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phenomenon@walisongo.ac.id

Immersing Digital Technology in Empowering University Students with Future Skills: Digital Fabrication Laboratory Workshop

Anita Fibonacci[1], Asep Kadarohman[1*], Hernani[1], Triannisa Rahmawati[2], M. Nurul Hana[3], Miarti K Nais[3], AN Razani[3], VW Haunan[3], Roslinawati Mohd Roslan[4]

[1]*Science Education Study Program, Universitas Pendidikan Indonesia, Bandung, Indonesia*
[2]*Department of Chemistry, Universitas Pendidikan Indonesia, Bandung, Indonesia*
[3]*Department of Chemistry Education, Universitas Pendidikan Indonesia, Bandung, Indonesia*
[4]*Sultan Hassanal Bolkiah Institute of Education, Universiti Brunei Darussalam, Brunei Darussalam*

Abstract

This study aimed to explore the perception of students in higher education regarding the role of digital fabrication laboratories in equipping students with the skills they need in the future. This study was conducted using a descriptive approach. The study was carried out through a DFL workshop involving students’ representation from the Department of Student Association from a state university in the West Java with a total population of 106 students. A purposive sampling technique was used to choose the participants, with total sample was 12 students. Data collection was carried out through survey and interviews to measure students' perspectives on the opportunities to use Digital Fabrication Laboratory in developing future skills in a workshop scheme. Quantitative data analysis was carried out using descriptive statistics using mean scores and percentages, while for the results of the interviews, using a thematic analysis. Study showed that according to participants, the Digital Fabrication Laboratory facility was able to develop several skills, namely creativity (14%), computational thinking (7%), soft skills (7%), teamwork (7%), technological literacy (22 %), entrepreneurship (14%) and digital design (29%). The results also showed that the digital fabrication laboratory has a role and benefits for students' future careers, with a mean score of 4.44 (very good). The results of the thematic analysis showed that participant perspective the advantages of DFL workshop can develop their skill namely entrepreneurship, souvenir entrepreneurship, business in Clothes Printing Properties, Gundam entrepreneurship, Support in entrepreneurship Courses, Teaching Media Supplier, so it can be concluded that students feel that the DFL workshop is useful for students' future careers.

Keywords: Digital Technology, Future Skills, Fabrication Laboratory

Teknologi Digital dalam Memberdayakan Mahasiswa dengan Keterampilan Masa Depan: Workshop Laboratorium Fabrikasi Digital

Abstrak

Penelitian ini bertujuan untuk mengeksplorasi persepsi mahasiswa di perguruan tinggi mengenai peran laboratorium fabrikasi digital dalam membekali mahasiswa dengan keterampilan yang dibutuhkan untuk masa depan. Penelitian ini dilakukan dengan menggunakan pendekatan deskriptif, melalui aktivitas workshop Digital Fabrication Laboratory (DFL) yang melibatkan perwakilan pengurus Himpunan Mahasiswa (HMJ) dari sebuah perguruan tinggi negeri di wilayah Jawa Barat dengan populasi berjumlah 106 mahasiswa. Teknik sampling yang digunakan adalah purposive sampling dengan kriteria tertentu. Pengumpulan data dilakukan melalui survei dan wawancara untuk mengukur perspektif mahasiswa tentang peluang penggunaan Digital FabLab dalam mengembangkan keterampilan masa depan dalam

Universitas Pendidikan Indonesia
Email: kadar@upi.edu

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skema workshop. Analisis data kuantitatif dilakukan dengan menggunakan statistik deskriptif menggunakan skor rata-rata dan persentase, sedangkan untuk hasil wawancara dilakukan analisis tematik. Kesimpulan dari penelitian ini menunjukkan bahwa menurut peserta, fasilitas Laboratorium Fabrikasi Digital mampu mengembangkan beberapa keterampilan, yaitu kreativitas (14%), computational thinking (7%), soft skill (7%), kerja tim (7%), literasi teknologi (22%), kewirausahaan (14%) dan desain digital (29%). Hasil menunjukkan bahwa laboratorium fabrikasi digital memiliki peran dan manfaat bagi karir mahasiswa di masa depan, dengan skor rata-rata 4,44 (sangat baik). Hasil analisis tematik menunjukkan bahwa peserta menyatakan keunggulan workshop DFL dalam mengembangkan skill mahasiswa antara lain kewirausahaan, wirausaha souvenir, bisnis di Properti Percetakan Pakaian, wirausaha Gundam, Pendukung untuk Mata Kuliah Kewirausahaan, Supplier Media Mengajar, sehingga dapat disimpulkan bahwa mahasiswa merasa bahwa workshop DFL bermanfaat bagi karir mahasiswa di masa depan.

