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Determining jewellery students' CAD competencies as a means to incorporate a student-led teaching strategy: A case study

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Abstract

The COVID-19 pandemic has forced many changes to educators' teaching approaches. The pandemic has also highlighted the role that technology and the fourth industrial revolution play in the future of tertiary education. Many educators have to adapt to these changes and adopt strategies to benefit the students' prospective positions in various industries. Computer-aided design (CAD) has revolutionised the jewellery industry, mainly through decreasing production timelines, increasing the accuracy of the pieces, and creating production-ready designs. Initially, the industry was slow to integrate the technology, but it is now widely used in jewellery manufacturing.

CAD has been implemented in a South African university of technology's jewellery programme as part of the jewellery design module. Between 2018 and 2020, there was an apparent and significant change with each intake of first-year students' ability to adapt to the CAD software. Students quickly comprehend the commands and easily gather know-how about the technology. The students' computer skills and increased understanding of technology mean that educators must adapt and adjust teaching strategies so that the students can benefit in their future employment.

This research aimed to ascertain why each cohort of students adapts to CAD more readily and what factors play a role in the process. The methodology included a literature review and a questionnaire. The questionnaire was completed by the current first, second, and third-year jewellery students, gauged their interest in technology, and sought information about their exposure to technology before enrolling in first year and compared this to their CAD competencies during first year. Students were asked how they experienced the CAD learning process. The questionnaire's findings created solutions to CAD-specific problems the students face and assisted with the CAD teaching approach.

The research results include the data from the completed questionnaires of the students and are discussed in this paper. The research ascertains how the CAD teaching strategy should be altered to enhance the students' teaching and learning experience while remaining relevant to their competency level.

Keywords: Computer-aided design, jewellery design, student-led teaching strategy

Introduction

CAD was first introduced to the jewellery industry during the 1990s and was only fully embraced by jewellery designers from the early 2000s (Dalrymple, 2010, p. 6; Bernabei, et al., 2016, p. 2). Although

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initially slow to be accepted and integrated by the South African jewellery industry, CAD is currently used by most local jewellery designers and seen as an integral part of the manufacturing process.

As opposed to the traditional method of handwork, the advantages of using CAD in the jewellery sector are that CAD will help achieve better product quality, as accuracy will improve; will help increase efficiency, as existing designs or components are re-used or edited; and will help reduce the manufacturing time (Wannarumon, 2011, p. 41; Bernabei, et al., 2016, pp. 2-3). Most importantly, the CAD design file can be exported directly to the production process, namely computer-aided manufacturing (CAM), which usually involves the milling or printing of the CAD design in wax. The wax model is then cast in the desired precious metal, and the casting is finished by hand to create the final jewellery item.

The CAD training will equip students to design and create accurate jewellery items without yet having the experience or technical skill to produce such a model in metal by hand fabrication. This ability to use CAD will position the student well in the industry for a potential job application. Master goldsmith Lewton-Brain (1996) notes the importance of educating students in CAD systems and providing training in practical jewellery skills and jewellery design to give them the best possible options for the future. Bernabei, et al. (2016, p. 6) confirmed this by noting that according to CAD teachers, "students who have acquired skills in CAD/CAM have a better chance of succeeding in the jewellery business".

CAD training in jewellery institutions

CAD training is already implemented in various institutions. Matejovska and Achten (2011, p. 58) conducted a study in the Czech Republic on using CAD in the architecture field. The researchers observed increased students' computer use and skills before they engaged in their tertiary studies. This was mainly due to computer ownership, where over 97% of the interviewed students owned computers before registering for their tertiary studies. This computer ownership resulted in increased use of CAD in practice and a faster application of the technology by the students (Matejovska & Achten, 2011, pp. 58, 62).

Consequently, the teaching of CAD evolves according to the competencies of the students due to their exposure to various technologies. Garcia-Ibanez and Vergara (2016, pp. 1,2) confirm that the CAD curricula should be developed in line with the level of the CAD learners and that various methodologies are required to teach CAD-related abilities, such as special abilities and visualisation skills. Furthermore, the authors agree that educators should conduct action research to improve students' learning and contribute to the discourse of the profession (Garcia-Ibanez & Vergara, 2016, p. 2). In a study conducted with engineering drawing students, it was found that the students improved their skills through web-based interactive learning compared to the traditional learning tools (Cerra, et al., 2014, p. 398). This finding established that the learning capabilities of the students could be increased, specifically in CAD, through self-learning methodologies such as web-based interactive learning. However, Cerra, et al. (2014, p. 400) note that access to online platforms and physical resources, and adapting to students' needs are crucial to successful web-based learning.

Using the Rhino3d software programme, CAD was taught from 2013 onwards to the second and third-year students in the university of technology institution studied. Rhino3d is reasonably priced and widely used in the South African jewellery industry. From 2017, first-year students were given introductory lessons during the second semester. The CAD lecturer noticed a significant change in each intake between 2018 and 2020 in the first-year students' ability to adapt to the CAD software. Examples of the students' CAD designs can be seen in Figures 1 and 2.

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Figure 1: CAD ring design by Tebogo Mokoka, third-year student, 2020

Figure 2: CAD pendant design by Bongani Sakasa, third-year student, 2020

At the university of technology, students are taught in a dedicated CAD computer laboratory, where the lecturer's interface of the Rhinocerous software is projected. As the lecturer explains on the interface (an example of this interface is shown in Figure 3), the students follow the instructions on a desktop computer. Further exercises are given where the students must complete the task independently.

