

Fostering Creative Collaboration in A Postsecondary Art and Design Course Through Multimodal Pedagogy Within Virtual Worlds

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Abstract

This research investigates the applications of Virtual worlds (VWs) to foster creative collaboration within art and design education, an under-explored area. It centers on three interrelated theoretical perspectives—team-based VW multimodal design, design thinking-oriented activities, and transformative arts engagement (TAE) practices. The research aims to 1) identify the affordances of multimodal design practices for promoting creative collaboration using VWs; 2) recognize and validate students' individual and collective creative actions in addressing complex constraints and difficulties during design thinking stages and activities in VWs; and 3) explore the transformative potential of collaborative VW multimodal design practices for empowering young design students with TAE-associated capacities—engaged agency, connection, and positive values and beliefs.

To achieve these aims, this study employs a practical action research design in the author's 8-week course with 15 second-year art and design students. The creative affordances of VW design pedagogy were examined using multimodal analyses that included three case studies of collaborative design processes and completed projects by three student groups. Students' perceptions of change in valuing the VW design practices for fostering their creative collaboration in relation to TAE capacities were evaluated using an innovative retrospective post- and pre-assessment. Finally, a constant comparative method was used to analyze fifteen semi-structured interviews to understand better students' perceptions of their collaborative VW design practices.

The findings indicate that the purposeful use of pedagogies aligned with the affordances of VWs creates a space for creative collaboration and empowers students to become innovative, autonomous, and resilient agents through a process of transformative engagement. The findings suggest that art and design education should foster both the individual and collaborative creativity of students, which often manifests itself through their resourcefulness in exploiting new digital affordances to produce meaning that is transformative and innovative.

Keywords: Creative collaboration, design thinking, VW design pedagogy, team-based multimodal design practices, multimodal social semiotics, transformative arts engagement

Dedication

To my precious son, Theodore, thank you for giving my life a powerful sense of purpose since the day you were born.

To my loving parents, Hua and Jianping, thank you for always being there for me and encouraging me to pursue my dreams without limits.

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List of Acronyms

Active Worlds	AWs
Group A	Ancient Chinese immortal town group
Group I	iCloud group
Group P	Pan's labyrinth group
SFU	Simon Fraser University
SL	Second Life
TAE	Transformative arts engagement
UBC	University of British Columbia
VCER	Virtual Commons for Education and Research
VWs	Virtual worlds

Chapter 1. Introduction

1.1. Personal Statement for Pursuing the Research

One of the primary goals of today's postsecondary art and design education is to cultivate self-directed and autonomous individuals who can collaborate in a group context and to develop their problem-finding and problem-solving skills, which will enable them to handle complex and unpredictable life and work situations that require creative and novel approaches (Bridgstock, 2016; Crosby et al., 2020). As an art and design educator, I have felt both fortunate and challenged by these goals: fortunate because art and design educators, especially in postsecondary institutions, often have greater curriculum freedom than educators in other disciplines. This is because art and design is typically taught through a constructivist¹, problem-based, and hands-on studio pedagogy (Shreeve et al., 2010; Svensson & Edstrom, 2011; Vanada, 2016). On the other hand, I found it challenging to provide an appropriate amount of pedagogical structure to effectively facilitate the uncertain and open-ended nature of students' creative design processes (Sawyer, 2011, 2017).

During my more than 11 years of experience teaching art and design in both China and Canada, I witnessed many students struggling to be creative in their first- and second-year foundational course assignments and projects. Their previous educational experiences, which primarily fostered a mindset focused on what they must do to pass, made them cautious about doing tasks that were less structured or required their own initiative. I found it difficult to balance the unavoidable tension between open-endedness

¹ Constructivist pedagogy is widely recognized in education as relating to constructivism as a theory or model of learning or meaning making whereby students create their own understandings through interaction with what they know and the ideas and knowledge they come into contact with. Richardson (2003) describes constructivist pedagogy as a representation of a process involving five characteristics: "1) attention to the individual and respect for students' background and developing understandings of and beliefs about elements of the domain (this could also be described as student-centred); 2) facilitation of group dialogue that explores an element of the domain with the purpose of leading to the creation and shared understanding of a topic; 3) planned and often unplanned introduction of formal domain knowledge into the conversation through direct instruction, reference to text, exploration of a Web site, or some other means; 4) provision of opportunities for students to determine, challenge, change or add to existing beliefs and understandings through engagement in tasks that are structured for this purpose; and 5) development of students' metawareness of their own understandings and learning processes" (p. 1626).

and structure in the constructivist art and design classroom. When I gave the students creative and conceptual assignments, many had no idea how to approach open-ended activities or problems requiring creative solutions. They would ask for additional instructions, which often confused them even more. However, when I gave them highly structured tasks with direct instructions, they tended to reject them in favor of more collaborative forms of learning. Given the fact that art and design learning increasingly occurs in complex collaborative digital environments, I found it even more challenging to provide a suitable level of structure and support not only to prepare my junior design students for acquiring the discipline-specific skills and techniques needed, but also to encourage them to negotiate conceptual conflicts between interests and perspectives and to take creative risks and explore the unknown as a group. In my past teaching in both countries, many first-year design students unfortunately continued to feel anxious about creative practice and collaboration as they progressed to the next level of art and design learning; some even left the program as a result.

This is a persistent concern despite calls for increased international scholarly attention to provide a collaborative learning environment that encompasses both freedom and structure for nurturing collective creativity (Davies et al., 2013; Osmond & Tovey, 2015; Sawyer, 2017). In China, a growing number of universities and colleges have recognized the pedagogical tension between the design foundation curriculum structure and the open-ended nature of design processes, as well as the need to redesign the curriculum to better equip junior design students with domain-specific skills and knowledge. These institutions have also advocated for creative collaboration as a transferable competency required for developing career paths in the increasingly interdisciplinary design industry (Wei, 2016).

My teaching experience and desire to support students' creativity motivated me to pursue this PhD research as a teacher–researcher. By investigating and redesigning an art and design pedagogy and sharing my experiences of implementing it in my own classroom, I hope to manage the balance of freedom and structure inherent in the constructivist art and design classroom and expand the scope of existing design pedagogies to create more learning opportunities that promote students' creative works and collaborations. Furthermore, as previously mentioned, self-directed and autonomous individuals in creative fields are lifelong learners who not only respond to externally motivated goals but are also able to pursue self-initiated social responsibility and

collaboration across disciplines and organizations (O'Neill, 2012a, 2014). Therefore, it is crucial for this art and design research to develop an exploratory and transformative pedagogical experience that is capable of building students' creative confidence, resilience, and capacity. Before describing my study and outlining my findings and discussion, I present in the following sections the research context and questions, the research contribution, as well as a literature review based on a thorough search of the main areas of focus for my thesis.

1.2. Research Context

In a typical professional design studio, the complexity of design problems requires teams of designers rather than individuals to engage in a recursive process of information gathering, sharing, synthesis, and idea generation, with collaboration among codesigners at the centre of this creative process (Vyas et al., 2013). As a result of globalization, collaboration in the design industry has become more interconnected, and the complexity of this interconnectivity has also increased (Alves et al., 2007; Larsson, 2003; Mattelmäki et al., 2011). This shift has been accelerated by the COVID-19 pandemic, which has forced a significant number of design professionals and students to switch to virtual or hybrid learning and to work collaboratively. Because of the speed of this change, it is more important than ever to assist design students in developing their capacity to collaborate with diverse teams physically and virtually so they can navigate this ever-increasing complexity and uncertainty with creativity, autonomy, and resilience (Lee et al., 2021; Weinberg et al., 2020).

Much art and design education is characterized by professional design studio practices and embraces collaborative design as a form of constructivist learning activity to support the creative processes and outcomes of design students (Dreamson, 2017; Fischer, 2004). Additionally, an increasing number of creativity scholars (Csikszentmihalyi, 1997; Engeström, 2001; Henriksen et al., 2017; Sawyer, 2007; Schön, 1984) have also emphasized a social and collaborative view of creativity, indicating that individual creativity arises from the person's interpretation of the sociocultural context and negotiation with others. Diverse educational technologies have been incorporated into collaborative design learning activities, demonstrating many benefits in enhancing and facilitating particular aspects of collaborative learning. These technologies include Moodle, a learning management system that promotes participation

and engagement (Lahti & Seitamaa-Hakkarainen, 2014); a virtual reality application that facilitates the collaborative creative process (Lee et al., 2021); synchronous and asynchronous idea sharing in 3-D virtual worlds (VWs) (Koutsabasis et al., 2012); the Second Life (SL) virtual world for interdisciplinary collaboration (Liao, 2016); reflection and communication in an online forum (Karakaya & Demirkan, 2015); and the Blackboard application for interactive design course delivery (Park, 2011). The cited authors provide valuable insights into how these technology-facilitated design pedagogies broaden the design educational scope in terms of space, time, concept, and technology, thereby creating new possibilities for fostering creative collaboration in managing complex design challenges. However, most of these studies have relied on interviews with teachers or students to ascertain their perspectives on the pedagogy they experienced. Further research is necessary to provide detailed analysis and descriptions of design learning activity transcripts to clarify the implicit aspects of a specific technology-supported design pedagogy.

