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Research Article

Exploring Apparel Design Students' Willingness to Use Virtual Reality in the Sketching Phase of the Fashion Design Process

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Abstract

Virtual reality (VR) is a computer-generated experience through projection of shapes, objects, and scenic views via headset or helmet device and interpreted as a genuine realistic environment. The interpretation of the highly realistic projection from the eye creates an immersive experience for the user. The use of VR technology is utilized in an array of industry applications as well as learning/training spaces. In particular, when VR is used in an educational setting, studies have shown positive or improved student achievement for a variety of academic disciplines in conjunction with creativity, inspiration, engagement, and motivation. VR used in industry applications, specifically within apparel industries, has been reported to enhance efficiencies in retail, enable virtual garment fitting, and reduction of physical samples in the apparel design and product development process. Regardless of these demonstrated favorable outcomes from education and industry, few research studies have investigated students' willingness to adopt VR as a tool for use within their desired academic discipline (feeding into their future career path). As use in the apparel design and product development process has been reported, an opportunity exists to explore VR as an educational tool to ideate fashion design ideas in an individual's apparel design process. Thus, the goal of this study was to provide initial insights into students' willingness to use VR as a sketching tool, compared to traditional sketching tools, during the apparel design process. A multiple case study design was employed to examine the phenomenon in eight selected undergraduate Apparel Design students. The study was guided through the lens of the Unified Theory of Acceptance and Use of Technology (UTAUT) framework to examine students' willingness based on performance expectancy, effort expectancy, social influence, and facilitating conditions to use VR. A learning module was developed in a 300-level apparel design course specifically to explore VR as a sketching tool in their design ideation process. Students received a demonstration for how to use the Oculus Quest VR equipment and experimentation/practice time using the equipment in conjunction with the Gravity Sketch (GS) VR application which allowed student users to draw in virtual space on an imported preexisting dress form. Following the practice time, students then completed an apparel design activity using the VR tool. Students then completed a survey in which data was collected through mixed methods by questionary scales and open-ended questions. The findings suggest a relationship between social willingness to adopt VR in their design ideation process while also providing a structure for future researchers to expand the use of this technology in apparel design coursework.

Keywords: Virtual reality; UTAUT; Willingness to use technology; Apparel design; Fashion education

Introduction

Virtual reality (VR) is defined as a computer-generated experience characterized as a genuine or recreated environment in which a user encounters telepresence [1]. VR can be experiencedby the projection of shapes, objects, and scenic views commonly projected via headset or helmet device worn by over the eyes. The interpretation of the very realistic imagery from the eye creates an experience that makes the user feel immersed in the generated surroundings. VR technology is being utilized in a variety of work, health, and learning/training spaces and has shown promising benefits, in particular, to positively impact student achievement [2]. Improved student achievement with the use of VR as a tool, has been explored within the context of creativity [3], for inspiration source [4], engagement levels [5], and learning motivation [2]. VR used in industry applications, specifically within apparel industries, has been reported to enhance efficiencies in retail [6], virtual garment fitting [7], and apparel design [8]. Fashion design is an ever-changing and evolving sector that relies on new technology to improve production processes [9]. Therefore, higher education courses are incorporating the latest technology to help students prepare for the fast-paced fashion business [10].

VR technology is an emerging technology in the field of fashion. In this fashion industry, VR is used in different forms or devices such as head mounted VR devices [4], VR googles [11], to simulate special environments for retail, and/or computer based virtual 3d design and fit modeling software (such as CLO3D or Browzwear) [12]. Despite the different types of VR technology offered by tech companies, it is commonly referred to visualizing a virtual element/space through a device or screen. Hodges, et al. [13] stated that it is critical to incorporate developing technologies into fashion design classes since students will need to use advanced technologies, like VR, professionally in their futures. Several studies have been conducted on the use of VR in education to assess student engagement levels [5] and learning motivation [2]. The VR form in Kennedy's study [5] was a head mounted device where in Wyss's et al. [2] research the VR form was a computer-based program. However, only a few studies have been conducted to determine if students are willing to use VR (regardless of discipline/field). These relatively few studies on willingness to use VR creates an opportunity to build knowledge for embracing new technologies connected to realistic application in disciplines. As the fashion industry is currently employing different forms of VR, it has been deemed valuable to provide initial insights into how Apparel/Fashion Design students view using VR as a tool for executing their design ideas. This study focused on the idea generation step in which a designer sketches design concepts, developing multiple designs and methods to tackle the design challenge at hand. Understanding students' willingness to use VR to virtually sketch garment design ideas and their perspectives on its use during the creative process can give educators and scholars of teaching and learning (SoTL) useful information when preparing to employ VR in apparel design classes.

Apparel Design Process (ADP) Tools: Traditional Vs. Technological

The apparel design process is described as a series of steps aimed at solving a specific garment-related problem [14]. One of the initial steps is the idea generating where designers develop rough sketches of apparel designs. Including VR as a sketching tool during the idea-generation stage aligns with the purpose of this study since students are first exposed to the technology in this initial phase of their design process, as compared to introducing a VR form in prototype/sample development after using traditional tools in the ideation phase. Utilizing the VR tool to create rough sketches at this initial ideation stage also allows students with the ease of swift digital editing.

Traditional tools commonly used in the idea-generating stage include paper, sketchbooks, colors (pencils, markers, watercolors, etc.), and tangible drawing tools. Technological tools are referred to as computer-based devices such as tablets, applications, or software, and in this study, the technological tool was VR through which sketching was digitally executed using a VR headset and two hand controllers. The VR headset is a wearable helmet that displays a screen depicting a virtual environment, and sketching is performed in a virtual space using two hand controllers that allow using various drawing tools in the VR fashion design application.