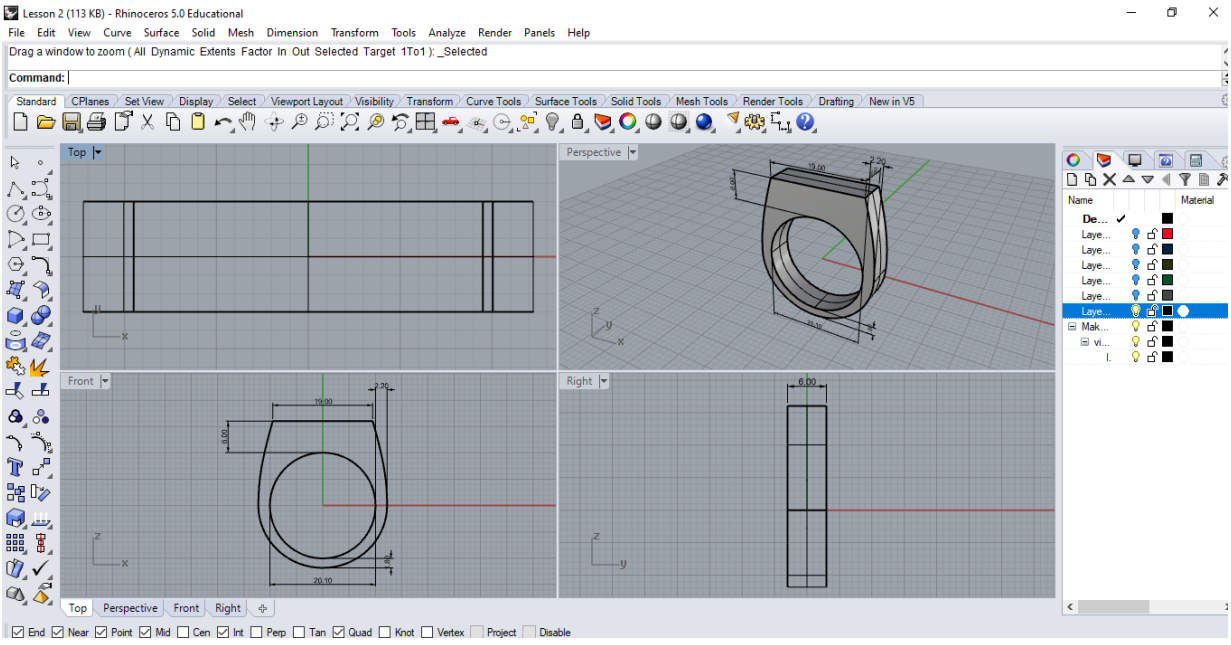

Figure 3: Example of the Rhinocerous CAD software interface

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With students comprehending the commands quicker and easier, it was apparent that the teaching strategy had to be adapted to the students' competencies and would ultimately benefit their future employment in the industry. This benefit is confirmed by Lin, Ulah, and Harib (2006, pp. 331,338), who note that a solid foundation in CAD/CAM at the undergraduate level is vital for generating economic growth. The CAD course offered in a programme should equip the students for life-long learning. Hence, the importance of developing and adapting the CAD curricula and teaching strategy according to students' competencies is vital in any training institution for improving the students' CAD-related abilities.

The adaption and assessment of the students' CAD-related capabilities will help develop a more student-led teaching strategy. In this strategy, the students are placed in the centre of the learning experience, giving them greater responsibility for their learning (Marvell, et al., 2013, p. 548). Rowley, Fook, and Glazzard (2018, p. 37) explain that student-led learning empowers students to take ownership of their learning. This strategy is essential to implement in tertiary education as it prepares students for the working environment through autonomy and self-expression. However, Rowley, Fook, and Glazzard (2018, p. 37) caution that a student-led teaching strategy should be a collaborative effort with the lecturer. The more experienced lecturer should act as a facilitator in the teaching process.

Research objective

The primary objective of this research is to investigatethe reasons for the increased application of the jewellery students' computer skills and understanding of technology, specifically in CAD, through a case study. If these reasons can be clarified, the educators can adapt and adjust teaching strategies so that the students can benefit in their future employment. The following strategies were used to reach the primary objective:

- Investigate the 'base-state' of students regarding their exposure to technology. This base-state indicated how the students were exposed to various technologies before their tertiary studies;
- Gauged the students' opinions about their current competencies in CAD and views about the CAD teaching strategy;
- Gained information from students regarding problems that they encounter in the current CAD teaching; and
- Explored possible solutions to CAD-specific problems the students encounter in terms of resources and teaching strategy. The students were asked their opinions about their future in the jewellery industry and the fourth industrial revolution.

Research methodology and design

The research followed a mixed method approach that consisted of a literature review and an online questionnaire. Data collected from the online questionnaire included the students' opinions, challenges, and knowledge about CAD.

The questionnaire was structured into four sections: the first section questioned the students' exposure to various technologies; the second section gauged the students' opinion on their current CAD competencies; in the third section the students were questioned about CAD problems they encountered; and the fourth section explored possible solutions to CAD problems faced and their thoughts about their future and future technologies.

Although the data obtained from the students' online questionnaire was mostly quantitative, qualitative data was obtained through open-ended questions that gave the students an opportunity

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to remark on their own opinions and experiences. The addition of these qualitative questions created a more in-depth response from the students, which could assist us in drawing better conclusions based on all the students' answers.

The questions in the questionnaire were formulated by adopting the recommendations of similar studies conducted about CAD teaching, whether the studies focused on student or lecturer participation. A study by Matejovska and Achten (2011) presented findings about CAD students before they registered for their studies and their opinions about their CAD practice. We used and adapted the questions from Matejovska and Achten (2011) for the first two sections of the questionnaire.

Sections 1 and 2 of the questionnaire are also based upon research by Garcia, et al. (2005) and Bernabei, et al. (2016). Garcia, et al. (2005) developed a questionnaire sent to CAD teachers at various Spanish universities to gauge various aspects of the present state of CAD teaching, including class duration and student capacity. Another study by Bernabei, et al. (2016) investigated the methods to incorporate into CAD in jewellery-design-based tertiary education institutions. In this study, a questionnaire sent to the CAD teaching staff of five institutions investigated teaching methods, perceived advantages and disadvantages, and possible problems faced by the CAD lecturer.

Sections 3 and 4 of the questionnaire included COVID-19-related questions and gauged the impact of the pandemic on CAD teaching and learning. Autoethnographic and phenomenological questions based on the CAD lecturer's observations and teaching experience were added in Sections 3 and 4 of the questionnaire.

Population

The participants for this project consisted of the entire student cohort of the tertiary institution's jewellery programme. Due to the small number of students registered in the first-year jewellery programme, all the jewellery students were invited to participate in this research. The participants included the first-year jewellery students (25 registered students), second-year jewellery students (20 registered students), and third-year jewellery students (29 students) of the 2020 academic year.

Results and discussion

Exposure

The first section of the questionnaire sought to understand what, if any, the student's previous exposure to or use of technology was before starting at a tertiary institution. The questionnaire presented various current technologies related to the fourth industrial revolution and asked what the students' level of exposure was to these technologies. The questionnaire also investigated for what the students used these technologies.

At least 80% of the students stated they had used or were still using smartphones, laptops, social media (Facebook, Instagram, and Twitter) and streaming platforms such as YouTube, Netflix, and Spotify. The students noted that they used these technologies for various purposes such as entertainment, connecting with friends, online learning, conducting research, learning about interests, and keeping up with current events.

Over 60% of the students used or still use gaming platforms such as PlayStation and Xbox for entertainment and to connect with friends, and 69% of the students used smart assistants and online learning platforms to assist them with research and learning.