Kata kunci: Teknologi Digital, Ketrampilan Masa Depan, Laboratorium Fabrikasi

INTRODUCTION

The era of Industry 5.0 has brought significant changes, especially in technology related to the Internet of Things (IoT), 3D Printing, AI, and Robotics, which are key components in the industrial world; unfortunately, technical skills to bridge industrial needs with the provision of provisions at universities are often still not synchronized. Globalization and the technological era are driving all sectors to swiftly adapt to meet the demands for future skills. Higher education, as a provider of graduates who will shape the future, must equip students not only with academic abilities, but also with the skills to navigate the challenges of tomorrow (Sady et al., 2019). The rapid pace of technological innovation necessitates immediate adaptive action at all levels, including in higher education (Breien & Wasson, 2022).

The skills needed for the future are changing along with rapid technological advances. Some skills needed in the future include complex problem-solving, critical reasoning, collaboration skills, and the ability to use digital devices (Serrano-Ausejo & Mårell-Olsson, 2023). In the context of higher education, creativity is a skill that is very necessary to survive in modern society (Karunarathne & Calma, 2023). Creativity is one of the most important skills in the era of Industrial Revolution 4.0 in order to be able to take advantage of opportunities that arise with technological advances because future challenges require the ability to provide innovative solutions, as well as the ability to create new things to provide fresh things in various fields (Akyazi et al., 2020). It is essential to equip students with practical skills that suit the demands of the times. One of the facilities that can be a bridge to meet this need can be provided by a digital fabrication laboratory.

The Digital Fabrication Laboratory does not only act as a conventional laboratory but is able to become a place to combine digital design concepts with the production of tangible products as a result of creative ideas (Togou et al., 2020; Weng et al., 2023). Technology provides flexibility that can develop the skills needed to face 21st-century challenges, such as the ability to think creatively, think multidisciplinary, additive manufacturing, work independently, and increase entrepreneurial intention (Rayna & Striukova, 2021). In line with this, research from Celani (2012) produced findings that digital fabrication was proven to increase student creativity.

Digital Fabrication Labs can also develop collaborative learning through a cross-disciplinary approach because they connect digital learning with "making" activities because both are learning environments, both digital and physical (Maravilhas & Martins, 2019; Soomro et al., 2023). Although the potential of digital fabrication labs has been recognized, there is still little research exploring the role of digital fabrication labs in equipping students to face challenges in the increasingly complex world of work, especially in developing thinking skills. Therefore, this study aims to explore the role of digital technology in fabrication labs as an infrastructure that can equip students with the development of thinking skills needed for the future.

RESEARCH METHODS

This study was conducted using a descriptive approach. The study was carried out through a Digital Fabrication Laboratory (DFL) workshop involving students from the Department of Student Association (HMJ) at a state university in the West Java area totalling 106 students. A total of 12 students were selected by purposive sampling with the criteria of (1) participants are active members of the management of the student association of the department under the faculty of Mathematics and Science Education, (2) students have a strategic position in management so that they can communicate the results of the workshop to students of their respective majors; (3) have a time commitment to participate in workshop activities from start to finish. Data collection was carried out through survey and interviews to measure students' perspectives on the opportunities to use Digital FabLab in developing future skills. First, the survey was conducted in the form of statements with an assessment scale ranging from 1-5, which was then followed up with interviews to explore the results of the answers from the participants. Quantitative data analysis was carried out using descriptive statistics using mean scores and percentages, while for the results of the interview, a thematic analysis was carried out using 6 phases from Braun & Clarke (2006).