Compared to traditional tools, the benefits include the ability to redo and undo processes, duplicate, transfer, cut, paste, construct layers, and draw straight and clean lines using grids, which have been reported as a simpler and time-efficient process than using traditional sketching tools and methods [15]. Figure 1 illustrates a VR-produced fashion item that was digitally sketched on a dress form.

Figure 1: Example of Virtual Sketching Output.
Note: Digital sketch using VR application "Gravity Sketch". Binhajib A (2022).

VR in education to engage learning

In general, virtual reality is a simulated space that can be experienced through sensory stimuli such as sound and visual images [16]; and viewed on a screen-based frame. Use of VR headsets or helmets allows individuals to watch and experience a virtual world that is comparable to the actual world [17]. Some studies regarding the use of VR within education have been conducted in recent years. These studies have focused on determining students' attitudes about VR use in the learning environment across college majors [18], other studies have investigated the impact of VR technology on student outcomes as an instructional tool [19], while others have studied students' engagement and learning motivation under VR conditions [2]. These studies suggest that students are positively motivated and engaged in the targeted learning context and that VR technology assists students' visualization skills. In general, studies suggest that VR can be an effective instructional tool in the classroom, particularly to assist with communicating ideas through visual/imagery output.

The Unified Theory of Acceptance and Use of Technology (UTAUT)

The UTAUT framework was developed by Venkatesh, et al. [20] and based on nine adoption or acceptance information technology theories: Theory of Reasoned Action, Technology Acceptance Model, Motivational Model, Theory of Planned Behavior, Combined Theory of Planned Behavior/Technology Acceptance Model, Model of Personal Computer Use, Diffusion of Innovations Theory, and Social Cognitive Theory. Figure 2 illustrates the UTAUT framework adapted from Venkatesh, et al. [20]

According to Venkatesh, et al. [20] the main factors that impact users' intention and behavior to use technology include performance expectancy, effort expectancy, social influence and facilitating conditions. There are two dependent variables in the UTAUT: Behavioral intention and use behavior. Behavioral intention is defined as the degree to which one is willing to use an information system [21]. In the sketching phase behavioral intention would be measuring if a student is willing to choose VR tool to sketch among all other available tools. The use intention is defined as a user's decision to adopt or use a technology to satisfy a specific goal [20], which in the sketching phase is a user's decision to use VR tool to sketch instead of using another tool. Therefore, we could state that behavioral intention is the willingness to use VR while use behavior is the actual decision to use of VR. According to Venkatesh et al., use behavior is the actual usage and adoption of a technology [20].

As illustrated in the UTAUT framework (Figure 2), there are four independent variables that significantly impact users' intentions to use technology: effort expectancy, performance expectancy, facilitating conditions, and social influence. Effort expectancy, the first factor, is described as the degree to which users believe that using the system is easy. Effort expectancy mirrors similar factors in other theories such as those that address perceived ease of use [21], complexity [22] and ease of use [23]. These factors indicate how difficult or easy it is for users to use the targeted technology, which has an impact on users' intention to use the technology. Thus, the following research proposition was developed for the present study:

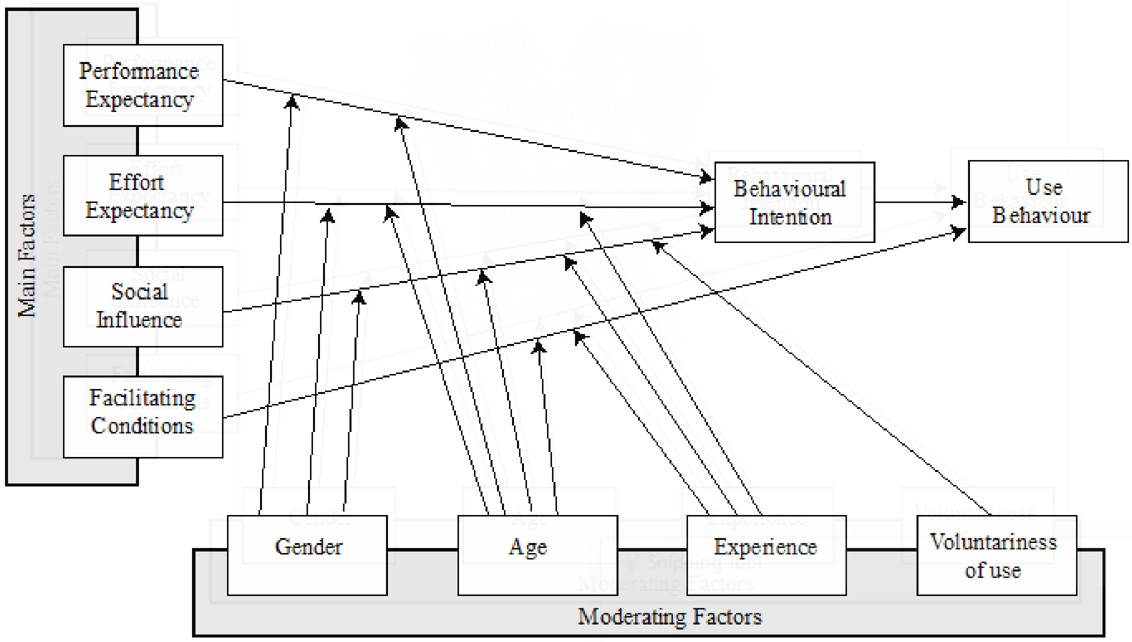

Figure 2: Unified theory of acceptance and use of technology.
Note: Unified Theory of Acceptance and Use of Technology. Adapted and shortened from Venkatesh, et al. [20].

