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3D Printing Dental Model as Three-Dimensional Learning Media Alternative

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ABSTRACT: Industry 4.0 is now the current industry revolution. The framework of industry 4.0 has already involved in many life sectors, including education. One of schemes in industry 4.0 is 3D Printing. This study analysed the problem of learning method in Health Polytechnic of Health Ministry Semarang in which the dental model previously used had flaws in the making and results. Then the challenge is the implementation of 3D Printing for the dental model. The main objective of this study is to understand 3D Printing modelling in dentistry. The method used is Research and Development (Research and Development) to explore the implementation of 3D Printing for learning media alternative including to its making. The results of this study are output in the form of 3D Printing dental model and 3D Printing Handbook.

KEY WORDS: Dental Model, Education, Industry 4.0, Learning Media, 3D Printing

I. INTRODUCTION

The development of the digital revolution in this century is increasingly providing convenience for human life. Experts say that currently, humans are in the industrial revolution phase called Industry 4.0. One of the keys to the era of the industrial revolution 4.0 is 3D Printing. 3D Printing is also called additive manufacturing, which is the creation of three-dimensional solid objects from digital data. The process is done by layer-by-layer. Each layer can be seen as a horizontal cross section of the actual object. The era of globalization requires the world of education to always and always adjust technological developments towards efforts to improve the quality of education, especially adjusting the use of technology in the teaching and learning process[1].

Health Polytechnic of Health Ministry Semarang students are set more on practice than theory. The need for implementing practice is in scope of patient and dental model. The tooth model made so far by manual sculpture with cast material. As a form of Community Service, the Health Polytechnic of Health Ministry Semarang often conducts examinations and provides free dental health education using dental models to the community ranging from children to the elderly.

The problem encountered using the manual sculpture technique from casts is that the standard physical form of each type of teeth is not fulfilled, because the level of student skills is not the same in making dental model. Not to mention, the dental model cannot reveal tooth structure in detail such as nerves, blood vessels, periodontal membranes, semen, pulp, dentine, and e-mail, causing suboptimal delivery of material, resulting in a decrease in the level of understanding from the community as well as during teaching and learning activities. The model of the teeth from the raw material of cast is susceptible to rupture. Based on cases that have occurred, several models of teeth rupture when introduced primarily to children. Therefore, techniques manual sculpture with cast material is not effective to use.

By the background above, this study focuses on how to model the teeth using 3D Printing technology. The preliminary study found that 90% of the Semarang Department of Health Polytechnic Dental Nursing students and the Department of Dental Nursing at the Health Polytechnic of the Ministry of Health, Tasikmalaya, Banjarmasin, Jambi and Yogyakarta, did not know about 3D printing technology. These results indicate that the development of 3D printing technology to make dental models as learning media has never been done so that it can be used as a reference for conducting this research. This method is expected to gradually become a substitute for manual sculpture technique as an increase in the ability of students and strengthening human resources in the health industry in this era of globalization.



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The main objective of this study is to understand 3D Printing modelling in dentistry, while specifically the objective of this study is to find out the benefit from the existence of 3D printing technology.

II. RELATED WORK

3D printing is a relatively simple robotic device. This system will not run without computer-assisted design using (CAD) software that allows objects to be created virtually. Software (CAD) is used in the industry, engineering, and is commonly used in dental laboratories, has even become an analytical feature in many dental operations [2]. The advantage of using 3D printing is that fabrication becomes faster, more precise, and more efficient in raw materials, meaning that errors that occur when the fabrication process can be suppressed, because first the dental model has been designed in digital format [3].

Rapid prototyping has been introduced since 1980 for orthodontics as a technique of physical tooth models based on CAD / CAM procedures[4]. CAD / CAM is Computer Aided Design / Computer Aided Manufacturing is part of technological developments that have been used in the implementation of 3D models based on virtual prototypes [5]. CAD / RP Engineering Integration for RPD manufacturing frameworks has been popularly used as an alternative to the conventional techniques used previously [6]. The use of 3D models can help various treatments, for example, can be used as a guide to operations[7]. The use of traditional dental components makes patients feel uncomfortable. This is because the forms that are created manually are not the same between the makers of one another. But with the help of machines such as CNC, the dental model made can be more comfortable for patients. Today, 3D Printing is a manufacturing choice that has better advantages [8].

