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Chapter

Virtual Reality and Creativity: Lessons Learned from a Luminaire Design Project

Hoa Vo and Peter Huesemann-Odom

Abstract

Current research in design education showed that experiencing virtual reality (VR) in learning led to higher creativity in students. However, some studies showed only a partial impact of VR on student creativity. Using video data analysis (VDA), the authors examined a half-an-hour excerpt of the recorded VR learning experience from a previous study on interior design students ($n = 13$). The authors sought an explanation for the partial impacts of VR on students' creativity via observing and interpreting one participant's (a) interaction with VR and (b) the context of the virtual environment. VDA analysis results indicated that the implemented VR technology was intuitive for a fundamental learner yet required time and practice to gain advanced skills. Exploration time was also necessary for students to fully demonstrate the novel, resolution, and style aspects of creativity in their works. The implication is that the partial impact of VR on creativity found in the previous study might be due to the constraints of time and expertise of students (i.e., learn and explore), not VR technology per se. Educators and institutions wishing to include VR in their curricula should allow students ample time and access to VR applications and headsets to practice and sharpen their expertise.

Keywords: virtual reality, creativity, creativity assessment, digital learning, education

1. Introduction

Creativity is the top desirable competency across industries in the Fourth Industrial Revolution or Industry 4.0 [1, 2]. Bermúdez and Juárez [3] developed a competency model for Industry 4.0 with four key dimensions: information and communication, management, organizational learning, and environment. Creativity makes up 44% of the last dimension, environment, together with research and transdisciplinary. Chaka [4] also analyzed 64 journal articles from eminent databases, such as Scopus and Web of Science, on Industry 4.0's desirable competencies and found notable discussions about "creativity" in 30 of them (47%). The all-time-high importance of creativity, thus, leads to the robust discussion of how educators across disciplines can facilitate their students to become more creative in Industry 4.0. According to Cropley [5], fast-moving and revolutionary technologies are at the core

of Industry 4.0. Hence, creativity education needs a technology-focused component to help students manage and tolerate complex and uncertain problems of the new industrial revolution and be able to communicate critical and practical responses. Although integrating technology into education appears to be straightforward, there is more to discuss. First, which Industry 4.0 technologies are beneficial to creativity? Second, how should the impact of said technologies on creativity be evaluated?

The first industrial revolution, or Industry 1.0, represented the mechanized and steam-powered production of increased functionality and quantity of products. Consecutively, Industry 2.0 introduced the mass production of standardized and interchangeable parts of products. Industry 3.0 then represented automated and digitized production, providing multiple iterations of products that meet various needs on the market. Industry 4.0, lastly, individualizes products for an ever-changing market using computer simulations and communication networks [6]. Technologies of Industry 4.0 cover augmented reality (AR), virtual reality (VR), digital three-dimensional (3-D) modeling and prototyping (e.g., additive manufacturing), robotics, and the Internet of Things (IoT), to name a few [2]. Among those, VR has become more important in education, especially for design disciplines, due to its affordability and accessibility [7, 8]. Remarkably, current literature shows that integrating VR into design education benefited students' creativity by reducing the cognitive load to process or improving the precision of their designs [9–12]. Therefore, design educators should focus on these technologies to prepare students for Industry 4.0.

Interestingly, empirical evidence on how Industry 4.0 technologies impacted creativity was partial. For example, Rojas et al. (2015) assessed the creativity of participants ($n = 38$) designing bottles in VR. They only found a significant increase ($p = .013$) in design newness (i.e., novelty), not in design function (i.e., resolution) and appearance (i.e., style) [13]. While comparing student designs in VR and the two-dimensional application window, Jin and Lee (2019) found a wide variety of ideas in the former but more efficient ideas in the latter [14]. In other words, Industry 4.0 seems to elevate certain aspects of creativity but not all. Similarly, the authors examined the creativity of students ($n = 13$) designing a custom luminaire in VR and showed improvements only in novelty ($p = .05$) and style ($p = .02$), each from one of two independent judges [15]. These results showed that only certain aspects of students' creativity increased with the use of VR, which led to a research question:

“What might explain the partial impacts of VR on students' creativity?”

