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# VIRTUAL REALITY SKETCHING FOR DESIGN IDEATION

Philip Ekströmer, Jens Wängdahl and Renee Wever

This paper explores if Virtual Reality sketching could be of use in the early phases of the design process. To gather a starting point for further studies, the use of a Virtual Reality software Gravity Sketch in the concept stage of designing an orienteering shoe was video recorded. The most interesting finding was that the designer mostly used Gravity Sketch as a modelling tool to verify pen-and-paper sketched concepts, instead of an ideation tool as was originally intended. To gather further insights, a study comparing pen-and-paper sketching to VR sketching was designed. This paper presents a pre-study which aimed to test the study design and explore areas of interest. The results from the pre-study suggest that workflow in VR sketching is quite different from pen-and-paper sketching and that surfaces, or volumes could be more effective for ideation in VR than line drawings. Finally, it was observed that the ability to undo made the students prone to undo and re-draw until they reached the intended result, which resulted in fewer completed sketches and fewer opportunities for re-interpretation.

Computer aided ideation, Virtual Reality, Ideation, Computer aided ideation,

## INTRODUCTION

In the last years, the commercially available Virtual Reality (VR) systems has reached a level where they allow for a fully immersive experience and immediate interaction, which are good conditions for design work. While VR has been explored for applications in many parts of the design process, including eliciting product aesthetics (Valencia-Romero & Lugo, 2017) and ergonomic evaluations (Aromaa & Väänänen, 2016), a recent systematic literature review of AR and VR in the design process found that few studies have been conducted on VR during the early conceptual stages of the design process (Keeley, 2018). As the early stages of the design process is generally dominated by sketching, this study aims to fill the gap in literature by exploring the use of VR to achieve 3D sketching and compare VR sketching to traditional pen-and-paper sketching. This working paper describes a pilot case study where VR sketching was used in the process of designing an orienteering shoe and a pre-study comparing VR sketching and pen-and-paper sketching.

## VR DESIGN SKETCHING

As stated in the introduction, there have been few studies on VR during the early stages of design. Some VR sketching tools have been proposed in literature (e.g. Space design (Fiorentino, De Amicis, Monno, & Stork, 2002), Surface Drawing (Schkolne, Pruett, & Schröder, 2001), Fluid sketching (Keefe et al., 2008) and Multiplanes (Barrera Machuca, Asente, Lu, Kim, & Stuerzlinger, 2017)), but these studies generally focus more on the technical and usability aspects and little on using the tools for ideation, which is the focus of this paper. There are several potential benefits of VR sketching for design ideation. In a focus group study with design professionals from furniture design and interior design, Israel et al. (2009) found that the key advantages with VR sketching compared to traditional sketching methods are *spatiality*, allowing the designer to walk into the sketch, *one-to-one proportions*, *association*, using existing objects as references in the environment and *formability*. In the same study, they found that the major functions of sketching, such as memory support, externalization aid and many of the properties of sketching (see (Buxton, 2007)) were also attributed to VR sketching, with only minor modifications. This suggests that idea sketching in VR should be quite similar to pen-and-paper sketching in regard to the workflow that is used. The immersive experience of VR sketching also allows our bodies to be part of the design process, making it possible to consider ergonomics early on. Petrov (2018) envisions that VR design systems in combination with 3D printers could enable mass customisation of objects such as prescription glasses that would be designed directly onto people's faces.

## PILOT CASE STUDY

To gather initial data, a master thesis project with the aim to develop an orienteering shoe for a Swedish running shoe company was used to explore the use of VR sketching in early design. The designer was outfitted with an HTC Vive VR system and asked to use it for ideation and concept development. This project was chosen based on the notion that it would be beneficial to use 3D sketching in the design of shoes, as they have a quite complex shape. The designer chose to use VR sketching in the development of the *upper*, the fabric part of the shoe, after initial pen-and-paper idea sketches. The software used in the study was Gravity Sketch Pro ("Gravity Sketch," 2017), a multi-platform tool for drawing and creating surfaces and shapes in a 3D space. To support his VR sketching, the designer made a digital last, the basic foot form used for shoemaking, in 3D modelling software Blender which he then imported into Gravity sketch. The last was used as a reference on which the concepts were sketched. Sketching data was collected by recording the screen while using Gravity sketch.