1. There is a positive relationship between effort expectancy and college Apparel Design students' willingness to adopt VR in the idea-generating stage of the apparel design process.

The second factor, performance expectancy, is described as the degree to which a given technology is perceived as useful and helpful while performing a job. Performance expectancy aligns to the fit for the technology and how well the technology will aid in achieving the expected outcome. Sair and Danish [24] investigated the relationship between effort expectancy and intention to use Mobile Commerce and found a strong positive relationship between performance expectancy and intention to use. Performance expectancy characteristics indicate whether a system lives up to the job it was designed to perform. Based on these findings, the following proposition was developed to examine the impact of VR performance expectancy on Apparel Design student's willingness to use VR during the idea-generating stage of the design process:

2. There is a positive relationship between performance expectancy and college Apparel Design students' willingness to adopt VR in the idea-generating stage of the apparel design process.

The third factor, social influence, is described as the degree to which an individual perceives that it is important that others believe he or she should use the new system. Some individuals have an elevated level of respect for individuals such as instructors, peers and social models who use new innovations [20]. Hussin, et al. [25] explored educators' acceptance of VR technology usage in Malaysian classrooms and found that social influence was the strongest element that influenced educators' willingness to utilize VR. These findings provide credence to the link between social impact and consumers' intention and desire to adopt VR. Therefore, the following proposition was developed for this study:

3. There is a positive relationship between social influence and college Apparel Design students' willingness to adopt VR in the idea-generating stage of the Apparel Design Process.

The UTAUT framework provides strong guiding structure for the purpose of the study, as the main factors directly align with the end goal of understanding apparel students' willingness to use, via behavioral intention, which can lead to behavioral use. In addition to these main factors, there are also facilitating conditions which can impact a student's end use or adoption of a technology, which again, is the use of VR as a tool within the sketching phase of the garment design process.

The fourth factor, facilitating conditions, is described as the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system [20]. According to Groves and Zemel [26], facilitating conditions include the materials and organizational support needed to use a technology system in order to accomplish a task. Facilitating conditions are also influences within the working environment (or learning environment, in the case of this study) that increase a user's willingness to adopt a technology (23) such as guided assistance, training, online references/resources, and workbooks. Lin C (27) investigated users' intention to use e-books under the UTAUT framework guidance and found that facilitating conditions significantly and positively impact users' intention behavior to use e-books. Based on this finding, the following proposition was developed to examine the impact of VR facilitating conditions and Apparel Design student's willingness to use it during the idea-generating stage of the design process:

4. There is a positive relationship between facilitating conditions and college Apparel Design students' willingness to adopt VR in the idea-generation stage of the apparel design process.

Types of facilitating conditions

In this study, facilitating conditions were resources provided for students to assist in the use of VR in the apparel design process for carrying out a course activity. Within this study, resources included the VR headset used in class, training, demonstration, and online training videos. The resources were selected for study inclusion after reviewing recommendations by other published authors who adopted VR or similar technology for educational purposes. The first resource to be considered when adopting new technology is training and practice. Since the study targeted students with no experience in VR design ideation, a training session was provided to students to demonstrate how to use the new technology. Including low/no-point value for training exercises with new technologies has been recommended in educational settings [28,29].

The second resource to consider when adopting a new technology is arranging enough space in the classroom/studio to execute use of technology (VR) -- a recommendation for educators [29,30].

A third resource is providing video tutorials to help students learn how to use VR through further instruction and encourage practice. Studies in which participants have watched video tutorials for operating a new tool have shown that videos are useful in learning a new technology [28-30]. Therefore, in the present, video tutorials were included to help supplement student learning of the VR application for fashion sketching.

The fourth resource is the planning time needed for each student to learn how to operate the VR equipment. Time should be considered based on the required task. For example, it was suggested that using VR as a sketching tool for 30 minutes is a sufficient amount of time for a student to accomplish a given sketching task [28]. Therefore, 30 minutes of practice/planning was outlined for students to familiarize themselves with the VR application prior to executing the design sketching task.

Finally, the fifth resource to consider when adopting VR is providing access to it. The more access students have to any given new technology (such as VR), the more they will be motivated to try it and then practice using it during leisure time [30,31].

Based on the findings and recommendations gleaned from the literature, the following propositions connected to the UTAUT main factor of facilitating conditions was developed:

5. Providing help/training/assistance is positively related to Apparel Design students' preference as a type of facilitating conditions.

6. Providing video tutorials is positively related to Apparel Design students' preference as a type of facilitating conditions.

7. Providing sufficient time is positively related to Apparel Design students' preference as a type of facilitating conditions.

8. Providing enough physical space is positively related to Apparel Design students' preference as a type of facilitating conditions.

9. Providing access to VR technology is positively related to Apparel Design students' preference as a type of facilitating conditions.

Method

Research design

An explanatory multiple case study approach was used. Explanatory case studies deal with questions of what' [32]. The purpose of this case study approach was to build propositions and provide initial insights for students' willingness to use VR in their design process for fashion educators and to build future inquiry. Qualitative and quantitative data collection methods were combined to enhance validation and facilitate a better understanding of the phenomena of interest [33,34]. In this study, propositions 1,2,3, and 4 were addressed through the UTAUT Willingness to Adopt survey scale and the proposition 5,6,7,8,9 were addressed through open-ended questions. Pattern-matching was utilized for statistical analyses for all data [35].

