Students' opinions on the use of 3d printing technology in physics, case study of ibn tofail university

Opinions des étudiants sur l'utilisation de la technologie d'impression 3D en physique, étude de cas de l'Université Ibn Tofail

Hicham EN-NKHILI [1], Abderrafya MITIQUE [2], Mohammed IGOUZAL [3]

[1] Laboratory of Electronic Systems, Information Processing, Mechanics, and Energy, Department of Physics, Ibn Tofail University, 14000 Kenitra, Morocco, hicham.ennkhili@uit.ac.ma
[2] Laboratory of Electronic Systems, Information Processing, Mechanics, and Energy, Department of Physics, Ibn Tofail University, 14000 Kenitra, Morocco abderrafya.mitique@uit.ac.ma
[3] Laboratory of Electronic Systems, Information Processing, Mechanics, and Energy, Department of Physics, Ibn Tofail University, 14000 Kenitra, Morocco Mohammed.igouzal@uit.ac.ma.

ABSTRACT. The rapid advancements in 3D printing technology and materials are revolutionizing the field of physics. While industries are reaping the benefits of these innovations, physics students are also poised to gain from this technological shift. To understand the current state of 3D printing in physics education, we conducted a case study involving 100 students from FABLAB-FSK. This research included an implementation phase and a survey to gauge student perspectives on the intersection of 3D printing and physics education. Our research aimed to assess the extent of students' familiarity with 3D printing technology, exploring their knowledge of its capabilities and its potential applications in physics projects. The survey focused on understanding their awareness of 3D printing's role in developing new materials and its effectiveness as a teaching tool in physical sciences.

RÉSUMÉ. Les avancées rapides dans la technologie d'impression 3D et les matériaux révolutionnent le domaine de la physique. Alors que les industries récoltent les bénéfices de ces innovations, les étudiants en physique sont également prêts à profiter de ce changement technologique. Pour comprendre l'état actuel de l'impression 3D dans l'enseignement de la physique, nous avons mené une étude de cas impliquant 100 étudiants du FABLAB-FSK. Cette recherche comprenait une phase de mise en œuvre et une enquête pour évaluer les perspectives des étudiants sur l'intersection de l'impression 3D et de l'enseignement de la physique. Notre recherche visait à évaluer le degré de familiarité des étudiants avec la technologie d'impression 3D, en explorant leur connaissance de ses capacités et de ses applications potentielles dans les projets de physique. L'enquête s'est concentrée sur la compréhension de leur conscience du rôle de l'impression 3D dans le développement de nouveaux matériaux et de son efficacité en tant qu'outil pédagogique dans les sciences physiques.

KEYWORDS. 3D printing, physics, FABLAB-FSK.
MOTS-CLÉS. L'impression 3D, la physique, FABLAB-FSK.

1. Introduction

It’s evident that Science, Technology, Engineering, and Mathematics (STEM) education is crucial for a nation's economic competitiveness, driving innovation, growth, and productivity, developing countries like Morocco face significant challenges. Moreover, Limited budgets for scientific laboratories and skyrocketing costs for educational materials and laboratories supplies hinder their progress in STEM fields. To resolve this problem, 3D printing ability to rapidly create personalized physical objects makes it a valuable tool across academic disciplines. Its use can enhance learning and participation in material production courses to develop students’ skills. In recent years, 3D printing technology has made significant strides in various fields, including physics [KAD 18], food industry [TES 22] and healthcare [MIC 15].

This technology has opened new possibilities for experimentation, prototyping, and visualizing complex concepts in the field of physics [GUA 22] . With 3D printing, students can now create tangible models of abstract physical concepts, such as molecular structures or gravitational fields [WIB 21].

This hands-on approach enhances their understanding of these concepts and allows for more interactive learning experiences. Furthermore, 3D printing technology has the potential to revolutionize physics research by enabling the production of customized experimental equipment and components [ZHU 20]. This can lead to more efficient and cost-effective experiments, as well as the ability to explore new areas of research that were previously inaccessible. Additionally, the use of 3D printing technology in physics can also contribute to sustainability efforts. By allowing for the creation of precise and customized parts, 3D printing can reduce material waste and optimize resource consumption in the field of physics. Moreover, integrating 3D printing technology in the physics curriculum can foster creativity among students and solve problems [AHM 20]. They can design and iterate on their own experiments, coming up with innovative solutions to scientific challenges. Overall, the positive impact of 3D printing on the education of primary, secondary school and university students are: (1), Improve observation and concentration, (2) Enhance creativity, (3) Improve independent learning habits, (4) Develop spatial imagination, and (5) Develop reflective and problem-solving ability [Che 21] .