A total of 134 minutes virtual reality sketching, divided into five clips, was captured. The footage was watched several times and the tools, and the approach used was noted. Further, written and oral feedback regarding the experience of using VR sketching was collected. In the first clip, the designer uses the ink tool, which makes a line similar to an ink pencil, and exhibits a workflow similar to idea sketching with pen and paper. He works fast, is not very careful with his lines and draws shape lines directly onto the last to quickly outline the general shape of the upper. An example can be seen in Figure 1. Using this workflow, he makes two concepts in 13 minutes. In the remaining four clips, the designer only uses the curved surface tool, which produces freeform surfaces (Figure 2), apart from a few short uses of the primitive shapes and stroke tool to make the lacing (Figure 3). The surfaces are drawn to follow the last and then modified using their Bezier points for a more precise fit. This workflow is closer to working with vectors or surface modelling. Using this workflow, he creates the first concept in 60 minutes and the second concept in 37 minutes.

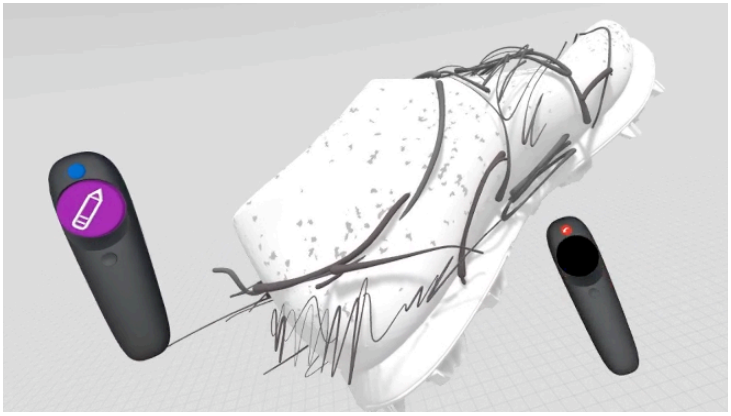

*Figure 1: The digital last with sketch lines drawn on top of it*

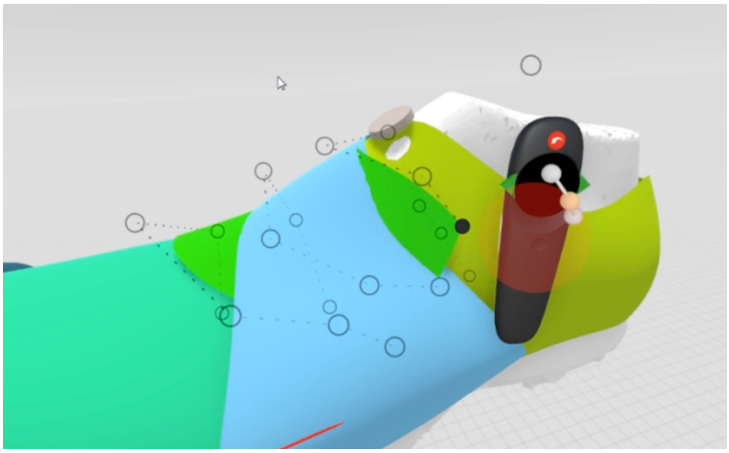

*Figure 2: The surfaces are manipulated using Bezier points to fit the shape of the shoe*

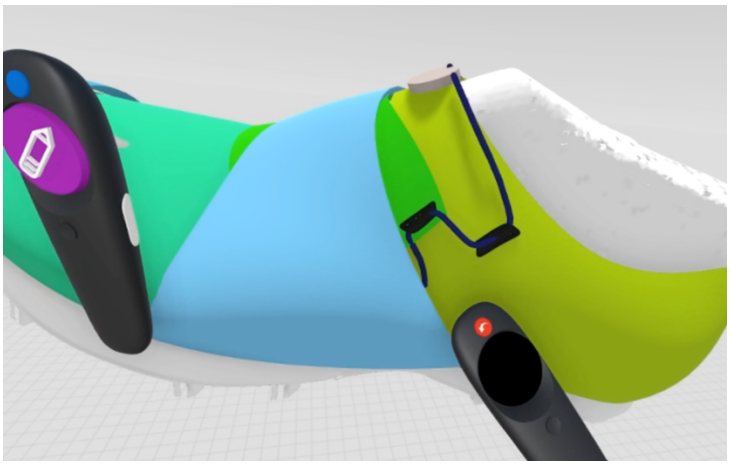

*Figure 3: The lacing is created using the stroke tool*

The majority of the time, the designer used Gravity sketch as a surface modelling tool, abandoning the fast, "sketchy" workflow for a more controlled and exact way of working. Also, he only worked on one last at the time, despite Gravity sketch supporting multiple imported objects in the environment. This was also true in the first clip. This controlled way of working is closer to working with traditional CAD tools than sketching. However, this might have been affected by the object being designed, as the last defines most of the shape of the shoe. If the shape of the object had been more open for exploration, the designer might have used a sketching workflow to a greater extent.

