Additive manufacturing in education

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Abstract. Additive manufacturing, or better known as 3D printing today is one technology that is rapidly growing in several countries. This technology is increasingly having an important role not only in business and everyday products, but in the world of education. 3D printer technology can be a medium of learning in the world of education in the implementation of the design in 2D and 3D design drawing students majoring in mechanical engineering. Therefore, research is needed to understand the use of new technologies in education. The purpose of this study was to analyze and gather information about the latest technology used by 3D printing. This research method using a literature review journals in the last 5 years. Findings from the literature review indicates the type of the latest technology used in 3D printing in manufacturing system design using computer-aided design (CAD). Overall, this review could be further research in instructional media in vocational education.

1. Introduction

Implementation additive manufacturing (AM) and 3D printer technology in education is growing as new applications in finding more efficient product creation. While technological advances continue to be made in terms of productive and quality, there is concern that the education and skills development lags by technical developments in terms of technology so as to inhibit the more widespread adoption of the technology [1]. Despite these concerns evolve before 3D printers applied educational activities, the current lack of a comprehensive literature review and can be accessed from how the 3D printer technology used in the vocational education system [2].

Printer 3D and prototype design involves the creation of learners in terms of the design process 2 (dimensions) to 3 (dimension), resulting in the ability of their skills into creative solutions in solving problems in the learning process. This process offers the students receive practical experience of the tactical basic concepts presented during learning [3]. They will be much more involved with troubleshooting to turn their ideas into reality in the form of a product. By using 3D printing technology, students learn to communicate more effectively by using a combination of traditional tools and means to write and print media (websites, images, videos, CAD software, etc) [4].

Generally, students requires a lot of materials such as models, tangible form, label it as a reference manual produced from the results that they've been working in software CAD (Computer Aided Design) for students more creative in making individual designs[5]. The focus and purpose of this literature review is to recognize the application of 3D Printing in learning in the education system. The scope from a new technology in education about software in additive manufacturing.
2. Method

Literature review of this review was carried out using Scopus, and Google Scholar EBSCOhost uses a combination of search terms "3D printer" and "CAD on 3D Printer" and "Additive Manufacturing" in combination with "teaching" and "education. extensive and expandable. The search titles are '3D printing', 'three-dimensional printing', 'additive manufacturing', and 'rapid prototyping'. After expert consultation, additional searches are carried out to include 3D printing applications in education. Relevant articles that are found in the references are also added [6]. In the process of additive manufacturing (AM) Literature review presented in this journal between 2014-2019, there has been a reference from the results of research in teaching and learning, this literature is mapped based on keywords or 3DP and AM domains, which have produced studies on topics on the provision of AM review processes, materials and applications [7]; 3D printing in the hybrid process [8]; AM and nanotechnology [9]; 3D Printing in Management [10]; Additive manufacturing trends in construction [11]; and the social impact of AM [12]. Literature review is the process of gathering materials, descriptive analysis, selecting categories and evaluating materials, which leads to the identification of patterns, themes and problems in the literature [13].

3. Results and discussion

The process of 3D printers can use CAD software system (Computer Aided Manufacturing) CAM (Computer Aided Manufacturing) system. CAD program currently offers a range of designing the construction of a product, what possibilities do we have? CAD CAM system for the traditional cutting methods, requiring the intervention of programming in order to form and complete set of processing with different performance and precision [14].

![Figure 1. Principle CAD CAM system used for 3D Printing.](image)

In Fig. 1 In a CAM system for product creation process the situation is much simpler compared to traditional subtractive technology. presented CAD-CAM systems used in the examples are presented to prepare the design and G-code for the produce using a 3D printer. In this case, as Geomagic CAD software is used [15]. As a component of CAM.

3.1. The range of available freeware or open-source CAD system

As a first step, the results of this study are very comprehensive for mapping in freeware, software or open source [16]. All these components are a very positive form of implementation that the amount of software can be posed on a 3D printer. Software found generally can be divided into three categories (see Table 1). Most of these softwares are intended for academic use in mechanical engineering drawings and are very suitable for creating a mechanical component construction design for the field of mechanical drawing engineering in the Vocational Education curriculum. As a rule, the procedure here is based on 2D sketches which are then converted to 3D images and converted to G-Code on additive manufacturing.

In other components, the basic shapes of geometric drawings such as cubes, cylinders, and drilling results can be made in great detail. Lots of variance and detail, like calculating the radius and shape of a chamfer, so it's easy and can be implemented. This procedure is comparable to conventional fourth generation CAD sources which aim to produce the principle of constructive solid geometry (CSG)
Some CAD software packages provide parametric development and without offering the full functionality of commercial suppliers, for example, in creating free form surfaces or integration in product life cycle management (PLM). Other CAD systems are more directed at artificial and creative, rather than technical, this application is also available.

In this case, also departing from the CAD system that produces 2D sketches or can then be converted into 3D volumes with the help of programming. In this case, the G-code that must be generated can then be used to help the program to create a 3D volume body from the resulting image to be processed on the 3D printer. This procedure is relatively very easy and efficient so that it is stronger than all other CAD systems regarding operations because the operator does not need to produce development using graphical mouse input together with input values and alphanumeric parameters but through coding.

