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RESEARCH ARTICLE

A study on 3D printing usage among Malaysian users

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ABSTRACT - In this research, the use of three-dimensional (3D) printing among Malaysian users was studied. The aim of the research is to establish the demographics and use of 3D printing in Malaysia. A questionnaire was distributed among 3D printing users during a 3D printing webinar and via social media groups consisting of 3D printer users. For the demographic section, 74 males and 8 females responded to the questionnaire, with more than 90% of the respondents have tertiary education. 39% of the respondents are from Greater Klang Valley, and 33% of the respondents are self-employed. The highest application of 3D printing is for hobby (i.e., 67% of the respondents), while the highest response for experience in 3D printing is 28% with 1–3 years of experience. Creality 3D printer brand is the most selected printer brand, with 64.7% of the respondents using the brand. 33% of the respondents used the printer at a heavy usage rate of 5 days per week, which is the highest response. For the material used, 85.4% of the respondents agreed that they normally used polylactic acid, while 79.3% of the respondents selected Cura as the most used software. Furthermore, 79.3% of the respondents stated that the infill percentage setting as the most changed setting, while 63.4% of the respondents agreed that bed levelling is the most common problem in 3D printing. In the opinion section, most of the respondents believed that 3D printing technology is still new and should be taught in schools. Based on the results, the research has successfully established the demographics and usage among 3D printer users in Malaysia.

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1.0 INTRODUCTION

Three-dimensional (3D) printing in Malaysia is considered a new emerging technology as the Fourth Industrial Revolution (IR 4.0). Malaysia has defined its own IR 4.0 direction [1], which exclusively includes 3D printing as one of the focused topics that are in the same direction as global IR 4.0. 3D printing is widely used in different areas as the technology reduces the use of tools as compared to other conventional methods, such as subtractive manufacturing technology. The initiative started in 1986 when 3D printing was introduced by 3D Systems [2] using the stereolithography method. In this method, photosensitive resin is selectively cured layer by layer in a vat. Inspiringly, Stratasys invented a new method called fused deposition modelling (FDM), where thermoplastic polymer is laid layer by layer on top of a heated bed to create a 3D physical model [3]. This method is much easier as it needs a minimum or less post-processing process as compared to the stereolithography method, which needs further curing. However, the printed parts lack of finishing and consume more time to print the same size of parts using FDM as compared to the stereolithography method.

3D printing can be used in various applications. Product development is one of the areas where 3D printing is first and mostly used. Large companies have been using this technology to aid their product development, but this technology is very costly for small companies. Nevertheless, as the technology advanced, 3D printing cost has decreased significantly, thanks to Dr. Adrian Bowyer, who made his 3D printing machine design open source [4]. Currently, more users can adapt 3D printing technology to develop and innovate their own products due to the price reduction and competition among 3D printer manufacturers. Some of these products have been used for food [5, 6], sports [7], product development [8–10], as well as for life enhancement purposes [11-15].

In Malaysia, 3D printing is considered a new technology at the education level and also at the industrial level. In secondary schools, the technology had been integrated into a subject named *Reka Bentuk dan Teknologi* (Design and Technology) since 2019 [16]. Nevertheless, there is no evidence or statistics on the use of 3D printing, which means that no study has been conducted yet among 3D printing users in Malaysia. The study is important to establish the demographics and the tendency of 3D printing users in Malaysia, especially for FDM 3D printers. Thus, this study was conducted to establish the demographics of users and several 3D printing applications by the users.

2.0 METHODS AND MATERIALS

In this part, to obtain the demographic results of 3D printing users in Malaysia, a questionnaire consisting of several elements was developed based on several criteria considered as important and normally occur to the user. The questions

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were designed with several prefixed answers and added with "other" so that the respondents could provide their own answer if necessary. This is important as different respondents could have different answers than the prefixed answers. At the end of the questionnaire, the comments and suggestions were made available, where the respondents could provide their own comments and opinions regarding 3D printing in Malaysia. The questionnaire was distributed to specific groups as the questions are very specific for 3D printer users and not the general population of Malaysia. This questionnaire was distributed during a webinar on the Future of 3D Printing on 13th October 2021, in the Facebook group of 3D Printing Malaysia and the WhatsApp group of 3D Printers Malaysia. The results of the questionnaire were accepted within a month period for concise data. The webinar on the Future of 3D Printing Malaysia had almost 150 participants while for the WhatsApp group of 3D Printers Malaysia has 102 participants.

