EXPLORING THE CHALLENGES TO INTEGRATE VR MODELLING IN PRODUCT DESIGN EDUCATION

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ABSTRACT
Over the past decade virtual reality (VR) headsets have become increasingly affordable and available. This in turn, has made virtual reality tools more accessible. Within the context of product design, one of the possibilities opened with VR, is the creation of 3D models within a 'virtual/immersive' environment. This has several advantages in the realm of product design education, including increased student engagement due the novelty of the approach and the appeal of the physical immersive experience. How to incorporate this type of 3D modelling in the curriculum however, remains rather unclear.
While there is continued interest on VR from segments of the academic community, its adoption within the context of product design education is still in its infancy. Moreover, because of the many different variables involved, and the differences inherent to any design project, the experience from a larger and wider variety of case studies is necessary. This paper reports from a case in which VR has been incorporated into a design project in a first-year course which is part of a product design degree course.

Keywords: Virtual reality, VR modelling, CAD, design education

1 INTRODUCTION
Over the past decade, virtual reality (VR) has experienced significant growth and evolution, driven among other by advancements in technology and increased adoption across various industries [1], [2], [3], [4]. The development of more powerful and affordable VR hardware has made it more accessible to a wider range of users, and an increasing variety of VR software apps have appeared on the market.
VR modelling or virtual reality modelling involves the creation and manipulating of 3D objects within a virtual environment using VR technology [1]. This typically includes VR headsets and hand motion controllers. This approach allows for a more immersive and experience compared to traditional computer 3D modelling methods. In the context of product design, VR modelling enables designers to explore and refine their concepts in a highly immersive environment, delivering an experience that is difficult to achieve with models represented on a traditional computer screen. This approach is increasingly being integrated into product design processes in various industries [5], [6], [7], [8]. Designers can use VR modelling to quickly create and visualize product concepts in a virtual environment. A footwear designer for example, can quickly start laying out three-dimensional geometry over the 3D model of a foot. This is in principle similar to sketching over a drawing of a foot in 2D. By experiencing their designs in virtual reality however, designers can understand spatial relationships, and ergonomic considerations better [3].
As the role of VR modelling becomes prominent in industry, there is an interest from the academic community to integrate VR modelling into product design curriculum. Despite this interest however, its integration into the product design curriculum is for the most part, yet to happen [2], [4]. And while there has been research looking at the incorporation of VR into design education, literature documenting attempts to implement this integration from different perspectives remains scarce.

2 BACKGROUNDS
This paper investigates the challenges and considerations that educators must address when integrating VR technology into the curriculum. This is done by examining the experience of incorporating VR modelling into a design project. Through a thorough analysis and investigation of this experience, best practices for educators seeking to do the same are revealed. In this sense, the paper can be considered to be autoethnographic in its approach. Autoethnography is a common method of inquiry in the education research and pedagogy [9], [10], [11].

A VR modelling activity was introduced as part of a first-year module within an undergraduate product design degree course. In this module students work on a term-long project where they are tasked with designing either a doorknob or a perfume bottle to be manufactured using moulds. Students follow a traditional design process, starting by doing research, subsequently generating ideas through sketches, they then move on to create CAD models of their designs, and finally 3D-printing these models to produce casts (figure 1).