The designer thought virtual reality sketching was most useful for validating design choices made with sketches. The strengths found were the ability to resize and turn the model, which were helpful when viewing and validating the design. However, the designer found that the tool was blunt and too imprecise to make small details. Moreover, the designer thought it was much faster to sketch on paper for this project. The major insight from the case was that the designer mostly used Gravity sketch as a modelling tool to create and verify whole concepts instead of an ideation tool. As the ability to resize and turn the model was considered most useful which could imply that VR systems have more use for viewing and validating the design rather than a creation tool. However, as the data comes from limited use in a single case, no conclusions can be drawn from this. To gather more data on the use of VR sketching for ideation, a comparative study is going to be undertaken. To prepare for this, a pre-study was created. This pre-study is detailed below.

## PRE-STUDY COMPARING VR SKETCHING TO PEN-AND-PAPER SKETCHING

This pre-study aimed to test the study design and find areas for further investigation. As the workflow used by the designer in the pilot study differed significantly from the expected workflow, this needed closer observation. Thus, the workflow used by the participants when VR sketching was observed. Moreover, the number of sketches and concepts per participant were counted to gather insights on how VR sketching impacts the ideation. The pre-study involved sixteen 5:th year industrial design engineering students. The students were separated into two groups (Group 1 and 2) with 8 students both groups. They were given two different sketching tasks. First, both groups had 15 minutes to sketch as many concepts of a *toaster for kids*. They were allowed to use any pens, markers or other sketching tools they feel comfortable using. Following this, Group 1 continued using pen and paper sketches and had another 15 minutes to sketch as many concepts as possible of a *tape dispenser for multiple tapes*. Group 2 instead used the VR software Gravity sketch. They first practiced using the software for 30 minutes, followed by a 10-minute break and then performed the same tape dispenser task as Group 1. The tools used by Group 1 and 2 for each task is showed in Table 1. The reason for using toasters and tape dispensers was that they have quite simple shapes that can easily be varied, and most people can sketch them without a reference.

*Table 1: Tools used by Group 1 (control group) and Group 2 in the two tasks*

| | **Group 1 (control group)** | **Group 2** |
|---|---|---|
| Task A: Toaster for kids | Pen-and-paper sketching | Pen-and-paper sketching |
| Task B: Tape dispenser for multiple tapes | Pen-and-paper sketching | VR sketching using Gravity Sketch |

This setup allows for comparison between design ideation using VR sketching and design ideation using pen-and-paper sketching, using Group 1 as the control group. Given that Group 1 and 2 perform similarly on task A, ruling out differences in ideation and sketching skill between the groups, the difference between the groups on Task B should be an effect of the differing sketching tools. The papers with the pen-and-paper sketches were collected after the task was done, while VR sketches were captured in a recording, as the final sketch will not show their workflow. The sketches and recordings were analysed by the author. Every distinct group of lines or objects (in VR) was considered a sketch. Stray lines, dots or objects were not considered sketches. The more defined sketches, with distinct forms and/or annotations, were considered concepts.

## RESULTS AND INSIGHTS

Because of problems with the recording software, the results on both task A and B from one of the students in group 2 was omitted. Thus, only 7 results from Group 2 were used. On Task A, where both groups used pen-and-paper sketching, Group 1 (8 participants) made 61 sketches of which 42 were concepts and Group 2 (7 participants) made 57 sketches of which 29 were concepts. Sketches per participant in Task A was 7,50 for Group 1 and 8,14 for Group 2. Concepts per participant were 5 for Group 1 and 4,28 for Group 2. This is shown in Table 2 below. In Task B, Group 1 made 46 sketches of which 36 were concepts and Group 2, using VR sketching, made 24 sketches of which 19 were concepts. Sketches per participant in Task B was 5,75 for Group 1 and 3,42 for Group 2. Concepts per participant were 4,5 for Group 1 and 2,71 for Group 2. See Table 2. In VR sketching, almost every sketch was also a solution. In pen-and-paper, there were a few participants who made more sketches than concepts.