The questionnaire consists of the demographic and usage sections. The purpose of the demographic section is to obtain the information of the respondents, such as age, gender, level of education, and occupation. Meanwhile, the usage section focuses on the type of machine, material, and usage period of the respondents. The data collection procedures are explained in Figure 1.

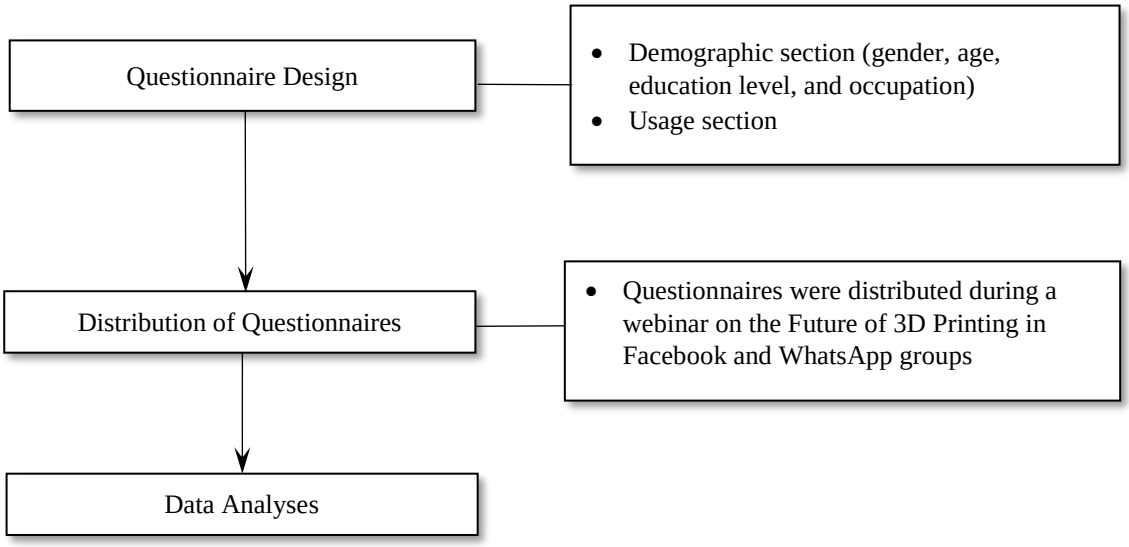

Figure 1. Process flow of data collection

3.0 RESULTS

3.1 Section 1: Demographics of Respondents

Throughout the distribution of the questionnaire, 82 respondents completed the questionnaire within a month period. Altogether, 74 males and 8 females submitted their responses, as shown in Figure 2. This shows that 3D printing is more preferred by males as the technology involves many physical and mechanical parts. The applications are also more physical, which are not preferred by females.

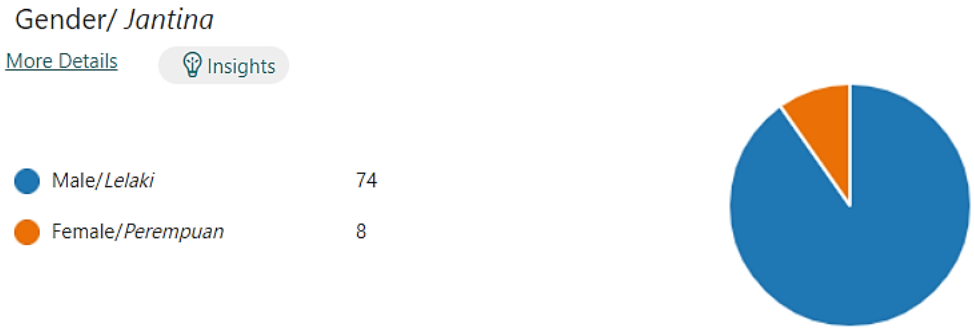

Figure 2. Gender data for 3D printing usage survey

Figure 3 shows the level of education of the respondents, in which 77 of them (i.e., 94% of the respondents) have tertiary education. This is unsurprising as 3D printing technology is not commonly used in primary education and is only used in specific industries related to tertiary education. Additionally, the technology is used for higher-level applications and is still making its way into primary education.

