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The Role of 3D CAD in Shaping Career Orientation in Fashion Education: Insights from the 3D4U Project

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Abstract. The present paper examines the relationship between learning virtual prototyping within an academic context and students' career orientation, as well as its association with perceived creativity and digital skills. It outlines the current state of the fashion industry and the growing need for specialized professionals, followed by a discussion of the role of universities in today's technological environment and the integration of CAD technologies and virtual prototyping into study programs. The "3D4U" project is also presented. A quantitative survey using a structured questionnaire was conducted with a voluntary, non-probability sample of 138 students from the six universities participating in the project. Within this sample, the findings indicate a very positive attitude toward the relationship between virtual prototyping and creativity and a relatively positive attitude toward the development of digital skills. The findings also show positive associations between perceived digital skills, creativity, and students' career orientation toward digital fashion and/or roles requiring competence in 3D CAD systems.

Keywords: Virtual Prototyping, Higher Fashion Education, Professional Orientation
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1 INTRODUCTION

The 21st century is an era of rapid technological advancements, bringing the Fourth Industrial Revolution, or Industry 4.0, to the forefront, with digital transformation at its core. Digital transformation is a disruptive force, defined as the advancement of business practices and processes, knowledge, and skills, to optimally integrate technology and rapidly impact society [1], and it focuses on the connection and collaboration of digital and physical resources [40].

The integration of these smart technologies into the industry marks a profound shift in the management of production and operations, revolutionizing traditional methods and offering significant opportunities in product development, production efficiency, and customer service [21], radically changing the nature of fashion businesses. The technologies considered pivotal are Big Data & Analytics, Autonomous Robots, 3D Simulation and CAD tools, the Internet of Things (IoT), Cybersecurity, Cloud Technology, 3D Printing, and Augmented and Virtual Reality. Furthermore,

digital fashion encompasses practices in physical stores and e-commerce, boosting online sales of fashion items [37]. These technologies can support the creativity of fashion designers and facilitate the development of a wide variety of products, as well as the establishment of smart factories to increase efficiency and sustainability [21,39].

In alignment with sustainability efforts, and establishment of a circular economy model, the European Union has proposed the introduction of a new tool, the Digital Product Passport (DPP) [38], which will serve to collect and share data throughout the product's lifecycle and present its characteristics regarding its environmental impact and sustainability, as well as the options and methods for its disposal and recycling. According to [28], integrating product digital twins into the Digital Passport is crucial, as this will enable real-time monitoring and analysis of a product's performance and environmental footprint throughout its entire lifecycle, thereby enhancing its transparency and traceability and providing valuable information. Furthermore, it will facilitate use by both manufacturers and consumers, enriching the database with visual data and helping to make more informed decisions.

It would be an oversight if, in mapping out the digital transformation, we failed to mention the rapid advancements in artificial intelligence and its impact on the fashion industry. With regard to the fashion industry, it has the potential to enhance both creative processes and the role of the designer [3,14,34], as well as the efficiency of production and business operations [16,21,23], introducing new dynamics to creative professions. However, the interaction between designers and AI systems varies significantly depending on the designer's expertise. Experienced designers tend to use AI tools more creatively, while beginners may rely on AI for feasible but less innovative solutions [34]. Thus, whether their creativity and imagination are enhanced or diminished following the integration of AI into the organic, so to speak, process of creation depends on how it is used and the risk of its misuse [3]. This underscores the need for continuous learning and adaptation as artificial intelligence and other technological advancements become more integrated into creative and production processes. In response to these changes, this study examines the current state of the industry, in relation to digital and CAD competencies, and the integration of virtual prototyping and 3D CAD systems into fashion and clothing curricula in higher education, focusing on how students' attitudes toward these technologies are associated with their professional orientation.

2 LITERATURE REVIEW

If they wish to optimally operate and innovate, fashion companies need to navigate this ever-changing and dynamic unfamiliar environment. They must be initiative-taking, adopt and adapt to new mindsets and management tools, and be able to integrate into digital culture in order to fully leverage the capabilities and opportunities offered by information and CAD technologies. To achieve this, training and expertise among the workforce are essential [21]. According to a study by [40] on job postings in the sector, the majority of positions require some level of digital skills, especially for designers.