The current research aimed to survey students at Ibn Tofail University to understand their experiences and opinions on using 3D modelling programs and 3D printers available at the Faculty of Sciences' FABLAB for their projects.

2. *Materials and Methods*

This research employed a qualitative case study approach to gain in-depth understanding of students' perceptions towards 3D modelling programs and 3D printers as educational tools. The case study method, as described by (Eisenhardt, 1989), is particularly well-suited for gathering detailed data from participants about a specific event or situation, allowing for comprehensive conclusions. This approach was deemed optimal for this study, given its objective of thoroughly exploring students' perspectives on these technologies in physics science.

The questionnaires were carried out in person (mainly at the University of Sciences Ibn Tofail, Morocco) and online (written in French using Google Forms/docs). The questions included in the survey analyzed respondents' knowledge of 3D printing technology and the opportunities it creates for physics education. The final number of respondents in the sample was N = 100.

The questionnaire consisted of 18 original questions. The first section gathered demographic information from respondents, including their gender, age, and year of study. The second section employed closed-ended multiple-choice questions to assess the respondents' general knowledge of 3D printing, their understanding of materials used in 3D printing, their preferred 3D printing project, and their perspectives on the ethical implications of 3D printing in physics education. The students were asked about their prior experience with 3D printing technology and their opinions on the FABLAB-FSK 3D printer's service quality in supporting their projects.

3. Results and Discussion

While 3D printing is widely adopted in universities, its implementation in other higher education and continuing education institutions remains largely undocumented. University studies on 3D printing highlight its use in promoting disciplinary knowledge acquisition through the creation of 3D printed systems, models, and prototypes. They also showcase its role in project-based learning, the integration of 3D printing skills development into existing and new courses and fostering collaborations beyond the university walls.

This study explored students' opinions on utilisation 3D printers in FABLAB -FSK. Initially, the survey recorded participants' gender, revealing that 65.4% were female and 34.6% male. Furthermore, it assessed students' knowledge of 3D printers, finding that only 11.5% owned one, while 88.5% did not, indicating limited familiarity with the technology. Therefore, the range of materials available for 3D

printing is quite limited, with many students (85.7%) using filament deposition or extrusion to create simple objects, while only 11 % utilize photopolymerization (laser and resin) and 3.3% used Powder melting (Figure 1a). Given the scarcity of 3D printers among university students, the FAB-LAB FSK provides a valuable opportunity for free access to 3D printing. This facility allows students to create complex objects, aiding them in successfully completing projects across various fields of physics, including mechanics (44%), robotics (33%), and mechatronics (18%), according to survey results (Figure 1b). In addition, the quality of the 3D printing used remains acceptable for printing objects used in the teaching of physics, therefore, 80 % of students are satisfied with the 3D printer at FABLAB-FSK and the same percentage rates the quality as average.

However, 20% are not satisfied with the quality of the 3D printer at FABLAB-FSK. Regarding the support service, most students (53.6%) are satisfied with this service, while 16.1% of the students surveyed stated that the service and the method of using the 3D printer need improvement (Figure 2a). This shows that the use of this new technology remains limited at Ibn Tofail University despite the efforts of the managers of FABLAB-FSK. therefore, we must support the FABLAB with another 3D printer to satisfy this need.