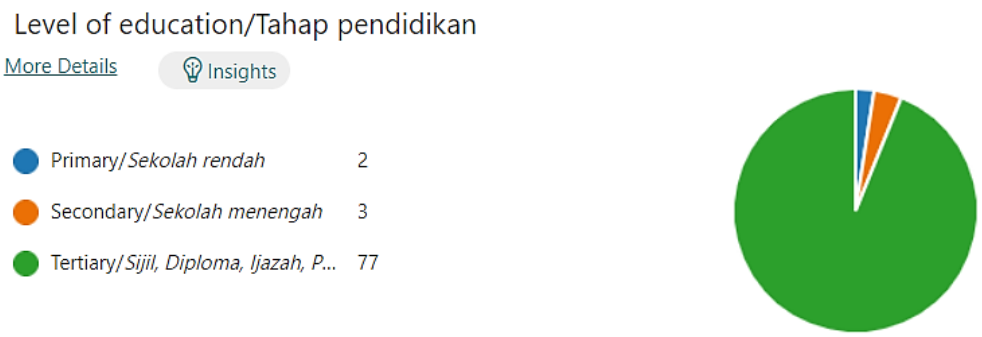

Figure 3. Education level data for 3D printing usage survey

Figure 4 shows the locations of printers used by each respondent. The highest usage was recorded in Selangor with 23 respondents, followed by Kuala Lumpur with nine respondents. If these two states are combined, the number of respondents would be 39% of the total respondents. This is expected as Greater Klang Valley is the most populous and economically important region in Malaysia, and it is a place with large and diverse populations. Greater Klang Valley is known for its rapid economic growth and development, as well as its number of important institutions, including universities, hospitals, and research centres. The second state with the highest number of respondents is Johor. This is mainly because many industries are located in Johor, as well as the impact from the nearby country, which is Singapore. The third state with the highest number of respondents is Pahang with nine respondents. This is probably because various higher institutions are located in Pahang, including Universiti Malaysia Pahang, International Islamic University Malaysia, and others. From this result, it could be noted that Pahang has the potential to become the Malaysian east coast 3D printing hub, with Selangor as the western hub and Johor as the southern hub. There is a high potential for the mentioned states as 3D printing technology is not yet fully established in Malaysia.

Figure 4. Printer location data for 3D printing usage survey

One of the questions in the questionnaire requires the field of occupation of the respondents, and the results are shown in Figure 5. The question is included in the questionnaire to determine the field of occupation that mostly uses 3D printing. Most of the respondents are self-employed (i.e., 27 respondents), with 33% of the total respondents, followed by the education field and the manufacturing industry. From these results, it can be deduced that 3D printing has more usage in the education field than in the manufacturing industry. This is a major finding as it could be difficult for the manufacturing industry to adopt 3D printing technology due to various reasons. One of the reasons is the reluctance to adopt new technology due to current technology is still relevant and cost-effective. If the manufacturing industry is willing to better adopt 3D printing technology, it could be the key point to boost manufacturing technology in the near future.

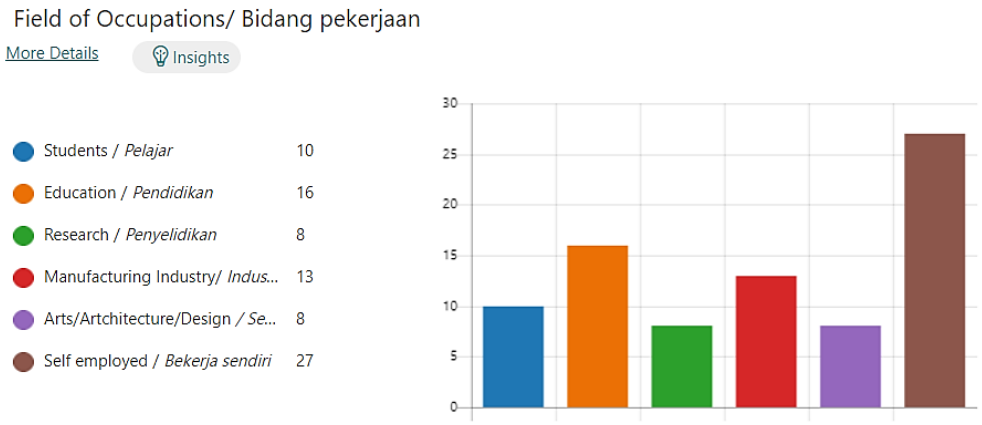

Figure 5. Field of occupation data for 3D printing usage survey

3.2 Section 2: 3D Printing Usage

Reason for using 3D printers is another question available in the questionnaire, but it was designed to have multiple answers as some respondents probably used 3D printing for several types of applications, such as for research and business purposes. From the results, the highest number of respondents (i.e., 67% of the respondents) used 3D printing for hobbies or self-usage. This is due to the limitless customisation of 3D printing technology, and it is suitable for users that prefer customisation or modification that suits their hobby. The second most selected reason is for business purposes. Starting a business using 3D printing technology is not difficult, as the only tool for a 3D printing entrepreneur is the 3D printer itself. A large number of equipment and devices are not required, and a decent 3D printer only costs around RM1,000.00. Furthermore, a standard 3D printer is compact and portable. The printer also does not create any troublesome residue and requires very minimal post-processing.