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While few of the students had used any of the other technologies listed – software programming, CGI/animation, robotics, and artificial intelligence– most had knowledge of these technologies.

When asked whether the students had previous knowledge or had used 3D software programmes before their tertiary studies, 31% of the students had heard of (14%) or seen someone (17%) using a 3D software programme, and 28% had used programmes such as Blender (an open-source 3D modelling programme and architectural and industrial design 3D modelling programmes before starting their studies in the jewellery programme (Figure 4). The remaining 41% knew little or nothing of 3D software before entering the tertiary institution.

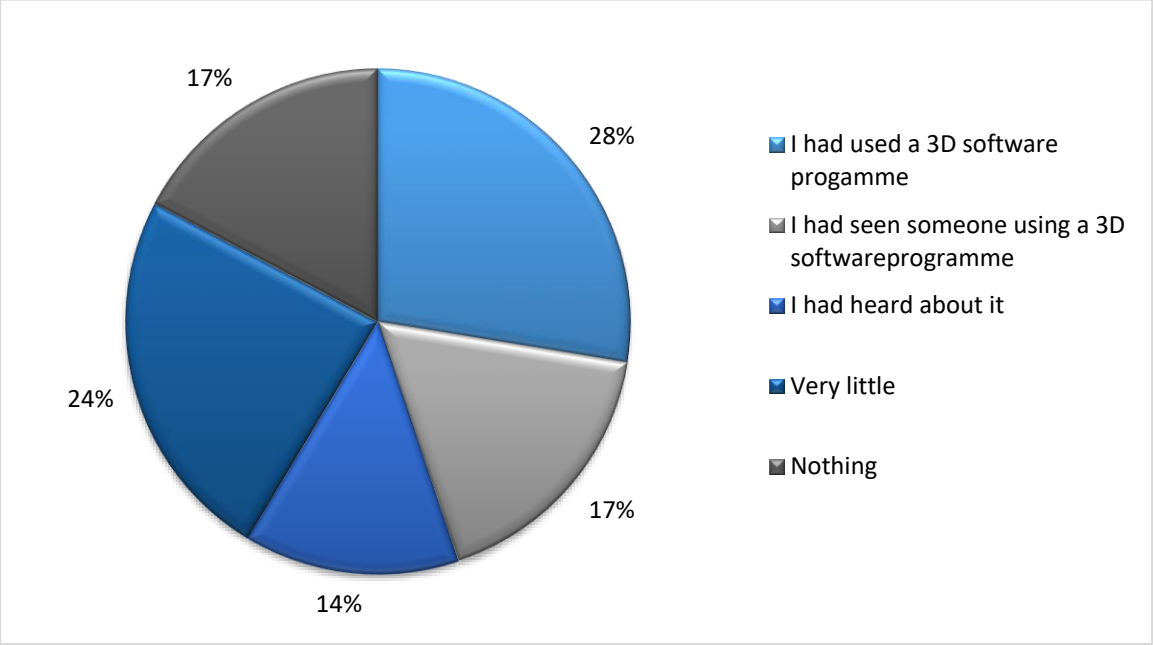

Figure 4: Students' awareness of 3D software before tertiary studies

With so many of the students showing an aptitude for the 3D software in their CAD class, it could mean that just the exposure to various technologies provides ease and confidence with using the newly introduced technology. Another possibility could be that the knowledge of 3D software provides them with aspirations of using these technologies. It can also be postulated that the students are further influenced by their newfound peers at the tertiary institution who have had previous exposure to these technologies.

If the students already engage and are familiar with several technologies, then these technologies can be explored for online teaching methods, for example, employing platforms such as YouTube or social media platforms for live streaming, instructional videos and forums, as well as using gaming disciplines as teaching methods.

Current competency

The next section of the questionnaire sought to understand how the students feel about their progress and what they think their competency is in CAD.

As seen in Figure 5, most students (93%) found the introductory CAD class exciting (62%) and informative (31%). The introduction demonstrates to the students where their skills will be useful and how learning the CAD software will assist them in the jewellery industry.

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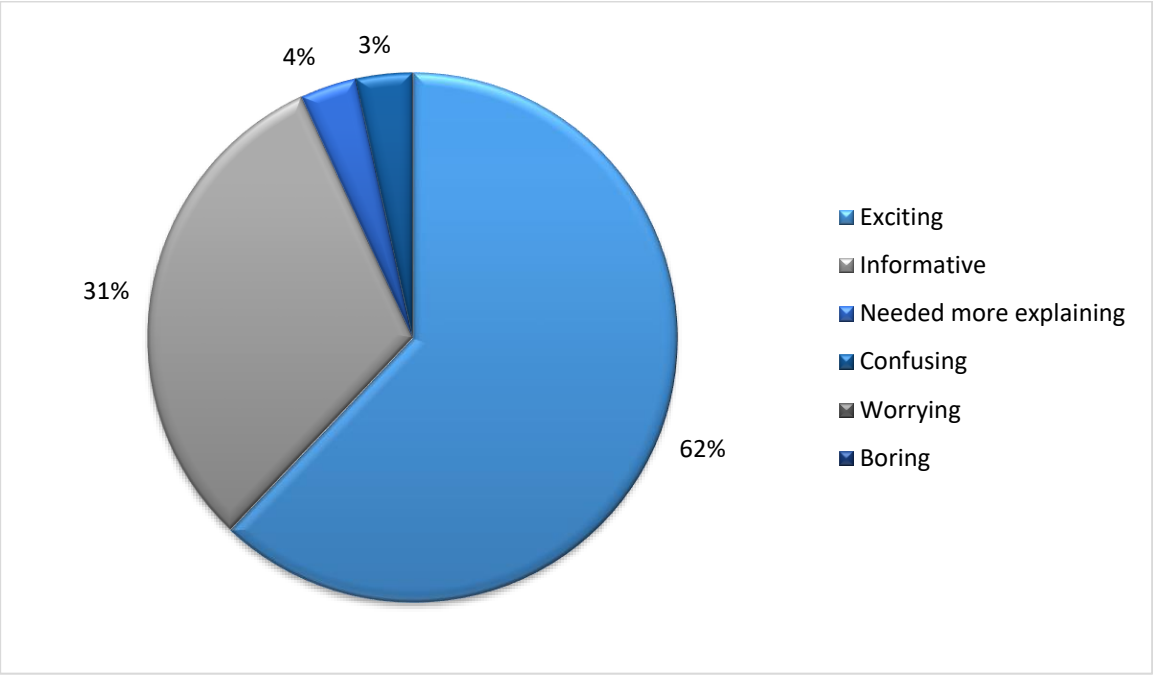

Figure 5: Students' experience of the CAD introduction class

Figure 6 shows that 69% of the students grasped CAD tools once the tools were explained by the lecturer. This clear grasp of CAD tools implies that the lecturer-led teaching remains important and can be implemented for online learning through online tutorials explaining and showing the various software tools in instructional and step-by-step videos. Figure 6 further indicates that it took a few lessons for some students to understand all the software tools (28%), and only one student took a few months to comprehend the tools fully.