*Table 2. Sketches and concepts (total and per participants) for each group on the two tasks.*

| | | Sketches | Sketches per participant | Concepts | Concepts per participant |
|---|---|---|---|---|---|
| **TASK A** | Group 1 | 61 | 7,63 | 42 | 5,25 |
| | Group 2 | 57 | 8,14 | 29 | 4,14 |
| **TASK B** | Group 1 | 46 | 5,75 | 36 | 4,5 |
| | Group 2 (VR) | 24 | 3,43 | 19 | 2,71 |

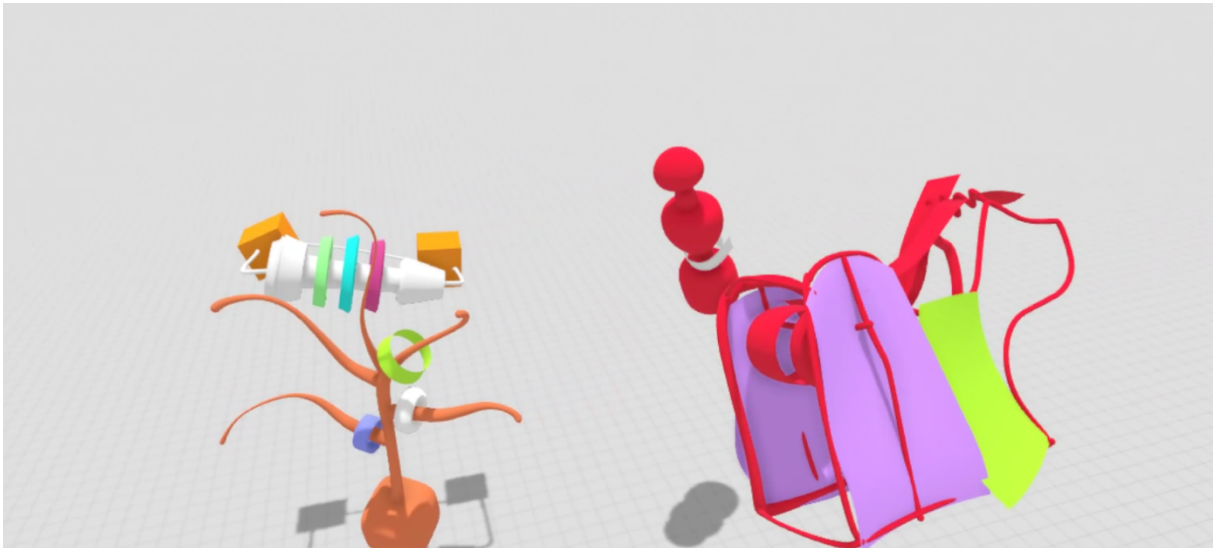

*Figure 4. Example from VR sketching in task B*

Similar to the designer in the pilot study, the participants in this study were observed to use the curved surface tool a lot. However, the most used tool was the revolve tool. This is not surprising as the task was to design a tape dispenser and tapes are easily made with the revolve tool. Their workflow was more like idea sketching sketchy than in the pilot study, as very few used Bezier points to control the surfaces or the revolves. However, a few participants still produced only one or two concepts. The use of surfaces might be because they feel a need for completely defining the shape, as was suggested by Alcaide-Marzal et al. (2013) This could explain why so few used line drawings and instead opted for surfaces. The rightmost tape dispenser in figure 4 started out as a line drawing, but after making other

sketches the student came back to fill in the sides of the dispenser with the curved surface tool. However, using line drawings in VR sketching might not be the most effective way of ideating. As surfaces and volumes are just as easy and quick to create as lines, using them instead of lines might be a way to convey more information in the same amount of time. This could be explored in a future study.

Interestingly, in Group 1 (pen-and-paper sketches) almost all concepts have some indication of how the tape is going to be cut (teeth, knives etc.). This is however not the case in Group 2 (VR). Out of 19 concepts, 11 have no indication of how to cut the tape. Moreover, one student made concepts without any indication of tape. Thus, while there seems to be a preference for completely defining shapes in VR, this did not make them create fully functional concepts.

The ability to automatically undo and redo is one the strengths of CAD tools identified in a study by Ekströmer & Wever (2019). However, in this study, the ability to undo seems to have been more of a drawback, as the students using VR sketching often chose to undo instead of keeping the imperfect shape and making another shape or line. This way of undoing and re-drawing until a satisfactory result has been reached resulted in fewer completed sketches and presented them with fewer opportunities for re-interpretations as every accident was undone before it could be decided if it was happy or not. How the ability to undo affects ideation should be explored in future studies.

Overall, the students seemed to enjoy using VR sketching as an ideation tool. One participant said that he felt he gained a lot more from 15 minutes in VR sketching than 15 minutes with pen-and-paper.

As this was a pre-study, it follows that the main study should be undertaken in the future. A similar study design will be used, but the participants should preferably be design practitioners. Further, the main study will compare VR sketching and pen-and-paper sketching using more parameters than number of sketches and concepts, such as number of re-interpretations and idea fluency. The differing workflow in VR sketching and pen-and-paper sketching that was evident in both the pilot study and the pre-study will also be explored further. To increase the validity of the collected data, either think out loud protocols or retrospective interviews will be used.

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