Today, as the use of technology is more prevalent across all sectors and continues to grow, it is safe to assume that acquiring and possessing skills related to digital media and technological tools is becoming increasingly necessary. Researchers who have studied this phenomenon refer to Digital Intelligence, that is, the development of abilities following successful interaction with digital environments, which unfolds in distinct stages and can be considered one of the multiple types of intelligence, such as linguistic or kinesthetic intelligence [21,40]. The literature shows that continuous technological learning and development of new skills in the field are beneficial for both the individual's creativity and cognitive strength, and the professional evolvement and integration [1,6,39].

However, [20], in their examination of the Greek fashion sector and the digital competencies required within the country's apparel industry, identify a significant obstacle to ongoing digitalization: the shortage of digitally literate and adequately skilled personnel. They argue that

addressing this gap necessitates the systematic updating of educational programs, both within higher education and in professional training contexts, in order to strengthen the digital capabilities of the current and future workforce. That aligns with other studies supporting the need for digital evolution of academic institutions and informed curricula [1,10,27], in order to bridge the gaps in technological competencies, while supporting the students by creating opportunities for experimentation and innovation [7,9].

In response to those needs, several universities are adopting new practices to modernize their curricula and offer their students a stronger cognitive foundation. At this point, previous research on the integration of 3D CAD systems into higher education in fashion was examined. These studies have primarily focused on the relationship between these technologies and students' skills. 3D CAD was used either as supplementary teaching material [33] or as the main subject of study, either as a separate course or in relation to patternmaking and 2D CAD technologies [2,4, 17,18,29,32,36]. In all cases, the sample consisted of fashion students, while [8] investigated the impact of using 3D CAD on students specializing in the apparel business sector, indicating that the professional benefits of mastering such skills may extend beyond the design sector. Overall, the attitudes towards the integration of 3D CAD curricula were positive, highlighting its positive association with students' creativity, confidence, and competence. Yet, because 3D design technologies are not yet widely embedded within higher education, most research to date relies on qualitative methods, or mixed qualitative–quantitative approaches, to document how virtual prototyping is taught and to evaluate students' learning experiences. Notably, there remains limited attention to how such training is related to students' perceptions of their professional futures. Given the broader issues that the literature revealed, such as the lack of digitally skilled professionals, this gap represents a field of interest for further research. The novelty of this study therefore lies in its exploratory quantitative focus on the relationship between 3D CAD education, perceived creativity, digital skills, and career orientation in fashion education. Rather than claiming broad generalizability, the study contributes evidence from a multi-institutional educational project and identifies factors that may guide future curriculum design, especially regarding the role of perceived digital competence in students' interest in digital fashion careers.

3 METHODOLOGICAL FRAMEWORK

3.1 3D Concepts for Fashion Education in Ukraine (3D4U)

The Department of Creative Design and Clothing of the International Hellenic University has included Virtual Prototyping in its curriculum in 2019 following a curriculum revision that accompanied the department's transition from a technological education institute (TEI) to a university-level institution (AEI). The course is part of the 3rd year in the 4-year program and requires knowledge of 2D CAD and other digital tools. The integration of the Virtual Prototype into the curriculum, as well as the way the course and the final assessment are structured, significantly enhances the educational experience and academic level of the students. In particular, in terms of general skills, it functioned as a catalyst for the cultivation of critical thinking, helping students develop problem-solving skills. In addition, extensive contact with three-dimensional digital environments helped develop spatial visualization and perception skills to varying degrees, while the experiential nature of the work contributed to the acquisition of both theoretical knowledge and practical experience in the creation of virtual prototypes, thus increasing the students' competence in areas related to their studies [31].

Moreover, it is worth noting that the long-term goal of the course is to establish cooperation with foreign university departments with the same or similar experience in three-dimensional clothing prototyping, in order to carry out joint projects. Through this contact, students from various academic institutions will come closer together in a broader and more diverse environment of cooperation and exchange of knowledge and experience. The present study was conducted in parallel and within the contexts of the 3D4U program. Therefore, it is necessary to describe its nature.