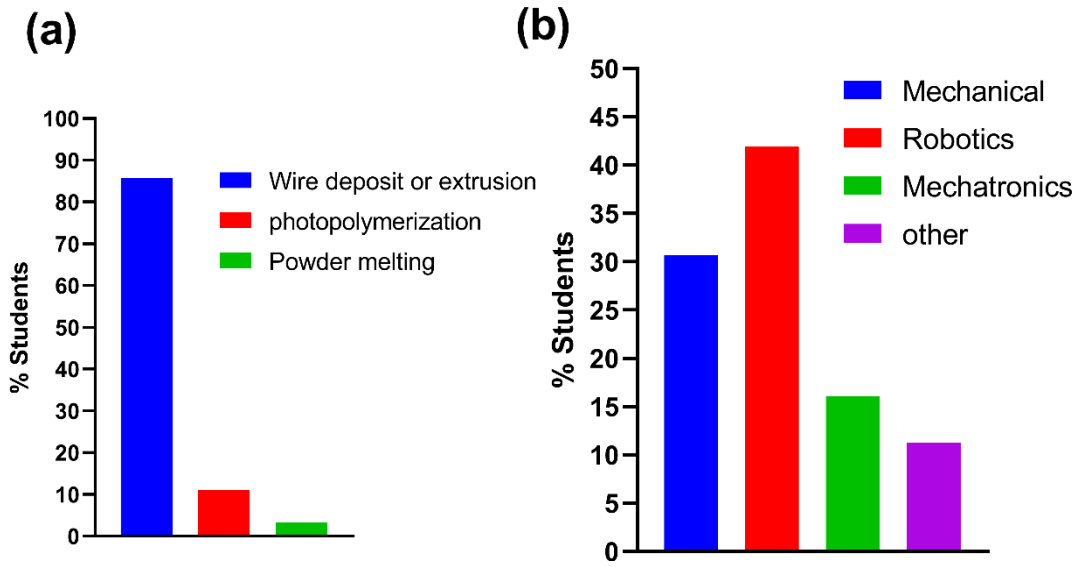

Figure 1. *Students' opinions: (a) Materials used in 3D printing, (b) Types of objects printed at FABLAB.*

When asked about using 3D printers in their physics learning, a strong majority (80%, N=80) of students expressed interest. However, 20% (N=20) indicated they wouldn't use 3D printers, citing the difficulty and time commitment involved. Therefore, students hold diverse views on the impact of 3D printers in different physics majors. Those who anticipate positive effects believe 3D printers can enhance learning by making it more effective and accessible. They also emphasize the technology's potential to facilitate understanding and improve teaching overall.

In addition, the study revealed a clear distinction in how students utilized 3D printed parts. Ninety percent of students considered the printed parts vital for their project's success, while 10 % employed them mainly for decorative purposes, and is the percentage by mass of the printed part in relation to the overall project and is different depending on the type of project carried out. Additionally, the most students (90.3%) reported that the 3D printer significantly accelerated their project completion compared to traditional methods and they were very appreciated in the work sector. This experience has fostered a clear understanding of the advantages and potential of 3D printing in physics education, encouraging its adoption for future projects and learning.

In other hand, students identified four key challenges in integrating 3D printing into their work (Figure 2b):

• Design complexity (35.5%): Students struggled with designing objects for 3D printing.

• Cost (20.6%): The cost of 3D printing materials and equipment was a barrier.

• Printing time (35.5%): The time required to print objects was an issue.

• Technical expertise (8.4%): Students felt they needed more training to effectively use the 3D printer.

The study revealed a strong interest in new technologies, especially among students in mechanics and mechatronics. Our findings suggest that many of these students are aware of both the advantages and limitations of 3D printing.

Item	Responses	
	Yes	No
Do you own a 3D printer?	87.1%	12.9%
Do you have access to the 3D printer at FABLAB-FSK?	93.5%	6.5%
Are you satisfied with the use of the FABLAB 3D printer to carry out your project?	80%	20%
Do you agree with using the 3D printer in physics learning?	80%	20%
What is the percentage of the printed part's usefulness in the overall project?	82%	18%
Does the 3D printer you use allow printing of complex objects?	93.5%	6.5%
Is the final object in which you added the printed piece operational (working)?	93.5%	6.5%
Did the 3D printer allow you to complete the work faster (compared to a traditional method)?	90.3%	9.7%
Have you personally handled the 3D printer?	51.6%	48.4%
The people in my network who use 3D printing are highly valued in the work sector.	96.8%	3.8%
Do you have knowledge of prototyping technologies and software acquisition?	54.8%	84.2%
Would you like to receive updated information about 3D printing?	85%	15%
Would you use 3D printing in your future educational career?	90%	10%

