

Identifying People's Preferences towards the Use of 3D Construction Printing Technology as a Home Construction Method in Indonesia

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ABSTRACT

Various sectors have undergone changes and developments with the existence of technology. One of the sectors affected by the development of the technology industry is the construction sector. The construction sector is experiencing slow growth compared to other sectors. The construction industry in Indonesia is still influenced by using quite a lot of human labor. One of the technologies in the construction industry is 3D construction printing. This technology is claimed to build houses faster, cheaper, and more efficiently. The community as a market and players from the construction sector take an essential part so that development using this technology becomes right on target, especially in the construction of residential houses for the community. The purpose of this study is to find out people's preferences regarding the existence of 3d construction printing technology for residential construction to open the potential for alternative house construction methods other than conventional methods. The research method is carried out using a qualitative approach. The data collection method uses an open-ended online questionnaire and is distributed freely (non-random sampling). This research also showed what kind of community category that interested in building their home using this technology. The collected data was then analyzed qualitatively through content analysis using the JMP program. The results showed categories of public opinion regarding using 3D construction printing technology as a house construction method, including Impressive, Sustainability, Innovation, Effectiveness, Inexperienced, Usefulness, Efficiency, Complexity, High construction costs, and Quality Test.

Furthermore, regarding people's preferences for using 3D Construction Printing to build their homes, 41% said yes, 41% said maybe, and 16% said no. This shows that this technology is mainly accepted by the public but due to a lack of understanding, research, and knowledge, so that many answers as possible. The community category most interested in using this technology to build their homes are people with a monthly income of around 3-6 million rupiah, and the occupation is government employees and entrepreneurs with the same percentage of 0,6 as other occupations below 0,5. The categories are inexperienced and usefulness. The results of this study are expected to be a consideration for stakeholders in building houses using the 3D construction printing method that can be used for residential homes in Indonesia.

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1. Introduction

The development of the industry is currently increasing rapidly, with the support of various facilities and infrastructure, especially with the presence of the internet network and easy access to the information[1]. Industry 4.0 becomes a state of changing the world both through the way we act, and work[2]. Especially in the construction world, development becomes a necessity

where humans need a place to shelter and live as a need for boards. With the sophistication of technology, such as the change in the time we used to send messages by mail, which until within a few days, now we can receive messages for only a few seconds through a smartphone application. This change in the construction world can also be realized. When humans can create a dwelling that used to take months and even years, now it can only be

realized in a matter of days with a small number of workers[3].

Work accidents in the construction sector in 2020 were recorded by BPJS Ketenagakerjaan reaching 177,000 cases, an increase from 2019 which amounted to 114,000 cases[4]. This figure is calculated based on the number of claims submitted by workers who have experienced work accidents, meaning that the actual number of work accidents is much greater (Bpjs Ketenagakerjaan, 2020). Meanwhile, the rapid growth of residential needs is also one of the basic importance of this technology.

The construction industry sector in infrastructure is a crucial sector in economic and social development that has an influence on human activities [5]. The development of industry began in industry 1.0 around 1784 which was characterized by mechanization, steam power and looms. Industry 2.0 around 1870 with the invention of mass production, machine assembly, and electrical energy. Developed again in 1969, industry 3.0 was characterized by automation, computers, and electronics. The next development at this time is industry 4.0 with the characteristics of Cyber Physical Systems, Internet of Things, and Network [6]

New technologies that take advantage of digitization and relationships make it easier for them to combine and double down on results. The results suggest that this technology accommodates 11 technologies: Artificial Intelligence (AI), the Internet of Things (IoT), big data, blockchain, 5G, 3D Printing, robotics, drones, gene editing, nanotechnology, and solar photovoltaics (Solar PV). With this technology, 3D Printing makes it faster and cheaper with less volume of production. [2]