The Department of Creative Design and Clothing (Kilkis) of the International Hellenic University (IHU) leads the 3D Concepts for Fashion Education in Ukraine (3D4U) from November 2023, to October 2026. Co-funded by Erasmus+, the project aims to increase the adoption of 3D technologies, such as 3D design, virtual prototyping, and additive manufacturing in higher education, strengthening related skills in fashion and supporting Ukraine's competitive capacity. The consortium includes eight partners: IHU (Greece), Technische Universitaet Dresden (Germany), Universitatea Tehnică "Gheorghe Asachi" din Iaşi (Romania), and three Ukrainian universities: Kyiv National University of Technologies and Design, Khmelnitsky National University, and Lutsk National Technical University, collectively covering a broad geographical area within Europe, alongside two nonacademic partners, Creative Thinking Development (CreThiDev) and the National Sectoral Partnership Fashion Globus Ukraine (FGU) [19].

3.2 Hypothesis

The aim of this study is to investigate students' self-reported career orientation in relation to their exposure to 3D CAD systems, in relation to the development of creativity and digital skills. According to [5], creativity is defined as the ability to express original and unusual ideas or to produce something new or imaginative, manifesting in various forms [22], including imagination, problem-solving ability, personal satisfaction, and proper assessment of various processes [13]. Within the context of the virtual prototype, virtual fashion utilizing 3D CAD has the potential to become a new medium for creative expression centered on clothing, leveraging the advantages and new possibilities of technology for the benefit of the creator [35]. Moreover, as stated by [39], today's professionals need to combine the skills of a creator with those of a fashion technologist and adapt to new digital environments. They must be able to use the appropriate digital tools, as well as evaluate their use and the quality of the results [40].

Finally, the experience and perceived quality of education play a significant role in students' attitudes toward their field of study. Students who actively participate in the educational process tend to demonstrate better learning outcomes and higher satisfaction, which can motivate them to achieve their goals [11]. When a student enjoys the educational process, they tend to increase their commitment and engagement with the subject [41]. Thus, a positive experience with this subject, as well as the quality of education perceived by the student, can be related to intentions regarding their professional future and interest in that specific field [12]. Specifically, within the fashion field, students' positive attitude, as well as their understanding of the applications and potentials of 3D CAD technologies, help to foster interest in and learning of these tools [15]. Furthermore, novel prospects for fashion originating from technological developments may encourage young creators to explore the roles and nature of clothing in various digital environments [26]. Taking all of the above into account and considering that present students are the professionals of tomorrow, as they come into contact with recent technologies through their curriculum, we can make the following hypothesis:

H: Research participants who report a more positive attitude toward 3D design tools are expected to report stronger career orientation toward digital fashion and/or roles requiring competence in 3D CAD systems.

3.3 Methodology

For the investigation of the exploratory research hypothesis and data collection, a quantitative, descriptive-analytical research method using a structured questionnaire was employed. The aim was to investigate the attitudes of students in fashion programs toward the ability to create virtual prototypes, specifically in relation to creativity, digital skills, and career orientation toward the field of digital fashion.

The participants were students from the five fashion universities (IHU, TUASI, KNUTD, KHNU, LNTU) that participate in the program 3D4U and include one or more courses in 3D CAD design in their curriculum. Moreover, due to its participation in the program and its advanced expertise in

3D/4D body scanning technologies for optimal virtual fitting of personalized clothing, the questionnaire was also sent to the Technical University of Dresden (TUD). To facilitate distribution, the questionnaire was created digitally using Google Forms. To accommodate people with different linguistic backgrounds, participants were given the option to choose between Greek, English, and Ukrainian. Participants voluntarily responded to a self-administered questionnaire, which they completed anonymously at their own convenience. Professors of the respective courses were asked to share the questionnaire link with their students, requesting their voluntary participation, in order to facilitate contact with students from foreign universities. Because voluntary non-probability sampling was used, the results cannot be generalized to fashion students at other institutions or in other disciplines [24]. Although the questionnaire was distributed across six universities, the final responses reflected varying levels of participation among institutions. The study is therefore framed as an exploratory, project-based investigation rather than as a representative cross-national study.