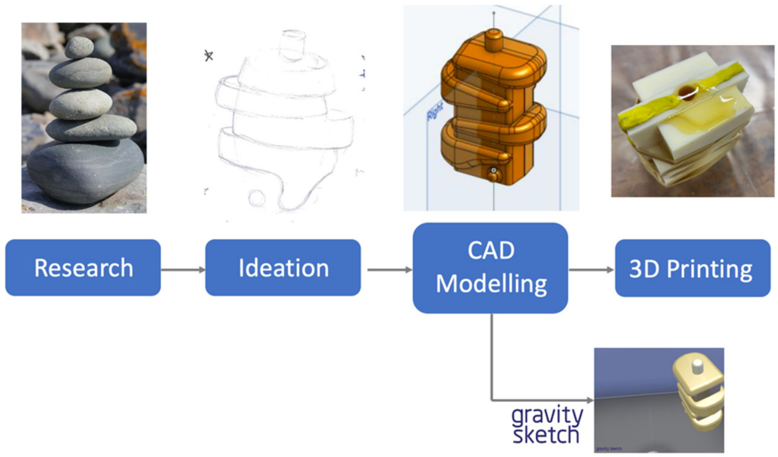

Figure 1. General project stages and VR modelling integration

For the VR activity, students were invited to three additional sessions held outside the regular schedule of the module. The sessions were an hour long, and due the headset-to-student ratio, three similar sessions were run on the back of each other. In total each student took part in two sessions, one each week. These sessions took place in the two following weeks after students completed their CAD modelling. Incorporating VR modelling in combination with traditional CAD modelling has the advantage of a scaffolded approach for students [1], [5]. Students were instructed to bring their laptops to the VR modelling sessions. This was essential to facilitate guidance and feedback during the sessions as will be discussed later. Students were given a feedback questionnaire by the end of the session.

Figure 2. Students during VR modelling session

The headset selected for this activity was the Meta Quest 2. The selection of this headset over other alternatives such as the HTC Vive, HP Reverb, or Pico VR, was primarily based on popularity, affordability, and versatility. The Meta Quest 2 works as a standalone device, eliminating the need for a high-performance PC. Moreover, there is an extensive library of apps on the Meta Quest store and a wealth of online resources and tutorials.

Gravity Sketch was chosen as the software for the VR modelling activity. There are other similar tools available on the market, such as TiltBrush and Masterpiece Studio, however, Gravity Sketch is specifically tailored towards product design. And being the first mainstream app of its kind, there is a substantial amount of learning materials and support available online, making it the best choice for educational purposes [3]. Moreover, as opposed to some of the other options, Gravity Sketch is free on the Meta Quest store.

3 SUMMARIES OF ISSUES

Although expected, it was impossible to anticipate the issues that would emerge as a result of integrating VR modelling into this design project. Therefore, the issues presented in this section were identified as the integration exercise took place and categorized afterwards. For discussion, these issues have been arranged in seven categories: Connectivity, File-Transfer, Account Management, Service Time, Suitability of models, Development of teaching support materials, and Curricular Integration.

3.1 Connectivity

A critical consideration for lecturers, is the need for real-time monitoring of students' activities within the VR environment. To provide guidance and feedback, lecturers must be able to observe what students are seeing. For this reason, the implementation of screen-casting is essential. This allows the student's view within the VR headset to be mirrored onto a computer screen for the lecturer's observation. In practice however, this requires that both, the VR headset and the computer are in the same Wi-Fi network. It is important to consider that most higher education institutions use Eduroam to provide Wi-Fi access to students and faculty. To gain access to the network however, Eduroam requires the installation of a certificate in the user’s device. Institutions generally support this process by providing ready-made installation packages and guides for the most common device types such as Windows and Mac PCs, and Android and iOS mobile devices. However, support for VR headsets is less common if at all available.

Furthermore, information found online quickly made evident the challenges to connect VR headsets to Eduroam. Some comments found on forums and discussions boards even suggested that it was not possible at all. It was almost by chance, and aiming to exhaust all possibilities before giving up, that success was achieved to connect the headsets to Eduroam using manual configuration settings. It must be pointed out however, that this was only possible by inputting network details during the initial device setup. Subsequent attempts to do the same via the settings panel did not work.

3.2 File-Transfer

This case study also showed the importance of understanding the intricacies involved in moving files to and from the VR headsets. An important consideration, particularly when VR modelling is used in addition to traditional 3D/CAD methods, is that while it is possible to transfer files by connecting the headset to a PC, this method presents inconveniences, especially if students have been working on their models using university computers. Just as an example, this would imply collecting all student’s files before copying them on to the headsets, or even having to physically connect the different headsets to several different computers. Moreover, files must be copied to a specific location within the headset folder structure, a task that may be challenging for students with limited computer skills. A situation that is not uncommon.