The authors dissected this question using Video Data Analysis (VDA) [16] of student experiences with VR in the same nine-week luminaire design project. This article presented the VDA analysis results of a recording excerpt of student experiences and discussed lessons learned from integrating Industry 4.0 technologies, especially VR, to design education, with an example from an interior classroom. The authors collected and analyzed data with approval (H22142) from their University's Institutional Review Board (IRB).

2. Literature review

In this section, the authors presented a brief history of VR and prominent creativity measurements to set the stage for the methodological decisions of this study. Through the first subsection, the authors walked the audience through the current

state of VR applications in design education. In most cases, research showed VR as an effective pedagogical tool, which resulted in multiple positive learning outcomes (e.g., creativity). In the second subsection, the authors discussed different components of creativity and how to measure each in its entity. Together, these subsections justified the importance of VR in design education and emphasized the need to measure corresponding learning outcomes accurately. After all, creativity is a complex phenomenon that is hard to comprehend, especially in light of new technology such as VR.

2.1 Virtual reality

From the mid-1960s to the late-1980s, virtual reality (VR) flourished thanks to the rapid development in computer displays and related technologies [17]. Ivan Sutherland introduced the concept of VR in 1965 with the ambition to make a computer-generated simulation of the physical world that “looks real, sounds real, feels real,” and “responds” to human interactions [18]. Said ambition formed four critical components of VR: (1) a virtual environment; (2) immersion; (3) sensory feedback; and (4) interactivity [19, 20]. A virtual environment refers to the representation of objects with shared attributes to their equivalences in the physical world. Immersion means the sense of presence or the like-real feeling of being in a virtual environment. Sensory feedback indicates the audiovisual and haptic perceptions relative to one’s physical position in a virtual environment. Interactivity represents the ability to manipulate and interact with a virtual environment and objects within it. For those critical components to work, VR media and systems are needed. Media are the virtual worlds created with computer graphics. For example, Gravity Sketch (GS) is a digital modeling application to collaborate and develop 3-D objects in a virtual environment [21]. Systems are equipment that allows one to immerse, receive sensory feedback, and interact with VR media. Examples range from a single device, like the head-mounted display (HMD), to a whole room with complex virtual visualization systems. Ivan Sutherland and his colleagues at the University of Utah created the first HMD in 1970, which heralded advancements such as BOOM (i.e., a small box containing two monitors) in 1989 and CAVE Automatic Virtual Environment (i.e., a room with stereoscopic images projected on the walls) in 1992 [18, 19].

VR becomes more accessible via web browsers and head-mounted displays (HMD) or headsets in the form of 360-degree captured photos or computer-generated simulations of real-life environments, including physical characteristics of shapes, colors, lighting, and so on [22, 23]. There are “tethered” and “stand-alone” HMDs that refer to headsets that generate and visualize VR graphics with or without connecting to external processing units (or computers), respectively [8, 24]. “Stand-alone” HMDs, moreover, are attractive to science and design educators due to their user-friendliness and cost-effectiveness [25, 26]. Said growths, thus, make VR an integral part of employees’ workflow and students’ learning, in industry and academia [27]. Current literature in design education even showed that VR pedagogical applications improved students’ comprehension of their designs’ real-world manifestation and user experience. Lou [11] examined two graphic design courses ($n = 30$, each) using VR or presentation teaching approaches. With VR teaching, 77.7% of students mastered course content compared to presentation teaching, with 40% of students. Moreover, 83.3% of students increased in creativity and imagination with VR teaching. With presentation teaching, the number was 34%. In VR course, 73.3% reported better information retention. Only 45% of students said the same in the presentation course. Also, according to Obeid and Demirkan (2020), Gravity Sketch (a VR design

application) enhanced attention and confidence in interior design students ($n = 42, p = .0001, p = .045$, respectively).