Technological developments are important for sustainable development, but also perpetuate inequality or create something new that provides limited access only to interested groups and affluent countries or through innate biases and there are unintended consequences. The McKinsey Global Institute Industry noted that from 2015, the construction sector belonged to a sector with a fairly slow digitization in development[7]. In Indonesia, it is common to use conventional wall construction to build houses. With conventional techniques, using human labor that takes a long time, high costs, and usually with relatively low quality[8]Even though the need for affordable houses and rapid development continues to increase based on percentages in 2019, where affordable housing was reduced from 39.19%. With a need of about 800 thousand units per year due to population growth of 1.4% per year. Over the past five years, housing has only reached 400-500 thousand unit[9]

One of the technologies in this development process is 3D construction printing. 3D Printer technology was invented in early 1984; although at first 3d printers only printed small and very complicated items, such as meat, sculptures, and clothes, the price was also very high;

now, 3d printer technology is a technology that is starting to be present in our lives in various industries[10]. The building industry is becoming one of the most polluting aspects; with 3D Printing, there is a possibility for zero waste, reduced transportation costs, and the development of recycled materials, an advance in urban making (Dus Architect in archdaily.com 2014).

3D Construction Printing is a construction method that is part of Industry 4.0, and this technology has significant potential in the construction process in project management[11]. In some studies, development using the 3D Construction Printing method uses a lower price than the price using conventional methods. [12]

The development of 3D printing building technology has been quite massively carried out by several construction practitioners abroad since 2014[13]). Much research on this technology is from literature outside Indonesia, but this technology still needs to be applied in Indonesia. From mass media sources, the Ministry of PUPR, Dr. Ir. M. Basuki Hadimuljono, M.Sc, revealed this technology in 2017 through internet media (metadata.co.id, 2017).

This technological need aligns with population growth and the need for home construction. As one of the primary human needs, the house is needed to shelter and carry out various activities. The demand for houses is increasing along with the increase in population. The government plans to build houses in 2020-2024; the Directorate General of Housing targets the construction of 51,340 unit flats, 10,000 unique houses, 813,660 self-help houses, and 262,345 housing PSUs. The need to construct a fast, cheap, and effective house is necessary to fulfill such requirements. This leads to the loss of some jobs that exist today, which will be replaced with other types of jobs influenced by robotics, artificial intelligence, and drones. [14]

The combination of BIM, AAD, and robotics performance in the design scope is also predicted to change the face of architecture. Complete automation of design from the design stage to manufacturing and construction is a beautiful dream for humankind, which consistently requires an exponentially growing amount of space to move. However, the discourse brought other discussions regarding the impact of automation, especially in the architectural sphere[15].

Life Cycle Assessment of the 3D Construction Printing method compared to other conventional method also show that 3DCP significantly reduces the environmental effect of potency Global Warming (GWP), acidification potential (AP), eutrophication potential (EP), smog formation potential (SFP), and fossil fuel depletion (FFD), [16]

Besides all the benefits of using this technology, people's preference is needed, especially in Indonesia, because this technology is very rare. This research is essential to know how much people know about construction methods for their home, such as

conventional methods, and adding another choice for developing their home with this 3D Construction Printing. The industry, contractor, and stakeholders will be helped to know how far their customers are interested in this home construction method.

2. Materials and Methods

The research method carried out with a grounded theory approach and qualitative research. The qualitative approach taken is open, so that the answers from the respondents are not limited to knowing the knowledge of the respondents. Grounded theory is a research approach that produces general explanations (theories) derived from phenomena, actions, processes, and interactions formed by respondents [17]. Furthermore, the data obtained are then analyzed and categorized according to research needs.

Samples were carried out using a non-random sampling method and used accidental sampling techniques. Accidental, which in Indonesian is an accident, means the technique of collecting samples by chance, so that anyone can fill out this questionnaire freely [21]. This step in collecting data uses an online questionnaire and is open-ended. When answering questions, respondents are free to fill in and have opinions so that it is expected that the answers are in accordance with the respondents' expectations that will be processed and analyzed by researchers in accordance with the topic of preference of 3d Printing technology in the world of Construction according to the Indonesian people.