In many of these technology-enhanced educational studies, research into the educational use of augmented reality has identified numerous affordances of VWs, such as SL, Active Worlds, and World of Warcraft, for constructivist learning, particularly for creative collaboration (Andreas et al., 2010; Dickey, 2005, 2011; Wood & Gregory, 2018). First, the personalized avatars, editable environments, and multimodal communication tools afford a sense of playfulness, copresence, immersion, motivation, and collaborative knowledge construction within the group (Girvan & Savage, 2010, 2019; Marone, 2016). Second, the building tools and the persistent environments, in conjunction with multimodal communication tools, provide opportunities for experiential learning, allowing the process of sharing knowledge to be dynamic and adaptive through actions among group members (Gül et al., 2008). Third, the ability to navigate freely constructed 3-D virtual environments and view and manipulate an object and setting from multiple perspectives enhances knowledge and use of design modes and facilitates reflective practice in remote collaboration (Dalgarno & Lee, 2010; Vosinakis et al., 2008). Despite the fact that few of these VW studies were conducted in design educational contexts, they identified certain VW affordances for collaborative constructivist learning that indicate their potential for design collaboration in design studio-oriented art and design education. However, I found no studies that discuss how to provide the right degree of structures to help students balance the creative process and the mastery of

technique and skills during their virtual collaboration, which typically comes with learning barriers (Warburton, 2009).

In addition, most VW studies have examined VW interactions exclusively to ascertain how to ensure engaging learning experiences and creativity (Childs, 2010; Ferguson, 2011; Freitas et al., 2010). However, only a few works consider students' physical and virtual interactions and engagement to explore the affordances² of *hybrid educational spaces* (Jung, 2011) when virtual environments are implemented in classrooms. Therefore, researchers should study the implementation of VWs in both in-world and in-class settings to better understand VW potentials and affordances to allow a practical design of learning activities.

Furthermore, many VW educational studies provide suggestions for collaborative constructivist learning through a perceived affordance lens (Dickey, 2005; Girvan & Savage, 2010, 2019; Kirschner et al., 2004), indicating that the potential use of any mode of the virtual environment is "a matter of perception" (Jewitt, 2013, p. 7). However, the implementation of any technology in educational contexts is not entirely determined by technological factors but is also profoundly influenced by sociocultural aspects (Veletsianos, 2009). From this perspective the use of Kress's (2010) social semiotic view of multimodal affordance appears appropriate in creating the VW-supported learning environment. According to Kress (2010, 2013), modal affordance is a complex concept that connects the material and the sociocultural use of a communicative mode. It highlights the mode's potentials and constraints for making meaning in relation to different situations, environments, and communities. Several media arts and design scholars (Burn, 2016; Gürsimsek, 2014) have used a social semiotic multimodal approach to study relevant topics, such as interactions and representations within SL, in which affordances of available communicative modes, such as graphic, text, sound, movement, and embodiment, orchestrate to provide the codesign environment for collaborative practice. This orchestration results in students' multimodal ensembles

² The concept of affordance is a term used in multimodal pedagogy to denote 'meaning potential' or a system of choices that constitute meaning (Halliday, 1978). It refers to the enablers and constraints of semiotic modes (e.g., image, speech, sound, gaze, gesture) and what they can express. Modes are not autonomous or fixed but are created through social processes. The term originated in Gibson's (1979) work to refer to properties of the environment interacting with an organism (i.e., physical properties that can complement situated actions). The concept of affordance was later taken up in the field of design, especially in the design of human-computer interfaces (Norman, 1999). See Section 2.3.2 for a further discussion of affordances.

(Jewitt & Kress, 2003), such as speaking, writing, drawing, designing, and movement, where each mode contributes distinctively to the overall meaning and serves as a sign of their understanding, engagement, and learning. Walsh (2007) incorporates multimodal digital affordances into literacy instruction to harness the creativity of the student design group by encouraging members to bring their unique social, economic, and cultural capital into particular modes or ensembles (e.g., image, text, colour, layout, and interactive objects) of their collaborative digital design. The previous studies examined the socially shaped affordance concept and provided a detailed account of the design of collaborative learning activities in technology-mediated learning environments. However, the key features of multimodal pedagogy and the possible impact of technology affordances and constraints on the implementation of the pedagogy have been vaguely described. For art and design educators and scholars interested in incorporating VWs into constructivist classrooms, this implies a need for future research into how the key features of multimodal pedagogy emerge in constructivist practice as students engage with VWs.

Finally, a number of design education studies have discussed the use of design thinking process stages as a framework for balancing the freedom and structure in constructivist design studio teaching (Bull, 2016; Osmond & Tovey, 2015; Scheer et al., 2012). According to Curedale (2013), the essential characteristics of the design thinking stages include empathy, collaboration, iteration, curiosity, optimism, and experimentation. Brown (2019) added to the characteristics of design thinking by defining it as a mindset that provides designers with the confidence and belief in their creative capacity to transform complex challenges into design opportunities. It is evident that the value of integrating design thinking in education extends beyond the design of artifacts and fits within the scheme of transformative education, which is characterized by a fundamental change in perspectives that leads to flexibility, autonomy, and resilience to changing circumstances (Mezirow, 1991, 1997; O'Neill, 2012a, 2014). Existing research that explores the intersection of multimodality and transformative learning experiences within a technology-integrated design studio collaboration is limited. In this study I aim to fill the gaps mentioned earlier by purposefully incorporating VWs' modal affordances into a design foundation course through the provision of codesign practices to design thinking, which have the potential to iteratively develop junior design students' capacities for creative collaboration and innovation, thereby

transforming their perceptions of themselves as confident, autonomous, resilient agents in the face of complexity and uncertainty.

1.3. Theoretical Orientations

In my research, I investigate the possible connection between three interrelated theoretical frameworks that have not been extensively studied in the prior literature: the use of design thinking to tackle collaboration challenges in art and design education, the implementation of VWs to support and expand collaborative multimodal designs, and the adoption of transformative arts engagement (TAE) to create a participatory environment for fostering creative collaboration. By combining the three theoretical frameworks, I expected to achieve a deeper understanding of how they influence and are influenced by one another, leading to a more holistic, explorative approach for creative collaboration in art and design education. However, I have divided the frameworks to clarify epistemological and ontological assumptions and literature related to each, allowing for a more in-depth examination of their main features in the subsequent literature review.

1.3.1. Using design thinking to address collaboration challenges in art and design education

Design collaboration is considered one of the most effective constructivist approaches in studio-based art and design education for fostering creativity, in which students are given an open-ended project assignment and work collaboratively through interactions and communications to discover the best solutions (Chiu, 2002; Vyas et al., 2013). Students and teachers interact in this environment based on the educational principles of supervision, consultation, and discussion (Park, 2011). Essentially, creativity within the context of collaborative design learning requires a shared vision for a design task (Paulus et al., 2012), diverse interpretations and ideas (Budge et al., 2013), reflective communication and discourse (Augsten & Gekeler, 2017; Schön, 1984), voicing all team members' ideas and establishing trust (Choi et al., 2019), experimentation with multimodal artifacts and tools (Vyas et al., 2013), and meaningful iterative practice for gaining expertise and new understanding (Karakaya & Demirkan, 2015)

Despite design collaboration's creative potential, various art and design educational studies have identified the following common factors that contribute to students' negative perceptions toward collaborative design, thus influencing their creative learning outcomes: power dynamics (Wen & Tsai, 2006); voicing everyone's creative ideas (Choi et al., 2019); share and challenges multiple perspectives (Oak, 2012); decline in motivation (Chae, 2016); the lack of a participatory and playful space to experiment, share, and take risks (Marone, 2016); and ambiguous assessment indicating little difference between collaborative and individual work (Pfaff & Huddleston, 2003). These challenges stem from the sociocultural nature of a collaborative process that is evolving and complicated (Lahti & Seitamaa-Hakkarainen, 2014) given the rising complexity of contemporary design problems. Therefore, they cannot be completely avoided without sacrificing the possibility to foster students' creativity. Nonetheless, art and design educators can provide the appropriate structure of curricula and pedagogy to foster maximally effective creative collaboration among students, thereby minimizing the negative perceptions of struggling students and further developing their capacity for creative collaboration.

The design thinking model developed by one of the world's leading design firms, IDEO, was chosen as a pedagogical approach to tackle some of these challenges in design collaboration. According to IDEO (2012), design thinking is a human-centred approach to innovation with five iterative stages—discovery, interpretation, ideation, experimentation, and evolution. In the first stage, designers build up a deep empathy for people and understand the design challenge as well as its context. They seek inspiration by observing and discovering people's needs to acquire eye-opening insights that allow them to keep people at the centre of every design step. Next, designers apply divergent and convergent thinking to generate ideas and synthesize the insights gathered in the discovery stage; additionally, they critically evaluate and develop their concepts and designs through many iterations. In the third stage, designers courageously brainstorm ideas and transform the knowledge of the problem into tentative solutions. During this process, designers continuously refer to the problem statement to reduce the number of solutions and refine those that are to be taken to the experimentation stage, in which designers create prototypes or solution models. The goal of prototyping is to present and receive feedback from users. Accordingly, designers learn what works and what does not, thus identifying the optimal solutions to meet people's needs. In the last stage the

final version of the prototype is presented and tested in front of the users. Results from this stage may reveal insights about the design, which may lead to a reformulation of the problem and a new cycle of investigation.

As illustrated above, the key features of the design thinking process not only share many bonds with creative collaboration in the studio-based design learning but also provide a concrete framework that assists the teacher in scaffolding students' effective constructivist learning. Therefore, I utilized and adapted design thinking to develop pedagogical approaches that address some of the issues associated with collaboration and increase students' participation and engagement in classroom collaborative design learning.