Pattern-matching is a data analysis method developed by Yin [32] where each data source is collected and analyzed independently, then synthesized in a comparative format to identify repetitive patterns that exist among the data (score/values or text) – as independent cases and among multiple cases (depending on the case study method employed in the research) [32,35]. Figure 3 provides a graphic depiction for the pattern-matching process explained by Almutairi, Gardner, and McCarthy [35].

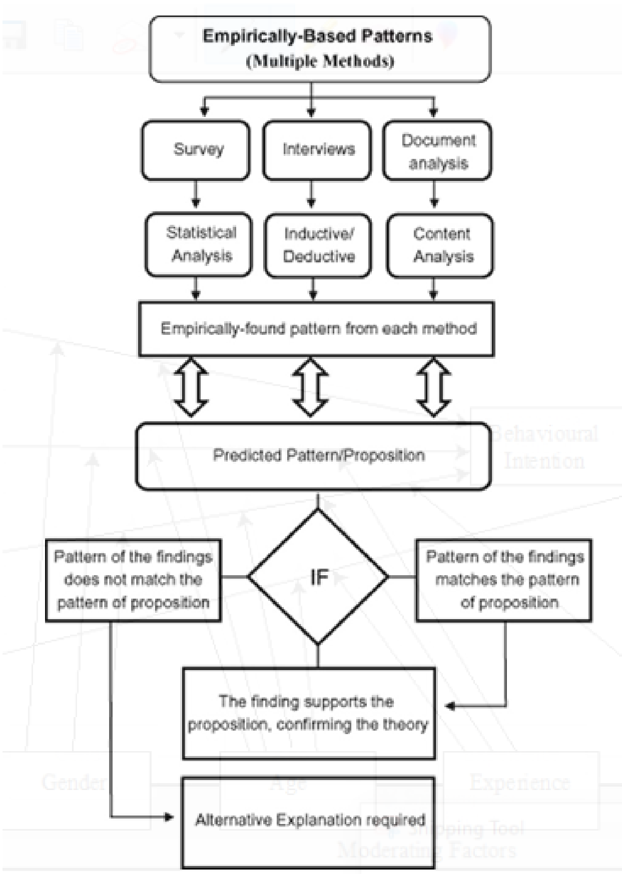

Figure 3: Pattern-matching process.
Note: This figure is a graphic depiction for the pattern-matching process. From Almutairi AF, Gardner GE, McCarthy A. Practical guidance for the use of a pattern: matching technique in case: study research: A case presentation. Nursing & health sciences. 2014 16(2): 239-44. Copyright Almutairi, et al. [35].

In this study, the pattern-matching process described and illustrated above was used as a guide, informed by past literature of use/adoption of VR, use of VR in educational settings, and apparel design pedagogy, for analyzing the collected data in this study. It is important to note that only survey data were included in this study, however the survey instrument gathered quantitative and qualitative (further detailed in the following sections).

Unit of analysis

Yin defined unit of analysis as the precision of the case study and how the fundamental problem and research questions can be answered [32]. In this study, the unit of analyses were responses from individual undergraduate Apparel Design students (upper level, junior/3rd-year status). The research focus was to understand students' willingness to use VR in the design process, therefore, the unit of analysis was limited to students working in a select apparel design course where the structured fashion design process was followed [37]. Technological tools are usually introduced or used in upper-level courses; therefore, the unit of analysis was limited to Apparel Design students in upper-level classes. To have included first-year Apparel Design students would not have been appropriate as they would have just begun to use traditional tools in learning fashion sketching basics.

Sample recruitment and course selection

Sample recruitment employed the purposeful sampling approach [32], which is acceptable for examining a specific participant group—in this case, undergraduate Apparel Design students who had experience use traditional sketching tools in Apparel Design classes, but who had not yet experienced VR to carry out any type of fashion design work. To assess the VR issues selected, students enrolled in a 300-level university course on Digital Textile Apparel within a department that offered a fashion design program of study. Students enrolled in this course had already studied basic traditional fashion design sketching techniques (prerequisite course) and were selected as participants for this study. Note: More proficient student participants (i.e., senior/4th year students) would have been accustomed to utilizing traditional sketching tools and may have been resistant to adopting a new technology. Targeting enrolled Apparel Design students enrolled in this particular course aligned with the goal of this study.

VR tool

An Oculus Quest VR equipment set served as the primary tool. Additionally, students used a sketching application with each VR equipment set, and Gravity Sketch (GS) constituted the VR application. This application allowed users to draw in virtual space on an imported preexisting dress form.

Instruments

Two forms of evidence were collected in this case study to address the goal and purpose of this study: a questionary scale and a set of open-ended questions. As discussed in the literature review section, effort expectancy, performance expectancy, social influence, and facilitating conditions all are main factors that can influence a user's willingness to use or adopt a new technology, which in this study was VR technology. The questionary scale was based on the UTAUT framework initially developed by Venkatesh et al. and then modified by Hussin, et al. [20,25]. The questionnaire was modified to explore student's particular interests in VR adoption and measured the UTAUT variables using the following: effort expectancy (4 statements), performance expectancy (4 statements), social influence (4 statements), and willingness to use (3 statements). Statements about facilitating conditions (4 statements) were adopted from Shen et al. who investigated factors that affect students' use of VR head-mounted displays in learning [36]. The constructs, measurement items, guiding source, and scale items are outlined in Table 1. All statements were evaluated with a 5-point Likert scale with 1=strongly disagree, to 5= strongly agree.

Table 1: Questionnaire items.