2.2 Creativity measurement

Creativity is a complex phenomenon to operationalize and measure. Hence, the wealth of knowledge in creativity research presents multiple creativity concepts, leading to various measurements. According to Corazza et al. (2021), the core aspects of creativity are originality and effectiveness [28]. These two aspects, however, are context-embedded or have their meanings changed depending on the corresponding disciplines [28, 29]. Lu and Kaiser (2021), for instance, described creativity in mathematical problem-solving as fluency (i.e., number), flexibility (i.e., variety), and originality (i.e., newness) [30]. This perspective reflected the works of Torrance (1966) and Leikin (2013), with the aspect of effectiveness translated into the number and variety of solutions that are relevant to solve the problems [31, 32]. Creativity in design disciplines, however, features the combination of originality (i.e., newness) and effectiveness (i.e., function or the value of serving a specific purpose) [33, 34]. Current creativity research in design literature also introduces a third aspect: style (i.e., appearance, attractiveness, sentiment) [35, 36]. This third aspect contributes to the sentimental values that occur when observing a design and, thus, is highly relevant to creativity in design disciplines [36]. The authors of this chapter, thus, defined creativity in the interior design discipline through three aspects: originality, effectiveness, and style.

With this conceptual skeleton, the authors adopted the Creative Product Semantic Scale (CPSS) [35], which measures creativity through three components: (a) novelty or newness, (b) resolution or functional value, and (c) style or appearance. Under each component, there are three sub-components with multiple 7-Likert semantic scales. There are 55 semantic scales in total. A study using the CPSS to measure the creativity of three chairs with a Norwegian sample ($n = 128$) showed sufficient internal consistency between criteria in each dimension (.78 to .85) [37]. Exploratory factor analysis also showed that the three components accounted for 74.9%, 77%, and 79.3% variance in the creativity of the chairs, respectively. A subsequent study with an American sample ($n = 185$) displayed the same results. The internal consistency ranged from .69 to .86, and confirmatory factor analysis was high (.91 to .94) [38]. However, rating 55 semantic items are time-consuming [39]. Hence, multiple researchers adopted a simpler CPSS of 15 items with five semantic scales per component [40, 41]. Wei et al. (2015), for instance, used said 15-item CPSS to assess students' creativity in an interior design project and found a satisfactory internal consistency for items in each dimension ($\alpha > .72$) [40]. Interestingly, a study on VR and creativity used only two components of novelty and resolution from CPSS. These two components indicated an adequate internal consistency (.62) and explained 72.6% variance in the creativity of participants ($n = 81$) [10]. Overall, CPSS is a conceptual- and statistical-reliable measurement of creativity.

3. Method

This study extended a previous study [15] on the learning experience of interior design juniors ($n = 13$) creating a custom luminaire with VR at a southeastern

university. The purpose was to seek insights on the partial evidence of VR impacts on creativity from the said study. The custom luminaire project lasted 9 weeks and required students to design an original and functional light fixture with an operable lamp for indoor use. The course instructor (i.e., the first author) partnered with Gravity Sketch (GS) to gain students access to Co-Creation, a collaborative VR modeling application. As students had minimal experience with VR, Meta Quest 2 headsets were chosen to run GS Co-Creation due to their user-friendly and intuitive nature. Students hand sketched 10 ideas of the custom luminaire, then revised three viable options in Co-Creation, refined one best option in Computer-Aided Drawing (CAD) software packages, and 3-D printed it as a scale model (see **Figure 1**). Two internal facilities supported students with VR headsets and 3-D printers (including supplies). Using the 15-item version of CPSS [40], two judges independently rated 10 sketches, three revisions, and one best option for every student. Averages of (a) novelty, (b) resolution, and (c) style ratings from the two judges determined each student's creativity. Paired t-tests for CPSS averages between 10 sketches, three revisions, and one best option indicated improvements in novelty ($p = .05$) from the first judge's ratings and in style ($p = .02$) from the second judge's ratings [15].

The authors adopted the qualitative approach of using Video Data Analysis (VDA) to examine a half-an-hour excerpt of the recorded learning experience of a student in Co-Creation via the Meta Quest 2 headset. VDA is the science of interpreting human movements, views, spatial usage, interactions, glances and gestures, facial expressions, and body postures to understand their social behaviors [16]. Based on that premise, the authors hypothesized that how students navigated and designed in GS Co-Creation might explain the partial impact of VR on their creativity. However, the authors collected no facial or verbal information as participants wore VR headsets in a formal classroom. Only their head movements (as shown via their changing views in the virtual environment) and hand gestures (as demonstrated via their controllers and pulled-up menus) were available for analysis. With such data, the author focused on the two metrics of VDA: (a) interaction and (b) context [16, 42]. Interaction elucidated how students used basic commands, manipulated digital models, and navigated