This online questionnaire is shared randomly via social media without any restrictions and characteristics of certain respondents, so that respondents from various backgrounds (location, age, occupation, gender, or income) can fill out this questionnaire. The data collection process was carried out in 1 week with the number of respondents as many as 108 people. . With details as follows:

Table 1: Characteristics of Respondents

Characteristics of Respondents	Level	F
Domisili	Badung, Bali	1
	Bandar Lampung	3
	Bandung	23
	Banjarmasin	1
	Banten	1
	Bekasi	1
	Bogor	3
	Cirebon	26
	East Java (Madiun, Mojokerto, Malang, Surabaya, Sidoarjo, Tulungagung)	8
	Jakarta	7

	Cilacap, Tasik, Sukabumi, Subang, Kuningan, Tegal, Karawang, Sumedang	12
	Central Java (Pati, Semarang, Yogyakarta)	4
	Jayapura	1
	Kitakyushu	1
	Depok City	1
	Sumatra Island (pematangsiantar, Medan, Natuna, Pekanbaru)	4
	Sulawesi Island	1
	Tangerang	7
	Yogyakarta	3
Gender	Man	42
	Woman	66
Age	Generation Z (17-25 years)	51
	Generation Y (26-35 years)	47
	Generation X (36-45 years)	10
Work	Student	36
	Freelancers	6
	Architect	8
	Lecturers/Teachers	10
	Government Employee	5
	Self employed	10
	Private Employees	31
Monthly Revenue	Between 0-3 million	55
	Between 3 million – 6 million	25
	Between 6million – 9 million	12
	>9Million	16

The data that has been obtained is then analyzed using the qualitative analysis method of content in the open coding stage by JMP program. This stage is the stage of identifying segments, codes, and categories of respondents' answers. The frequency of each category is presented in the form of a diagram through distribution analysis

Results and Discussion

The initial stage in this study is to analyze the content by doing open coding from respondents' answers related to knowledge of 3D construction printing as a building construction method

1. Results of The Analysis of Public Preferences regarding 3D Construction Knowledge in the World of Construction in Indonesia

How to name open coding based on respondents' answers can be seen as follows:

"Because I just heard about 3D printing in the construction world" (Female, 21, Sidoarjo, Student)

"I'm barely informed on social media" (Male, 27, Bandar Lampung, Architect)

Based on the quote above, several keywords were analyzed and obtained, namely: "Just heard", "Looking for Information on social media". The findings of these keywords are put together into categories (open coding). Based on the results of the analysis of this study, 8

categories were found related to aspects of 3D Printing Technology Knowledge in the construction world. The grouping is divided into codes as in (Table 1). The aspects are divided into two, namely the aspect of Knowledge (Inexperienced, Experienced, Know from Information, Formal Education) and also the aspect of Potential (Sustainability, Convenience, Novelty, Complexity).

Table 1: Coding Results of Public Knowledge Preferences on 3D Printing

No	Category	F	Code
1	Inexperienced	41	Don't understand, Don't know, Don't know, Haven't seen, Haven't used, Haven't heard, just heard in construction, Don't know
2	Experienced	27	Have heard, have seen, have known, have made, have known, worked in the field of architecture, have known, have participated in training, have read, have heard, know, provide knowledge,
3	Know from Information	33	Internet Information Sources, Youtube Information Sources, Friends' Sources of Information, Home Seller Information Sources, Media Information Sources, Literature Information Sources, Exhibition Information Sources, Advertising Information Sources, Article Information Sources, Video Information Sources, Film Information Sources, Lecturer Information Sources
4	Formal Education	11	Formal Education
5	Sustainability	1	Keep up with developments, Keep growing
6	Ease	1	Eases work, speeds up
7	Novelty	5	Potential, Compared to conventional, New technology,
8	Complexity	2	Advice, Risks

(Source: Analysis Results,2021)

Analysis of this data uses distribution analysis. The results of the data analysis showed that in knowledge of people's preference for 3D Printing Building in the Construction World was quite high where based on respondents, as many as 61 people answered Yes, 28 people answered No, and 19 people answered May.