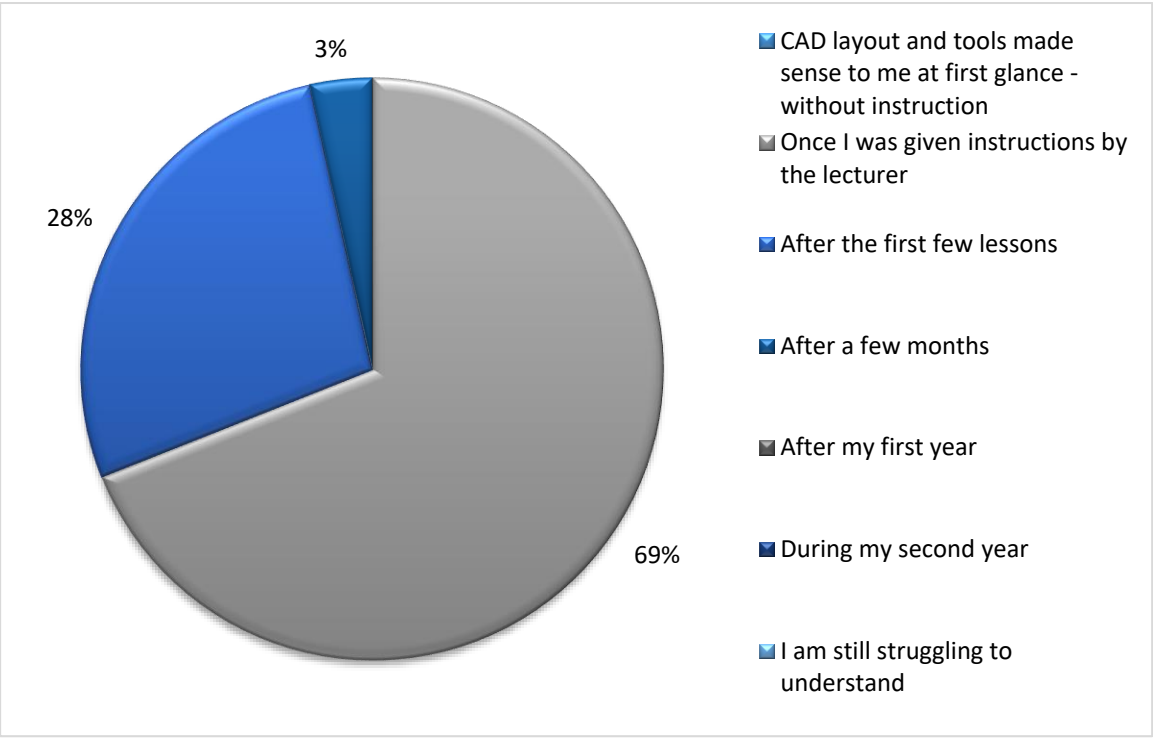

Figure 6: When students comprehended CAD layout and tools

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When asked how the students felt about their overall CAD experience, the response was positive. One student responded, *"I heard [a bit] about CAD before I came to university. When I arrived at university, I got a chance to work on CAD and through the lessons I [received] and practice I got the basic ideas of how the software works and now I am able to create a printable piece and I can be creative on the software"*.

When exposed to CAD, another student was astounded by the capabilities of 3D modelling and how it helps them design. The student noted: *"I was shaken by the idea of dimensional transitions, how you can build anything from nothing. To take a 2D structure to [an] 3D form from a push of a button at the comfort of your seat. Very exciting".* Several students said that they came to see the advantages of CAD over time, and to understand how the software could help them with design. A student who initially struggled with CAD enjoyed it once they understood it better: *"I just started liking CAD now as I have a way better understanding how and why things are done the way they are"*. Several students mentioned that they would like to have more classes, access to laptops, and the CAD software to improve their CAD skills.

When asked whether they can see themselves using CAD in the future, 90% said yes, and the rest of the students said maybe. Half of this 10% group responded that they would use it for jewellery-specific and related design work, and the other half responded that they would use it for any design-related work.

Problems faced

The questionnaire then examined obstacles the students faced both before and during the COVID-19 pandemic.

When asked whether once a week (before COVID-19) was enough time spent on CAD, 59% of the students answered no (Figure 7), and when given the option to suggest more hours, 72% suggested more days and/or hours a week. Around half the students (48%) suggested two classes, and a fifth (17%) suggested three or more classes. The remaining 7% suggested more hours per class. One student commented: "Technically two classes per week, but realistically one class per week will be enough considering that students have other subjects to focus on, so more classes might be a bit overwhelming even though it can be beneficial".

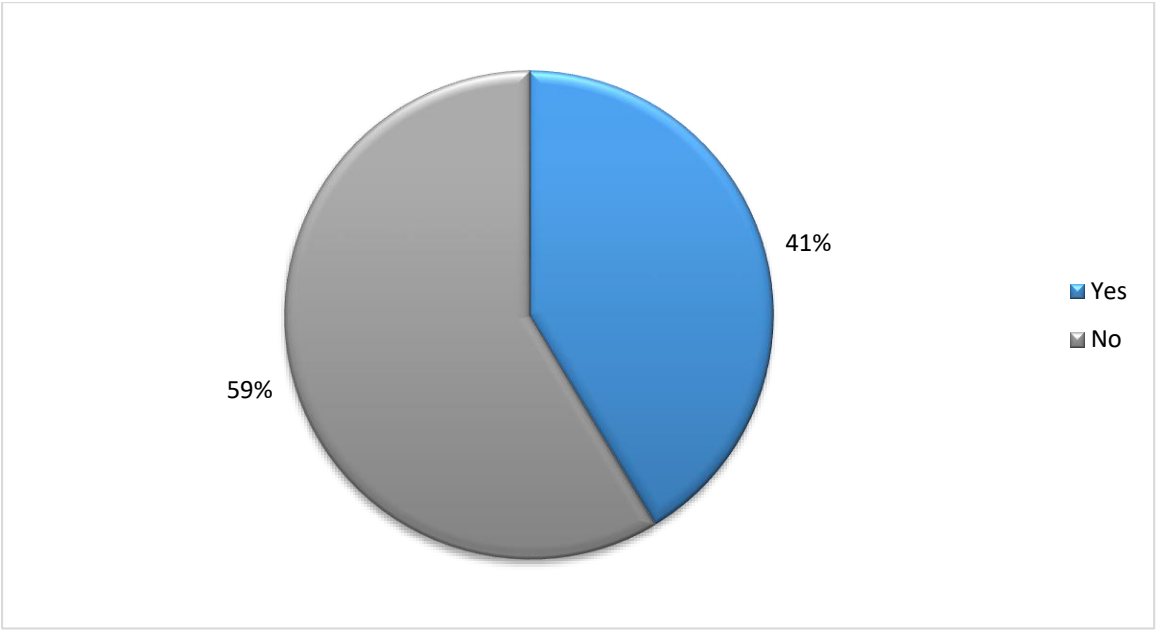

Figure 7: Students' opinion regarding whether there are enough CAD teaching hours per week