Files can be transferred online by uploading them to LandingPad, Gravity Sketch's proprietary platform. The files can then be accessed directly within the Gravity Sketch app on the headset. This approach however, presented several issues that lectures ought to be aware of when guiding students through this process. First, to use LandingPad, it is necessary to create a separate account with its own login credentials. This can be done directly on the LandingPad website, and from within GravitySketch in the headset. The later however, did not work for the students in this case. While students were asked to register at LandingPad in advance, several did not, and because they only needed the account at the time of importing their models, and because the account in principle can be registered from within Gravity Sketch on the headset, it seemed the simplest option to do it that way. Attempts to register for LandingPad directly within the headset failed. Several students were unable to log in after receiving a Single sign-on (SSO) code via email. Moreover, it was not easy for students to know whether the registration had worked within the Gravity Sketch interface.

Registering for a LandingPad account on the website using a PC and subsequently logging in on the headset proved to work. Nonetheless substantial time was spent while trying to sort out these issues, causing further delays and disruption of the sessions.

3.3 Account Management

Another critical consideration for lecturers interested in implementing VR modelling, is the limitations the number of user accounts that a single headset can hold. Thereby constraining the seamless rotation of students in and out of the VR modelling sessions. This is an important consideration, particularly as the ratio of students to headsets increases, requiring that several students share the same headset.

To set up the Meta Quest 2, it is necessary to use a Meta.com account without which the headset cannot be used. While in principle it is possible for different users to use the same headset without switching accounts once it has been set up, this is impractical in a scenario like this for several reasons. The first, is that as previously mentioned, screen-casting is essential for guiding students throughout the activity, and this requires that both, the headset, and the PC to which the headset is casting, are logged on the same account. In practice this means that each student must use an individual account. Furthermore, sharing accounts presents additional issues, such as the fact that all settings within the headset, including those associated with LandingPad and Gravity Sketch, are tied to the current user.

The Meta Quest 2 headsets can accommodate only three distinct user accounts besides the administrator account. In this case, the lecturer's account served as the administrator account, with three students subsequently added to each headset. While manageable within the scope of this trial, the inconvenience of identifying and managing student accounts on each device surfaced as an issue that would have to be addressed if more students were involved in the activity and had to share the headsets available.

3.4 Service time

Another issue evidenced through this experience, is the service time of the battery, a factor that becomes particularly important when consecutive VR modelling sessions must be scheduled back-to-back due time constraints. In this case, it was observed that the Meta Quest 2 headsets offer approximately one and a half hours of continuous running time on a full charge. This became an issue during the first week, as the need to recharge the headsets between sessions resulted in delays and the disruption of the overall flow of the sessions.

The headsets are equipped with a charging cable; however, its short length made it impossible to re-charge the headsets while being used, because students are constantly moving around. This issue was addressed by purchasing three-meter-long charging cables; however, these were only available for the second round of sessions the second week. The longer cables made it possible to recharge the headsets during the activity itself and allowed the students to continue working seamlessly in subsequent sessions.

3.5 Model Suitability

While it is possible to export models from most popular CAD packages that can then be imported into Gravity Sketch, this experience highlights that the exported models are not ideal for manipulation within Gravity Sketch. Models to be imported into Gravity Sketch must be of the polygonal mesh type. Most popular CAD packages can export models in one or more of the most common mesh model file formats such as OBJ, or STL. The mesh models created however, are geared towards 3D printing and/or physical simulations such as FEA and CFD, not further 3D modelling. Consequently, these meshes simply re-create the geometry using triangles (figure 3).

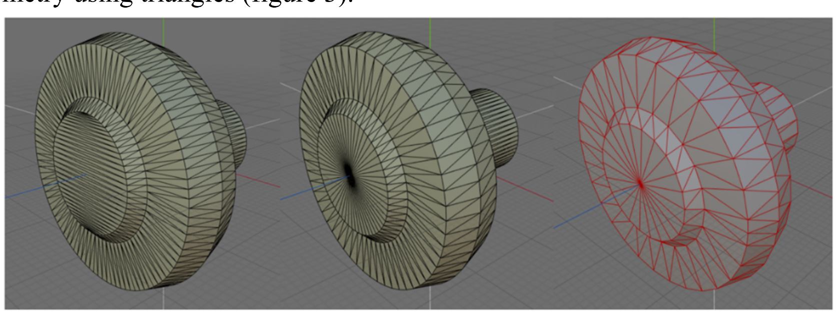

Figure 3. Examples of polygonal mesh models generated from the same geometry, using several CAD software packages: Fusion 360 (left), OnShape (middle), SolidWorks (right)