The age category that knows about 3D Construction Printing is the most, namely in the age range of 20-24 years. This is because several categories are the most for 'Experienced' reasons which can be seen from the code have known, have used, which we can assume that in the age range of 20-24 years is a productive age that is more updated with information and curiosity. We can see this in **Figure 1**.

From this data, the reasons a person knows about this technology are various.

"In building applications have never heard" (Male, Tangerang, 51st)

For example, this statement sentence by answering 'No' to the question of 'is it knowing this 3d Printing technology in the Construction World?' reasoned in the category 'Inexperienced' with the code Not To Hear.

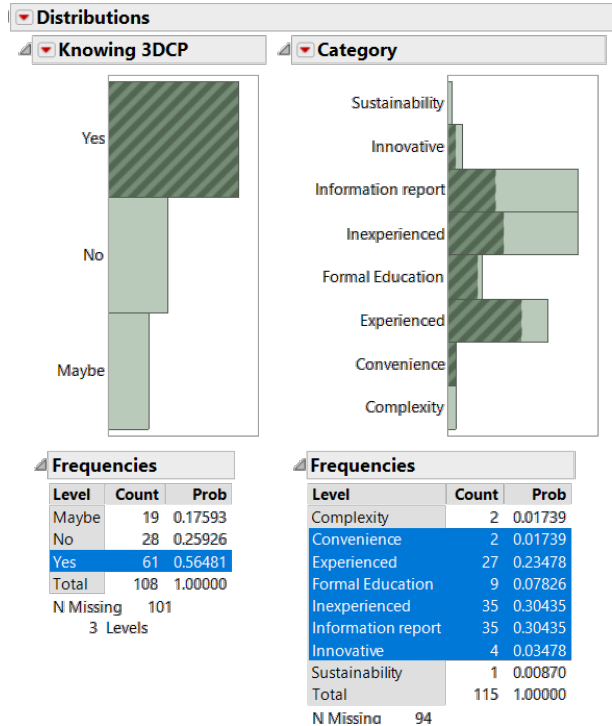


Figure 1: Analysis of Possible Distribution of Answers on Knowledge Frequency of 3D Construction Printing

"Because I have seen a video using the tool" (Male, Banten, 30th)

In the statement, who replied 'Yes' to the question of 'is it knowing this 3d Printing technology in the Construction World?' reasoned in the category 'Know from Information' with the code 'Video Source of Information'.

"Harming the menial workers" (Men, Jakarta, 30th)

On the grounds of this statement, the respondent replied 'No' to the question of 'is it knowing this 3d Printing technology in the Construction World?'. The statement falls under the category of 'Complexity'

In Figure 1, it is shown that as many as 56% of respondents know about this 3D Printing technology with various categories (Inexperienced, experienced, formal education, novelty, convenience, and know from information). As many as 25% of respondents have no knowledge about this technology under the categories (Inexperienced, Experienced, Novelty, Sustainability, Complexity, and Know from Information). Then as many as 19% said they might know about this 3d Printing Technology with the categories (Inexperienced, Experienced, Formal Education, Complexity, Know from Information). The existence of this 'Maybe' option on the question 'do you know 3d printing technology in

the construction world?' is intended for respondents to answer more according to their knowledge, because this technology is quite new in Indonesia (journal literature sources from Indonesia do not yet exist, reports about this technology are quite rare and few are indeed 'intentions' to search on sources on the internet). There is a 'maybe' option for respondents who have indeed heard but do not understand and hesitate by answering 'yes' or 'no'.