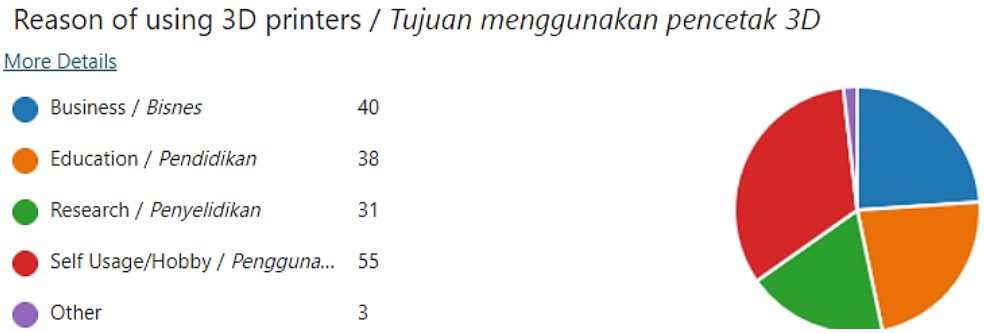

Figure 6. Reasons for using 3D printers for 3D printing usage survey

Figure 7 shows that the longest length of experience using 3D printers is 1–3 years with 23 respondents (i.e., 28% of the respondents). Hence, it can be said that 3D printing technology is relatively new in Malaysia. Moreover, nine respondents have 1 month or less experience, which also supports the idea of the young age of 3D printing. One of the reasons is that the price of 3D printers is becoming more affordable, and the printers can be easily purchased online at affordable prices.

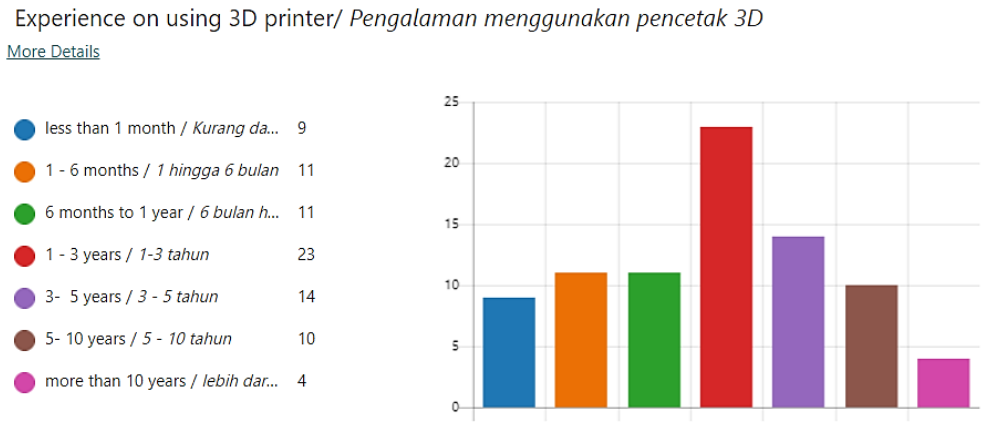

Figure 7. Length of experience of using 3D printers for 3D printing usage survey

This 3D printing survey focuses more on FDM rather than other types of 3D printing. The option for other 3D printer models is available so that the respondents can state other models unavailable in the given options. For this part, the question has multiple answers because some of the respondents might use different printer models. Figure 8 shows that the most used 3D printer model is Creality with 53 respondents. This is mainly due to its affordable price, and there is lots of support available, especially on social media (3D printing groups) and YouTube. The second most used 3D printer model is customised 3D printers, especially for research purposes, followed by the Ultimaker 3D printer with decent printing quality. Other 3D printer brands used by the respondents include VORON, CreatBot, Tevo, UP, MakerPi, Wanhao, Moment, ForceMaker, Skriware, Tenlog, and Tiertime. Although the "Others" section was selected by 26 participants, which should be the second most selected 3D Printers, the participants responded with 3D Printer models that are different from each other.