III. SCOPE OF RESEARCH

The research was conducted in Health Polytechnic of Health Ministry Semarang. The respondents were students of Dental Nursing in as much as 40 persons. The output of this research is 3D Printing dental model and the handbook. This research is the way to contribute towards The College Three-Duties including to education and teaching, research and development also community service.

IV. METHODOLOGY

The method used was Research and Development in Four-D conceptual. The steps are Define, Design, Develop and Disseminate respectively. The explanation of each step is portrayed below:

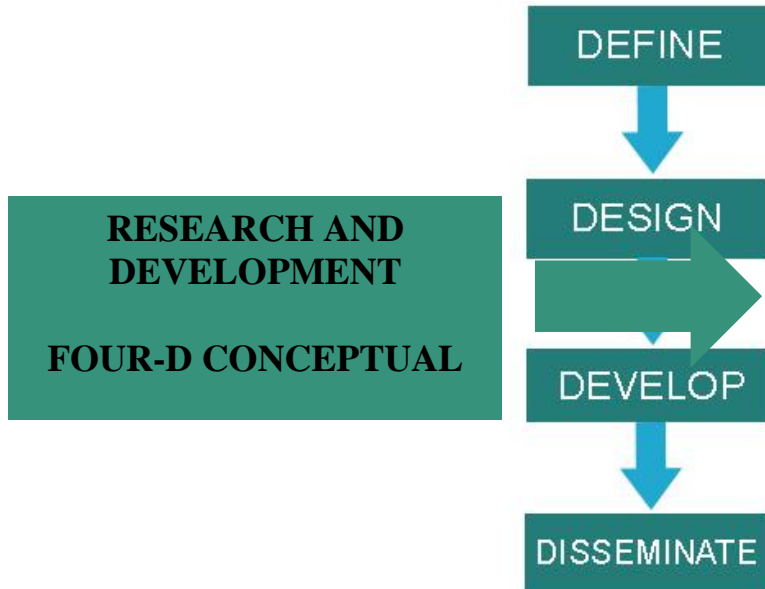


Fig1. Research Method

Define

The first step, i.e. Define is done by doing analysis on problem, the students, the concept of academic and also task of identifying student's skill. In the end, is to define the purpose of the research. The final result of Define-step is the urgency of research.

Design

The dental model is determined as single-tooth. It is designed by using software named FUSION360. While the 3D Printing method used is FDM (Fusion Deposition Modelling) and the material is PLA (Polylactic Acid) filament.

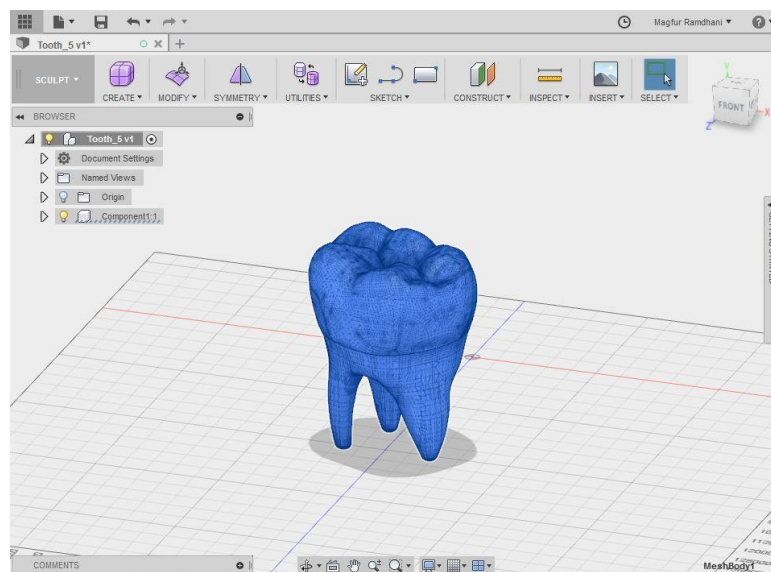


Fig2. Dental Model

Develop

The step of develop is done by involving the lecturer to validate the result of 3D Printing dental model. It is intended to take the confirmation towards the result. We also have cooperation to Gudang Mikon Banyumanik to work with as the technical support.

