple process that allows for an exceptional level of customization over the product's design. 3D printers also produce less waste than other tools and machines used in the manufacturing industry (Setiawan., et al, 2023). While there are several types, most 3D printers work by following the commands included in a CAD file. Therefore, they only release material in areas where it's needed. With a 3D printer, manufacturing companies can achieve a more efficient production process that minimizes waste.

Figure 3. Concept and Benefit of 3D Printing in Manufacturing Industry

Figure 4. Lecturer & Students Practice with 3D Printing: A Co-Working Team

The next activity is lecture and students practice with CAD software for 3D printing (Figure 4). To be able to take part in this session, the students need a laptop or computer. For students who do not bring computers, we provide computers and software needed for this activity. This activity required students to make a 3D modelling object of their choice. One of the main advantages of CAD software is that it allows us to optimize our models for 3D printing, by adjusting various aspects, such as size, shape, orientation, resolution, and infill. These factors can affect the quality, strength, and appearance of the product, as well as the printing time and cost. From the explanation and the practice given, it can be seen that students are very enthusiastic about this activity. For some students, this is something new for them so the activity is full of questions about the operation of this CAD software. Of course the trainer try to patiently answer all the questions given until they are all answered.

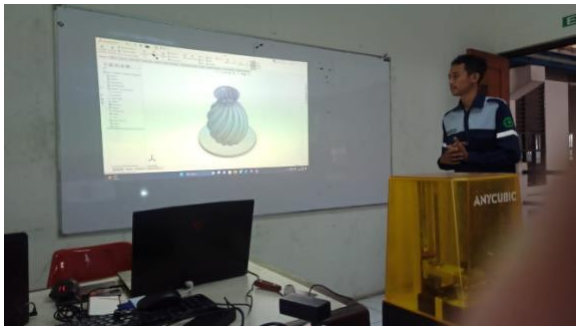

Figure 5. Drawing Presentation of Design Manufacturing's Student

After resting, the activity continues with demonstration of making products using a 3D printing machine (Figure 5). One of the students' 3D modeling results is selected to be used to make the product. The type of 3D printing machine used is digital light processing (DLP). It works by exposing a layer of photosensitive liquid resin to a UV-laser beam, the resin then hardens in the desired pattern, and the object is built layer by layer until it is complete. DLP is a 3D printing technology used to rapidly produce photopolymer parts. It's very similar to SLA with one significant difference, where SLA machines use a laser that traces a layer, a DLP machine uses a projected light source to cure the entire layer at once. DLP printers are popular for their ability to quickly produce objects and parts with intricate designs with a high degree of accuracy. They are relatively affordable, so they are often found in offices. Limitations of DLP printing include strong odors produced by melting photopolymers in the printing process, and the risk of warping in larger items. Because the product manufacturing process takes a long time, some students are allowed to ask questions about the prospects for the 3D printing business. how to get tools, how to get market demand and how to maintain this 3D printing machine. Discussions were also held so that several questions were answered in front of the class (Figure 6).

Figure 6. Discussion Between Students and Instructor

After about 4 hours of the product manufacturing process, it finally became a 3D printed product (Figure 7). The product cannot be used immediately, the product requires further processing known as post processing. Post processing will maximize the quality and mechanical performance of the product, such as strength, durability and hardness. After printing and removing the object from the build plate, it is necessary to clean the part. The product was rinse twice for three minutes in ethanol or IPA, preferably using ultrasonic cleaning or agitation. After cleaning, make sure to properly UV cure. The last step includes removing the supports with a model cutter. Finally, it is possible to improve the aesthetics or function of the part through optional post-processing steps such as sanding, polishing, priming and painting. At the end of the activity, a group photo was taken and the 3D printed products were handed over to SMK 5 Babat Lamongan representatives (Figure 8). The continuation of this activity is online student assistance between trainers and students when they encounter problems related to 3D printing.

Figure 7. 3D Printing's Product

Figure 8. PPNS and SMK 5 Babat Lamongan in 3D Printing Training

The evaluation results of this 3D Printing training activity received a positive response from the students. The majority of SMK students as participants said that the training material was delivered with a clear systematic and the resource person was able to present the material clearly and coherently. This activity was also published in several mass media. The websites that convey news and responses to this activity include, https://www.enciety.co/ppns-beri-pelatihan-software-cad-kepada-puluhan-siswa-smk/ and https://jatim.telusur.co.id/detail/ppns-beri-pelatihan-cad-dalam-implementasi-pemanfaatan-3d-printing-kepada-siswa-smk

CONCLUSION

This community service have been successful in helping government programs in improving the quality of human resources by providing 3D printing education to participants. Material from this training can provide an understanding and ability to use 3d printing from designing and producing which can be utilized to support and simplifying work.