1.3.2. VW-supported collaborative multimodal design

Researchers across disciplines have found that diverse VW affordances facilitate highly multimodal collaborative learning in the constructivist-based educational context, suggesting their potential for creative collaboration in constructivist art and design studio classrooms (see section 1.2). To foster creative co-construction of knowledge using VW technology, art and design educators need to play a crucial role in designing (Kalantzis & Cope, 2010b; Kress & Selander, 2012) a space for exploration, manipulation, communication, and collaboration. However, the modal affordances of a technology do not determine a particular type of learning; rather, they prompt students to take specific actions (Bezemer & Kress, 2016). Kress's (2010) social semiotic view of multimodality fits well within this design-oriented, constructivist-based research because it investigates how affordances of communicative modes provide the meaning-making possibilities and limitations for the teacher and student agency.

Using this perspective as a pedagogical basis for this research, I move beyond viewing VWs affordances as "perceivable properties" (Jewitt, 2013, p. 6) and focus instead on how the modal affordances of the VW platform can be incorporated into the art and design studio classroom as a means of designing a collaborative learning environment, demonstrating how the modes shape students' learning. The social semiotic view of multimodality also has implications for sketching an alternative assessment, in which the teacher's assessment practice becomes the recognition of the learning outcome of the student's engagement as signaled in their multimodal meaning-making actions rather than the metrics predefined by those in power. Consequently,

assessing students' creativity in VW-based design collaboration becomes the recognition of their "semiotic resourcefulness" (Bezemer & Kress, 2016) in collaboratively exploiting the meaning-making potential of diverse VW modes and demonstrating their sensitivity to their social and material learning environment throughout the design thinking processes. These collaborative multimodal designs reveal the students' motivating interests in specific VW modes and agency, which can be used to guide further pedagogical design refinement toward a more student-centred pedagogy.

1.3.3. Transformative arts engagement

Although VWs provide a stimulating environment for encouraging collaborative creativity (Alahuhta et al., 2014; Han, 2019; Ward & Sonneborn, 2011), they are fundamentally transdisciplinary (Koutsabasis et al., 2012) and require continuous exposure and practice to achieve technical mastery (De Leon, 2011). When junior design students with limited digital design experience participated in collaborative design using this new and inherently complex VW technology, they may have encountered a disorienting dilemma (Mezirow, 1991) that challenged their initial expectations for design learning and practice. However, this disorienting dilemma is an integral aspect of transformative learning, which has the potential to function as a catalyst for students to question assumptions, resulting in transformed views and beliefs (Taylor, 2007). Consequently, I adopted and combined the TAE conceptual framework (O'Neill, 2012a, 2014) with the design thinking model and multimodal pedagogy to create a more holistic pedagogical model for developing transformational collaboration opportunities.

According to O'Neill (2014), TAE is a "learner-centred approach that fosters agency and empowers learners to be autonomous, self-directed learners" (pp. 205–206). It occurs when art learners deeply engage in a critical and reflective exploration of the specific context of learning and relationships and take actions to bring about positive and meaningful transformative changes to themselves, others, and their communities in relation to the art activities in which they are engaged (O'Neill, 2012a). The three subject areas collectively form the theoretical and pedagogical foundation for this research, with the ultimate goal of helping junior design students develop capacities to transform their perceptions of themselves as creatively confident, autonomous, and resilient agents capable of addressing complex and uncertain design challenges.

1.4. Research Questions and Context

The presented problems, outlined within the topic areas, and objectives of the research provide the foundation for constructing the following two main research questions:

1. How might the purposeful use of multimodal pedagogy leverage the affordances of VWs to foster creative collaboration among junior art and design students?
2. How might the multimodal pedagogical approach in conjunction with the TAE framework create transformative learning opportunities through VW-based collaborative design processes?

To answer the questions, I employed a practical action research design, which Mills (2007) defines as a process of inquiry in which the teacher reflects on a specific problematic classroom situation in an ongoing systematic and recursive way and takes actions to change that situation, thereby improving teaching and learning. As an art and design educator, I sought to inquire about creativity and collaboration issues that arose in my classroom, as well as take actions to foster my students' creative collaboration and improve my teaching practice. Consequently, I incorporated VW technology into a preexisting Design Fundamentals course in the Department of Art and Design at Zhengzhou University, in which action research was applied. The original Design Fundamentals course was a required design studio course for junior art and design students that emphasized the development of basic design knowledge and skills.

After reflecting on the initial pedagogical aims and shortcomings of this course, as well as advice from my department's colleagues and insights obtained during my doctoral studies, I revised the Design Fundamentals curriculum in 2017 to fit the newly adapted course utilizing VW technology for this research. Additionally, I integrated SL, one of the most popular online virtual environments, and Virtual Commons for Education and Research (VCER), which is supported by the University of British Columbia, into this course to enhance students' creativity and my teaching. In the spring 2018 term, the department approved the redesigned design fundamentals course and published it on its website to recruit participants. The research sample comprised 15 second-year art and design students (11 females, 4 males) who had little or no digital design experience and voluntarily enrolled in this VW-blended course in the fall 2018 term; classes were held two times per week for 2 hours per session for 8 weeks in total.

For creative collaboration and the transformative learning experience to occur in the VW-blended design research program, teachers and students must engage in dialogues and activities free from coercion and open to different perspectives (Mezirow, 1997). Therefore, I see myself as an equal partner in collaboration (Pine, 2009) with my student participants, serving as a “designer” (Kalantzis & Cope, 2010b; Kress & Selander, 2012) of the VW-integrated learning environment to facilitate this kind of learning while collecting and interpreting the data.

To participate in the collaborative VW design projects, 15 students formed three equal groups based on their shared interests in design topics or themes. They were also responsible for maintaining their weekly design journals with virtual project snapshots reflecting their design progress. The student design journals served a dual purpose: collecting research data (participants’ views of their own and team members’ design practices) and engaging students in a continuous reflection on their own and group design learning and processes. At the end of the program each group shared their projects in VCER for presentation and peer evaluations, which were captured using the Coccinella screen recording application for analysis of the completed group projects. In addition, I documented my after-class observations of the entire course program in screenshots and daily field notes. The recording, screenshots, and field notes provided complementary data sets that captured students’ individual and collaborative design processes in both the virtual and real worlds.

Because this elective course at Zhengzhou University does not require a score-based assessment, I provided each student with a pass/fail evaluation, comments, and feedback 2 weeks after completion of the program.

1.5. Research Contributions

In my research I investigate the potential of a VW-integrated art and design course to foster creative collaboration, contributing to a significantly less-explored realm in art and design educational research, as illustrated in the following areas:

1.5.1. Theoretical contribution

In my study I integrated three theoretical frameworks for employing VWs in art and design education to foster creative collaboration. Even though there is improved understanding of the potential of a VW-enhanced learning environment and its implementation to encourage collaborative creativity and learning, few studies have explored theoretical frameworks and developed a feasible pedagogical model to address pedagogical challenges in facilitating design collaborations. Moreover, the three primary underpinning subject areas—the design thinking model (IDEO, 2012), social semiotic multimodality (Kress, 2010), and TAE (O'Neill, 2012a, 2014)—have been studied to develop creativity and collaboration across disciplines, including design education (Ejsing-Duun & Skovbjerg, 2018), language and literacy (Albers & Sanders, 2010), and music education (Bolden & Nahachewsky, 2015). However, I am unaware of any research that has explored the parallels between the three theoretical approaches to promote creative collaboration via VWs in art and design education. Therefore, I hoped that the research would provide a new theoretical foundation for an in-depth understanding of contemporary art and design education, particularly applications of digital design environments utilizing VWs for creative collaboration.

1.5.2. Methodological contribution

This research offers an innovative methodology for assessing students' creativity in their VW collaborative design processes and completed projects. Although the widely adopted portfolio and critique of methods of assessment in the contemporary art and design studio classroom can identify the stability and certainty of knowledge and skills as predefined learning goals, they often overlook the fact that art and design activities and processes are inherently unstable and uncertain (Danvers, 2003). Many art and design scholars (Belluigi, 2016; Dineen & Collins, 2005; Webster, 2006) have argued that such utilitarian and hierarchical assessments cannot fully recognize students' efforts and capabilities in addressing many of the design challenges, resulting in a decreased level of motivation and diminished sense of self or agency that is detrimental to creativity.

In this research I applied a multimodal social semiotic approach (Kress, 2010) to examine how groups of students use their creativity resourcefully to exploit the semiotic potentials of the unfamiliar VW platform and make multimodal meanings (e.g., drawing,

sound, animation, written text, music, and avatar design and interaction) within their collaborative designs. These multimodal meanings constitute the research data and are signaled in each student's weekly design journals, their self-taken VW screenshots, and video files of their completed project presentations, yielding descriptive interpretations that allowed me to engage in discussions with students about their VW engagement and then shape the next pedagogical prompt. By recognizing students' interests, agency, and semiotic works in all modes, I fostered "a culture of valuation" (Kress & Selander, 2012) that facilitated the development of a learner-centred learning environment conducive to creative collaboration.

Furthermore, this research is grounded in sociocultural theories of learning (Vygotsky, 1978) that approach learning as a dynamic, ever-changing process in which the learners create their own subjective relationships through experience. At the completion of this research I employed an innovative retrospective post-pre assessment (Hiebert et al., 2011) to measure students' perceptions of changes in their design learning and engagement in relation to TEA learning capacities. This method addresses a primary concern with using a traditional pre-post measure of learning when students have not yet experienced the learning activity or formed an understanding of what it means to be involved in the activity, and therefore do not know what they do not know. Therefore, applying the post-pre measurement and then the open-ended interview after students had participated in the VW-integrated design course, allowed me to make a more informed comparison of students' prior knowledge and understanding of design learning and creative collaboration, which can be used as indicators of the perceived impact of their VW-supported collaborative learning on each TAE learning outcome.