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During COVID-19, classes were halved due to social-distancing requirements. When asked if the students would be interested in online classes to supplement their missed class due to the COVID-19 protocols, 59% of the students replied yes. We asked the students if they had access to a computer. Of the students who answered yes, 65% have their own computer, 25% have access to a family computer, and 10% said they could use a computer at the community centre (Figure 8). Conversely, Figure 9 shows the breakdown of reasons students cannot attend online classes, with 24% not having access to a computer or laptop, 14% not having the right specifications to run the software, and 48% not having access to the software programme. Some students (9%) cited a lack of data as a problem, and 5% have network coverage challenges. When asked whether the students would do homework if they had access to a computer with the right specifications and the software, 100% responded that they would revise between classes to further their CAD skills (Figure 10).

This information about resources clearly highlights the importance that access plays in online teaching and for the students to revise for improving their CAD skills.

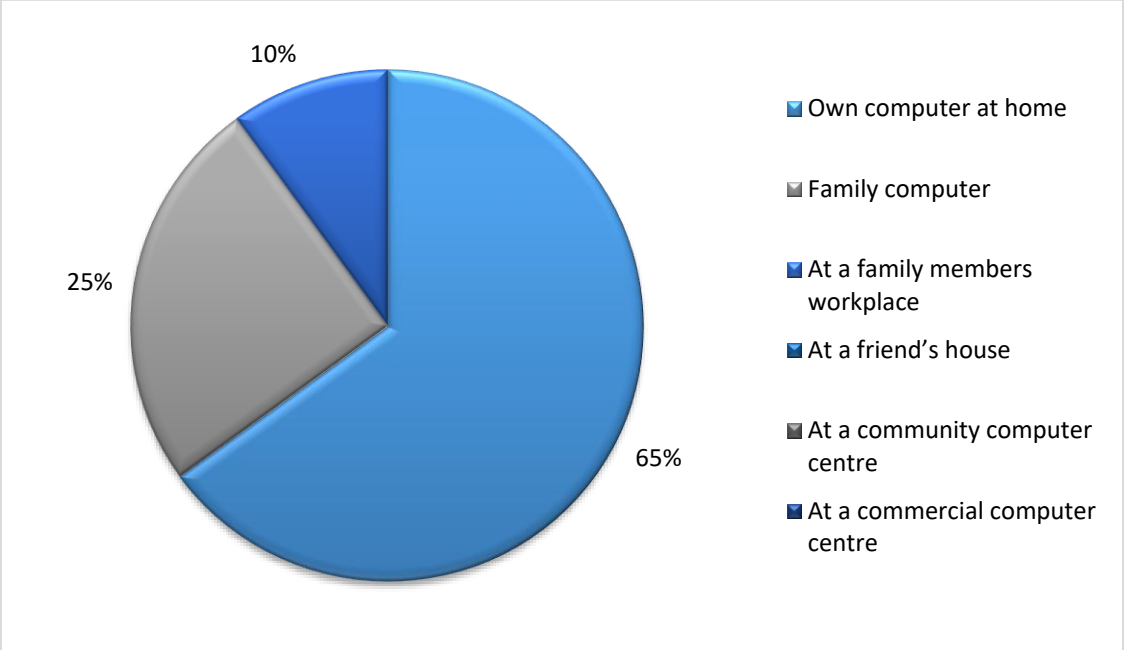

Figure 8: Students' after-hours access to a computer or laptop

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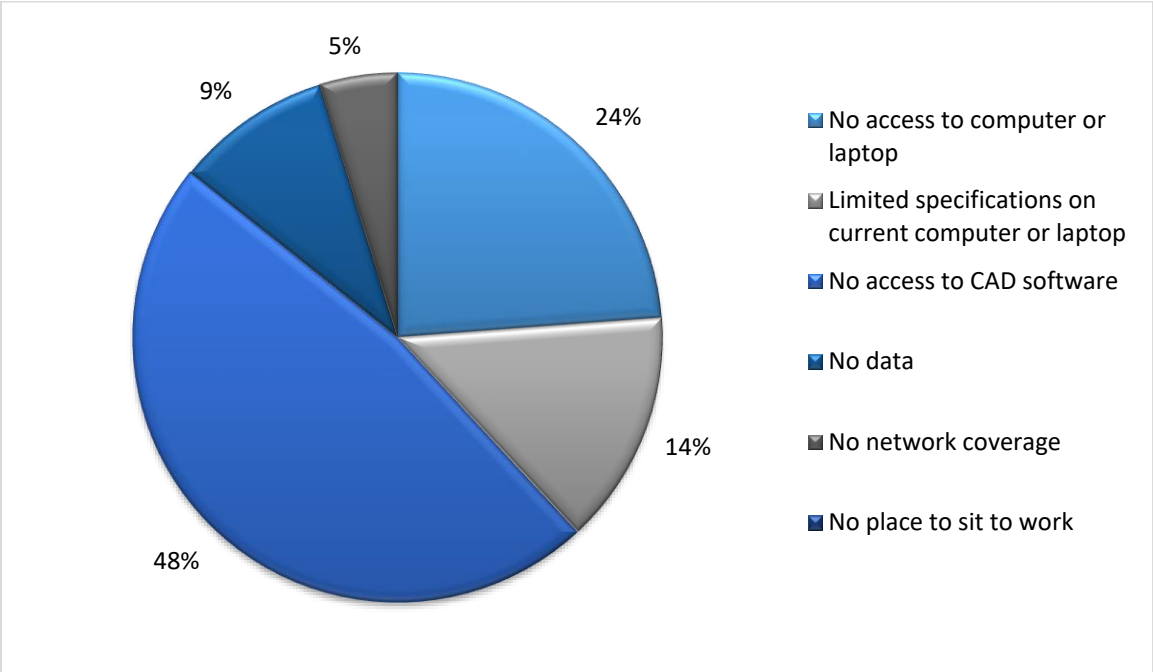