Construct	Item	Source	Scale Items
Effort Expectancy	EE	Hussin et al. [25]	- Using virtual reality is simple and easy to use.
			- It easy for me to master the VR application/system.
			- Learning how to use VR application/system is easy for me.
			- Interaction with the VR application/system is clear and easy to understand.
Performance Expectancy	PE	Hussin et al. [25]	-Using VR devices are useful to develop design sketches and ideas.
			-Using VR devices increased my productivity in developing design ideas.
			-VR is very useful in enables me to sketch my design faster.
			-VR is very useful in instilling student's learning spirit and interest towards course content.
Social Influence	SI	Hussin et al. [25]	-An individual who influenced my behavior thinks I should use VR as a sketching tool.
			-My class peers make me to think that I should use VR as a sketching tool.
			-Having the professor and the researcher was very helpful in helping me to adopt the VR application/system.
			-In general, the class environment support the usage of VR application/system

Behavioral Intention (Willingness to Use)	WU	Hussin et al. [25]	-I plan to use virtual reality devices in the future to sketch my designs (or continue to do so).
			-I assumed that I will be using (or think about using) virtual reality in the future for design sketching.
			-I intend to use virtual reality devices in the future in the design process to sketch my designs (or continue to do so).
Facilitating Conditions	FC	Shen et al. [36]	-I have the necessary resources in class to use VR in sketching my design.
			-I have the knowledge necessary to use VR.
			-The VR is not compatible with other design software I use.
			-An instructor or group of students are available for assistance with VR difficulties

The second part of the survey included open-ended questions. Five of the questions were developed and modified to address the propositions that align with the different facilitating condition types: 1) help/training/assistance, 2) video tutorials, 3) sufficient time for practice, 4) adequate physical space, and 5) access to VR technology. These facilitating conditions refer to the resources (organizational and technical infrastructure) that supported the use of VR as a sketching tool within the fashion design course. The open-ended prompts for student response were informed by published research from Bixter, et al. [38] and Ghobadi and Sepasgozar [39] who gathered participant perceptions and attitudes toward VR adoption using the UTAUT framework. These open-ended question prompts are outlined in Table 2.

Table 2: Facilitating Conditions Prompts.

Proposition	Prompt
Providing help/training/assistance is positively related to Apparel Design students' preference as a type of facilitating conditions.	-Did you need help or prefer to be helped while using VR? Please explain why or why not?
	-Which facilitating conditions helped/did not help you learn to use VR?
Providing video tutorials is positively related to Apparel Design students' preference as a type of facilitating conditions.	-What facilitating conditions do you need to improve your experience with VR? For example, more video tutorials, more help/assistance, more space, more access to technology, or more time to practice? - What suggestions do you think would improve the facilitating conditions to use VR?
Providing sufficient time is positively related to Apparel Design students' preference as a type of facilitating conditions.	
Providing enough physical space is positively related to Apparel Design students' preference as a type of facilitating conditions.	
Providing access to VR technology is positively related to Apparel Design students' preference as a type of facilitating conditions.	

Integrated into the open-ended question portion of the survey instrument included some general questions to the student participants to gather data that could potentially provide insight into features that could be integrated into the VR sketching application, learning module structure and extended resources, and general qualitative data that supported/verified responses from each student (positively or negatively on the 5-point scale). Table 3 outlines these additional open-ended questions pertaining to the VR learning experience within this study.

Table 3: VR in Apparel Education Prompts.

Educational Insight	Prompt
Enhanced features (equipment or application) to execute intended fashion sketch idea	-What are the features that you look for in using VR in sketching?
Comparison to traditional sketching tools – informing curriculum	-How does the VR application help or hinder you in sketching your designs compared to a traditional method?
Intrigue with VR technology – interest in new technologies/learning new tools to execute discipline workflow	-If VR was not a tool to use in this class, do you believe you would be interested in using this technology in your design process? Why/why not?
Industry support/validation of VR as tool for coursework workflow success	-If your peers/ classmates/ friends use VR in their design would that increase decrease your willingness to use VR? Why or why not?

Industry support/validation of VR as important tool for career success	-If more fashion designers adopt VR in the design process would encourage you to adopt VR in your designs? Why or why not
Student connection - informing curriculum to align/support with student interests	-What suggestions would you give if VR were to be used in apparel design courses?

Data collection procedure and timeline

During a single week in the academic semester, two course meeting sessions were devoted to the VR sketching module. Each participant had a hands-on experience using a VR tool: first a training session followed by a design session. Prior to the VR sketching module, students had already completed an online background and screening survey. The survey acted as a screening tool to exclude first-year and graduate students, as well as individuals with prior expertise using VR in apparel design. Those accepted as participants then began the training session which included a VR demonstration, a video tutorial, and training to use the VR equipment. The design session constituted the second day of the VR sketching module. Students utilized VR technology to sketch a garment of their design. Students were placed into small groups and given a VR headset for 30 minutes to complete a fashion sketch. Figure 4 is one example of a student's sketch created using the Gravity Sketch application.