1.5.3. Educational contribution

My research contributes to art and design education and related educational fields in two ways. First, it offers an instructional model based on the design thinking process, multimodal pedagogy, and the TAE framework that has the potential to leverage the affordances of VWs for creative collaboration and transformative learning opportunities. Second, it presents multimodal analyses of students' individual and collaborative contributions during the VW-integrated design course, which provides insights for teachers to further engage in cycles of dialogues with students to enhance the pedagogical approach. Consequently, the analyses serve as an alternative form of

assessment that prompts further communication and interaction between the teacher and students, leading to ongoing new understandings into the possibilities of using VWs for collaborative learning and fostering creativity in future art and design education.

1.6. Thesis Structure

I have organized this thesis into seven chapters. In Chapter 1, I outline the content of each succeeding chapter, introduce the research subject areas, describe research methods and findings, and discuss the research contributions.

In Chapter 2, I present a literature review of the three interrelated theoretical perspectives that constitute the theoretical foundation for this research, including creative collaboration in art and design education and the design thinking mode, VW-supported design collaboration in relation to the multimodal pedagogy, and the TAE theoretical framework.

In Chapter 3, I propose the framework of this research based on the literature review. I explain the relationships between the elements and concepts of the aforementioned key theories and depict them in visual graphics.

In Chapter 4, I outline the research methods, including the aims, learning outcomes, program design, research site, participants, data collection and analysis procedures, and ethical considerations.

In Chapter 5, I present case studies of three individual design groups' creative collaborations within VWs. I analyze each participant's VW screenshots, the associated weekly design journals, and final presentation videos by using a multimodal social semiotic approach to understand how each group's creative actions manifested themselves in their collaborative design processes and completed design projects.

Using a constant comparative method in Chapter 6, I investigate students' responses to the post-pre assessments and semi-structured interviews through the lens of TAE, resulting in four emerging themes as the second part of the research findings.

In Chapter 7, I present a summary of the research findings and a comparison of the existing literature and theories. I then offer the educational implications of the results, limitations of the research, and next steps for further investigation.

Chapter 2. Literature Review

2.1. Overview

In Chapter 2, I critically analyze and synthesize the literature regarding three interrelated theoretical concepts and frameworks. Section 2.2 examines the literature related to theories of creative collaboration and the common collaboration challenges in art and design education. It follows the definitions of the design thinking model and presents how it may address some of the collaboration challenges for fostering creativity. Section 2.3 presents relevant studies on the educational use of VWs that add value to existing design learning to encourage creative collaboration. Additionally, it offers a review of a multimodal social semiotic approach (Kress, 2010) as both pedagogical and analytical approaches to support and recognize students' collaborative creativity in their design learning processes and outcomes. Section 2.4 introduces O'Neill's (2012a, 2014) conceptual framework of TAE, which reinforces the transformative aspects of the two theoretical models mentioned previously that enable a transformation in perspective. Collectively, these three theoretical concepts establish a pedagogical and theoretical framework for this VW-integrated design course, ensuring an educational experience that encourages creative collaboration among junior art and design students through an iterative and repeated experience. More critically, it develops transformative learning opportunities for students' positive and meaningful design engagement, which has the potential for fostering a sense of empowerment among students to be more agentive, autonomous, self-reflective, and resilient when addressing ever-challenging creative tasks.

2.2. Creative Collaboration in Art and Design Education and Design Thinking

2.2.1. Concept of creativity

As Kaufman et al. (2008) have suggested, researchers must clarify their beliefs regarding creativity in any study on creativity. However, the definitions of creativity often change due to specific economic, technological, and cultural climates, which produces challenges with one's conceptualization of creativity. In this section, I explore the

discussions regarding creativity within an educational environment to determine the philosophical understanding of creativity that underscores my entire study in art and design education.

Despite its importance, creativity received little attention from scientists until the 1950s. Only a few researchers had studied creativity, and they saw it as the mental properties of those who were born with inherent creative abilities, such as memory, attention, and logical reasoning (Barron, 1969; Guilford, 1966; Torrance, 1962). Several creativity studies related to art education have sought to measure the variations in individual creative abilities and have focused on the psychological mechanisms that affect an individual's creative behaviors for generating alternative ideas (Beittel & Lowenfeld, 1959; Russell & Waugaman, 1952; Wilson et al., 1954). Although individual psychological approaches may be one important way to conceptualize creativity, they have caused some educators to focus on the few students who exhibit special talents, leaving the majority of students' diverse learning processes to go unsupported and unrecognized (Ranker, 2015), which has led to unfair social divisions in classrooms (McLeod & Cropley, 2013).

In the 1980s and 1990s, the published research in the psychological area of creativity converged on the sociocultural approach, explaining that the social and cultural contexts influence creativity in individuals, groups, and organizations (Amabile, 1996; Csikszentmihalyi, 1997; Sternberg, 1988; Vygotsky, 1978). These researchers were psychologists, sociologists, anthropologists, and artists who studied varied domains, such as visual arts, music, business, athletics, and mathematics, in different cultures. They discovered that conceptualizing creativity requires an understanding of the interaction between the personality traits of a particular type of individual and the social factors (e.g., education, collaboration, support, environment, and cultural background) that impinge on that learner. Within these conceptions, Vygotsky's (1978) idea of "everyday creativity" allows educators to understand that creativity is not merely the privileged ability of a few genius students but rather a social act that all students exhibit in numerous ways throughout their everyday lives. As Vygotsky states, "Creativity exists, not only where it creates great historical works, but also everywhere human imagination combines, changes, and creates anything new" (Vygotsky, as quoted in Smolucha, 1992, p. 53).

A progression from this perspective on creativity is Csikszentmihalyi's (1997) systems model, which implies an interactive relationship among society, culture, and individuals. In this model, creativity is viewed as a complex process that is observed only when these three nodes of the model affect each other. The individual's creative output must be endorsed by the relevant field of gatekeepers who can determine which idea or product is innovative in the specific domain, such as teachers, gallery owners, policy makers, and company managers. From this perspective, to promote students' creative output, educators must provide environments and experiences that support and recognize their creativity in their learning processes and outcomes.

More recently, Sawyer (1999) expanded the dimension of the systems views of creativity by connecting group participants, the collaborative contribution to the domain, and the emergent and unpredictable processes of the sociocultural field. Sawyer (1999) has claimed, "All creativity is an emergent process that involves a social group of individuals engaged in complex, unpredictable interactions" (p. 466). In Henriksen et al. (2017) interview, Sawyer has emphasized that creative teaching involves designing a constructivist learning environment in which learners can engage with creative practices. As Sawyer has stated, "Whatever creativity is, I don't think you can teach it. You can design experiences, and by engaging in those experiences, a learner might learn to become creative" (p. 15). This suggests that the teacher's role is not only as a gatekeeper but also a "designer" (Kalantzis & Cope, 2010b; Kress, 2010) of a constructivist learning environment that is conducive for students to experience and actively construct knowledge associated with creative outcomes.

Based on the key concepts of creativity and for this study, I define creativity as social and collaborative in nature and that it can be fostered through constructivist learning experiences. The sections that follow examine the pertinent literature with a focus on facilitating creative collaboration among students in constructivist-based art and design classrooms.

2.2.2. Creative collaboration in art and design education

Art and design education has traditionally emphasized printed mass communication; creativity in this field has been characterized by a problem-solving process (Cross, 2006) in which student designers creatively and effectively use visual

elements, such as images, written texts, colours, textures, shapes, and layouts typeset and graphic illustrations as solutions for their intended audience (Mateus-Berr & Reitstätter, 2017). However, as innovation technology has advanced and human communication and interactions have become more complex, communicative modes available for design have expanded to include extensive multimodal presentations, such as motion graphics, 3-D animation, interactive website design, and other forms of multimedia. Today, art and design education encompasses a broader range of disciplines that generate new strands of design (Abdulla, 2021), requiring students to develop creativity as a core 21st-century capacity to adapt to changing socio-technical environments (Mishra & Mehta, 2017; Scheer et al., 2012).

Due to these changes, many design educators and researchers (McDonnell, 2016; Osmond & Tovey, 2015; Oxman, 2006b) have argued that understanding creativity as a problem-solving process appears to be overly simple to capture today's increasingly expanded and complex digital design phenomenon, although such a process still plays an important role. They have argued that creativity must be considered within the entire scope of design, including people, technology, processes, products, contexts, and social interactions. As a result of this broader understanding of creativity, many design educators and scholars have agreed that creativity is a fundamental capacity for individuals to flexibly, autonomously, and resiliently work based on incomplete information and in situations of unpredictability, complexity, and risk as well as know how to collaborate in diverse teams, handling changes that are part of life and work situations that demand innovative approaches (Bull, 2016; Choi et al., 2019; Crosby et al., 2019; Osmond & Tovey, 2015). To foster this creative capacity, scholars call for the adoption of collaborative and dynamic learning situations in which students can develop their understanding of the context complexity and learn how to cooperate with diverse team members (Bull, 2016; Osmond & Tovey, 2015). This collaborative experience would empower students with the creative capacity necessary to move along with the constant change as “communicator[s], translator[s], and innovator[s]” (Crosby et al., 2019, p. 12).