A 5-point Likert scale [25,42] was used for the questionnaire in order to measure students' attitudes more accurately and ensure a higher degree of reliability for the tool (1-Strongly Disagree, 2-Disagree, 3- Neither Agree nor Disagree, 4- Agree, 5-Strongly Agree). The questionnaire included 35 Likert-scale items, organized into an introductory section and three thematic groups regarding the relationship between 3D design and creativity, digital skills, and future career attitudes. Additionally, it included separate questions covering students' demographic characteristics, such as age, semester of study, and university, accompanied by an introductory letter describing the purpose of the research and instructions for proper completion. The letter emphasized that participation is voluntary and that the survey is anonymous, which increases the honesty of the responses and reduces bias in the data [24].

3.4 Result Analysis

The questionnaire remained available for one month and yielded a total of 138 responses from the participating 3D4U-related institutions. Descriptive and inferential statistics were used to analyze the data, and Microsoft Excel and SPSS were employed. Cronbach's alpha was used to assess internal reliability. According to [30], the acceptable internal consistency reliability level is approximately α= 0.70. For the questionnaire, as a whole, α = 0.78 was found, which is therefore acceptable.

Regarding the demographic composition of the sample, 39.9% of participants were between 18 and 21 years old, 39.1% were aged 22–25, 10.1% were 26–30 years old, and the remaining 10.9% were over 30 years old (Table 1). Regarding gender, 89.1% identify as women, 6.5% as men, 3.6% as something other than the previous two options, while 0.7% chose not to answer (Table 2). Regarding the university of study, 52.2% are from IHU, 15.2% from KNUTD, 13% from KHNU, 10.9% from LNTU, 8% from TUASI, and finally 0.7% from TUD (Table 3). 20.3% of participants stated that they are in their 7th semester of study, 13.8% in the 5th, 12.3% in the 3rd, 11.6% in the 9th, 11.4% beyond the 10th semester, 8% in the 8th, 6.5% in the 10th, 5.8% in the 1st, 4.3% in the 6th, 2.9% in the 4th, 0.7% in the 2nd, while the remaining 2.2% stated that they had graduated (Table 4).

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	18-21	55	39.9	39.9	39.9
	22-25	54	39.1	39.1	79.0
	26-30	14	10.1	10.1	89.1
	30+	15	10.9	10.9	100.0
	Total	138	100.0	100.0	

Table 1: Age.

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	Woman	123	89.1	89.1	99.3
	Man	9	6.5	6.5	10.1
	Other	5	3.6	3.6	3.6
	I do not wish to answer	1	.7	.7	100.0
	Total	138	100.0	100.0	

Table 2: Gender.

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	KHNU	18	13.0	13.0	13.0
	KNUTD	21	15.2	15.2	28.3
	LNTU	15	10.9	10.9	39.1
	TUASI	11	8.0	8.0	47.1
	TUD	1	.7	.7	47.8
	IHU	72	52.2	52.2	100.0
	Total	138	100.0	100.0	

Table 3: University of study.

		Frequency	*Percent*	*Valid Percent*	*Cumulative Percent*
Valid	0	3	2.2	2.2	2.2
	1	8	5.8	5.8	8.0
	2	1	.7	.7	8.7
	3	17	12.3	12.3	21.0
	4	4	2.9	2.9	23.9
	5	19	13.8	13.8	37.7
	6	6	4.3	4.3	42.0
	7	28	20.3	20.3	62.3
	8	11	8.0	8.0	70.3
	9	16	11.6	11.6	81.9
	10	9	6.5	6.5	88.4
	11	10	7.2	7.2	95.7
	12	2	1.4	1.4	97.1
	13	1	.7	.7	97.8
	15	1	.7	.7	98.6
	18	1	.7	.7	99.3
	28	1	.7	.7	100.0
	Total	138	100.0	100.0	

Table 4: Academic Semester.

In the introductory section of the questionnaire (Questions 1–5), the majority of participants stated that they were first introduced to 3D design through a university course (63%), are familiar with its applications in fashion (75.4%), and find the process enjoyable (68.1%). Furthermore, 76.8%

recognize both the limitations of 3D tools and the importance of virtual prototyping for the future of the industry.