REFERENCES

Fanuc. (2010). Fanuc Series oiMate-Model Dfor Lathe System Operator's Manual. Fanuc Company: Japan

Feeler. (2002). FV-600/800/1000 (A) Maintenance Manual. Fair Friend: Taiwan

Jumandono, M., & Juniani, A. I. (2017). Analisa Pembuatan dan Perakitan Kerangka Chassis Mobil Minimalis Roda Tiga Menggunakan Metode AHP (Analytical Hierarchy Process). Proceedings Conference on Design and Manufacturing and its Applications, 1509, 11–14, http://journal.ppns.ac.id/index.php/CDMA/article/download/311/264

Juniani, A. I., Singgih, M. L., & Karningsih, P. D. (2021). Design for Manufacturing, Assembly and Reliability on Product Redesign: Literature Review and Research Direction. 2nd Asia Pasific Conference on Industrial Engineering and Operations Management, 218–231.

http://ieomsociety.org/indonesia2021/proceedings/

Karuniawan, B. W., Rachman, F., & Setiawan, A. A. (2019). Optimasi Parameter Mesin Fused Deposition Modelling (FDM) Terhadap Kekasaran Permukaan Produk Menggunakan Metode Taguchi. Journal Techno Bahari Volume 6. https://jurnal.poltera.ac.id/index.php/technobahari/article/view/63

Karuniawan, B.W., Rachman, F., Yoningtyas, M.T. (2022). Metode Taguchi untuk Optimasi Parameter Mesin Printer 3D terhadap Kwalitas Produk Material ABS, Jurnal AUSTENIT, Vol. 14, No. 2., https://doi.org/10.5281/zenodo.7265857

MTS. (2005). CNC Exercises for the FANUC programming key MTS TeachWare Teacher Version. MTS Mathematisch Technische Software-Entwicklung GmbHKaiserin- Augusta-Allee 101 • D-10553 Berlin.

Prabowo, R. S., Setiawan, P. A., Juniani, A. I., Wiediartini, & Erawati, I. (2018). Reliability analysis of hanger shot blast KAZO machine in foundry plant. MATEC Web of Conferences, 204. https://doi.org/10.1051/matecconf/201820403007

Rahman, M. F. F., Juniani, A. I., & Setiawan, T. A. (2020). Perancangan Jok Ergonomis Dalam Fabrikasi Mobil Minimalis Roda Tiga. Proceedings Conference on Design Manufacture Engineering and Its Application, 2654.

Setiawan, T. A., Sarena, S. T., Purnomo, D. A., & Juniani, A. I. (2023). Embracing Risk Factors into Product Redesign Model based on DFMA and Concurrent Engineering : A Review for Research Opportunities. 1–6.

Sholeh, A., Iviana Juniani, A., & Novrita Devi, Y. (2018). Analisis dan Perancangan Sepeda Statis untuk Rehabilitasi Penderita Stroke. Politeknik Perkapalan Negeri Surabaya, 11–16.

Swansoft. (2007). Swan NC Simulation Software. Nanjing: Swan Software Technology Co.Ltd

Putri, A.S., Karuniawan, B.W., Rachman, F. (2022). Analisis Pengaruh Variasi Parameter 3D Printing terhadap Kekuatan Tarik pada Filamen ABS Menggunakan Metode Taguchi, Proceedings Seminar Master PPNS tahun 2022, Volume 7 No 1 Pages 22, ISSN (P): 2548-1509 ISSN (E): 2548-6527, https://journal.ppns.ac.id/index.php/SeminarMASTER/issue/archive

Rachman, F., Kurniawan, B., & Yoningtias, M. (2021). Optimization of 3D Printing Process Parameters on Tensile Strength of ABS Filament Material Product Using Taguchi Method. The 4th International Conference on Applied Science and Technology (iCAST 2021) (p. 263). Samarinda, Indonesia, https://icast.isas.or.id/2021/wp-content/uploads/2021/10/Program-Book-iCAST-2021-ES.pdf

Setiawan, A. A., Karuniawan, B. W., & Arumsari, N. (2018). Optimasi parameter 3D printing terhadap keakuratan dimensi dan kekasaran permukaan produk menggunakan metode Taguchi Grey Relational Analysis. Conference on Design Manufacture Engineering and its Application (p. 165-168), Surabaya.