Disseminate

The dissemination is done through a seminar to introduce the 3D Printing dental model towards the respondents. The respondents take a look at the physical form of dental model and give the feedback. In addition, the respondents also get the demonstration on how to print the dental model.

V. EXPERIMENTAL RESULTS

The followings are the results of research comprising the printer type, design in detail and print-out result as well as the seminar.

Dental Model Design

Modern dentistry requires technology so that 3D representation is more accurate [9]. The design of the model showed in Figure 2. is made with the type of FDM printer with the brand ANYCUBIC Kossel Linear. The dimensions that can be made by the 3D Printer are 230 x 230 x 300 mm. The raw material used is PLA (Polylactic Acid) filament. This is the printing process using the yellow colour PLA filament.

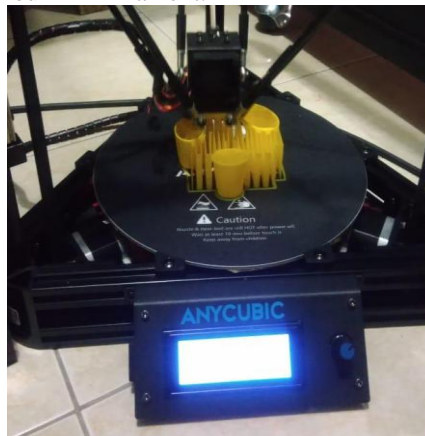


Fig3. Printing Process in 10%

Figure 3 shows the printing process is running 10%. The percentage can be seen by the screen on the printer. The printer prints the design according to the dimensions of X, Y and Z in the FUSION360. Below is when the process is running in 50%.



Fig4. Printing Process in 50%

Based on the Figure 4, it can be seen that the contents in the dental model have hollows. These hollows show the reason why the dental model made by 3D Printing is lighter than it made by using casts. This research used FDM 3D Printer using PLA material. Polylactic Acid is a thermoplastic biodegradable material, is one of the popular ingredients of bioplastic which is used to make plastic cups for medical implants. The parameters given to compare dental models made from cast material and using 3D Printing are strength, weight, time of manufacture, flexibility and accuracy.

Pre-processing involves the formation of a model. A model consists of representations of geometry, material, and load[10]. In general, tolerance and accuracy on FDM printers depend on printer calibration and the complexity of the model made. The process of FDM is plastic material used to be extruded through a nozzle[11]. PLA is a material from 3D Printing that can be used to make parts dimensional accurate, with 0.8 mm detail and a minimum feature of 1.2 mm. the tolerance applied to this PLA material is 0.5 mm and uses a thickness of 1-2 mm. By having a minimum thickness of these numbers, this can make the power of the 3D printing dimension model strong. This PLA material has the advantage that the PLA material works at low printing temperatures so that when the printing results are already cold, the edges of the model can be sculpted in accordance with the wishes of the 3D model makers so that this PLA 3D Printing material has advantages if compared to other 3D Printing materials, namely ABS (Acrylonitrile Butadiene Styrene) which is thermoplastic in the industry "injection moulding" which is used for LEGO materials, electronic housings and automotive bumpers. However, if the two materials are compared, the PLA is superior to ABS. In addition, PLA is suitable for use in 3D printers of FDM type (Fusion Deposition Modelling). Therefore, this material is used in 3D Printing. This PLA material can form a three-dimensional model when it melts and then extrude through a nozzle to build layers until final printing. The extruder is the part that prints from the PLA material that is inserted.