The first section (Questions 6–15) recorded a generally positive attitude toward the impact of virtual prototyping on creativity, flexibility of thought, and problem-solving, with agreement rates ranging from 54.3% to 73.9%. Questions regarding difficulties in using the software yielded more balanced responses, with no clear negative trend. At the same time, nearly half of the participants (46.4%) disagreed that 3D design limits the artistic dimension or that switching between different environments constitutes a significant obstacle, during the creative process. In the second section (Questions 16–25), students assessed their digital skills. The majority stated that they had previous knowledge of other digital tools (67.4%) and that they could effectively combine different digital media (55.8%). At the same time, a significant percentage found the learning process for 3D CAD software more challenging than expected (45.7%) and reported that they were unable to fully develop their skills in their desired level within the time of the course (61.6%). Exposure to 3D CAD software inspired about four in ten to explore further technologies, while 63.8% would prefer a blended teaching approach combining traditional and digital methods from the start of their studies. Finally, 45.7% stated that they feel confident in their 3D design skills, while the 19.5% responded negatively.

Questions 26–35 examined students' professional orientations in relation to virtual prototyping and digital fashion. Following their exposure to 3D technologies, 65.3% of participants reported that they would consider new career pathways (Q26), and 71% indicated an intention to continue developing skills in virtual prototyping beyond their studies (Q28). Moreover, 63.1% expressed interest in specializing in digital technologies within the fashion and apparel sector (Q33), while 68.1% stated that they would be interested in pursuing careers in digital fashion and virtual environments (Q35). Regarding employability, 51.5% considered it likely that they would apply for positions requiring proficiency in 3D design (Q31), and 68.9% agreed that 3D skills provide a competitive advantage in the job market (Q34). In relation to curricular adequacy, 45.7% believed that their program offers a sufficient foundation for the demands of Industry 4.0 and the Metaverse, while 31.9% adopted a neutral stance (Q27). At the same time, 51.4% reported feeling unprepared for current industry requirements (Q29), and 54.3% viewed limited access to 3D tools after graduation as a barrier (Q32). Finally, a substantial majority (84.1%) agreed that free access to additional 3D learning tools, whether provided by companies or universities, would be beneficial (Q30) (Table 5).

	Q26	*Q27*	*Q28*	*Q29*	*Q30*	*Q31*	*Q32*	*Q33*	*Q34*	*Q35*
Strongly Disagree	4.3	8.7	5.1	5.1	3.6	7.2	7.3	1.4	4.3	5.1
Disagree	8.7	13.8	4.3	16	3.6	13.0	3.6	9.4	12.3	9.4
Neither Agree nor Disagree	21.7	31.9	19.6	27.5	8.7	28.3	34.8	26.1	14.5	17.4
Agree	31.2	29.0	29.0	35.5	23.9	23.2	32.6	25.4	34.1	23.9
Strongly Agree	34.1	16.7	42.0	15.9	60.2	28.3	21.7	37.7	34.8	44.2

Table 5: Professional Orientations and 3D CAD (%).

Following the descriptive analysis, additional statistical tests were conducted to further examine relationships within the dataset. Pearson's correlation coefficient (r) was used to identify associations between variables. This measure assesses the strength and direction of linear relationships without implying causality. In this cross-sectional and self-reported dataset, correlations were interpreted as associations rather than causal effects. Correlations were interpreted as follows: weak (r = 0.1–0.3), moderate (r = 0.3–0.5), strong (r = 0.5–0.7), and very strong (r = 0.7–1.0).

The strongest positive correlations observed were between professional interest in digital fashion (Q35) and specialization in digital technologies (Q33) (r = 0.64), indicating that participants interested in careers in digital fashion also expressed a desire to specialize in relevant technologies. A similarly strong correlation emerged between continuation of skill development (Q28) and career exploration (Q26) (r = 0.60), suggesting that exposure to 3D technologies motivates further professional development. The strongest negative correlations were identified between continuation of skill development (Q28) and difficulty transitioning between 2D and 3D environments (Q14) (r = −0.42), indicating that those intending to further develop 3D skills perceive the transition as less challenging. Additionally, confidence in 3D skills (Q25) showed a negative correlation with perceived importance of 3D (Q5) (r = −0.35), suggesting that lower confidence is associated with assigning less significance to 3D technologies.

Several additional correlations were relevant to the study's hypotheses. A moderate positive correlation was found between Q15 and Q35 (r = 0.39), indicating that participants who view 3D technology as enabling new career prospects also show greater interest in digital fashion professional field. A weak positive correlation between Q25 and Q31 (r = 0.28) suggests that students who feel more competent are somewhat more likely to consider applying for positions requiring 3D CAD skills. Finally, a very weak positive correlation between Q4 and Q32 (r = 0.15) indicates that awareness of the limitations of 3D tools has only a minimal association with concerns about access to such tools after graduation.