Meanwhile, based on the job category, respondents' data shows that the architect's work category is 100% aware of 3d construction printing. Then Lecturers / Teachers, Freelancers, Private Employees, Entrepreneurs, Government Employee, Students / Students. Jobs that are completely ignorant of this technology are unemployed and menial workers. This can be seen in Figure 2 below:

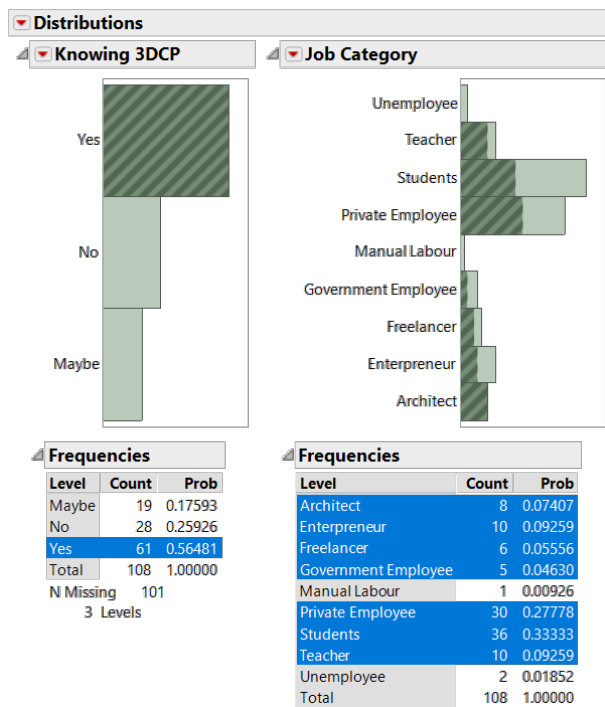


Figure 2: Job Categories Respondents to the answer Yes to Knowing about 3D Construction Printing

Based on the amount of income, the results show that in the salary range of 3-6 million is the income category that knows the most about 3d Construction Printing as much as 0.76%, followed by income >9 million with a percentage of 0.625%, then 6-9 million as much as 0.58%, and at least in 0-3 million with 0.45%. This shows that the income is a little less aware of 3d construction printing technology. This can be seen in Figure 3. This means the information of 3DCP is spread around the average community in Indonesia with the occupation such as Students, Teacher, Architect, Freelancer,

Entrepreneur, Private employee, and Government Employee.

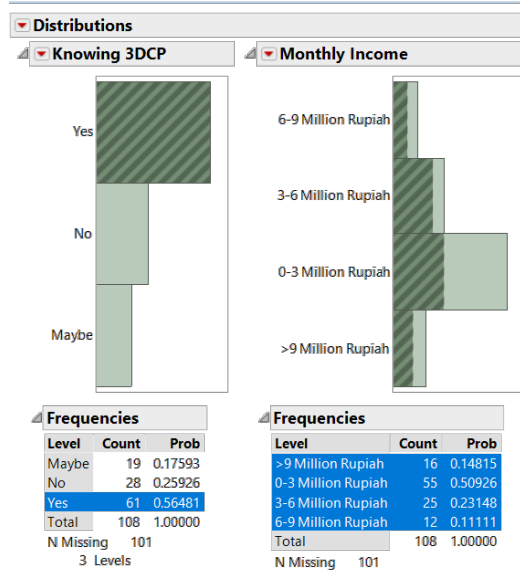


Figure 3: Income Category on knowing about 3D Construction Printing

2. Results of The Analysis of Public Preferences regarding the Use of 3D Construction in the Construction in Indonesia

The question of knowing the knowledge of the use of 3d Printing building technology is to find out to what extent the public knows and can explain the reasons for the use / benefits of technology in building this house. The results of its analysis of this question are as follows:

"Both because it makes work easier, but increases the unemployment rate of building workers" (Women, Bandung, 27th)

These reasons fall into several categories, such as efficiency, and complexity.