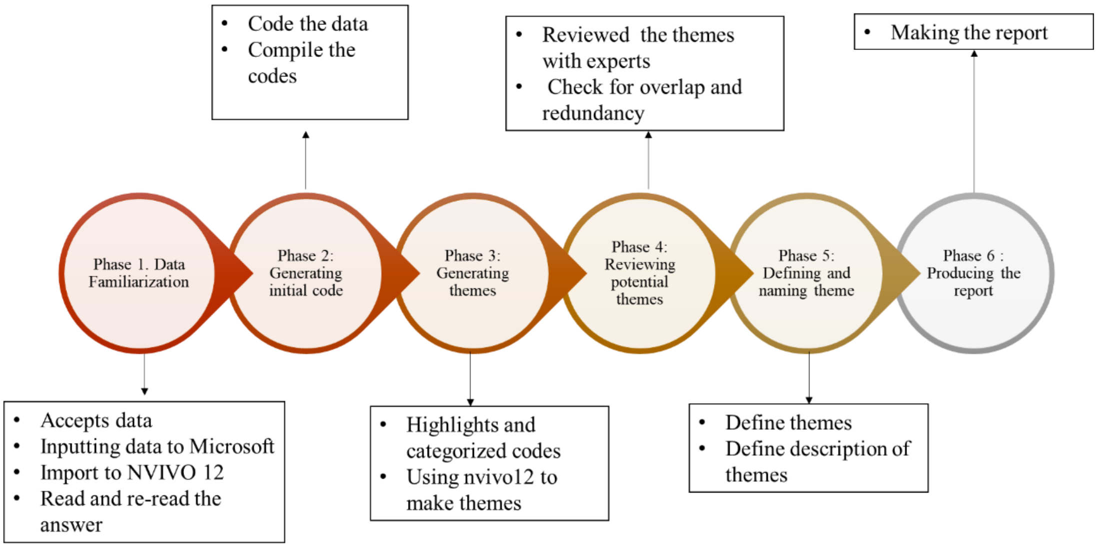

Figure 1. Thematic Analysis Procedure

Digital fabrication laboratory workshop activities were carried out in a fabrication laboratory owned by a state university in Bandung. This laboratory supports additive manufacturing, subtractive manufacturing and formative manufacturing processes. Some of the equipment in this fabrication laboratory includes: Mini CNC laser cutting LS-6040, CNC laser cutting LS-1390, 3D printer Flashforge Adventurer 3, 3D Scanner Laser cutting, and 3D Printer, 3D Scanner, and UV Printer and several devices others such as computers, laptops. Meanwhile, the materials used include: acrylic, eSun Bio PLA, eSun Resin, Sunlu 3D printer filament. The service scheme is carried out through workshops with participants being students from the Department of Student Association (HMJ) from physics education, mathematics education, chemistry education, biology education and computer science education study programs.

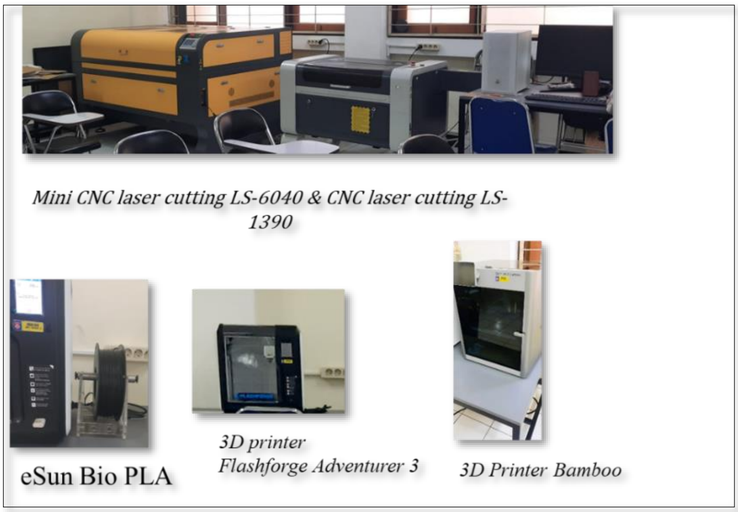

Figure 2. Equipment and Materials (own authorship, 2024)

The digital fabrication laboratory workshop activities were carried out by adopting several steps from Fransisca et al., (2021): (1) Preparation; (2) Screening; (3) Implementation; (4) Evaluation. Preparation activities were carried out using several procedures, namely determining the objectives and theme of the workshop material, determining the workshop committee, making invitation letters and permission letters.