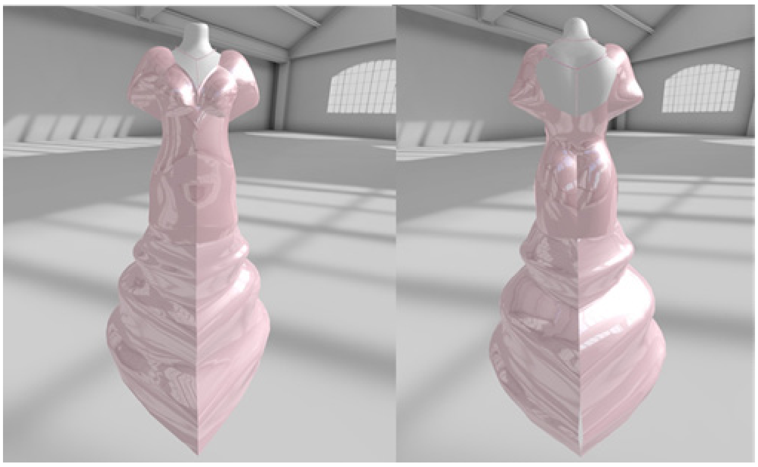

Figure 4: VR Fashion Design Sketch.
Note: Design sketch created by one of the student participants of study using the Gravity Sketch application. Binhajib A (2022).

After completing the VR sketch, student participants responded to the survey questionnaire (scale and open-ended questions) and data were analyzed.

Data analysis procedure

Quantitative and qualitative data were examined separately. Numeric data were evaluated using SPSS whereas qualitative data were analyzed though a developed narrative summary [per suggestion of Yin [32]] and content analysis. The pattern matching analysis technique was used to address the propositions and aided in the identification of response patterns among cases. The pattern-matching technique was independently executed by the authors and matches were compared for reliability of the analysis for interpretation. The pattern-matching technique allowed for subsequentially identification and comparison of patterns that manifested in the data. In order to identify patterns between the willingness to use construct in comparison to the other constructs, participant responses were put in ranked order from the lowest to the highest degree of 'willingness to adopt' score (see example of ranking in Table 4). The pattern matching technique was useful to identify data patterns or forms (suggesting relationships) among constructs within the individual student cases and comparing them to literature. After the pattern-matching data analysis technique was completed, propositions were either supported or modified based on the findings.

Table 4: The Mean Participant Scores for UTAUT Constructs.

UTAUT Construct	Number of scale items	P.1	P.2	P.3	P.6	P.8	P.4	P.7	P.5
Willingness to Adopt VR	3	3	3	3	3	3.67	4	4	**4.33**
Performance expectancy	4	4	3.25	3.75	3	2.75	2.75	3.5	4
Effort expectancy	4	4	3	4.25	3.25	2.75	**2.25**	3.25	4

Social influence	4	3.5	3.75	3.5	3.5	3	4	3.5	4.25
Facilitating conditions	4	3.25	4	3	3.25	3.5	3	3.75	3.25

*Bold numbers represent lowest and highest participant mean scores

Findings and Discussion

Participant information

Eight undergraduate Apparel Design student participants constituted the sample used in this case study, where each student's responses were a single case. Three student participants were juniors (37.5%) and five were seniors (62.5%). Students at this level had already studied fashion design skills, rendering them a strong fit to meet the study's purpose. Six students self-evaluated their sketching skills at an intermediate level (75.0%), and two (25.5 %) evaluated themselves as advanced prior to the VR sketching module via the screening survey. Among all eight students, only two had previous experience using VR; however, neither used the same VR tool in the present study, nor used any VR design application. It was critical to ensure participants included in the study did not use the same VR program while using VR in the fashion sketching activity. Six students (75%) had previously only used paper and pencil (traditional tools) while sketching their designs. One student (12.5%) only had experience with sketching design ideas with a tablet (technological tool), and one student (12.5%) had experience using both paper and pencil and a tablet to sketch the designs. During the facilitation of the VR sketching activity, all students initially sketched their designs using either traditional tools or tablets, which provided insight into their preferred/comfort for sketching tool. This sketching tool was noted via observation as their inclination for sketching tool might have impacted their willingness to use VR as a sketching tool view. All eight participants met the study inclusion criteria.

Willingness to adopt VR

The researcher compared the data from the survey via pattern-matching technique and reported patterns that suggest potential relationships between willingness to use constructs (Table 4).

Participant summary: The overall results showed that mean student response scores to all items (effort expectancy, performance expectancy, social influence, facilitating conditions, and willingness to adopt VR) ranged between 2.25 and 4.75, meaning that no students selected 1 or 2 (disagreeing with the items), nor did anyone select 5 (strongly agree with the items). Table 4 outlines the data values organized by cases (student participants: P1, P2, etc.). Previous studies have also reported a relatively narrow range of participant scores using the UTAUT scale [40,41] for technology adoption and therefore suggest that sample size large or small does not necessarily yield to larger ranges in mean scale scores.

The scores for willingness to adopt VR in Table 4 show that P.2, P.6, P.1, and P.3 all had the same 3.00 mean score, the center point on the 5-point Likert scale. The central point of the Likert scale indicates "undecided." Therefore, this could be interpreted that the four students were undecided about their willingness to adopt VR. On the other hand, P.8, P.4, P.7 and P.5's mean scores fell in a range between 3.67 and 4.33, indicating that the participants were undecided, but leaning toward a willingness to adopt/use VR as a sketching tool.

The performance expectancy scores for P.1, P.2, and P.3 fell in a range from 3.25 to 4.00, indicating that the participants were undecided on how they agreed (or disagreed) the VR tool would perform in the manner that they expected to execute their fashion design sketch idea. This could mean that they found VR somewhat useful for performance, but that they could not totally agree about how useful it might be as a tool to perform consistently to execute their design ideas through virtual form. P.6 was also undecided about performance expectancy, possibly indicating the individual could not decide if the VR application was useful during the sketching task nor if she/he were willing to use it. On the other hand, P.8 and P. 4 scored 2.75, possibly indicating they did not consider VR to be useful in sketching (compared to preferred tools – traditional or tablet); however, their willingness to adopt VR was high. This indicates that P.8 and P.4 were willing to adopt VR, regardless of whether they thought it useful or not. Finally, P.7 and P. 5 scored 3.50 and 4.00, respectively. The scores for these two suggest that they found VR useful and were willing to adopt it (Table 4).