Comparison of results between 3D Printing technology and manual creation can be analysed through parameters of strength, weight, manufacturing time, flexibility and accuracy. As a result, the tooth model from casts is heavy, not resistant to collisions so that when it falls or collides with a hard object, the cast easily cracks until it breaks. Whereas when compared with the results of 3D Printing, the results will be stronger because they are made of *polylactic*, so the results are lighter and resistant to impact. In addition, the time of manufacture, 3D Printing is faster, because it is basically done by a machine. So that users only need to design the model that they want to print. When printing takes place, this printing runs automatically according to the design made so that the time spent is more efficient and effective. The time needed to print in a matter of hours, depending on the desired size. With the same size, in the model of a manually made tooth, making casts fully uses human power. The time used to manually model teeth between one person and another person is different, depending on abilities and skills. As a result, the time needed also varies, which can reach 2 days or more. Next is the point of flexibility. Manually making dental models must be carried out carefully, because if there is an error, it must be repeated so that the results match the needs. This means that all this time, no experiment can be done before the process of making it. While the 3D Printing method, through the design that is made, can be seen in advance the results of making so that when there is a design that needs to be changed, then changes can

be made first before the printing process. This causes fewer errors compared to manual creation. Because the calculation on 3D Printing is fixed, the results applied are a continuous calculation.

Guidebook

The guidebook created is the 3D Printing Handbook in the form of operating guidance and design of dental models. The following is the front cover of the guidebook and one of the contents.

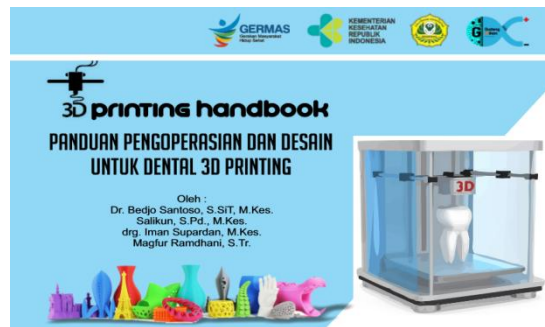


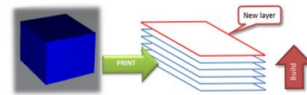
Fig5.Cover Page

Here is one of the contents

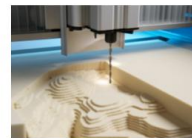
1.2 Apakah 3D printer itu ?

3D printing disebut juga dengan additive manufacturing, adalah pembuatan benda padat tiga dimensi dari sebuah data digital. Additive manufacturing adalah proses penggabungan material untuk membuat objek tiga dimensi. Proses tersebut dilakukan secara layer by layer. Tiap layer dapat dilihat sebagai irisan penampang horizontal dari objek sesungguhnya.

3D printing adalah lawan dari subtractive manufacturing yang berprinsip memotong bagian dari logam atau plastik seperti mesin frais (milling machine). Teknologi 3D Printing membuat Anda dapat membuat objek kompleks hanya dengan menggunakan material yang relatif lebih sedikit dibandingkan dengan metode traditional manufacturing.



Gambar 1.3 Additive manufacturing



Gambar 1.4 Subtractive manufacturing

4

Fig6.Content

The guidebook is made for reading material before using 3D Printer so that it can meet the research objectives to find out how to make dental models using 3D Printing technology. This guidebook was made in collaboration with Gudang MikonBanyumanik.

Seminar for dissemination

Along with the education line, 3D Printing was introduced through a seminar conducted by the institution and working partner.



Fig7. Presentation of The Material

The involvement of the students in the seminar is to spread out the 3D Printing technology. By doing observation, the students get along with the new technology that they so far didn't use.



Fig8. Students in Observation

VI.CONCLUSION AND FUTURE WORK

The things that can be concluded from the research done is that 3D Printing technology can be implemented in the field of dental nursing through its use as an alternative to dental learning media models. Besides, 3D Printing technology has the advantage of being able to make a three-dimensional design checked in real form because it lighter, requires a relatively shorter time, and energy efficiency than making it using conventional methods made from gypsum. The implementation of 3D Printing has already used in the Health Polytechnic of Health Ministry Semarang and proved to be learning media for the students.

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BIOGRAPHIES

Salikun was born in Bumireja-Cilacap, Indonesia, in 1962. He received the Bachelor of Education degree in IKIP PGRI Semarang, Indonesia in 2002, and M.Kes (Master of Health) degree in Health Promotion from Diponegoro University, Semarang, Indonesia, in 2006.