Next, the reliability coefficients α were calculated for each section individually, in order to improve validity and ensure accuracy in subsequent statistical tests. After that, the same test as before (Pearson correlation coefficient) was performed to identify correlations between the different sections of the questionnaire. The p-value Sig(2-tailed) indicates whether the correlation was significant at the selected alpha level. It represents the probability that a given r-value would occur by chance alone. Thus, it appears that there is a moderate positive correlation between creativity and the introductory questions, which explore students' broader attitudes and relationship with 3D, as well as between creativity and career orientation. This suggests that perhaps broader knowledge of 3D CAD tools and a positive outlook are linked to the stimulation of creative thinking during their use, while suggesting that students who perceive a positive impact on their creativity are likely to make future career choices within the fields of virtual prototyping and digital fashion. There is a strong positive correlation between digital skills, creativity, and career orientation. Thus, students who demonstrate enhanced creative thinking tend to handle digital tools with greater ease and operate with relative comfort in digital environments, while this same comfort and ease is very likely to be linked to their future career choices (Table 6).

		Introduction	*Creativity*	*Digital Skills*	*Professional Orientation*
Introduction		1			
Creativity	Pearson Correlation	**.445****	1		
	Sig. (2-tailed)	<.001			
Digital Skills	Pearson Correlation	**.244****	**.549****	1	
	Sig. (2-tailed)	.004	<.001		
Professional Orientation	Pearson Correlation	**.249****	**.474****	**.581****	1
	Sig. (2-tailed)	.003	<.001	<.001	

**. Correlation is significant at the 0.01 level (2-tailed).

Table 6: Correlations Between Variables (Pearson Correlation).

Finally, a multiple regression analysis was conducted to examine the extent to which introductory familiarity, perceived creativity, and perceived digital skills were statistically associated with career orientation within this sample. Unlike correlation, regression estimates the expected change in a dependent variable associated with a one-unit change in each predictor while holding the other predictors constant. However, because the study is cross-sectional, observational, and based on self-reported perceptions, the regression results should not be interpreted as causal evidence.

Dependent Variable: Career Orientation

Predictor Variables: Introductory Familiarity, Creativity, Digital Skills

Results:

Regression Coefficients (β):

- Introductory Familiarity: 0.1029 ($p=0.529$); not a statistically significant predictor.
- Creativity: 0.3499 ($p=0.026$); statistically significant positive association. Higher perceived creativity was associated with higher reported career orientation.
- Digital Skills: 0.6809 ($p<0.001$); strong and statistically significant positive association. Perceived digital skills were the strongest predictor in the model.

Adjusted R^2: 0.360. The model explains 36% of the variance in Career Orientation, indicating a meaningful but partial association.

Model Significance: The overall model is statistically significant ($p < 0.001$).

Therefore, within this sample, Digital Skills emerged as the strongest statistical predictor of Career Orientation, with each one-unit increase associated with a 0.6809 increase in the dependent variable. Creativity also contributed significantly, though to a lesser extent. Introductory Familiarity did not demonstrate a statistically significant relationship with Career Orientation. Overall, the model indicates that perceived digital skills and creativity are associated with students' professional orientation, while a substantial proportion of variance remains unexplained. This suggests that future models should include additional personal, institutional, pedagogical, socioeconomic, and labor-market variables.

4 DISCUSSION

For the majority of the sample, their first encounter with virtual prototyping and 3D CAD tools took place in the classroom, thus requiring them to learn not only a new tool but also a different way of thinking within the academic setting. Engagement with this specific technology was positively associated with an understanding of its significance within the broader fashion environment, while there also appeared to be an awareness of both its capabilities and its limitations. After all, the fashion industry is an interconnected ecosystem. Even if an individual is not an active participant in the sector's technological developments, they must at least be informed about it so as not to fall professionally behind. In this way, the course may have provided an opportunity for a deeper understanding of the subject to all students, regardless of their future goals, thereby enriching even those who do not wish to specialize in the field of digital fashion and 3D CAD.