Figure 9: Students' reasons for not learning or revising online

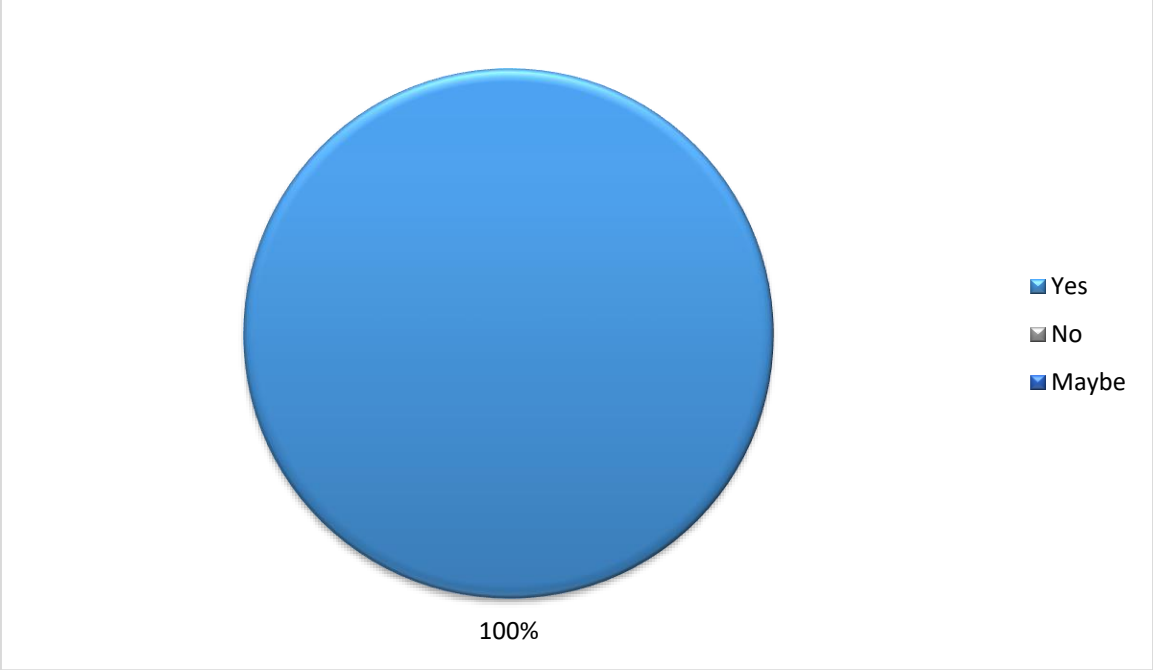

Figure 10: Students who would revise if they had access to a computer with the software

Solutions

The last section of the questionnaire gauged the students' opinions regarding possible solutions and concerns they have. The students were also asked their opinions about the fourth industrial revolution and what role they think the fourth industrial revolution will play in their futures.

We asked the students if they could complete online classes at their places of residence if they were given a computer and the CAD software. Figure 11 indicates that 83% of the students said they could complete online learning at their residence. Of the students that could not do online classes at their place of residence, 40% of them said they have no data (30%) or network coverage (10%) where they

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live, 20% have safety concerns when carrying around a laptop, 30% said their environment was not conducive to learning, and 20% said that they prefer one-on-one classes.

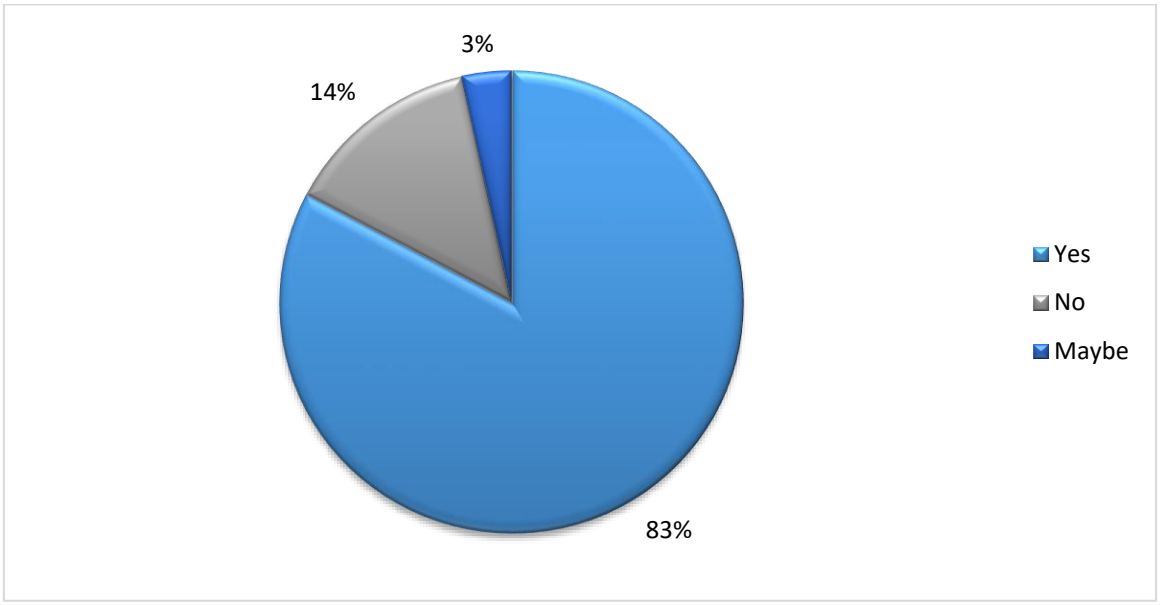

Figure 11: Students' accommodation's conduciveness for working online

When asked which platforms the students would prefer for online classes, the highest-rated choice at 58.6% was the institution's online learning platform. A close second was YouTube with 44.8%, online meeting platforms such as Zoom and Skype at around 30%, and WhatsApp at 24.1%. The ideal online teaching method for the students thus would be to integrate the platforms (such as YouTube and Zoom) within the institution's own online learning platform.

We also wanted to know which teaching methods would best meet the students' needs regarding online learning. Figure 12 shows that 72% of the students said they prefer online videos, with step-by-step videos are done by the lecturer (52%) being the most popular option. A small number (10%) of the students cited a combination of two or more of the options, and only one student responded that they prefer in-person classes.