Core to current art and design pedagogy is constructivist-based, atelier-styled design studio teaching and learning (Osmond & Tovey, 2015; Sawyer, 2017), which emphasizes learning by doing (Dewey, 2009/1916) and has not changed substantially from its historical models, the Ecole Des Beaux Arts (1819–1914) and the Bauhaus

(1919–1932) (Broadfoot & Bennett, 2003). Fundamentally, it promotes a design studio culture that encourages creative and collaborative activities in which participants naturally interact with one another, thus retaining the studio as a shared space (Fallman, 2007). When a studio culture is effectively implemented in an art and design classroom, design collaboration on an open-ended and ill-defined design problem offers students creative learning opportunities in which they gather and share information, understand design constraints from multiple perspectives, and develop optimal solutions (Lahti et al., 2004). In this studio culture, teachers and students engage in a continuum of exchange of ideas, dialogues, knowledge, and expertise rather than relying on didactic approaches based on the certainty of expert knowledge, which reflects the uncertain and open-ended nature of creative production (Shreeve et al., 2010). Social collaboration is therefore essential to the creativity of studio-based art and design education. As Csikszentmihalyi (2014, p. 162) has stated, “Creativity cannot exist in a vacuum.” Rather, it often emerges from the process of collaboration and interaction, and peers play a crucial role in supporting the creativity of individuals (Mockros & Csikszentmihalyi, 2014).

Using a constructivist view of human perception and thinking processes as a foundation, Schön (1984) described design as both a social and creative process in which designers engage in reflective practice within a design situation to generate both a new understanding of the phenomenon and an uncertainty or change in the situation. This conception of reflective practice is a dialogical mode of thinking and doing (Schon, 1984) and is widely adopted in ongoing professional and educational development in design that entails “reflection-in-action” to assist individuals in becoming more skillful at managing complex and uncertain design situations (Schön, 1987). In the literature, creative collaboration is characterized by the rapid and increased complexity of ill-defined and open-ended design problems that require the integration of multiple perspectives, knowledge, skills, and abilities in the design task (Budge et al., 2013; Paulus et al., 2012), reflective communication and discourse (Augsten & Gekeler, 2017), trusting relationships (Choi et al., 2019), experimentation with multimodal artifacts and collaboration-oriented tools (Vyas et al., 2013), and meaningful iterative practice for gaining expertise and new understanding (Karakaya & Demirkan, 2015). These characteristics of creative collaboration reflect the highly constructivist structure of design studio learning (Sawyer, 2017), which emphasizes students’ active roles in co-

constructing knowledge (Duffy & Cunningham, 1996; Land & Jonassen, 2000), experiential learning and materiality (Jonassen, 1994), and reflection (Jonassen & Land, 2011). Simultaneously, they reveal the open-ended and uncertain nature of this kind of design learning, which serves as a space where creativity exists (Bull, 2016; Sawyer, 2017). However, the open-endedness and uncertainty of the collaborative process often present multiple challenges to team members, which may hurt their creative collaboration (Paulus et al., 2012).

2.2.3. Collaboration challenges in art and design education

Pedagogically, critical concerns of collaborative design include the development of students' "designerly way of thinking" (Cross, 2006) and the management of their communication and relationships (Crosby et al., 2019). According to Cross (2006), a designerly way of thinking focuses on rapidly producing satisfying solutions through a complex and iterative process of structuring problems, defining constraints on the design task, and evaluating tentative solutions. When students engage in the collaborative design process, they are expected to be highly interactive and communicative to share their expertise, generate varied design ideas, reflect on those ideas, and advance their design task, thereby enhancing their capacity to think in a designerly way (Oxman, 1999). However, because collaboration is a combination of individuals in a particular sociocultural environment, interactions can be plagued with relational and process complications (Bene & McNeilly, 2020). For instance, Webster (2006) has argued that there is a tension between critic-led design assessment and free and collaborative development of creativity in studio design classrooms. She discovered that even though many students value the guidance and feedback critics (often teachers or industry professionals) provide during the group critique sessions, they perceive the interactions with the critics as stressful and unsafe. Webster observed that students frequently gave their oral presentations and then passively accepted the barrage of comments from the critics that followed, albeit sometimes with uncomfortable or puzzled facial expressions. She concludes that in such an environment, students are less likely to individually or collectively critically reflect on how the design situation is perceived and understood, thus further eliciting conformity rather than promoting the freedom to construct their understanding of design and what it means to be a designer within a social, collaborative setting. To promote creative collaboration in design education, educators must reform

how they use their power in assessment and establish a nonthreatening learning environment that fosters a feeling of community for effective and creative cooperation (Gaimster, 2008).

Choi et al. (2019) have further demonstrated that the traditional group-based summative assessment causes students' anxiety about sharing their ideas with peers and prevents them from taking creative risks in their design learning. Through conducting action research on university students from three design disciplines, Choi et al. demonstrated that the importance of creative risk-taking in design collaboration is dependent on sharing and questioning multiple perspectives, and they advocated for a balance between the ambiguous and flexible in-class group activities and traditional assessment structures to overcome the challenges of voicing everyone's creative ideas. Similarly, Oak (2012) has explained how forms of argument are central to the performance and understanding of a design team, resulting in the creative group decision for solving the "wick problems" (Buchanan, 1992) of design involving moral and practical choice dilemmas.

Art and design education is a technology-rich academic discipline (Fleischmann, 2020). However, multiple studies have shown that the difficulties of providing socio-emotional support are a significant factor that makes digital group design challenging, reflecting the uncertain and open-ended nature of creative collaboration (Shreeve et al., 2010). According to John-Steiner (2006), socio-emotional support focuses on developing trust, motivation, openness to experimentation, resilience to face failure, and willingness to accept criticism and suggestions among partners, which are developed through frequent and meaningful interactions and dialogues using a variety of communicative modalities and media (Mitchell & Ziguers, 2009). However, Holton (2001) noted that when members collaborated on a web-based project, the diversity of their ideas, cultural values, prior experiences, goals, and geographical locations created challenges to creative collaboration, calling for fostering in-depth dialogue about the project theme to build trust for creative collaboration. Moreover, Han (2015) identified that design students encountered learning difficulties in a 3ds Max introduction studio course and lost motivation to take advanced 3-D courses as a result. Similarly, Yang et al. (2021) discovered that technostress had a negative impact on students' willingness to work on their group assignments utilizing the online collaboration platform—Miro or Mural—resulting in a significant decline in group productivity. However, students reported that

communication and social interaction, such as accountability, clear task distribution, and time management were the most influential factors in creative teamwork.

Marone (2016) suggested that design educators should establish a learning community by providing students with a participatory and playful environment for digital exploration, manipulation, and modification. Playful gaming elements, such as repeated exploration of shared interests and resources, experiencing failure as a natural and fun part of the process, collaborating with peers, and learning from one another, promote deep and meaningful communication and social interactions within this community, thereby fostering motivation and connections among individual members with diverse backgrounds, skills, and experiences for creative collaboration. However, Pfaff and Huddleston (2003) have claimed that if a teacher's assessment reveals little difference between group and individual contributions on specific learning tasks, students are more likely to report a negative feeling toward collaborative work. Traditional utilitarian evaluation structure may work effectively in information-accumulated learning, but it reduces the ambiguity and open-endedness of individual participants' creative efforts in collaborative design learning (Danvers, 2003). Therefore, art and design educators must adopt appropriate interventions to achieve a balance between open-endedness and structure in creative collaboration so that students can achieve and learn more than they can individually (Freeman, 1996)

2.2.4. Design thinking

Design thinking is a human-centred collaborative approach that has been widely used to generate innovative ideas for problem-solving in several sectors, such as design, engineering, business management, environmental sustainability, educational practices, and countless others (Kloeckner et al., 2017; Lin et al., 2020; Rauth et al., 2010). In constructivist studio-based art and design education, the balance between the guiding structure and open-endedness of the collaborative process for nurturing creativity remains a pedagogical challenge for educators. Design thinking provides design educators with "a flexible, accessible structure" (Henriksen, et al., 2017, p. 140) for creatively addressing this educational practice dilemma. Moreover, design thinking emphasizes the importance of iteration experience in enhancing knowledge, skills, ideas, awareness, and solutions (Bull, 2016). By incorporating design thinking in the iterative collaborative process of students, it is expected that they will internalize it as "a

mindset” (IDEO, 2012, p. 11), giving them confidence in their creative capabilities to think and act in a designerly way (Cross, 2006).

The term “design thinking” was first formalized by Peter Rowe (1987) in his pioneering book *Design Thinking*. Rowe characterized design thinking activities as episodic, in which designers continually switch between problem exploration and solutions based on their intuitions and presumptions. Since its origin, other models and adaptations of design thinking have evolved. The cognitive model, for instance, focused on how designers employ a range of cognitive, strategic, and practical procedures during the creative design process (Cross, 1997; Dorst & Cross, 2001; Lawson, 1993). Another example is Buchanan's (1992) liberal art of design thinking, which emphasized integrative thinking about the social world and avoided separating cognition from the design context.