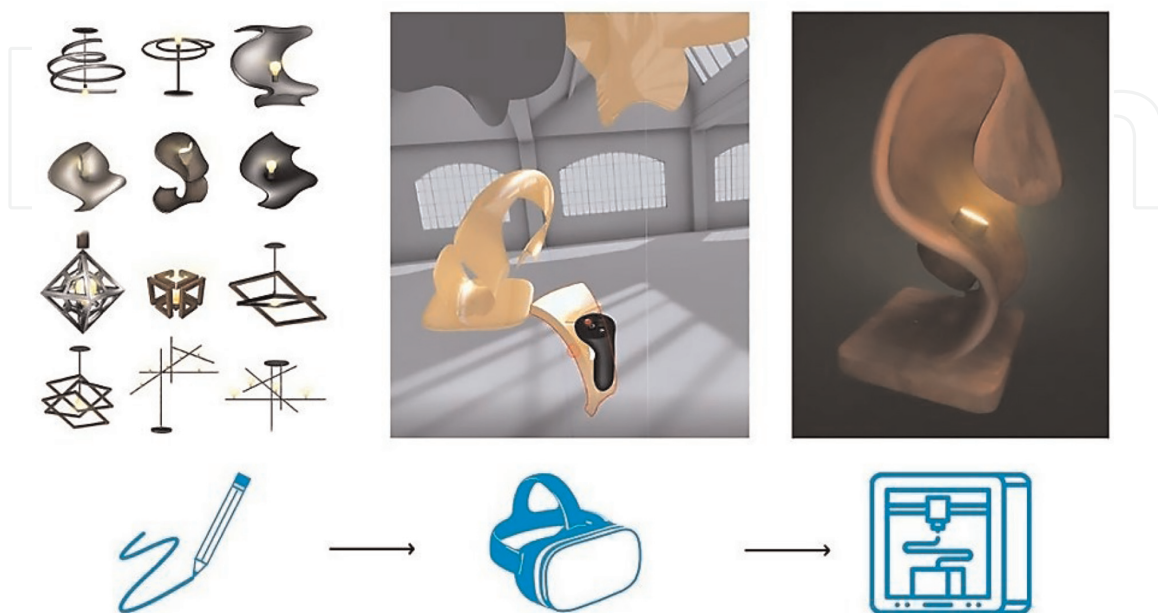


Figure 1.
The design process in the nine-week custom luminaire project.

GS Co-Creation's virtual environment. Context described the virtual environment's dimensions, such as space and lighting properties. The observation checklist for (a) interaction included which controller(s) the participant used, what menu/command the participant pulled up from the controller(s), what geometries the participant created with the controllers, where the participant stayed, and where they looked at in the virtual environment of GS Co-Creation. Regarding (b) context, the observation checklist contained the tangible elements such as the lower horizontal surface (i.e., floor), the vertical surfaces (i.e., walls), the upper horizontal surface (i.e., ceiling), and the intangible element of lighting in the GS Co-Creation virtual space. Also, the authors chose an excerpt from a participant who had minimal VR experience in the third week of the project. The authors expected to observe prominent details related to the VR learning curve as the participant was a new learner and only exposed to GS at this project stage.

4. Results

The authors used two metrics to analyze a half-hour recording excerpt of a student sketching in GS Co-Creation (during the third week of the project): (a) context and (b) interaction. **Figure 2** depicts the GS Co-Creation interface, which contains the shared virtual environment, two controllers with GS command buttons, 2-D reference photos, and 3-D models. At 00:19:00, the video went dark, indicating a problem with Wi-Fi casting. The video resumed at 00:21:33, demonstrating that the student knew how to use the headset, although slowly.

4.1 Context

Regarding (a) context, the shared virtual environment was a warehouse-style structure with rectangular windows on the walls and skylights on the roof. The surfaces were pale gray, including the floor, the walls, and the ceiling, which was an angled roof. No indications of a specific location were available since the windows only showed white surroundings. Although those features were static, the light intensity changed depending on where the student was moving in the environment. The command menus appeared as rectangular tabs with small icons showing the different modeling options, such as creating surfaces, strokes, primitive forms, and other functions (e.g., getting 2-D reference images, saving, and exporting sketches). For each modeling option, there are sub-commands to change colors, materials, and even reflections.