Table 1. *Descriptive table student's answers*

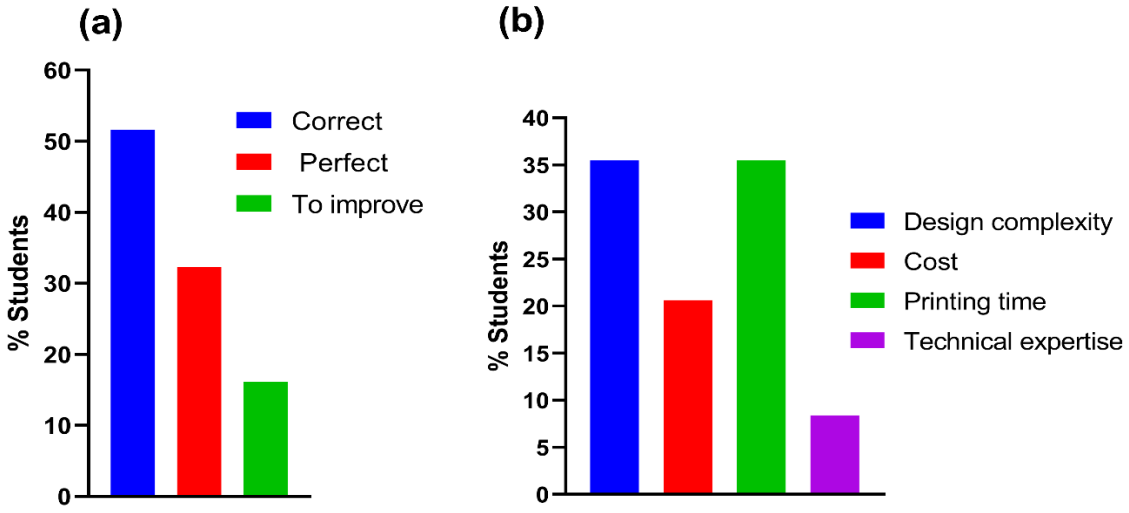

Figure 2. *Students' opinions: (a) Service the FABLAB-FSK 3D printer, (b) The obstacles integrating the 3D printer*

4. Conclusions

This study investigated student experiences and views on 3D printer use at Ibn Tofail University. The findings indicate that students generally welcome this new technology, and that female students demonstrate a higher level of familiarity with 3D printers. Key findings are summarized in three essential points.

Students have general knowledge about the use of 3D printing technology in physics field, which they obtained mostly from the FABLAB-FSK.

The survey highlights a strong interest among physics students in the latest advancements of 3D printing technology within their field.

Given the rapid advancements in technology, incorporating 3D-printed models into physics classes for final projects appears promising. This approach could provide students with modern, tangible learning tools, and complementing traditional teaching methods. A combined approach, integrating both traditional instruction and these modern tools, could create a more engaging and effective physics learning.

To gain a more comprehensive understanding, future studies should explore student perspectives from multiple angles. This includes examining their project success, analyzing classroom production and implementation activities, and conducting long-term studies across different student populations.

5.Acknowledgment

The authors would like to thank all FABLAB students for their responses.

References

[AHM 20] AHMED, W., & ZANELDIN, E. « The Innovation of Using 3D Printing Technology in Mechanical and Manufacturing Engineering». *IOP Conference Series: Materials Science and Engineering*, n°1,p. 012002, 2020.

[CHE 21] CHEN, J., & CHENG, L.»The influence of 3D printing on the education of primary and secondary school students». *Journal of Physics: Conference Series*, n°1,p. 012072, 2021.

[EIS 89] EISENHARDT, K. M. «Building Theories from Case Study Research». T*he Academy of Management Review*, n° 4, p.532, 1989.

[GUA 22] GUAMÁN-RIVERA, R., MARTÍNEZ-ROCAMORA, A., GARCÍA-ALVARADO, R., MUÑOZ-SANGUINETTI, C., GONZÁLEZ-BÖHME, L. F., & AUAT-CHEEIN, F. Recent Developments and Challenges of 3D-Printed Construction : *A Review of Research Fronts. Buildings*, n°2,pp. 229, 2022.

[KAD 18] KADHIM, N. M. S. M. «New technologies and their impact on the development of architectural education,» *1st International Scientific Conference of Engineering Sciences (ISCES)*, Diyala, Iraq, pp. 231-236 , 2018.

[TES 22] TESIKOVA, K., JURKOVA, L., DORDEVIC, S., BUCHTOVA, H., TREMLOVA, B., & DORDEVIC, D.. «Acceptability analysis of 3D-printed food in the area of the Czech Republic based on survey». *Foods*, n°20, p.3154. ,2022.

[WIB 21] WIBAWA, B., SYAKDIYAH, H., SIREGAR, J. S., & ASRORIE, D. A. «Use of 3D printing for learning science and manufacturing technology» *the 2nd science and mathematics international conference*. Transforming.. Jakarta, Indonesia,p. 060002, 2021.

[ZHU 20] ZHU, Z. H., ZHANG, N., WANG, T., & HAO, M. Y. «Short Review of Polymer Composites for 3D Printing». *IOP Conference Series: Materials Science and Engineering*, n°1, p.012046, 2020.