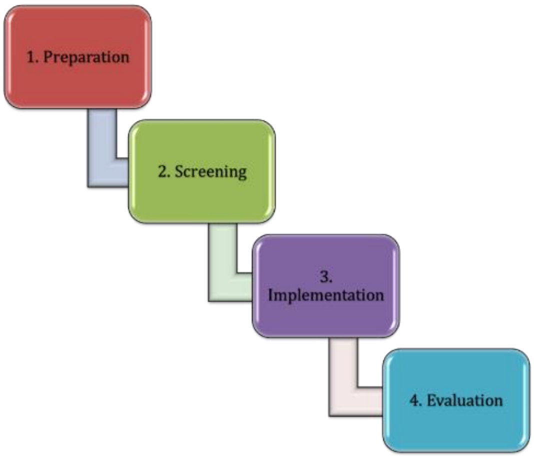

Figure 3. Flowchart Activity

The next step is planning which involves several stages, namely determining speakers and accompanying instructors, making a rundown of the event, ensuring the readiness of the hardware and software that will be used, ensuring all invitations have been distributed, ensuring all workshop needs are ready. The steps for implementing the activity were carried out with an expert presentation explaining digital design tools and materials, the activity continued with discussion and question and answer and continued with practical activities for making prototypes desired by the participants, accompanied by the Digital Fabrication Laboratory instructor. Evaluation steps are carried out to obtain input and recommendations for improving future activities.

RESULT AND DISCUSSION

The era of Industry 5.0 has brought significant changes, especially in technology, which are key components in the industrial world. Unfortunately, technical skills to bridge industrial needs with the provision of provisions at universities are often still not synchronized. Therefore, it is necessary to have a Digital Fabrication Laboratory workshop which contains technical training in the use of manufacturing equipment Tangible Digital-Based Products. Workshops are non-formal activities, which build participants' intrinsic motivation to participate and implement learning by doing (Houghton et al., 2022; Yliverronen et al., 2021). Participants expected to produce certain products. The workshop scheme is carried out so that participants has a large role in producing the product. Digital Fabrication Laboratory or what is commonly referred to as Fabrication Laboratory is a laboratory that provides an environment and equipment with digital designs for manufacturing physical objects (Celani, 2012). Bull et al., (2009) defines digital fabrication as the process of turning a digital design into a physical object. Digital Fabrication Laboratory is an international digital laboratory network that provides new technological tools for digital manufacturing of goods (Santos et al., 2018).

Preparation and screening steps are carried out before the workshop implementation stage to ensure that all equipment, materials, materials, invitations, attendance lists, evaluation instruments and certificates are all ready before the workshop implementation. Furthermore, the implementation of the digital fabrication laboratory workshop activities began with an opening represented by Faculty leaders and Study Program leaders. The next activity is a presentation of material regarding the basics of digital design which explains digital design tools and materials such as CorelDraw X6, Corel Laser and other software. The presentation of the material is carried out using the lecture method. The activity continued with an introduction to the tools, as well as discussion and questions and answers. Sommier et al., (2022) stated that transformative, interdisciplinary and intercultural pedagogical approaches in higher education for sustainability are very effective in building student creativity in higher education.

Figure 4. Tools Introduction

(own authorship, 2024)

The next step is direct practical activities by participants. For participants who do not yet have the required software, students are given the option to use a computer from FabLab, but for those who already have the required software, they can immediately design and make the prototype that the participant wants, accompanied by the instructor. Digital design for 3D printing must be converted into .stl format and ready to slicing using Flashprint software as Figure 5 shown.