In recent discussions of design thinking, a human-centred approach to problem-solving has been added to the designers' responsibilities (Brown, 2019; Goodwin, 2011; Oehlberg et al., 2012). Tim Brown, the chair, and co-CEO of one of the most influential design consulting firms, IDEO, has asserted that design thinking resides at the intersection of three concerns: deep empathy for people's needs and motivations, a profound understanding of the potential of technologies, and an awareness of the pertinent requirements for positive social impact (Brown, n.d.). His firm's design thinking model, the IDEO model, posits five phases or stages of design thinking, which employs creative activities to foster collaboration and solve more unpredictable and complex problems in human-centred ways. The five phases include discovery, interpretation, ideation, experimentation, and evolution (IDEO, 2012). Although they are described linearly here, the phases always combine to form an iterative approach in practice that designers, students, and educators can test and adapt to suit their specific challenges. As the CEO of IDEO, Sandy Speicher (n.d.) stated, “Design thinking is not limited to a process. It is an endlessly expanding investigation” (para. 3). Below is an illustration (Figure 1) and summary of the IDEO design thinking model; (IDEO, 2012):

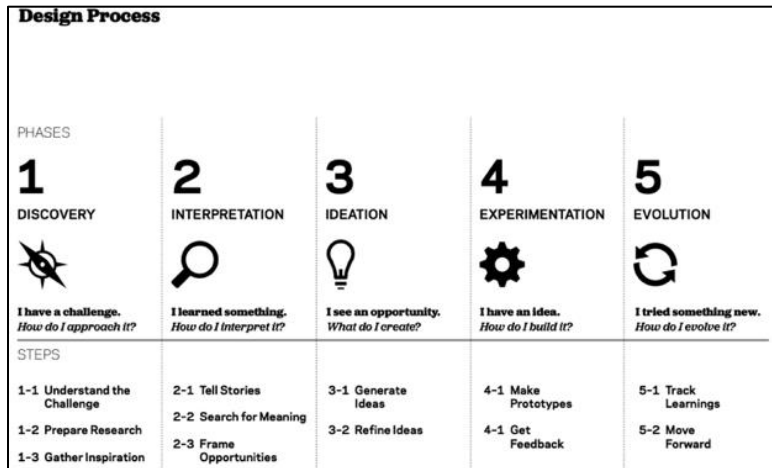


Figure 1. The IDEO model of design thinking

1. Discovery. The first phase is to cultivate empathy for people and understand the design challenge in context. In this phase, designers investigate people’s needs to gain eye-opening insights that allow them to keep people at the centre of every design process.

2. Interpretation. In the second interpretation phase, designers synthesize the discoveries to frame the design opportunity. Designers interpret the complexity of users, the problem, and the context to seek patterns or meaning. By the end of the interpretation phase, designers turn the meaning into actional opportunities and condense thoughts into a problem statement that guides the design process.

3. Ideation. In the third phase, designers explore problems and solutions from new angles and think imaginatively. Team brainstorming is the most common method to generate ideas and develop tentative solutions. Ideation includes a perpetual attention switch between problem and solution explorations. In this phase, designers must continuously refer to the problem statement to reduce the number of solutions and refine those that are to be validated.

4. Experimentation. The fourth phase concerns experimentation. Designers turn the ideas from Phase 3 into tangible, testable solutions. Designers learn what works by constructing prototypes or solution models. The goal of prototyping is to present ideas and request feedback from potential users to identify the optimal solution to meet their demands.

5. Evolution. In the fifth evolution phase, designers exhibit the prototype to users and obtain feedback. As user testing can quickly reveal design flaws, designers must reexamine the prototype, communicate corrections to people who can help refine the solution, and repeat additional ideation sessions before the winning prototype or solution concept evolves.

From this description, it is evident that the IDEO model of design thinking is a constructivist approach to problem-solving (Curedale, 2013) in which divergent thinking (for creating choices) and convergent thinking (for making choices) oscillate throughout different phases of the design thinking process (Brown, 2019). All of this is strongly centred on a collaborative mode of transforming multiple perspectives into actionable problem-solving ideas from a human-centred view. Brown (2019) has argued that designers who place people at the centre of every process are the only ones capable of providing solutions that satisfy people's needs the most. Brown's notion supports the previously discussed idea of the "teacher as a designer" (Kalantzis & Cope, 2010b; Kress, 2010), in which the educator assumes the role of a designer to become more empathetic to students' needs and collaborate with them in every stage of the teaching process, which can result in best possible solutions to educational challenges. Concurrently, the IDEO design thinking model offers a flexible structure of idea divergence and convergence that was developed through iterative cycles of teamwork in construction and reflection (Schon, 1984). This can be utilized to provide flexible support and grounding to balance the open-endedness and instruction of creative collaboration (Watson, 2015), thereby addressing the collaboration challenges in constructivist design classrooms.

2.2.5. Design thinking for creative collaboration

Multiple studies have examined the potential for design thinking to address collaboration challenges and foster creative collaboration in design educational contexts (Bene & McNeilly 2020; Jobst et al., 2011; Leinonen & Gazulla, 2014; Scheer et al., 2012). For instance, Bene and McNeilly (2020) presented a literature review on the use of design thinking to foster a collaborative culture in student learning. The two authors identified some striking parallels between the design thinking and team building processes, which can be used to address some common challenges in collaborative learning environments, including communication, interactions, team conflicts, power

dynamics, and expectations (also see Section 2. 2), thereby fostering creative collaboration among student teams. Bene and McNeilly discovered that design thinking and building a team share a common bond in defining the problem and developing a shared vision. In addition, they identified that concept divergence and convergence in design thinking are comparable to brainstorming and goal setting in the team-building process. Moreover, in the design thinking process, developing empathy for clients and team members through iterative feedback and reflection parallels valuing all team members' views and fostering trust and reliability in collaborative team building. Last, seeking multiple perspectives and knowledge in design thinking is like accepting suggestions from diverse sources in team building. The authors concluded that, although design thinking is not a panacea for all collaborative issues, the process appears helpful in systematically assisting students to avoid some of the collaboration pitfalls and fostering team cohesion for new and creative learning outcomes.

Leinonen and Gazulla (2014) investigated how the human-centred design thinking model presented an alternative approach for addressing a “wicked problem” (Buchanan, 1992) of research-based collaborative design learning with new technologies. By adopting design thinking as a mindset, the researchers recognized that the design process relies on a shared, social construction of understanding with the people who will intimately use the tools. Consequently, the research was conducted by the five stages of the design thinking process, which included contextual inquiry (exploration of the sociocultural context of design), participatory design (involvement of participants in every process of design), and product design and software as a hypothesis (the iterative process of technology design for obtaining feedback). The results indicated that a design thinking mindset enabled design researchers to engage in an open dialogue with participants and collaborated with them to co-create more experimental and creative prototypes within a systematic and analytical structure.

Jobst et al. (2011) argued that project-oriented, group-based design thinking education assists design students in becoming innovative individuals. Through interviews, the authors found that students were able to gain five critical innovation competencies by learning design thinking as a holistic approach to addressing design challenges involving increasing social and sustainable issues. The five competencies were open-mindedness, empathy, creative confidence, connecting with other disciplinary knowledge (called T-shaping), and addressing ambiguity. In addition, they concluded

that the design thinking process mediated the intergroup cohesion and between-group competition of the interdisciplinary design students through a constant exchange of information and interaction facilitated by the teacher as a coach, which generated a climate that constantly motivated them to improve their own or their group's performance.

Finally, Scheer et al. (2012) claimed that design thinking as a team-based learning process provides teachers with support for practice-oriented and holistic modes of constructivist forms of learning in projects. By testing a design thinking project with 125 high school students and a team of 12 teachers, the results verified an improvement in viewing the classroom experience for all participants, resulting in a positive attitude toward constructivist learning and an increase in its use in education. Notably, the results demonstrated how the design thinking process provided a pedagogical structure to foster integrated competencies in different phases, thus assisting the teachers in setting the frame for balancing construction and instruction in constructivist learning. However, the authors argued that only when the complex process phases were run through as a whole could the learning and teaching be pertinent to what Dewey (1938) promoted— inquiry-based learning, leading to consolidated and expanded competencies for developing complex and socially oriented 21st-century skills.

2.2.6. Summary

In Section 2.2, I first reviewed and synthesized the most influential literature on creativity, including its history, theories, methods, key factors, and phenomena. Upon critically evaluating the literature's strengths and weaknesses, I discovered an academic consensus on a social and collaborative view of creativity, which forms the basis of my research on this topic. Then, I examined the existing studies on the characteristics of art and design education, revealing that it is constructivist, collaborative, and technology rich in nature. These studies also defined creative collaboration and discussed its significance in art and design education. Despite the presence of collaboration-oriented technologies, several studies have indicated that some common critical collaboration challenges stem from the tension between open-ended creative collaboration learning and the guiding structure inherent in constructivist design classrooms. Therefore, I also reviewed the literature regarding the human-centred IDEO design thinking model, which consists of a team-oriented, flexibly structured, and iterative process, indicating its

potential use as a systemic pedagogical approach to balancing the tension for fostering creative collaboration.

However, I propose two additional questions to guide my next literature review: Despite the availability of learning collaboration technologies, which technology might best foster creative collaboration in design-thinking-framed art and design classrooms? What forms of pedagogy and assessment can leverage the technology's affordances to support and recognize students' creative acts in group collaboration across the design thinking processes? Section 2.3 examines relevant literature pertinent to these two questions in detail.

2.3. Virtual Worlds and Multimodal Pedagogy

This section explores relevant studies on VW technology to identify possibilities for creative collaboration in art and design education. Additionally, the section presents the concept of social semiotic multimodality (Jewitt, 2013; Kress, 2010) to explain how the modal affordances of VWs are theoretically aligned with design thinking pedagogy and constructivist learning and therefore leverage these affordances to promote creative collaboration. Finally, this section provides an investigation of literature concerning multimodality and social semiotics (Bezemer & Kress, 2016; Kress & Bezemer, 2015) as an alternative form of assessment of students' learning and creativity.

2.3.1. What are virtual worlds?

VWs are not design platforms per se, but why were they selected to facilitate design creativity instead of other technologies in this research? Before delving into their educational advantages for design education, a clear and usable definition of VWs is needed to guide the investigation of the relevant area (Scheer et al., 2012). VWs have been present since the late 1970s. They have developed over the past two decades from text-based, multi-user dungeons (MUDs) in the early days to sophisticated, 3D-animated graphic designs that offer multimodal interactive features. Accordingly, the definitions of this technology have also evolved as researchers' and educators' perspectives have grown.