His current interests research is about the topics in Industry 4.0. The author has experiences participated in training of Innovative UKGS (School Dental Health Unit) management and managed to receive various awards, one of which was in the field of school community empowerment, namely Awarding from the University of Indonesia for his active participation in implementing the Innovative UKGS / dental immunization program in 2012. The author also conducted research, several among them are in the field of dental health promotion, namely Evaluation of the Implementation of UKGS in Semarang Regency National Education in 2011, also Irene's Donut's Innovative UKGS Program Evaluation Reviewed Clinical Aspects and Parent Satisfaction of Children in 2013. In 2013, he played a role in "Asian Conference of Oral Health for School Children" as a speaker. In 2016, he gave a public lecture at the Manado Polytechnic on Dental Immunization while in 2018 gave a Scientific Seminar on the students of the Health Polytechnic of Health Ministry Aceh with the topic of Implementation of Dental Immunization in the community. Currently in 2019 the author serves as the Chair of the Diploma IV Dental Nursing Study Program of the Health Polytechnic of Health Ministry of Semarang, as well as managing the Innovative UKGS / dental immunization program in several Primary Schools and Kindergartens in Semarang City.



Bedjo Santoso was born in Semarang, Indonesia, in 1970. He received the Ph.D in the Department of Dental Teaching and M.Kes (Master of Health) degree in the Department of Dentistry and Health Promotion from Gajah Mada University, Indonesia in 2001.

He has done research about The Effect of Biography towards UKGS (School Dental Health Unit), Beta Flugaris as Disclosing Solution as well as Information System for UKGS Monitoring. Those researches were done in 2014 and 2015. He is also active in writing as his writing are published in Suara Merdeka, a well-known newspaper in Semarang, Indonesia. His writings are about Dental Nurse Standardization, Sustainable Education for Dental Nurse and Dental Nurse Individual Practice in 2012, 2013, 2014 respectively. He is now a lecturer in Health Polytechnic of Health Ministry, Semarang, Indonesia serving the lecture of Dental Health Education, Dental Health Management, Dental Assistance, Dental Anatomy, Dental Nursing Psychology as well as Communication in Dental Nursing.



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Iman Supardan was born in Banyumas, Indonesia, in 1956. He received the drg. (Dentist) degree in the Dentistry Faculty of Gajah Mada University, Indonesia in 1986 and his M.Kes (Master of Health) degree in the same university in 2002 majoring in Dental Health Service Management.

Besides being a dentist, he is also a lecturer in Health Polytechnic of Health Ministry Semarang. Some subjects he teaches are Health Promotion and Dental Health Education. His current research interests include industry 4.0 in dental nursing. He has done research lately about desensitization using modified dental chair resembles to control anxiety of children dental treatment. Besides, the research has been done is about fruits as the disclosing solution as well as to prevent bacteria. Not to

mention, he has great interests in dental caries prevention. His published papers previously discuss about UKGS (School Dental Health Unit), determinant factors of tooth pulp caries, factors affecting dental nurse productivity, dental health empowerment and its status as well as application of interactive software in improving dental health knowledge of children. In addition, he was the speaker in several dental health seminars held in Banjarmasin, Surakarta, Lampung, Jakarta and Tasikmalaya, Indonesia.



Khomsatun was born in Pati, Indonesia, in 1962. He received Bachelor of Education degree in UM Purwokerto, Indonesia, in 1998, and the Master of Health (M.Kes) in STIKES Cipta Bina Husada, Purwokerto, Indonesia in 2013.

He has joined Department of Environmental Health in Health Polytechnic of Health Ministry, Semarang as a Lecturer since 2007. He teaches the lecture of profession ethic, people empowerment, sanitation clinic, housing sanitation and also people health counseling. His current research interests include river pollution, Larva Destroyer with electrical voltage to control Aedes Aegypti mosquitos as well as environmental sanitation in scabies disease that was done in 2007, 2008, 2010

respectively. He was the speaker in General Stadium seminar 2007 conducted in Health Polytechnic of Health Ministry Semarang. Besides, he was the General Chair of Writing for Publication Workshop in 2009 in Health Polytechnic of Health Ministry Semarang.