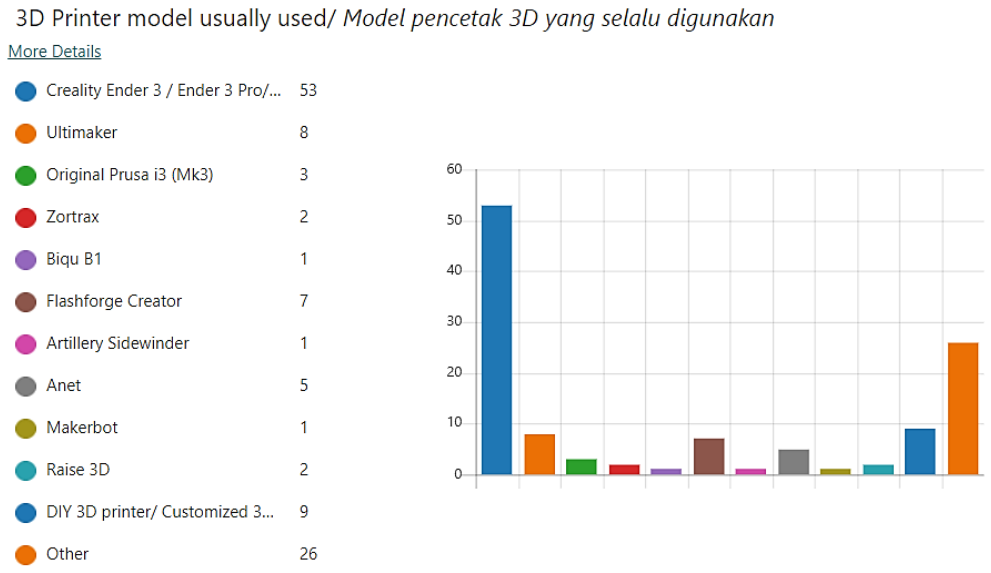

Figure 8. 3D printer models for 3D printing usage survey

The usage rate of 3D printers for each respondent was determined, and the results are shown in Figure 9. The usage rate was evaluated on a weekly basis. 27 out of 82 respondents (i.e., 33% of the respondents) indicated heavy usage of 3D printers, followed by light and medium usage with 20 respondents each, and light usage with 15 respondents (i.e., 18% of the total respondents). From the results, it can be determined that 3D printers are always used by users.

3D printers require materials to produce 3D parts. The printer alone could not create parts by itself. A material that is normally used is thermoplastics which melt if heat is applied and solidify below a certain temperature, depending on the type of materials. Multiple selections were permitted for this part, where the respondents could pick any related materials that suit their normal usage. Figure 10 shows that polylactic acid (PLA) is the most used material among the respondents. This is because PLA is easy to work with, environmentally friendly, and has minimum problems. The second most used material is acrylonitrile-butadiene-styrene (ABS). The material has better heat application as compared to PLA, as well as good finishing as the outer layer of the printed part can be easily improved using acetone. However, printing parts using ABS requires a heated chamber and better part adhesion to prevent problems during printing. Nylon is the least used material for 3D printing as the temperature required for 3D printing is around 270 °C. Nylon is suitable for high wear-and-tear applications (e.g., gears), but not all printer models can reach this temperature as an all-metal extruder is required.