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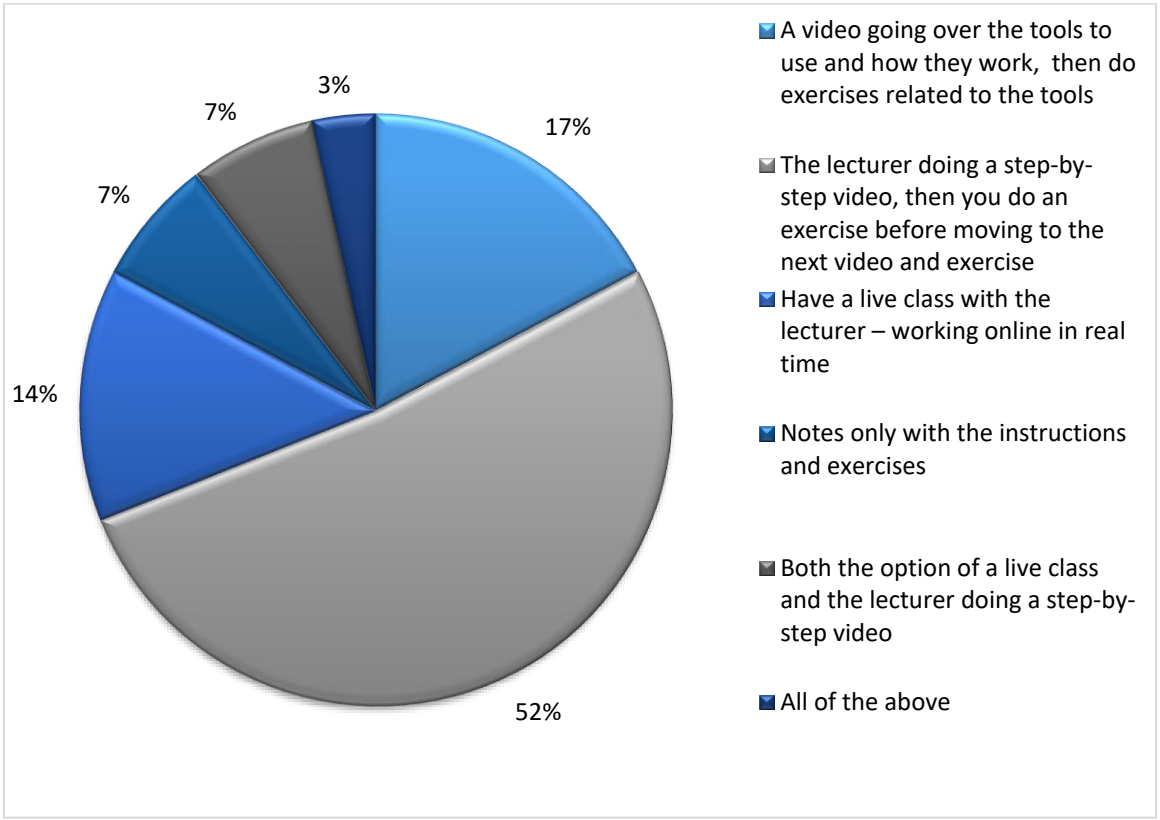

Figure 12: Students' choices regarding suitable methods for online learning

The students were forthcoming with their suggestions regarding online learning. Several students mentioned instructional videos as a possible solution: *"Video instructions are better because one can play back where they missed a step".* Another student suggested that *"The [instruction] videos should be online to be downloaded and viewed anytime".*

One student proposed the following: *"Come up with fun-learning activities related to the programme. Most art students are virtual learners with photographic [memory]. And our brains tend to capture what we do with our bodies more than what we do sitting down".*

When we asked the students what their interest would be in learning CAD in a gaming format, most of the students (79%) said yes, indicating that using gaming incentives could be incorporated as an option in the teaching method (Figure 13). Gaming could be implemented in various ways, such as various levels of learning or new tools that can be unlocked once having successfully completed a previous exercise, or using a 'reward' system for learning more 3D modelling skills.

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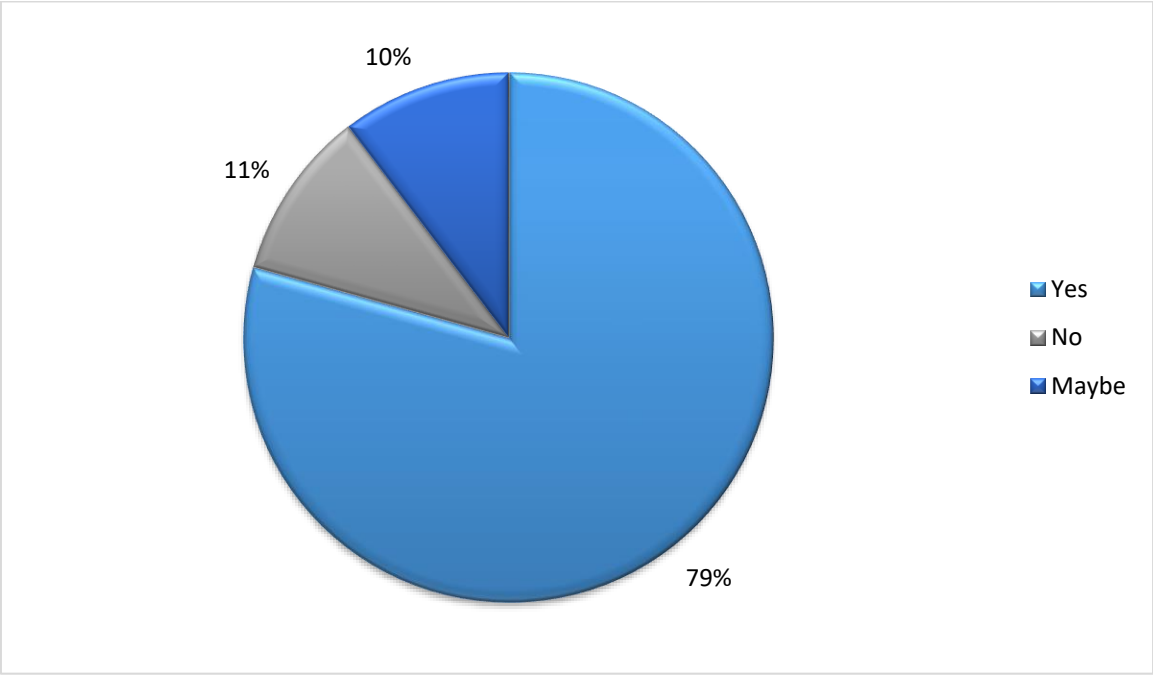

Figure 13: Students' interest in learning CAD using a gaming format

Most of the responses confirmed the importance of the lecturer facilitating any online teaching and that the students would like access to lecturers for guidance. One student suggested that *"If the lecturer [cannot] be a part of the live meeting, then having a diligent student who understands the programme well or an online tutor for the students while going over the lesson to assist them. TeamViewer could also be a handy application to show individual students on their programme what the problem is and how to fix it".* In this instance, an online forum could be a feasible solution where the students can raise their questions and respond to each other with the lecturer answering at allocated times.