Figure 2.
GS Co-Creation interface screenshots from the VDA excerpt.

4.2 Interaction

In terms of (b) interaction, the student used the controllers to create and place geometric shapes (i.e., pink cubes) on top of each other. The student changed their position in the virtual environment and overlooked the composition of the pink cubes from above then started to delete all the pink cubes. Their classmates occupied the shared environment, creating different shapes in various colors as well. The student created a new shape, a white rectangular box bordered with a thin black line, moved on to the color wheel command (see **Figure 2**), and selected several colors (first pink, then a light yellow). The student looked around (as if investigating the environment), reselected a darker shade of light yellow, and used the controllers to create a square column. Looking over the column, they placed another rectangular geometry on top of the column. Said process was repeated by reselecting the color and browsing the color wheel. The student created additional forms in orange for the column but then deleted them all.

They then restarted by creating three orange rectangular shapes and laid them on top of a light-yellow column. After that, the student continued adding another rectangular shape at a 90° angle to the pile of columns and constructed two rectangular shapes on top. They moved to another corner of the room and created four more rectangular shapes stacked on top of each other. The student then made up-and-down gestures with the controller but did not create other shapes with these movements. Instead, they opened the menu toolbox. After selecting the stroke tool, the student drew two parallel yellow-colored strokes independently above the earlier created geometric shapes. Erasing these strokes, they created a curved line with the right controller moving to the left, creating a curved line. The student once again erased those stroke lines, then drew their name with the strokes yet deleted them completely again. The stroke drawing continued as the student formed multiple arches over the top of the stacked rectangular shapes. As the student moved around, they hovered the right controller across the geometric shapes, which made them turn red (i.e., indicating the ability to select object using the controller).

The student opened the menu again and activated the primitive object tool. During the next minutes, they repeated creating and erasing the geometric objects. Afterward, the student drew several spirals on both sides of the stacked rectangular shapes from top to the bottom, but then again erased them. Next, they drew a circle followed by nonspecific circular lines to form a structure on top of the stacked rectangular shapes. The student then used both controllers to grab and bring the group of geometric shapes closer to their view. They looked up to the ceiling and down to the floor of the environment, activated the menu, and selected paint color tool. The paint color tool offered multiple options in tone, shade, and reflectivity. The student made multiple selections over again. They also moved the controller back and forth to assign such options of tone, shade, and reflectivity to the surrounding geometric shapes. After that, the student turned 360° and opened the menu again to continue modeling with the revolve tool. They started with a moderate thickness and the star profile, then assigned a reflective material to the newly created shape. While making a variety of star-like shapes with this tool, the student also stretched and distorted those into different angles. They also spent time playing with different variations of the star-like shapes and continuously changed their choices of tone, shade, and reflectivity.

After a while, the student activated the stroke menu and selected a color by pulling and pushing the color wheel to choose a blush color. They also pick a material for the stroke by pointing to the reflectivity options below the color wheel. The student started creating undefined circular shapes with the stroke tool in rapid movements. After



Figure 3.
Examples of VR sketches in GS Co-Creation from the VDA excerpt.

completing the sketch (see **Figure 3**), the student teleported around it and appeared to be thinking about revisions with their controllers hovering over the sketch several times. The student again decided to delete the sketched strokes and then opened the menu again to select the primitive object tool. They started with a cube in light yellow and enlarged the object by pulling both controllers apart. The student added two additional cubes and then erased them all. Repeating with another cube, the student placed two more cubes on top of each other. They kept going back and forth to the menu with the primitive object tool to create more cubes one on top of another. The student then pulled one of the cubes to another direction and changed its height, width, and depth.

The student created a new column next to the four cubes and kept placing additional cubes and rectangular shapes on the column and deleted all of them together. Next, the student explored the surface tool on the menu with the bridge curve option. A curve appeared between the controllers, which got bigger and smaller as the student moved the controller toward or pulled them away from one another. The student then paused for a moment and activated the revolve tool again with a six-sided shape. They first drew a flat hexagon border, moved the form with both controllers around the four cubes, and changed its size. While this tool was still activated, the student erased the smallest cube on the top and moved the hexagon shape to the left side of the piled cubes. They also pulled the form in different directions and changed its size, trying to make it more prominent. These movements created several tower-like structures (see **Figure 3**). During these creations, the student moved back and forth, closer and away from the sketches. Suddenly the student looked up to the ceiling of the environment and shortly to the floor. Then the screen turned black.