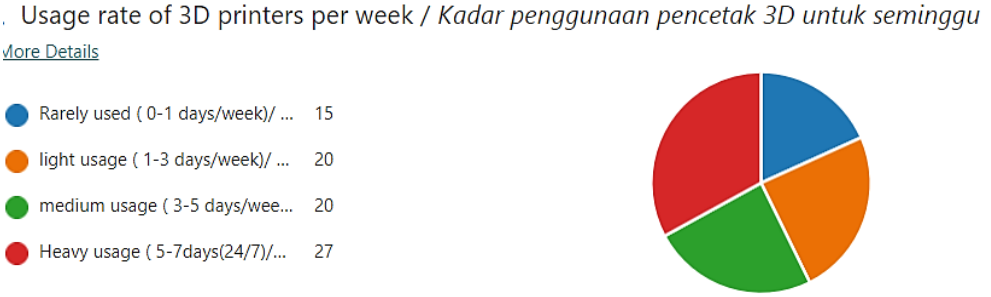

Figure 9. Usage rate of 3D printers for 3D printing usage survey

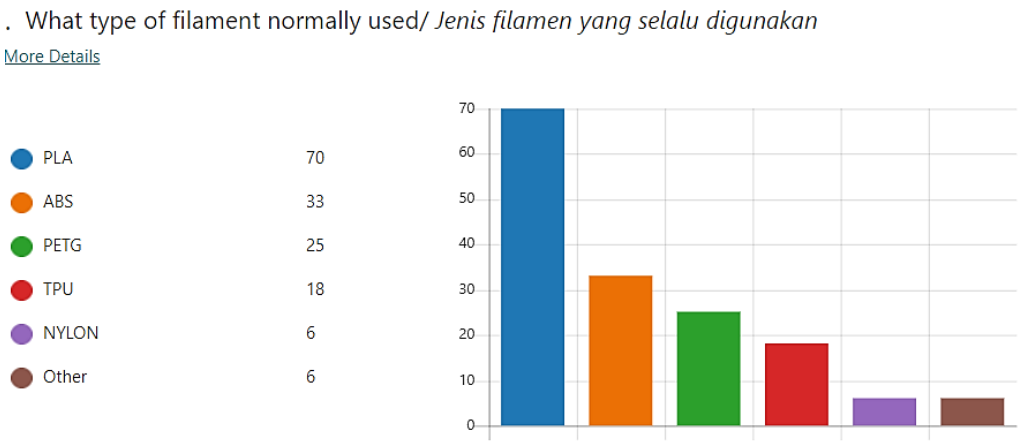

Figure 10. Types of materials used for 3D printing usage survey

In order to generate G-codes for a 3D printer, the digital model needs to go through the slicer software. Multiple selections were also allowed for this part for each respondent. Figure 11 shows that the most used software is Cura with 65 respondents (i.e., 79.3% of the total respondents). This is due to the ease of user interface and various settings (i.e., Basic, Advanced, and Expert modes). A beginner in 3D printing can use the Basic mode, and they can choose the Expert mode to change different settings in Cura to obtain the desired 3D-printed parts. Furthermore, Cura can be used for other printers and is not only limited to Ultimaker printers. The second most used software is Slic3r, which is one of the pioneer software before Cura was introduced in the 3D printing community.

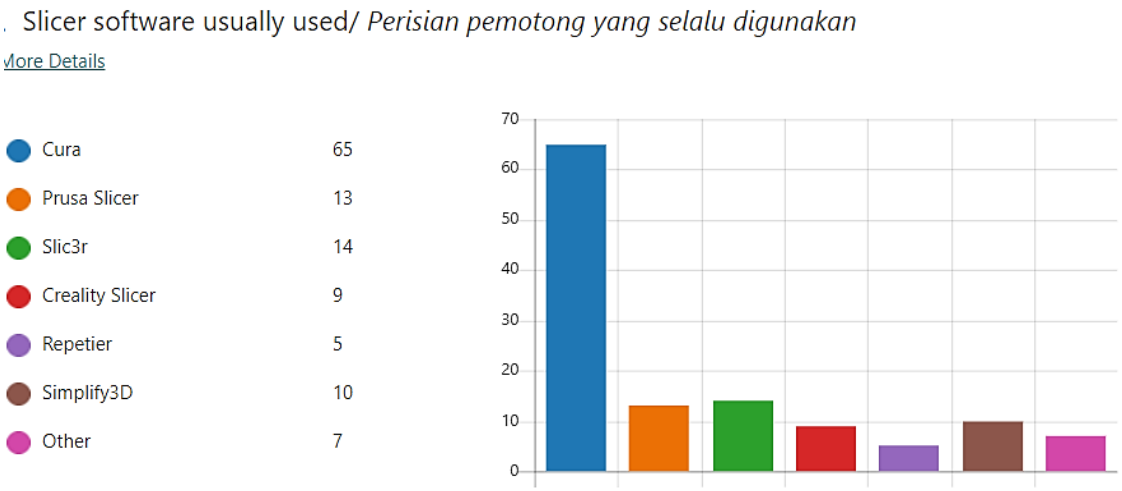

Figure 11. Slicer software used for 3D printing usage survey

Several parameters need to be controlled in 3D printing to obtain the desired 3D-printed parts. Figure 12 presents the common settings in 3D printing, and the infill percentage is the most changed setting with 65 respondents (i.e., 79.3% of the total respondents). The infill percentage setting determines the strength and weight of the parts. For functional parts, a higher percentage setting is required, while a lower infill percentage is needed for display parts. Furthermore, a lower infill percentage reduces the weight of the part and simultaneously reduces filament usage. The second most changed setting is the support with 55 respondents. The support is important, especially for parts with overhang features. If the support setting is not correctly applied, these features will not be printed properly, resulting in poor quality printed parts. Additionally, for complicated parts, if the support setting is not properly applied, there will be a problem for the printed parts, which is the difficulty of removing the support material. The third most changed setting is the adhesion and infill pattern. The adhesion setting controls the adhesion of 3D-printed parts to the platform during 3D printing.