One possible reason for these patterns could be that students did not view the VR application as useful for sketching garments since the application was built for sketching and designing in general, and not specifically for designing fashion apparel. Sair and Danish [24] examined the performance expectancy of mobile commerce to determine how consumers perceive online shopping as useful. Participants were asked to evaluate the technology for a specific use: online buying and selling. This approach was counter to the present study in which participants evaluated a VR application that was not specifically designed for apparel sketching.

Effort expectancy scores for participants P.1, P.2, P.3, and P.6 ranged from 3.00 to 4.25. Comparing participant scores of effort expectancy (EE) to others, EE scores were higher than their willingness to adopt VR scores. This could be interpreted to mean that all four participants (P.2, P.6, P.1 and P.3) viewed VR as an easy tool, but they were undecided about adopting it. On the other hand, P.8 and P.4 scored 2.75 and 2.25, respectively. Their lower scores in effort expectancy suggest they did not totally agree that VR was easy or required less effort. However, it may suggest that even though the VR tool was not easy to use, they were willing to adopt it. P.7 scored 3.25 and P.5 scored 4.00. This indicates that both P.7 and P.5 found VR an easy tool to use, and therefore it could have impacted their strong willingness to adopt it (Table 4).

One possible reason could be that effort expectancy was shown to have a different relationship with the willingness to use construct in other studies. For example, Raman et al. reported that effort expectancy had a significant positive relationship to willingness to use technology in the classroom [41]. Furthermore, Lin examined acceptance to use e-books with 320 random individuals chosen from the public as a sample and found that effort expectancy had no direct influence on intention/willingness to use [27]. However, effort expectancy had an indirect link to intention to use e-books when moderated by facilitating conditions.

All three participants (P.1, P.6 and P.3) received the same mean scores for social influence with 3.50 and 3.00 in willingness to adopt VR. Based on their scores, their answers regarding the impact of social influence ranged between undecided and agree. This suggests that students somehow agreed with statements about social influence; however, they were still undecided about their willingness to adopt VR. On the other hand, P.8, P.7, and P.5 scored higher for a willingness to adopt VR than for social influence, perhaps meaning they were undecided to almost agreeing to social influence but were willing to adopt VR. Overall, all eight participants had high scores for both variables. Finally, P.2 scored 3.75 for social influence and 3.00 for willingness, showing that this participant agreed with social influence, but remained undecided about their willingness to adopt VR, thus supporting the proposition. The findings, therefore, align with reports found in the literature and support a positive relationship between social influence and intention to use technology [25,27].

Scores for facilitating conditions show that P.3 was undecided about whether facilitating conditions were sufficient and whether they were willing to adopt VR, scoring 3.00 for both facilitating conditions and willingness to adopt VR. On the other hand, P.1, P.6 and P.2 scored higher (3.25 and 4.00) for facilitating conditions than for a willingness to adopt VR. This could mean they found facilitating conditions somehow sufficient, but they remained undecided about adopting VR. Finally, P.8, P.4, P.7 and P.5 scored lower for facilitating conditions (3.00-3.75) than a willingness to adopt VR. However, the overall scores showed that students were undecided regarding agreeing to facilitating conditions and willingness to adopt VR. It is concluded that facilitating conditions may influence students' willingness to adopt VR, a result that is consistent with findings in the literature [27,36,40].

In summary, the quantitative results illustrate a potential positive relationship between the independent constructs (social influence and facilitating conditions) and the dependent construct (willingness to adopt VR); while effort expectancy and performance expectancy suggest a slightly negative or no relationship to willingness to adopt VR, among the student participants in this case study. These findings provide insight for Fashion Design educators to design VR activities (or possibly other new technologies) to be structured in a social setting to allow students to interact and engage in problem-solving exchanges to learn and practice the new tool. Additionally, educators can enhance the facilitating conditions outlined in this study to assist student learning so as to support students' willingness to use VR technology in their fashion design process. Suggestions to enhance the facilitating conditions are detailed in the following sections. Conversely, SoTL educators may consider excluding measures that gather data on effort expectancy and/or performance expectancy from pedagogy studies as findings in this study suggest it may not lead to useful data. Rather future studies could consider exploration of alternative frameworks (beyond UTAUT) to inform study constructs and developed or utilized instruments for data collection.

List of preferred types of facilitating conditions

VR training, practice and assistance: Student participants emphasized the importance of practice and training as important types of facilitating conditions. For example, P.7 stated, "Having help on hand," while P.3 wrote, "If I get stuck then yes, I would prefer to have help while using VR." Overall, the pattern matching technique of qualitative responses to the open-ended questions within the survey showed that all eight participants preferred having an assistant or direct help when using VR, regardless of if they considered it difficult or not. Students shared that direct and individualized assistance is preferred if they need to be reminded of certain steps/functions of the technology or if they desired more training in general to learn basic functions of the equipment and sketching application. This finding aligns with the Joundi, et al. report stating that (new to the technology) students prefer additional training and assistance to use VR [28].

Sufficient time: Time was one of the facilitating conditions that students mentioned when expressing their levels of success using VR in the design process. Students stressed the importance of having sufficient time to properly train and use VR. For example, P.3 wrote, "I think being able to give students enough time to work on their designs is very important for success." Pattern matching showed that time was mentioned by six of the eight participants. Therefore, the majority of the participants in this study felt like sufficient time (at least the 30 minutes allowed in this study, but more time could be considered) should be provided to effectively use VR in the design process. This finding of sufficient time was also supported by findings of Joundi, et al. who mentioned how students need sufficient time to navigate a new technology and perform a given task [28].