After about 2:30 minutes, the student came back to the environment looking at the sketches created earlier, still having the hexagon tool activated. The student was now inside a hexagon ring, pulling it toward different directions. They then drew another smaller hexagon shape inside the hexagon ring and deleted the giant hexagon ring and tower-like structures. The student activated the hexagon tool and flipped the left controller back and forth to change the axes of the hexagons (see **Figure 3**). After a while, the student erased all other cubes while keeping the hexagons. After changing its size several times, the student activated the color wheel again and made the hexagons light blue. The student continued to experiment with its height and the excerpt ended with the student finishing the hexagons in the virtual environment.

5. Discussion

Based on the VDA analysis of the excerpt from the learning experience designing with VR in a nine-week custom luminaire design, the authors noticed two prominent

observations. First, the student displayed proficiency in using Co-Creation, yet focusing on a limited number of tools. Second, the student constantly drew and then deleted the sketches. The excerpt was recorded in the third week when students transferred their three most potential 2-D sketches into GS Co-Creation to develop 3-D models. As a result, both observations were legit and shed some light on the partial impact of VR on student creativity. The first observation indicated that the student could navigate the virtual environment and retrieve and use the menu tools of GS Co-Creation. During the whole excerpt, the student was fluent in both controllers, creating, moving, or scaling geometric shapes. Nevertheless, the student limited the variety of geometric shapes to cubes, strokes, and multi-side profiles (i.e., hexagons and stars). These shapes are primitive or revolved (i.e., a profile moving along a central axis), showcasing an articulate yet fundamental VR modeling skill. This is comprehensible. In the third week, students had just completed the VR onboarding process through tutorial videos on GS's official YouTube channel. The student's comfort level, as shown in the excerpt, revealed a smooth learning curve or at least the intuitiveness of GS Co-Creation and Meta Quest 2 headset. As all the sketches were undefined structures (i.e., piles of geometric shapes), the authors speculated that the student had yet to develop the three revisions of their custom luminaire. In other words, the student was still exploring VR technology (i.e., GS Co-Creation and Meta Quest 2 headset).

The second observation confirmed the authors' speculation as the student kept creating and deleting their sketches. While stacking the geometric shapes on top of each other, they used different options each time (e.g., cubes, stars). The act of stacking designated a consistent theme in the student's creation, despite no defined form of a custom luminaire shown in the excerpt. While no hand sketches were brought into the virtual environment, their top choices among the 10 hand sketches indicated the same theme of stacked/piled geometric shapes (see **Figure 4**). In the third week of the project, there was still room for exploration as the student was in the early stage of the design process (i.e., developing three revisions of the custom luminaire from the 10 preliminary hand sketches). The student even tried the hexagon and star shapes to diversify the theme of stacking/piling. Another notable point was that the student showed a high level of concentration on their sketches. Except for a few times looking around the virtual environment, these students fixed their view on the sketches and dedicated themselves to trying different tools, colors, and shapes. At least for this student in the current excerpt, designing with VR in GS Co-Creation was

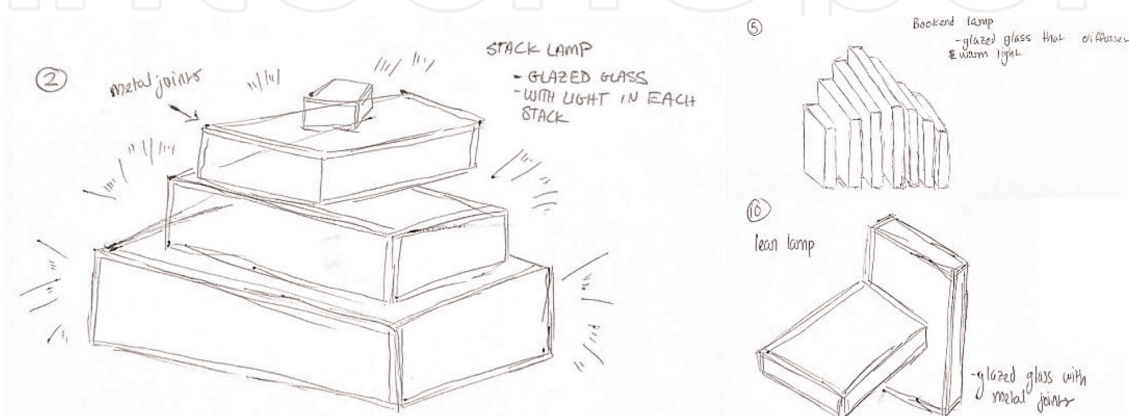


Figure 4.
Three choices of hand sketches from the student in the VDA excerpt.