Table 2: Coding Results of Community Use Preferences regarding 3D Printing

No.	Category	Code
1	Impressive	Nice, Good, Cool, Building Shapes, Interesting, Amazing, Challenging Decorative, Architectural History, Neat, Accurate, Support, Shocked, Interested, See results
2	Sustainability	Progress, Promising, Sustainability, Future, Building, Environmental Impact,
3	Innovation	Construction progress, Emerging technology, Progress, Revolutionary, Advanced, Innovative, Future Technology, Solutions, Potential

4	Effectiveness	Simpler profession, Effective material fabrication, Presentation not long, Human resources, more effective results, more practical work, precision, Accurate, Easy, Easier, Ease of realization, Ease, Ease, Building according to design, According to job specifications
5	Inexperienced	Lack of knowing, Not knowing, Not yet knowing ,Not understanding, not knowing, not yet practical, not ready for mass, not yet clear
7	Usefulness	Benefits, Helping Architects, Helping Planners, Good technology, Helping technicians, Useful, Helping Clients, Helping Contractors, Helping with work, Functionality, Very detailed,
8	Efficiency	Work Efficiency, Save time, Job reduction, Fast work, Fast construction, Fast construction process, Fast time, Faster to complete, Fast, Access,
9	Complexity	Increase unemployment, Comparison, Limitations, Reduce employment, Need for study, Number of machines less, long process, sophisticated
10	Expensive	Impressions of expensive, Wasteful of materials, Expensive mobility
11	Cheap	Save workers, Minimize costs, Reduce costs, Low costs, Cheap, , Reduce handyman costs
12	Quality Test	Quality, Quality, Poor quality, Questionable strength, Strength Test

(Source: Analysis Results,2021)

In this analysis of the knowledge of the use of 3d printing building technology in the construction world, the impressive category is the highest category with 50 items, 24% of 11 categories. Inside this category there are codes such as: Good, Cool, Building Shape, Interesting, Amazing, Challenging Decorative, Architectural History, Neat, Accurate, Support, Shocked, Interested, See results. Followed by the Efficiency and effectiveness category with 32 items each, and 15% of the 11 categories with effectiveness codes such as Simpler Profession, Effective material fabrication, Long presentation, Human resources, more effective results, more practical work, precision, Accurate, Easy, Easier, Ease of realization, Ease, Building according to design, According to job specifications. For the efficiency code is Job Efficiency, Save time, Job reduction, Fast work, Fast construction, Fast construction process, Fast time, Faster to complete, Fast, Access. Followed by 23 items, or 11% of the usefulness category, namely the Benefit code, Helping architects, Helping Planners, Good technology, Helping technicians, Useful, Helping

Clients, Helping Contractors, Helping with work, Functionality, Very detailed. Then in the category of 21 items with 10% namely innovation, with the code Progress of construction, Technology develops, Progress, Revolutionary, Advanced, Innovative, Future Technology, Solutions, Potential. Henceforth, the Experienced category is 5% with the code Less knowing, Not knowing, Not sure, Not understanding, not knowing, not yet practical, not ready for bulk, not yet clear. Cheap Category 9 items, 4%, Sustainability Category 9 items 4%, Quality test Category 5 items 2%, expensive category 4 items, 1.9%.

3. Analysis of People's Preferences regarding the Desire to Use 3D Construction Printing Technology

This question has the aim of knowing how much interest the public has in applying this technology in people's lives. The research question is 'If possible, do you want your home to be built with 3d printing technology?' and include why.