Video tutorials: Participants agreed that the tutorials were useful and mentioned that even more tutorials would have helped them use VR to design their garments (more efficiently and more accurately representative of their conceptualized design). P.8 suggested, "more video tutorials," and P.4 stated, "I think more tutorials in the sketching app and sitting down to sketch would make VR more successful." (Note: all students took a standing position when completing the VR design activity although they were not instructed to sit or stand to complete the sketch.) The overall pattern showed that five out of eight students preferred to have more video tutorials that explain how to use the tools in the VR application before implementing any action using the tool. These and similar comments made by other students supported additional training, an approach used in previous studies using video tutorials to teach participants how to use new technology [30,36,42].

Physical space: Arranging a class to have enough physical space for VR is a key factor when using the technology. Some students felt the need for a larger space when using VR; they were afraid of hitting someone or objects around them while using it as their eyes were covered with the VR headset device. P.2 stated, "Maybe a better space for using it where there aren't other objects/furniture" in the near space. However, the pattern matching results showed that only three participants mentioned a concern about physical space while using VR. The majority did not mention they had a problem with the physical environment of the activity. Nevertheless, since it was mentioned by students' space to complete an activity using VR technology where headsets are worn and visibility of surroundings is obstructed by the tool, adequate physical space to perform the VR activity should be considered. Educators need to pay special attention to available classroom space when planning VR in their curriculum. Ghobadi and Sepasgozar drew attention to the same issue [40]. One of their participants felt restricted when using VR and was afraid of being hurt. Therefore, having enough free physical space for students to move and use VR is important as plenty of space prevents them from hitting nearby items while also helping them to feel safe.

Access to VR technology: Providing access to VR within a department, college or university is very important because students should feel encouraged to use the technology. P.3 wrote, "I think having access to this technology and properly training students to learn this cool new tool/skill will help me stand out when applying for industry positions." Having conveniently accessible VR equipment aligns with the Matome and Jantjies report: student access to VR technology is important since it can be expensive for students to purchase as a class tool [31]. Similarly, Dorrington et al. also stated that access to VR technology will increase opportunities for students to explore it [30].

Propositions for further exploration:

As described in the findings and discussion sections, some of the original propositions posed in this case study research warrant modification for future study employment. Below are suggestions for how modifications may take form to guide future researchers.

1. There is a negative relationship between effort expectancy and college Apparel Design students' willingness to adopt VR in the idea-generating stage of the apparel design process.

2. There is a negative relationship between performance expectancy and college Apparel Design students' willingness to adopt VR in the idea-generating stage of the apparel design process.

It is important to note that many of the pattern-matching mean score values for the student participants in this study aligned with the median score value [3] or near to the median score and suggest that their views on the outlined constructs were that of 'undecided'. This finding welcome researcher to build on the initial insights outlined in this study, propose alternative propositions, and further add to educator understandings of students' willingness to use VR in the apparel design process so as to craft meaningful learning experiences that support career readiness.

Implications and Recommendations

Five types of facilitating conditions were mentioned and preferred by Apparel Design students using VR in the design process, and listed from the "most preferred" facilitating condition to the "least." Thus, educators should make it a priority to address facilitating conditions based on student preferences. During the study, students only asked for help during the training session; no students asked for assistance during the following design/sketching session of the garment they digitally produced. Hence, it is important to have someone available to assist students during the training period. Having an assistant to help the main course instructor will help accommodate the needs of students working at the same time, and to make the training process progress as smoothly as possible. This will give students adequate time to practice VR use before executing a design. In the present study, training and design required 30-80 minutes over two sessions to complete. In this time, students were asked to learn how to use the VR headset, use Gravity Sketch tools, accomplish a task, and sketch a garment.

The researcher noted during this study that there were rarely any online videos that showed how to design garments in Gravity Sketch. Thus, all video tutorials were about using the tools/functions within Gravity Sketch in general to create shapes, but not to design garments. However, educators could either search for new video tutorials to include in the training process or develop their own that are crafted to align with the course activity. Finally, in the present study, the main researcher provided a VR headset for each student who was only able to use it when the researcher was present. If possible, educators could search for university resources that provide access to VR equipment both during in-class and outside class hours to allow students time to use it and not feel pressured. For example, educators could determine if a VR tool is available through library check-out loan, or if there is a center within the university that allows students to explore VR on their own time. Another option would be to purchase VR tools using student technology fees.

Limitations and Future Studies

This study had a number of limitations. First, due to the course's rotation offering within the larger curriculum and the project structure within the class, it was not possible to collect data from multiple students over multiple semesters. Having a larger sample size to include in the multiple case study analysis may have provided the possibility to perform other statistical analyses or yielded different results and discussion. Second, the open-ended questions were intended to obtain information from students about facilitating conditions; however, collecting the data though semi-structured interviews may have helped gain more in-depth, rich information regarding those conditions by allowing the researchers to ask follow-up questions or for clarification of participants' comments. Researchers conducting future related studies are encouraged to test the modified proposition to search for factors that could play a role in the connection between performance expectancy and willingness to use.

In conclusion, the findings of this study provided valuable insight into future educational considerations to enhance the student learning experience of using VR in the fashion design process and prepare students to completely enter the fashion industry.

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Conflict of Interest

Authors declare no conflict of interest.

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