attainable and enjoyable, as shown in their level of (fundamental) competency and persistency (i.e., the cycle of creating and deleting). The completion of their sketches, however, did not reflect the functional aspect of a luminaire. Again, this excerpt was from the third week and was not representative of the outcomes of this project.

6. Conclusion

The educational contribution of this study is two-fold. First, GS Co-Creation and Meta Quest 2 headsets were intuitive enough for a smooth learning curve in fundamental skills. Second, the student's tendency to prolong the exploration (of shapes, sizes, colors, and materials) was evident in this excerpt. The first contribution aims at educators and institutions wishing to include VR in their curricula. While VR and related technologies have become affordable [25, 26], the authors suggested the adoption of GS Co-Creation and Meta Quest 2 headsets for design education. As shown in the excerpt, despite having minimal VR experience and practicing GS for the first time in week three, the student participant could control the application and headset to create geometries. This observation resonates with the VR literature in Section 2, which indicated that specific technologies of VR were accessible and beneficial to learning, such as HMDs (e.g., Meta Quest 2) and GS. VR researchers also praised Meta Quest 2's balance between accuracy and affordability [43, 44]. The second contribution, however, is a reminder to educators and institutions that, despite being intuitive, VR technology still requires time and practice to attain advanced skills. The fact that the student participant could only use primitive or symmetrical geometries might restrict their ability to construct complex and detailed VR models for their custom luminaire. In other words, their works had limited demonstrations of the novel, resolution, and style aspects. Educators and institutions must ensure that students have ample time and access to applications and headsets to explore and develop their ideas when integrating VR into the curriculum. While VR technology allows students to create, erase rapidly, and recreate sketches, giving more room for creativity, time, and expertise might play again for the student to fully execute their VR models. Henceforth, the time constraints to practice and increase expertise might lead to partial learning outcomes, such as elevating some but not all aspects of creativity [15].

As the course instructor, the first author also made the improvements below in the custom luminaire design project in fall of 2022. Fellow educators who wish to apply VR to their teaching can consider such improvements as starting points for their classrooms.

- A. GS Co-Creation and Meta Quest 2 headsets are still the choice of VR technology for students due to their smooth learning curve and intuitiveness. The first author/instructor provided a teaching assistant (TA) for students to accelerate their learning speed instead of the tutorial videos from GS's official YouTube channel. Co-Creation allows up to 10 students to work simultaneously, so the TA tutored a group of five students in the virtual environment. Students practiced with the TA step-by-step and asked specific questions for their VR models. The first author/instructor, thus, expects to see a clear improvement in student ability to demonstrate all the novel, resolution, and style aspects and, subsequently, significant statistical evidence for the positive impact of VR on creativity.
- B. The tendency to prolong exploration in GS Co-Creation led to the adjustment in the project timeline. The first author/instructor added two extra weeks for

students to explore and revise their sketches in VR. While this approach increased the overall project time, it allowed students to build and revise complex idea representations, which were better for novel, resolution, and style assessments.

These improvements can also serve as references for design educators who wish to incorporate VR technology into their pedagogies to enhance student creativity.

One limitation of the VDA analysis in this study is that the authors only examined one student at a specific stage of their design process. Hence, the two observations in the discussion above are not generalizable for the whole sample ($n = 13$). While the authors have more recordings to dissect, VDA is a time- and effort-intensive method that requires an extended timeline for further analysis. In the scope of this chapter, the authors only presented a snapshot of the VR learning experience of interior design students in a nine-week custom luminaire design project through a typical excerpt among the recordings. For future research, the authors aim to analyze more recording excerpts from multiple students during the third and fifth weeks of the project. This extensive analysis will show whether the two observations in this chapter withstand different students.

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Conflict of interest


The authors declare no conflict of interest.

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