Among previous diverse conceptions of VWs, Bell's (2008) vision of VWs has been widely accepted by various VW scholars. Bell (2008) drew on the combined definitions that were based on earlier key works by Bartle (2003), Castronova (2006), and Koster (2004), describing VWs as “a synchronous, persistent network of people, represented as avatars, facilitated by networked computers” (p. 2). The significance of this definition is its emphasis on avatars as a unique technical feature that distinguishes VWs from similar technologies. However, Girvan (2018) claims that Bell does not clarify whether multi-player games are set within VWs, so educators may find it challenging to understand whether VWs should be categorized as massively multiplayer online role-playing games (MMORPG), resulting in devaluation of their potential for educational purposes. The other popular definition comes from Schroeder (2008) who specially refers to the VW user experience as providing an sense of “being there together” (p. 2) by defining VWs as “a computer-generated display that allows or compels the user (or users) to have a sense of being present in an environment other than the one they are actually in, and to interact with that environment” (p. 2). However, solely highlighting the user experience is equally insufficient for educators, as they must consider a definition that describes their students' experience being mediated by various VW tools. To explore the educational potentials of VWs, Girvan (2018) provides an accurate and comprehensive definition of VWs based on the consideration of unique technical features and user experiences. He defines VWs as:

shared, simulated spaces which are inhabited and shaped by their inhabitants who are represented as avatars. These avatars mediate our experience of this space as we move, interact with objects and interact with others, with whom we construct a shared understanding of the world at that time. (p. 1099)

This definition of VWs offers precise insights into VW capacities; thus, it can be utilized to guide this research in the art and design educational area. These VW capacities also generally demonstrate why these online virtual environments—including Active Worlds (AWs), Minecraft, World of Warcraft, and the most well-known, SL—can easily attract millions of users around the globe. In 2020, World of Warcraft was estimated to have over 11 million total subscribers (MMO Populations, n.d.). By 2021, more than 70 million SL registered accounts had been created, with average daily usage of 200, 000 users across 200 countries (Daniel Voyager, 2021). The personal, social, and financial impacts of VWs have led to the emergence of exploring VWs as a teaching

and learning tool across various disciplines, from art education to business marketing, from medical studies to astronomy, and from museums to language learning (Barab et al., 2007; Han, 2015a; Huang et al., 2013; Kiourt et al., 2016; Lin & Lan, 2015; Walia et al., 2017). These studies have exploited a range of affordances that facilitate collaborative learning activities, such as fostering a sense of presence and copresence, interacting, embodying avatar-based users, creating 3D environments, utilizing construction tools, and increasing users' engagement in their learning tasks. Accordingly, many art and design educators have indicated their increasing interest in employing VWs to mediate collaborative design learning activities (Gaimster, 2008; Gu et al., 2011; Han, 2015b, 2019a). Nevertheless, design researchers (Koutsabasis et al., 2012; Vosinakis & Koutsabasis, 2012) have indicated that VW-based collaborative design activities and research are still in their infancy because VWs were not initially developed for design education, so design communities must determine the extra value that VWs can add to the existing digital design practices. Therefore, it is necessary for design education researchers to investigate the degree to which VWs affordances contribute to the design phases and activities of collaborative design projects that involve students' cooperation.

2.3.2. Affordances of virtual worlds for creative collaboration in education

The concept of affordance

A substantial body of literature has examined VWs for educational purposes through an affordance lens (Alahuhta et al., 2014; Dalgarno & Lee, 2010; Dickey, 2003; Warburton & García, 2010; Wood & Gregory, 2018). These studies have provided valuable resources for researchers and educators who are interested in implementing VWs for learning and teaching. In this research, I adopt a lens of multimodality to investigate creative affordances of VW design pedagogy for collaborative design learning activities; consequently, it is necessary to clarify the term's definition and examine the educational affordances in the existing literature to develop a coherent, theoretical understanding of VWs.

James Gibson (1979), a perceptual psychologist, who was the first to introduce the term *affordance* to describe how the animal's anticipated activities are provided by the existing environment. Donald Norman (1988) later appropriated this term within the

interactive design system. He explains, “the term affordance refers to the perceived and actual properties of the thing, primarily those fundamental properties that determine just how the thing could possibly be used...Affordances provide strong clues to the operations of things” (p. 9). Since then, various definitions of affordances have emerged. Employing Norman’s concept, Kirschner (2002) specifically defines educational affordances of a technology as “the relationship between the properties of an educational intervention and the characteristics of the learner that enable a particular kind of learning by him/her” (p. 19). This indicates that different users’ perceptions of a technology’s affordances determine how that technology can be utilized for learning.

Early investigation of virtual worlds’ affordances

Dickey (2003) provided one of the earliest analyses of VWs’ pedagogical affordances (particularly AWs) in the VW literature, identifying specific tools within this VW platform that can facilitate constructivist learning activities:

- Discourse tools are the synchronous chat tools that provide learners with immediate feedback, peer learning, and role reversal. In communication, each user is granted a unique name, which maintains anonymity, consistency, and accountability. A unique identity also affords students and teachers a degree of control over the learning environment.
- Experiential tools provide perspectives and movements for an avatar-mediated user, which allow a sense of presence as learners examine the objects from multiple perspectives.
- Resources tools, such as the integrated Web browser, offers opportunities to effectively exemplify concepts and construct knowledge.

Warburton and García (2010) examined relevant literature on VWs, especially SL, and identified eight pedagogical affordances of SL experiences that can facilitate creative learning and expressions: (a) extended or rich interactions, (b) visualization and contextualization, (c) authentic content and culture, (d) identity play, (e) immersion, (f) simulation, (g) community presence, and (h) content production, which provides opportunities for creation and ownership of the learning.

By incorporating VWs’ key characteristics, Dalgarno and Lee (2010) proposed three broad categories that demonstrated five primary learning affordances of such environments in higher education:

- 3D simulations and microworlds facilitate (a) learning tasks that lead to the development of enhanced spatial knowledge that represents the explored domain, (b) experiential learning tasks that would be impractical or impossible to undertake in the real world, and (c) learning tasks that lead to increased intrinsic motivation and engagement.
- 3D environments, as interfaces to learning resources, facilitate (d) learning tasks that lead to improved transfers of knowledge and skills to real situations by contextualizing learning.
- 3D multi-user virtual learning environments (e) facilitate tasks that lead to more diverse and/or more effective collaborative learning than is possible with 2D alternatives.

2.3.3. Recent investigation of virtual worlds' affordances for creative collaboration

Multiple interpretations: Multimodal information

Many art and design educators (Han, 2015a; Lu, 2010a, 2013; Stokrocki, 2014a) have found that VWs' multimodal information is organized and presented in unique and compelling ways, providing students with opportunities to generate multiple interpretations of creative exploration. For instance, in the Art Café Island in SL, Lu (2010a) organized learning events to teach digital art to university students, including collaborative learning by exploring, collaborating with other avatars to collect information, attending events, building 3D objects, expressing their reflections in writing, and hosting exhibitions. During the teaching process, Lu identifies that the collaborative nature of the SL visualization enabled students to explore information and communicate ideas in real time as a team. This resulted in students' sense of presence and copresence in the immersive virtual environments and contributed to their sense of engagement, which is a prerequisite for generating creative and meaningful content for learning.

In another example of art educational practice, Stokrocki (2014a) conducted an SL-based, new media multiliteracy online undergraduate course to promote responsive visual culture. By utilizing SL's multimodal communicative resources, Stokrocki designed the course as a playful art treasure hunt in which the virtual environments were enhanced by both realistic and imaginary artworks that offered interactive functions for exploration and sensor-triggered note cards for research. Additionally, the course was connected with other web-based forums for group discussions. The findings suggest that

while SL's multimodal information is intended to simulate physical objects, it also contains distinctive features and concepts that could only exist in VWs. This type of information presentation forms a mixed-dimensional reality within which students become deeply immersed in learning to navigate virtual environments and interact with objects and tools. Consequently, students develop rich multiliterate communication skills and understand the art treasure, which expanded their interpretations of artworks in authenticity, stereotype, superstition, and cultural appropriation.

In a VW-incorporated, graduate-level art course by Han (2015a), VWs were noted to encourage students' practice of visual-learning theory, which was more difficult to apply in the physical art classroom. These VWs appealed to students because their information was presented as culturally diverse, highly imaginative, and interactive. Students felt immersed when they collaboratively experienced the creative artworks from different cultures and countries by literally interacting with them via avatars: students walked around, jumped over, ran through, and flew above the artworks. Additionally, they triggered the sensors embedded in the artworks for information or animation displays. Compared with visual learning in the traditional art classroom, where students usually just read or see artworks on a 2D website or PowerPoint presentation, this direct and collaborative engagement with the mixed reality enabled them to critically interpret the purposes for including certain communicative elements and generate more ideas for implementing visual learning theories into their own virtual space constructions creatively and effectively.

Given these findings, VWs' multimodal information yields multiple representations of reality that encourage students to produce various interpretations. As students collaboratively interact with the multimodal information, such as images, sounds, and animation via virtually presented bodies—avatars—they may feel a sense of presence, copresence, and immersion through their diverse embodied experience. In summary, VWs' multimodal information can prompt students to explore, interact, and interpret via avatars, which afford the user's embodiment of a virtual identity outside the physical being. When employing VWs in art and design education, one can expect the information displayed in VWs to enhance students' creativity via their avatar-mediated explorative experience and, specifically, to provide students with opportunities to develop novel and critical understanding or ideas that otherwise may not have occurred to them.