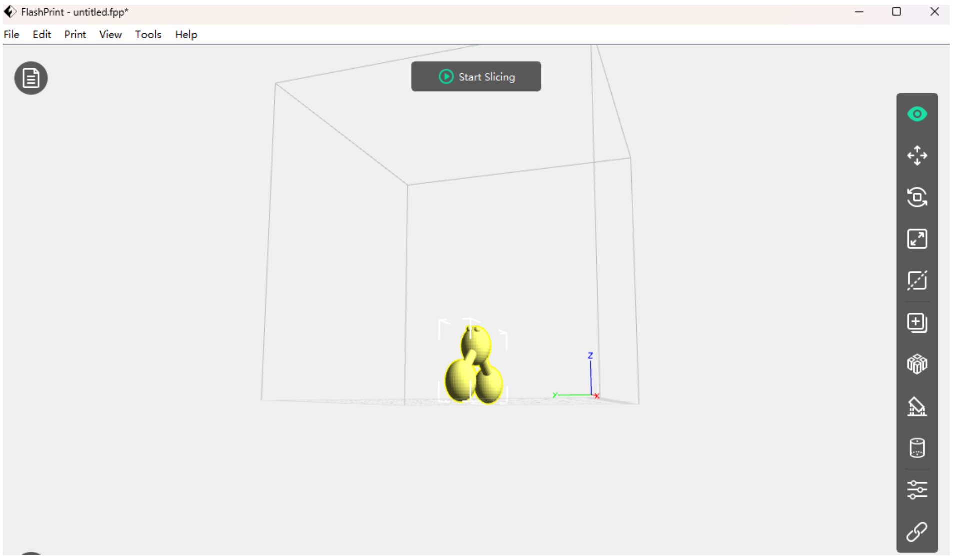

Figure 5. Digital Design For 3D-Printing

After completing digital design, students are invited to immediately practice printing the design results independently but still under the guidance of an instructor. Participants were asked questions regarding what product they wanted to make and the answers that emerged from the participants are presented in Table 1.

Table 1. Planning Product made by Participant

No	Type
1	Souvenir
2	Learning media
3	3D object
4	Name tag
5	Customize Key Chain

This direct practical activity is very important to stimulate innovation and creativity, as stated by Beyers (2010) that an environment where someone can create a tangible prototype without right or wrong answers stimulates improving cognitive skills related to lateral thinking which is used to find ideas. Examples of participants' work can be seen in Figure 6.

Figure 6. Example of product made by participant (own authorship)

The evaluation step was carried out to assess the success of the program and obtain input regarding things that need to be improved for the implementation of the next workshop program. A questionnaire was distributed to training participants containing statements regarding the participants' satisfaction with the implementation of the workshop. Interviews and documentation activities were also carried out to see the success of this program as a basis for improvement in future activities.

Table 2. Participant Respond

No	Respond	Percentage (%)
1	Happy	46
2	Enthusiast	27
3	Attracted	18
4	Challenge	9

Based on Table 2, there is some information that can be gathered, like the majority of students (46%) who had received DFL training felt happy, and the rest stated they felt challenged and attracted. It showed that more than half of the participants have a positive attitude toward the Digital Fabrication Laboratory. The results of interviews regarding what reasons why participants felt happy were: (a) learning new things related to the world of digital fabrication; (b) able to learn new knowledge; (c) advanced technology updates. This feeling of excitement is associated with the ability of the Digital Fabrication Laboratory to support collaboration, interdisciplinary work so as to make the learning process through mistakes and rapid prototyping (Morin & Moccozet, 2021).