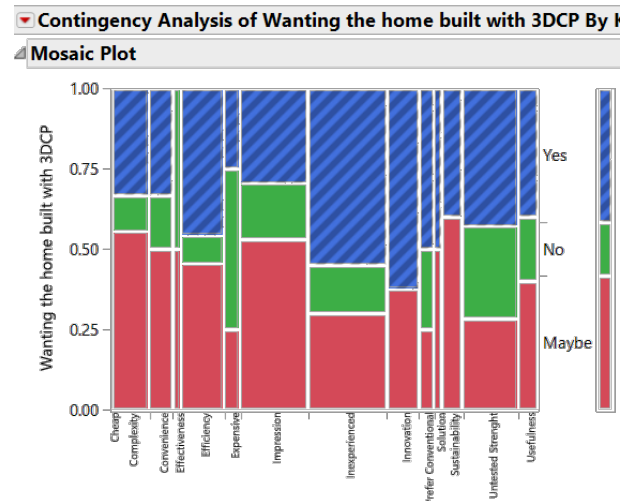


Figure 4: The need of respondents that said Yes to their Category Distribution

In Figure 4, it is shown that the percentage of Yes and Maybe has the same portion, which is 41% with 45 items. While 'No' as many as 18 items or 16%. This shows that this technology is mostly accepted by the public but due to lack of understanding and knowledge so that many answer as possible. There are 14 categories in this question, namely Impressions, sustainability, innovation, effectiveness, Inexperienced, untested strength, usefulness, efficiency, expensive prices, low prices, ease of complexity, convenience, conventional trust, and solutions can be seen in Table 3.

Table 3: The Result of Coding People's Desires Using 3D C Construction Printing Technology

No.	Category	Code
1	Impressions (23)	Dream design, Great, Neat, Unique shape, Detailed, Aesthetic, Pride, Okay, Real look, Precision, Neat, Unique, Interesting, Suggestion, very interesting, Clearer description of the house, maybe, The sea is there using the tool, Clearer, More detailed, More Sophisticated, Cool, Not Finished Building, Desire, Less interested, More precise, Depending on the results and design
2	Sustainability (9)	Energy saving, Environmentally Friendly, Green building, Development of Constructive technology, Calibrated in Climate aspects, Sustainability, Sustainable Material Use, Development Technology, Technological Progress
3	Innovation (14)	Modern, Trying new technologies, Utilization of technology, Advanced and precise, better results technology, New experience, New paradigms and innovations, Modern, Innovative
4	Effectiveness (4)	Effectiveness, Structured, Accurate
5	Inexperienced (23)	Lack of understanding, Haven't seen it directly, Haven't known the cost, Haven't imagined, Want to know more deeply, Don't know, Don't know how, Experiment, Haven't tested, Haven't been sure of technology, Don't know the technology, Don't know the technology, See the technology later, Haven't been interested, Haven't been sure about the quality, Don't know the quality, Don't know the cost, don't know the maintenance, See the construction process, Need to know more, Need to know more about the technology, See more

6	Untested strength (15)	Not yet guaranteed strength, Strength for earthquakes, do not know the strength, Consideration of construction strength, Safety, sturdiness
7	Usefulness (6)	Assist in development, useful use, utilize technology, assist, useful
8	Efficiency (17)	Construction process efficiency, Process, Efficiency, Time saving, fast, Faster, Buildings so faster, speed up the construction process, Fast to complete
9	Expensive Prices (8)	Expensive Cost
10	Cheap Prices (3)	Cheap, Affordable
11	Convenience (9)	Ease of technology, Ease of work, imagine as desired, Facilitate development, Ease of visualization
12	Complexity (11)	Difficult availability, Risks, Possibility of defects, Limitation of tools, want to buy a finished house, Comparison with conventional, Less sure material, Financial situation, According to budget, Not sure about costs, Depending on costs
13	Conventional Believers (5)	Conventional, Prefer manual, Job opportunities for handymen, Half conventional, Comparison with human work
14	Solutions (5)	Villa development, development solutions, Minimal human error, can see the design for real, Provide solutions

construction printing method are freelancer, entrepreneur, and government employee jobs with a value of 0.6%. Followed by student employment 0.472%, private employees 0.40%, lecturers /teachers 0.40% which can be seen in **Figure 5** while those who do not want to use 3d construction printing are unemployed, manual workers. For those who answer perhaps, work with the categories of architects, government employees, lecturers / teachers, private employees, students / students it is because they do not know about the knowledge of 3d construction printing. This shows that the market of the development method with 3d construction printing is people who also know about the 3d construction printing method.