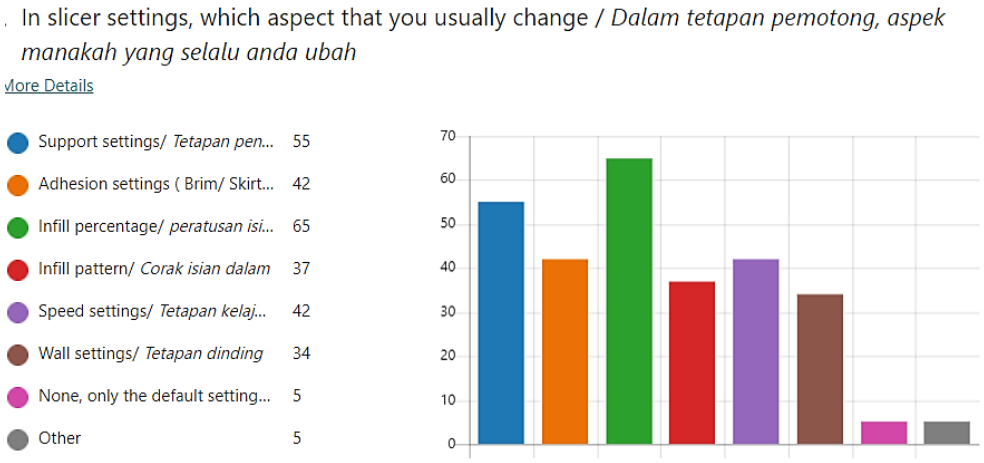

Figure 12. Slicer settings changed for 3D printing usage survey

3D printing is different from 2D printing (i.e., paper printing). Problems may arise throughout the process of printing, either before the printing starts or during the printing process. Figure 13 shows common problems in 3D printing, and multiple answers were provided for respondents to select. The most common problem in 3D printing is bed levelling with 52 respondents (i.e., 63.4% of the total respondents). Bed levelling is very important, especially when printing the first layer. If the printer is not properly levelled, some printing locations will be too close to the nozzle, and some will be too far. The filament will not adhere to the bed if the location where the filament is deposited is too far from the bed. Therefore, the parts will not be properly printed, and the expected 3D-printed parts will be different from the 3D model. However, a more decent printer usually incorporates a bed levelling sensor, which will greatly reduce the problem of bed levelling but at a higher cost. The second most common problem with 45 respondents is clogged nozzles. If the nozzle is clogged, no filament can be extruded out from the nozzle; thus, no parts will be printed.

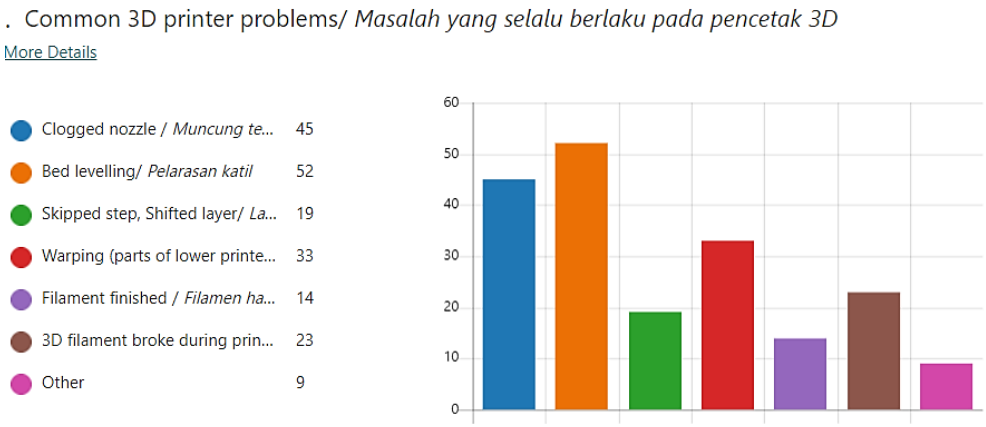

Figure13. Common problems for 3D printing usage survey

3.3 Section 3: Respondents' Opinion

In this section, the opinion of the users regarding 3D printing technology is very important for the industry and the government in order for this technology to strive in the future. Only selected opinions were extracted because there were too many responses from the respondents. These opinions are tabulated in Table 1. The maturity of the responses determines the criteria for the selected opinions, as immature and insensible views are irrelevant to the study.