In general, exposure to 3D design was associated with students' perceptions of creativity, imagination, and flexibility of thought across a variety of fields. A strong ability to integrate knowledge and use both 2D and 3D design environments was evident in individuals who do not struggle to learn new tools or program functions and are interested in developing their 3D skills after graduation, linking their future interests to their cognitive and digital skills. Participants who wish to pursue a career in the digital fashion industry are more focused and practice their skills in this field more frequently. In contrast, individuals who tend not to place much emphasis on 3D tend to be uncertain about their respective abilities. However, as already mentioned, the course was the first exposure to the subject for a large portion of the student body, and since becoming familiar with a new concept requires effort and time, for some students the creative process faced a hindrance and was related to feelings of frustration and dissatisfaction.

In terms of digital skills, the relationship appears to be relatively positive, but not for the overwhelming majority, nor perhaps to the extent that was expected. This could be partly

explained by the fact that it was their first experience, but also by the students' view that the course duration was insufficient for them to develop their skills to the desired extent within an academic framework and under guidance. They also appeared to view a different approach to the curriculum, one that incorporates a blended teaching method, as more conducive to building digital skills with parallel learning of digital and traditional tools and methodologies from the outset. Consequently, such an approach may help cultivate a collaborative mindset from the very start of studies and to apply knowledge from various fields in combination, potentially making the transition from analog to digital methods smoother and easier, even for those with no prior experience, and facilitating a more fluid adaptation to the needs of the labor market.

Practical exposure to 3D CAD systems and virtual prototyping -and theoretically to other modern technologies- was associated with interest in further professional development. Students were interested in exploring concepts such as digital fashion (avatar skins, digital showrooms, virtual prototyping and modeling, etc.), Industry 4.0, and the Metaverse. Individuals interested in working in the field of digital fashion reported a wish to explore new career options and specialize in the relevant technologies. Furthermore, the prospect of seeking employment within the 3D CAD sector is closely linked to a sense of competence and readiness.

Although students, to a certain extent, did not feel fully equipped for the needs and conditions of the contemporary fashion work environment, they recognized the importance of 3D CAD technology and its impact on the apparel industry and the future of the field. For the vast majority, the course laid the basic foundations of knowledge and skills upon which they wish to continue building after the course and their broader studies, and they aspire to specialize in digital technologies within the apparel and fashion sector. Furthermore, the competitive advantage these skills offer in the broader job market is widely recognized.

The strongest association with attitudes regarding future career choices was students' perception of their own digital skills. Exposure to the virtual prototype through a course in the curriculum was linked to students' reported development of existing skills and acquisition of new ones. Students who felt equipped with these skills also tended to report stronger interest in new paths. Particularly well-positioned to seek job opportunities in this field were those who demonstrated greater comfort and proficiency in using digital tools, which allowed them to creatively leverage their potential to the fullest extent. Thus, students who report stronger characteristics of digital intelligence may be better positioned to fill the gap in specialized professionals that the fashion industry faces. However, these decisions are not merely technical in nature. The perception of creativity also appears to play a significant role. Students who recognized the benefits of using 3D design technologies in their creative process reported interest in pursuing careers in contemporary digital fashion environments. The course may have offered them a new platform for expression and allowed them to explore the role of clothing in various contexts, and may have inspired some of them to become the professionals of tomorrow.

The results suggest that students view the inclusion of the virtual prototype in their curricula as a positive development. In fact, there appears to be a desire to extend the course over a longer period or to adopt a blended approach combining digital and traditional design methods. Survey participants reported a positive association to their creative thinking and imagination, as well as their digital tool management skills, which was also related to their reported professional intentions. Furthermore, easier access to both design tools and learning resources appeared to be particularly important for supporting professional interest, suggesting the need for meaningful collaboration between universities and industry stakeholders, as well as for the development of more inclusive and accessible tools, even after graduation.

The findings should be interpreted as exploratory and sample-specific. Within this non-probability sample of students participating in 3D CAD-related curricula, perceived digital skills and creativity were positively associated with career orientation toward digital fashion and 3D CAD-related roles. The regression model explained 36% of the variance in career orientation, indicating a meaningful but partial association. A substantial proportion of variance remains unexplained, suggesting that future research should include additional individual, institutional, pedagogical, socioeconomic, and labor-market variables. Larger probability-based or stratified samples,

longitudinal designs, and comparisons between students with and without exposure to virtual prototyping would be needed before stronger claims about generalizability or educational impact can be made.