The monthly income category showed that the highest percentage of wanting their homes build by 3d

The job categories that have the highest percentage of choosing the 'Yes' answer in wanting to use the 3d

construction printing method is the income around 3-6 million rupiah as seen in **Figure 6**.

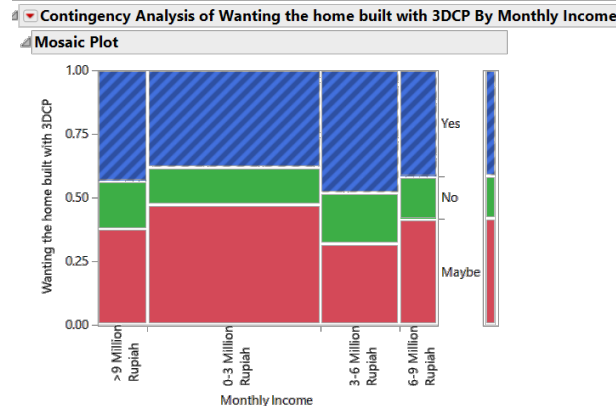


Figure 4: Categories of Monthly Income in answering 'Yes' want to use the 3dcp method in development.

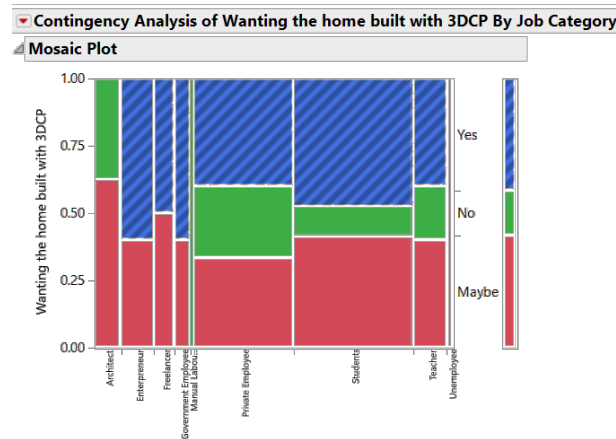


Figure 6: Categories of Job Category in answering 'Yes' want to use the 3dcp method in development

3. Conclusion

Knowledge about 3D Construction Printing is still relatively small and is widely known by the public. People who know about this technology generally come from information, namely the mass media, and are notified when they receive an education. The use of 3d construction printing technology that is known by the public is the greatest because it is impressive where the factor in it is that this technology is sophisticated, good, and cool. In general, it can be seen in Figure 6. 3d Construction Printing technology is a technology that is still being developed both from technology, materials and

from an economic point of view[18]. Based on research from the UK, development using this technology can reduce the cost of building a house by 30%. This is because of it.

Figure 7: People's Preference for 3D

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reduces the cost of transportation and also reduces wasted materials [12]. Residential buildings that use this technology also vary in shape, where the shape of the building can adjust the design of the BIM software [19]. Although for the strength of some parts of the house, it is better to use manual systems such as foundations, roofs, and columns in the construction of walls, 3d construction printing technology excels in speed, structure, and cost [20].

Figure 7 showed about what people's preferences for 3D Construction Printing technology. This result means 3DCP has the potency to be used by Indonesia's society even though this technology is inexperienced. The most interested in this technology are those who know about this, such as entrepreneurs, teachers, students, government employees, architects, and private employees. They see this technology from information reports such as media and formal education. Suppose information about the various advantages of 3dcp technology is disseminated and known to more people. In that case, this technology can be a solution to help build construction that is environmentally friendly, cheap, and fast for the community.

Recommendations

Traditional construction is still the construction method used today. With the existence of industrial technology 4.0, people have a choice in building a dream house with 3DCP that has various advantages. In addition to reducing design costs and freedom, the use of 3d construction printing can speed up the time for house construction. Future research needs to share more about the potency, challenge, and risk of this technology if implemented in Indonesia. The real research experiment using 3dcp will be good insight for scientific study.

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