### Table 1. Cad system category freeware or Open Source by Example.

| CAD System  | Freeware (F) or Open Source (O) | Desktop, Mobile or Browser (D), (P), (B) |
|-------------|---------------------------------|----------------------------------------|
| Autodesk 123D | F                               | D / M                                  |
| solidwork   | F                               | D                                      |
| Catia       | F                               | D                                      |
| Sketch UP   | F                               | D                                      |
| Free CAD    | OS                              |                                        |
| Onshape     | F                               | B / M                                  |
| Tinker CAD  | F                               | B                                      |
| OpensCAD    | F                               | D                                      |
| jest        | F                               | D                                      |

In the table 1 explain about, a lot of software that has been used by students in education in the 3D Printer process, autodesk is a freeware category that can be applied on desktop or mobile. Solidwork is a software that has the same features as Autodesk. This software is included in the freeware category and can be used on the desktop. In the next stage, catia, onshape, sketch up, tinkerCAD software are in the freeware category except for autocad systems that are included in the OS category. After the test phase of software tools were found, various CAD tools, which are now considered closer, further restricted. The focus of the range has the CAD system suitable for machine drawing technique. In addition, an additional software package better suited for creative design also selected.

### 3.2. Autodesk 123D Suite

Understanding and Use of Autodesk, Autodesk Inventor is a program specifically designed for engineering purposes such as product design, machine design, mold design, construction design, or other engineering needs. Autodesk Inventor is a parametric feature-based solid modeling program, meaning that all objects and antargeometric relationships can be modified again even though the geometry is ready, without the need to start over. This makes it very easy for us when we are in the process of designing a product or design. To create a 3D model that is solid or surface, we must first make a sketch or import 2D images from Autodesk Autocad. After the drawing or 3D model is finished, we can create a working drawing using the drawing facility. Autodesk Inventor is also able to provide movement simulations of the products we design and has tools to analyze strength. This tool is quite easy to use and can help us to reduce mistakes in making designs. Thus, in addition to the costs we have to spend will be reduced, the time to market of the objects we design can be accelerated because we have already simulated the objects we design on the computer before entering the production process. In Autodesk Inventor there is a choice of templates that we want to use. Each
3.3. Free CAD
Computer Aided Design is a computer program for drawing a product or part of a product. The product you want to draw can be represented by lines and symbols that have a certain meaning. CAD can be in the form of 2-dimensional images and 3-dimensional images. Starting from replacing the drawing table function, CAD software has evolved and integrated with CAE (Computer Aided Engineering) and CAM (Computer Aided Manufacturing) software because this CAD software is mostly a 3-dimensional drawing application or commonly called solid modeling. Solid models allow us to visualize the components and assemblies that we make realistically, besides the models have properties such as mass, volume and center of gravity, surface area, etc [19].

3.4. Co-Occurrence analysis
Vosviewer software is a device that is detailed and explained by Van Eck and Waltman [20] used to analyze the final data, to see the distribution of data patterns. VOSviewer shows, there are 84 journal documents about additive manufacturing in education between 2014-2019. Then vosviewer analyzes using Co-Occurrence which is an analysis of the subject's mapping of research or topics. The keywords appear above 174 times, in 84 titles and abstracts of papers and find 30 thresholds. If we want more rigid results, we can change this amount. We can replace it with a bigger or smaller amount.

Figure 2. Co-Occurrence analysis.

Figure 2 shows the mapping of the density visualization of VOSViewer. The red color represents the highest number of items and highest element weight, followed by yellow and green items. The red color means that these words, such as 'Additive model', '3D Printing', 'Utility functions', 'Grated Computer Aided Manufacturing' are widely used by researchers. Our consideration is in the words in
green, such as 'Fused fillament fabrications', and 'AM in broadcasting'. In the middle between red and green, is yellow, blue and purple. Words such as, 'robotic arm', 'benefit of 3D', 'Manufacturing facilities', 'Weld Component', give researchers the opportunity to be investigated further. Researchers can conduct future research on research topics based on these words in the visualization mapping of green and yellow densities.

4. Conclusion

3D printers are an important step in developing more effective and efficient product manufacturing techniques in the learning process of making prototypes or products with very unique display solutions. A special feature of additive manufacturing (AM) techniques is the ability to produce, based on G-code control for machines that are developed directly from the CAD model to produce the next detailed part. The combination of CAD software and software used to produce G-codes from .stl developed in CAD for printing process control is an extraordinary program of technology specific additives for CAD CAM systems.

This contribution is an update to the CAD system specification which has been explained with special consideration to the needs of students in using additive manufacturing. This, it can be said is very, beneficial or even students can use it for free to the CAD system, the convenience for users is very high and also various functions are indicative of one comprehensive technological development. In addition, market analysis software in open source CAD freeware is different because it allows free or inexpensive access. The five CAD software packages are analyzed here in detail and compared. clear differences can be explained with respect to user friendliness and scope of functions.

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