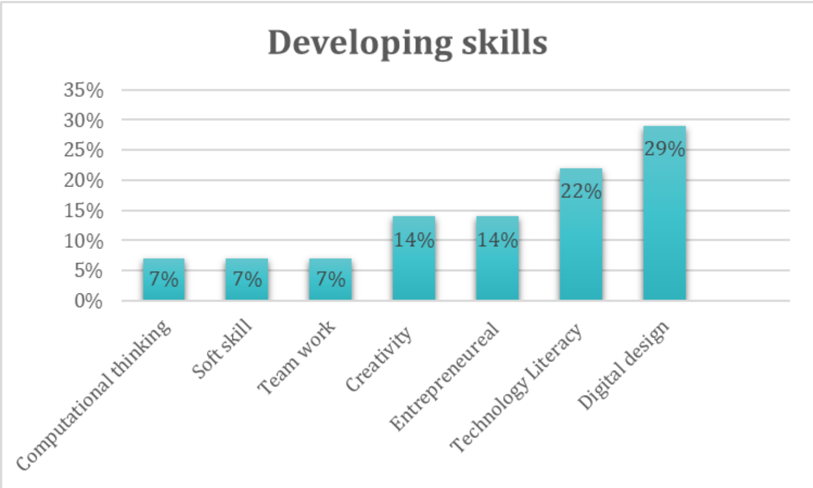

Figure 7. Developing Skills according to Participants

The evaluation results showed that participants stated that there were several skills that were developed with the Digital Fabrication Laboratory facilities as presented in Figure 7. Based on Figure 7, information was obtained that the majority of students (29%) who had received DFL training stated that DFL was able to develop digital design skills. In comparison, 22% stated that it was able to improve technological literacy, 14% stated that they were entrepreneurial, and the rest stated that the skills developed were teamwork, soft skills, and computational thinking. Digital Fabrication laboratories, provide access to a range of digital fabrication tools and technologies, such as 3D designing and printing, electronic circuit design, PCB milling, large CNC machines, 3D scanning, laser cutting, molding, in order to improve digital design skills and technological literacy (Soomro et al., 2022). By using these tools, people can get a better grasp of digital design technology and processes, which improves their technological literacy and digital design skills.

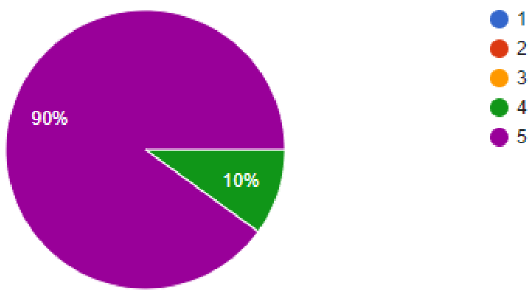

Figure 8. Students' Answer About FabLab in Developing Creativity

Figure 8 showed that 90% of participants gave a score of 5, and 10% gave a score of 4 for the statement that this workshop could develop creativity with an average score of 4.89, which includes very good criteria. From these results, it can be concluded that students feel that the digital fabrication laboratory workshop is able to develop student creativity. The physical environment in marker spaces, which allows people to do some "making" processes, can stimulate creativity and innovation (Harron et al., 2022; Kohtala, 2017). In the context of the Digital Fabrication Laboratory, which is part of markerspaces, the results of a study by Soomro et al (2023) found that new technology such as 3D printing has a positive effect on problem solving abilities, creative competence, self-confidence, and inspiration to become an innovator. Trahan et al., (2019) found that an atmosphere where a learner and teacher have the freedom to "fail" in carrying out a task, will help stimulate them to experiment further, explore, and collaborate with other participants, and this is what become the strength of the environment that can be provided in the digital fabrication laboratory.

Creativity that begins with creative thinking is important to survive in the modern environment (Karunarathne & Calma, 2023). Thinking is a mental exercise that people do when faced with a problem or situation that needs to be resolved. At this point the creative process is connected with the process of creating something new using something that already exists. Davies et al., (2013) states that creative thinking is a process that aims to produce new ideas. University students' creative thinking cannot be formed without intelligent activity and the accumulation and representation of abundant specific knowledge (Lv et al., 2023). In educational context, Azcárate & García (2022) found that the direct integration approach of Fabrication Laboratory management is suitable for use at the university level. Science and Technology Park FabLab is one of the FabLabs owned by the University of Nairobi. This FabLab has been around for approximately 3 years and is the first FabLab to be integrated into a "business incubator" environment.

One famous example of a Fab Lab is the MIT Fab Lab at the Massachusetts Institute of Technology (MIT) in the United States. MIT's Fab Lab was one of the first fabrication laboratories founded by Professor Neil Gershenfeld, who was also one of the people who popularized the Fab Lab concept. MIT's Fab Lab provides a variety of equipment such as 3D printers, laser cutting machines, and other equipment used by students, researchers, and the community to design and manufacture various types of products. FabLab can be a place where individuals and groups can learn, collaborate, and design products using digital technology. This shows that Digital FabLab has the potential to become a new era in technology that can bridge the digital world with the real world, and has the power to develop creativity. Checiu et al., (2024) states that from the perspective of how the brain works, creative thinking involves fundamental thought processes, which can help us find new ways to solve problems. Creative problem solving is a multifaceted process that involves understanding the problem, formulating solutions and hypotheses about the problem, searching for solutions, analyzing the solutions, and finally presenting the results. Based on the definition above, the author states that creative writing is the ability to analyze something based on data or information in order to produce new ideas to understand it.