Table 1. Opinions from respondents

Opinions
"The technology is expanding and should be taught in schools as an additional subject"
"Hopefully, the technology keeps expanding and is accepted by the community"
"The technology is a new thing and will become more mainstream"
"Malaysia is still lacking in the 3D printing industry"
"The exposure of the technology to the community is terribly low, but it is making progress"
"Hopefully, there are more grants from the government for the 3D printing small business owner or start-up company to grow the business"
"Small market and less demand"

Table 1. (cont.)

Opinions
"There are still many people not having the opportunity to explore 3D printing"
"Still new and good to explore at the school level"
"Slow adoption"
"We are still at the infancy stage, whereas other modern countries have exposed AM in primary schools. Our Reka Bentuk subject or similar needs to bump up with digital sketch, 3D modelling, followed by concept modelling via 3D printing"
"Additive manufacturing (3D printing) needs to be expanded in various sectors"
"The popularity is rising"
"There will be more users in the future"

4.0 DISCUSSION

In the demographic section, the users' level of education is mostly tertiary education. This is mainly due to the lack of exposure during primary and secondary education levels. This is reflected in the respondents' opinion section as most of the users suggested introducing 3D printing technology at the school level. However, it could not be achieved in a short period, and there is still a long way to go so that primary and secondary education can finally adopt the technology. The location of 3D printing usage is in line with the centre of economic activity as most of the respondents are from Selangor. Moreover, from the demographic section, most of the respondents are self-employed and not from the manufacturing industry. This shows that our industry still does not fully adopt 3D printing technology, and this gap should be improved to increase the efficiency of the manufacturing industry.

Meanwhile, in the usage section, the most used 3D printer brand is Creality due to its affordable price, ease of support, and replacement parts. In addition, the usage level is very promising as most of the responses of the 3D printing usage rate are above average. The material usually used is PLA, which is suitable for many applications and easy to work with. Most of the respondents also used nearly similar slicing software, which is Cura. Moreover, the users are familiar with 3D printing settings and problems, although the length of experience is only 1 year. This shows that 3D printing can be easily learned, and everybody can use the technology as long as they have the opportunity to learn and use it.

The final section shows different types of opinions from each respondent. Most of the respondents have almost identical understanding even though the technology is still in the early stage in Malaysia. Furthermore, many respondents thought that this technology should be taught at the school level as this technology is promising and a lot of potential can be developed. Even though the Ministry of Education Malaysia has introduced a 3D printing subject in the latest syllabus of *Reka Bentuk dan Teknologi* subject, it is only at the surface level, and not all teachers have experience regarding 3D printing. Thus, training for the trainers, especially for the teachers involved in 3D printing, is the most significant way in order for 3D printing technology to be easily adopted at the school level.

5.0 CONCLUSIONS

In conclusion, the evaluation of the demographics of 3D printing users in Malaysia, along with the insights gathered from the completed questionnaires, presents a clear call to action for both the industry and government. The findings underscore the urgent need for targeted initiatives and policies to support and expand the use of 3D printing in Malaysia. Notably, the study reveals that more than 67% of users engage with 3D printing technology as a hobby, indicating a significant interest and potential for personal creativity and exploration. Additionally, an overwhelming 85.4% of respondents agree on the suitability of PolyActic Acid (PLA) material as the preferred choice for 3D printer filament, further validating its popularity and widespread acceptance among users. Furthermore, the study highlights that 79% of respondents use CURA software as their preferred 3D slicer software, indicating its dominance and popularity within the Malaysian 3D printing community.

By utilizing the results presented in this article, stakeholders can make informed decisions to drive innovation, foster collaboration, and create a conducive environment for the growth of 3D printing technology. It is imperative that industry players and government authorities take proactive steps based on these findings to ensure that Malaysia remains at the forefront of the 3D printing revolution, unlocking its full potential for economic, educational, and technological advancement. Emphasizing the hobbyist aspect of 3D printing can lead to targeted initiatives and resources that encourage and support individual enthusiasts in Malaysia, further enhancing their skills and fostering a vibrant maker community. Moreover, recognizing the overwhelming preference for PLA material and CURA software can inform industry decisions and promote the availability of high-quality PLA filaments and accessible 3D slicer software to meet the specific needs and preferences of users in the country.

6.0 ACKNOWLEDGMENTS

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