Again, a few students reiterated the importance of having access to the software and hardware for successful online CAD learning. One student commented: *"Yes, if we can get laptops that have the right specifications to run the Rhino software. We will engage more on online learning via Zoom or live classes, making it easier for us as students to learn the programme swiftly".*

In our final questions, we specifically asked about the fourth industrial revolution and how the students felt about it. Overall, most students indicated that hearing the term 'fourth industrial revolution' made them curious and excited, while others were wary and nervous.

The students were asked what they knew about the fourth industrial revolution. Figure 14 shows that 34.5% had some knowledge, 28% had a reasonable amount of knowledge, 14% knew nothing, 21% very little, and only one student replied that they knew a lot.

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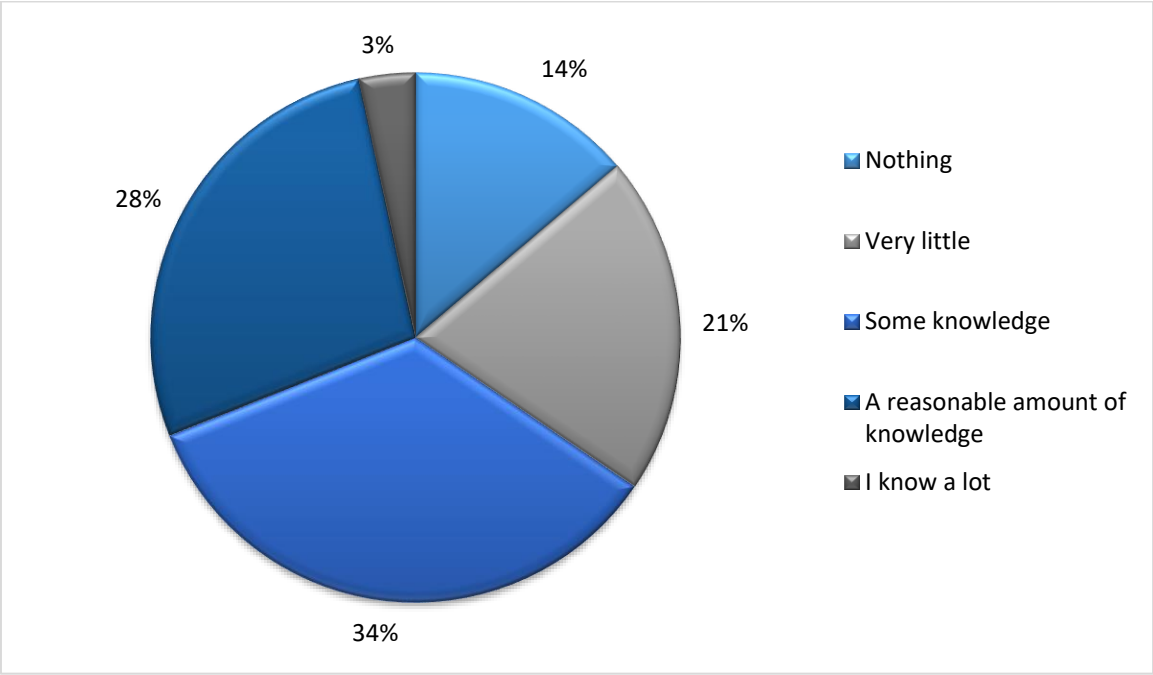

Figure 14: Students' knowledge about the fourth industrial revolution

The questionnaire then asked students in an open-ended question to mention their outlook about the future regarding the fourth industrial revolution. The answers ranged from overwhelming concerns about South Africa's socio-economic issues to concerns about an inability to keep up due to a lack of resources. Some students were worried about the new technology furthering inequality in the country, with one student cautioning, *"Increased unemployment may drive economic inequality in society".* A student also mentioned that the fourth industrial revolution could drive unemployment: *"I feel it will/is replacing the workforce on the production industries, thus means more [people] are [losing] their jobs through it's fast and efficient"*. Another student voiced this concern: *"it will make my job obsolete and that all working-class people will be out of a job".*

The lack of basic amenities in some of the poorer communities in South Africa was also mentioned with a student stating: *"Our continent isn't ready for that. We still have people that don't have access to running water and toilets. We can't really be talking about the prospect of 4IR".*

These students are concerned with their own development and also how their development will affect the rest of the country, and was very aptly put by the following comment: *"Not everyone has access to laptops/computers, quality education, and even the internet. How on earth will they catch up while the rest of the world is living in a digital era. This only means one thing for them, they will simply be left out, and that's not the world I want to live in".*

Conclusion

This paper aimed to gauge the students' CAD competencies so that CAD teaching can be improved in the jewellery programme. There is currently limited research available on CAD teaching for jewellery design and implementation. The study data was gathered through a questionnaire that was sent to all the registered jewellery programme students. The information gained in this research will be implemented in CAD teaching to improve the students' employability and address possible CAD-specific problems faced by the students.

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The first section of the questionnaire showed that most students were exposed to technology before studying at a tertiary institution. This exposure is ultimately beneficial for the students, as it helps familiarise them with the CAD software and tools.

Most students viewed themselves as competent in CAD and as understanding the CAD tools. Although most students found the experience positive, they mentioned that they only understood better once explained by the lecturer.

One of the prevailing problems that the students mentioned was the lack of resources required to complete online classes and revise. Other problems mentioned by the students include access to data and network problems.

The students are optimistic about using CAD in the future. However, concerns and apprehensions about the possible negative effect of these new technologies were raised. The students mentioned socio-economic problems such as unemployment and inequality as potential negative consequences of the fourth industrial revolution.

The students' overall positive responses and suggestions to this questionnaire provide a good online learning foundation on how to proceed with and adopt their suggested teaching strategies. Although a student-led teaching approach can be incorporated as a teaching method, the students mentioned that they still prefer lecturer input and teaching and are comfortable making suggestions about various teaching methods. Consequently, the students will become part of the CAD teaching methodology. Through student-teacher teaching collaboration, the students will become active role-players in their own learning experience.

This type of research is vital to address the unique challenges faced by South African students. How educators can improve the CAD teaching methodology in South Africa, specifically in jewellery design, should be considered an evolving process that is aligned to and influenced by student abilities and technologies.

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