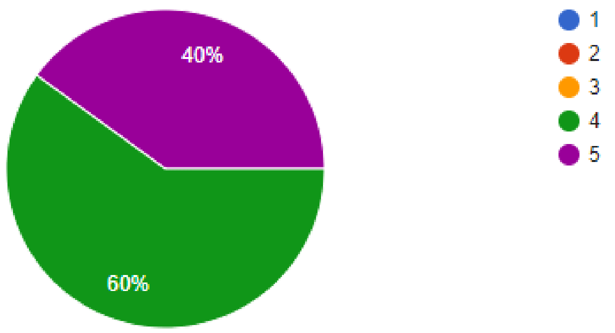

Figure 10. Profile of Assessment Results regarding Future Career Development

Based on Figure 10, showed that 60% of participants gave a score of 4 and 40% gave a score of 5 for the statement that the workshop material provided could provide benefits for future careers, with an average score of 4.44 (very good) so it can be concluded that students feel that this DFL workshop is useful for students' future careers. The results of the questionnaire were linear with students' answers. When asked the question whether students were motivated to use DFL facilities, participants answered that they were motivated by DFL for the reasons that emerged (a) adding new skills; (b) stimulate an entrepreneurial spirit; (c) develop creativity. Student participants were also asked questions about what opportunities students could develop through digital fabrication laboratory workshop activities, and the results of the thematic analysis of student participants' answers are presented in Figure 11.

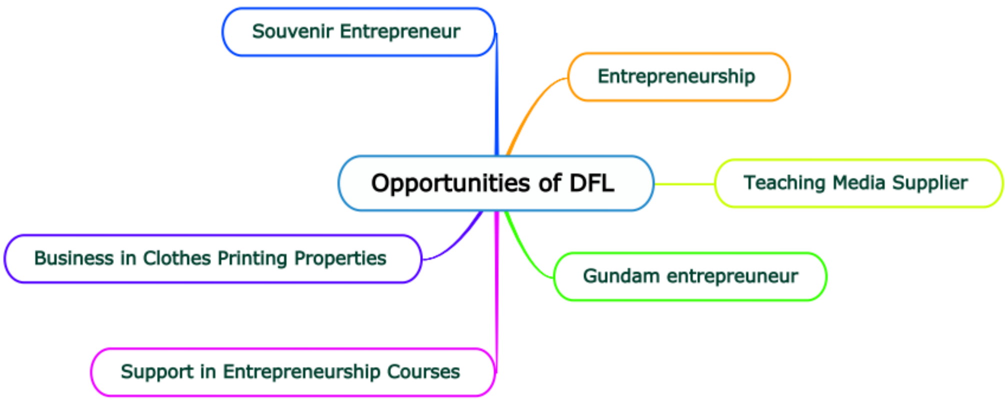

Figure 11. Thematic Analysis of Participant Answer

Based on Figure 11, the results of thematic analysis showed that according to participant perspective the advantages of DFL workshop can develop their skill namely entrepreneurship, souvenir entrepreneurship, business in Clothes Printing Properties, Gundam entrepreneurship, Support in entrepreneurship Courses, Teaching Media Supplier, so it can be concluded that students feel that the DFL workshop is useful for students' future careers. Linier with the results, research has shown a significant positive correlation between happiness and creative thinking. Positive affect, including happiness, concentration, feeling active, and interested, has been found to be positively correlated with creativity (Morin & Moccozet, 2021).

CONCLUSION

The conclusion of this study showed that according to participants, the Digital Fabrication Laboratory facility was able to develop several skills, namely: creativity (14%), computational thinking (7%), soft skills (7%), teamwork (7%), technological literacy (22 %), Entrepreneurship (14%) and digital design (29%). The results also show that the digital fabrication laboratory has a role and benefits for students' future careers, with a mean score of 4.44 (very good). The results of the thematic analysis from the interviews with the participants showed that the role of DFL in developing students' careers in the future is entrepreneurship, souvenir entrepreneurship, business in Clothes Printing Properties, Gundam entrepreneurship, Support in entrepreneurship Courses, Teaching Media Supplier so it can be concluded that students feel that the DFL workshop is useful for students' future careers.

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