5 CONCLUSIONS

The evolution of technology and its impact on the apparel industry are clearly evident. The Fourth Industrial Revolution is still unfolding. Technological advancements offer creators new possibilities and new avenues of expression to explore to their advantage, by learning proper usage and avoiding abusive practices. In conclusion, the need for new professionals equipped with digital skills becomes clear. Furthermore, the role of academic institutions in this new environment must be directed toward fostering innovation and supporting students, cultivating their talents and skills, and laying the groundwork for the future.

Academic institutions have not widely adopted 3D CAD systems and virtual prototyping in their curricula yet, even though they are not a recent development, as their complexity and the limitations that accompany them, particularly the cost of the equipment and software they require and the lack of specialized teaching staff, have posed obstacles. However, the international academic community is making significant efforts to modernize and incorporate new media. For this reason, the research conducted to date has primarily employed qualitative methods or a combination of qualitative and quantitative methods, with the aim of determining teaching methods of Virtual Prototyping and the outcomes of the students' experience. What distinguishes this study from much of the previous work is its exploratory quantitative focus on the relationship between 3D CAD education, perceived creativity, digital skills, and career orientation in fashion education. The contribution is not the discovery of an unexpected causal mechanism, but the empirical documentation of how students exposed to 3D CAD and virtual prototyping within fashion curricula perceive these constructs together, always with a focus on students' own perspective. Nonetheless, it is important to recognize the limitations of non-probability sampling. The questionnaires were distributed digitally by professors at the six institutions to their respective students. Therefore, the results are only applicable to this specific sample and cannot be generalized to the larger population of fashion and apparel design students or other related creative fields. The self-reported nature of the data also limits the extent to which the findings can be independently verified through third-party performance or employment outcomes.

The results of the study showed that students perceive a positive relationship with learning virtual prototyping, consistent with previous research. A tendency was observed among students to report interest in career paths related to 3D CAD and digital fashion, associated with critical and creative thinking as well as the development of skills through the lens of Digital Intelligence. Nevertheless, many students found the difficulty in accessing the appropriate tools after graduation and emphasized that easier access, not only to the appropriate design tools but also to learning tools, whether from the academic or industrial environment, may strengthen their professional interest. Therefore, the importance of modern technologies within universities is underscored. Modern academic institutions must navigate between traditional and digital media and design methodologies, in order to find the right balance for the maximum benefit of their students. Discussions regarding the benefits, as well as the limitations of implementing this technology, are crucial in raising awareness of the possible issues and stimulating solution plans. During this transitional period, universities require resources. They must have the appropriate operational equipment (hardware/software) to the extent that they can fully meet the needs of the student community; at the same time, they need teaching staff who are proficient in these technologies and capable of teaching them to all students. Thus, the need to support the professors themselves through training and professional development opportunities becomes apparent. At the same time, the importance of collaboration between academia and industry stakeholders is highlighted, not only to bridge the gap that may exist between them, but also to support students and offer additional opportunities, so as to cultivate future scientists and specialized professionals, as well as individuals with a passion for the fashion industry and a willingness to innovate.

Future studies may focus on larger populations, utilizing probability-based sampling methods in order to increase the objectivity of the results, make them broadly generalizable, and more clearly examine the relationship between 3D design and professional orientation, along with the development of various skills. Furthermore, research could be conducted among fashion students who have not been taught virtual prototyping and those who have, to compare skills such as pattern comprehension, creative thinking, or the effective presentation of a collection, and to identify—if any—the contribution of knowledge of this technology to other fields of education, and understand how this could be related to future professional choices. Finally, it would be interesting to investigate whether students' level of digital skills depends on how the respective courses are taught and to what extent it is due to external and cultural factors, such as the users' age and place of origin, the ease of access to technological resources, the university's location, as well as its equipment and the resources allocated for technological modernization. These would help to form a clearer picture of students' attitudes toward their future professional development. Longitudinal follow-up would be especially valuable for determining whether reported intentions are later reflected in internships, first jobs, or specialization choices, while external assessments of student work could complement self-reported perceptions.

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