For the purpose of further 3D modelling however, not only the arrangement of these polygons is important, but also the type of polygon. In general, it is better if the mesh is mostly made of quads (four sided polygons) rather than triangles. Therefore, another valuable lesson from this study was the need to re-topologize the models that are going to be imported into Gravity Sketch. In the context of 3D modelling, Topology refers to the arrangement and structure of the vertices, edges, and faces that comprise a 3D model. A good topology ensures efficient and easier manipulation of the model during editing. Depending on the complexity of the model, the mesh generated, and the skill of the student. This is a process that can take up some time.

3.6 Development of Teaching Support Materials

This experience also shed light on the instructional design challenges around VR modelling. In contrast to a traditional classroom setting, where both the student and lecturer can easily point at the same place on a screen, VR modelling lacks this common point of reference. This complicates communication and feedback between the lecturer and student.

In a traditional CAD classroom for example, the lecturer can easily take control of the mouse to demonstrate procedures. In VR however, this is more difficult. Similarly, during a live demo, students in a traditional classroom can readily switch between the projector screen and their own screens. In VR, this is not possible. The only feedback that the lecturer can provide with such fluidity is auditive. These underscores the need for teaching support materials that allow the lecturer to provide visual feedback 'inside the headset.' And while video tutorials could aid in in this scenario, their development requires significant time and effort.

In this case, students were given a series of instructions at the beginning of the first session. These focused first on explaining the students how to add their account to the headsets, and then start screen-casting. For this purpose, it would have been good to have screenshots of the headset interface, and even better a video for the students to watch in advance. In this case however that was mostly done using verbal descriptions of what the interface looked like and what the process was. Once screen-casting started, it was easier to tell the students what to do. The other set of instructions students received at the beginning, had to do with an overview of the Gravity Sketch interface and how to performs some of the most basic functions, such as hand motions used to navigate the workspace (panning, zooming and rotating). Students were asked to start by completing a quick 'getting started' interactive tutorial available within Gravity Sketch by default. This worked well as a starting point. As the students continued working on their models however, it was necessary to guide them verbally constantly. This underscored the importance of clear and simple verbal instructions and highlighted the complications of students moving at a different pace through the process, while not being able to easily call everyone's attention to a single screen.

3.7 Curricular Integration

The study has also highlighted time-related issues associated with integrating VR modelling into the curriculum. In this case, the VR modelling sessions in which students took part spanned over a period of just two weeks. However, and even though in this case not all students in the cohort participated, this still resulted in a substantial time investment. While this can be alleviated with additional hardware and efficient logistics, it remains an important consideration. Moreover, in this case the sessions were offered as an extra-curricular activity, however, the formal adoption of VR modelling with its learning objectives and assessments would require changes to the curriculum, which is a time-consuming endeavour. In addition, in many instances, the curriculum is already densely packed with modules and content, leaving little room for additional material without overwhelming both lecturers and students.

4 CONCLUSIONS

By providing an immersive platform for conceptualization, prototyping, and refinement, VR modelling offers an appeal that traditional CAD modelling approaches cannot provide. As VR modelling continues to gain terrain in industry, this is a skill that those universities not already considering incorporating in their curriculums should not ignore.

This paper has presented the findings derived from integrating VR modelling into a design project in a first-year product design degree course. These findings have revealed that it is possible to carry out this integration successfully, however, significant challenges must be overcome. From connectivity and file transfer issues to account management and instructional design constraints, the successful integration of

VR modelling into the curriculum, requires a strategic approach that addresses technical, logistical, and pedagogical considerations. While some of the issues highlighted here may be linked to the specific VR headset used in this case. This insight should prove valuable for any lecturer planning to implement VR modelling in a similar scenario. Moreover, the fact remains that the headset used in this case is the most popular and affordable on the market.

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