Embodiment: Avatars as visual self-representations

The second affordance identified in the existing literature is the customized avatar as a visual self-presentation. According to Girvan (2018), “the avatar is “the inhabitant of the virtual world—which provides the user with an active agent with which to encounter the world. These avatars, their appearances, and abilities mediate our experience of the virtual world and our interactions with others” (p. 1094). Many related studies on avatars have focused on personalized avatars that promote users’ experiences and support social interactions in VWs. For instance, manipulating the avatar’s appearances, gestures, emotions, and movements can encourage the user’s perceived autonomy in VWs and improve intrinsic motivation for self-directed learning, leading to continuance intentions (Jensen, 1999; Liao, 2008; Lu, 2010b; Yee, 2006). An experimental case study demonstrates that the coexistence of another visible avatar increased participants’ experience of presence, which contributed to the creation of embodied conversational agents in a collaborative environment (Jung, 2011). Lin and Wang (2014) reveal that the choice of self-presentation is driven by “strategic roles” (p. 215) that the user pursues to fit specific situations and to better communicate with others in VWs. In client meetings in VWs, users tend to dress their avatars more formally to make the meeting similar to a real-world meeting and to represent the professional characteristics of their identities in real life when interacting with clients (Hakonen & Bosch-Sijtsema, 2014). Ward and Sonneborn (2011) claimed that altering the appearance of an avatar creates “salient visual markers” (p. 219) that enables users to adopt the different “hats approach” (p. 219)—to think like that avatar so that they can generate more novel solutions that may be constrained by their real-life identities to help other people.

Moreover, in the VW literature related to art and design education, Gaimster (2008) proposes that, on an individual level, experimenting with new virtual identities allows students to experience situations that would be impossible or uncomfortable in real life; hence, they can be themselves and live their wildest fantasies. On an interactional level, the ability to adopt different roles or be anonymous in VWs can foster a nonthreatened collaborative learning environment and can specifically facilitate students’ self-esteem as they build trusting relationships within the critique sessions that allow them to experience this form of assessment as engaging, creative, inspirational, and reflective. However, Gaimster also notes that the anonymous avatars could lead to

unpleasant or unsettling experiences, such as harassment and aggressive comments. Therefore, she suggests that educators must know the students' identities before confirming their participation. Furthermore, other VW studies have highlighted avatar-based artworks as interactive innovations. Rather than considering avatars to be mere images, some VW artists created avatar bodies as a distinctive medium to interact with the audience in various ways, such as assemblage, performance art, and machinima (movies made in VWs), thereby extending the concept of digital art to a range of representations, symbolic elements, and emotions (Lester & Pathfinder Linden, 2009; Liao, 2008; Skinner, 2019).

These studies provide convincing evidence that the appearances and functionalities of avatars allow users to understand their VW experiences. Users can project nearly any imaginative characters they desire onto modifiable avatars; thus, they may perceive themselves as autonomous agents embodying the particular identities of their interests and may be willing to remain in their tasks for longer times in VWs. Equally, the virtual environments are continually "(re)designed" (Bezemer & Kress, 2016) by users' interactions that contribute to a sense of embodiment, such as building, observing, moving, and gesturing. Such an interactive process among the ever-changing virtual content, avatar-mediated agents, and social practices is likely to foster more profound engagement with VWs. When representing different identities in collaborative situations, the involvement of other avatars can increase the degree of social interactivity, enabling users to feel more embodied in their adopted avatar identities and more bonded with other avatars who share the same virtual space. Finally, the avatar-based innovations between artists and audiences foster collaborative productions of meanings that are fundamentally multimodal, experimental, interactional, and expansive (Lester & Linden, 2009). Both artists and audiences utilize various avatar functions to interact with each other, producing unique embodied meanings in their VW experiences. Therefore, creating and utilizing an avatar is an experimental art activity for creative design and collaboration. The perceived autonomy, intrinsic motivation, commitment, experimentation, and relationship building are vital factors that predict individuals and teams' creativity in an educational setting (Csikszentmihalyi, 1997; Sawyer, 2012). These factors are evidenced through the avatar's distinctive affordance of embodiment. Thus, there is a reason to believe that VW avatars could facilitate individuals and teams' creative idea generation in art and design education.

Persistent environments: Content-creation tools

Another added value of VWs is the affordance of creating persistent content utilizing the prim system (Figure 2), which encourages individuals and team members to express themselves uniquely and creatively. Although many digital games also offer users opportunities to create content, they are often confined within the pre-existing designs. Conversely, VWs are dependent on the sandbox games in virtual spaces, which are not predetermined by narratives, objectives, or rules. Therefore, users have a high level of freedom and agency in choosing their VW participation instead of being constrained by the predesigned sensory data that determine users' virtual behavior trajectories (Kuznetcova & Glassman, 2018). Moreover, to construct in VWs, users must redesign and combine the prims (the basic geometric building blocks) to which they must apply images or textures to achieve the desired 2D or 3D content. Thus, VW designs are sometimes considered "imitative recreations rather than purely original works" (Ward & Sonneborn, 2011, p. 36). However, a successful imitative recreation must be rendered artistically and incorporate certain novel features that are possible only in VWs. This action requires proficient design skills, multidisciplinary knowledge, and creativity beyond simple imitation (Merrick & Gu, 2011). Therefore, the VW prim system offers opportunities for students to learn by performing experiments and constructing knowledge rather than being taught passively, thus creating premises for constructivist learning (Duncan et al., 2012).

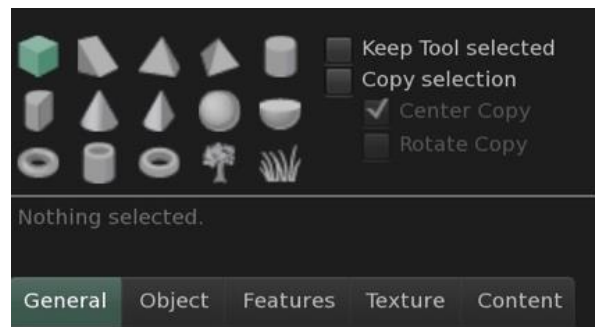


Figure 2. Prims in Second Life

Additionally, many VW studies on collaborative creations have reported that team members feel more psychologically immersed in the virtual environments while directly interacting with the 3D content via avatars, such as walking through or flying over content and employing the first- and third-person views (Bhagwatwar et al., 2018;

Koutsabasis et al., 2012; Vosinakis et al. 2011; Weiley & Pisan; 2008). Specifically, Weiley and Pisan (2008) find that compared with designing in professional 3D modeling platforms (e.g., 3ds Max) as an observer, VWs' interaction ability allows team members to develop a persistent mental connection to the shared place as a critical aspect of their VW experience. With an increased sense of place, they are more likely to transform the environment they construct into a "habitation they are a part of" (p. 345), thus fostering team members' motivation to build their own environment through collaboration. The interactive function also allows team members to assume dialogic roles to exchange ideas. In an actual user interface collaborative design project conducted by Vosinakis et al. (2011), the synchronous interaction was shown to be valuable for team members to explore and evaluate the designed prototype and detect critical issues that would be more difficult to identify in professional graphic applications, thereby facilitating workflow and the creative problem-solving process. Similarly, Bhagwatwar et al. (2018) report that when a team of people directly examined the 3D objects related to their task topic, they generated more creative, practical, and relevant ideas. Other studies on VW-based collaboration have reported that the synchronous and evolving nature of VWs enabled team members to monitor any change made in the group project, which motivated them to be continually aware of each other's design activities and resulted in a more coordinated and persistent design team (Koutsabasis et al., 2012; Vosinakis et al., 2008).

Overall, these studies highlight the affordance of content-creation tools, which allow the users to feel autonomous, experimental, immersive, motivated, and collaborative. This type of experience leads to increased group exploration and knowledge construction, which seldom occurs within one digital or physical learning environment, thus adding value to codesigning activities in VWs.

Collaborative experimentation: Concurrent users and communication tools

Certain studies have investigated how VWs afford collaborative experimentations in which virtual team members can see spatial positions and movements of others while communicating utilizing the chat tools. According to Koutsabasis et al. (2012) and Merrick and Gu (2011), utilizing personalized avatars to convey nonverbal information as well as VWs' multiple communication channels (textual, auditory, and graphic functions) facilitates team members' communication and improves their awareness of others'

presence and actions, leading to a greater feelings of copresence and immersion. Bhagwatwar et al. (2013) claim that compared to the traditional ICT systems, VW technology offers much more than typical communication mechanisms, such as voice chat and instant messages. This technology leverages shared places, synchronous and asynchronous communication, and users' feelings of immersion to produce an effective brainstorming environment that promotes creative collaboration.

More recently, Guegan et al. (2016) further examined the impact of avatars' appearances on the creativity of a brainstorming group that comprised university engineering students. The results confirm the critical role of avatars in mediating users' behaviors and feelings when interacting with others: the participants who embodied expert avatars perceived themselves as more creative and offered innovative ideas to help others. This finding is consistent with the notion of a "digital embodiment" (Gee, 2007) in video games in which the users and their avatars eventually become one through continued immersion into their avatars' experiences, highlighting Csikszentmihalyi's (1997) state of flow. In a VW-integrated hybrid class, although Christopoulos et al. (2014) find that students rarely utilized VWs' chat tools to exchange information when they were in the classroom. However, when they cooperated remotely, most students considered that brainstorming about their projects in VWs was an interesting and inspiring experience that fostered better team engagement. The ideas of copresence and collaboration have also been identified as crucial factors that foster communities of play, which can be utilized to empower students to explore knowledge, share ideas, negotiate meanings, and collaborate because of their common interests (Alahuhta et al., 2014; Marone, 2016; Warburton, 2009).

In summary, these scholarly works highlight the key functions of VWs — multimodal information, avatars as visual self-presentation, content-creation tools, concurrent users, and synchronous and asynchronous communication tools. These functions contribute to VWs' pedagogical affordances, which can be utilized to foster individual and team creativity (Figure 3).

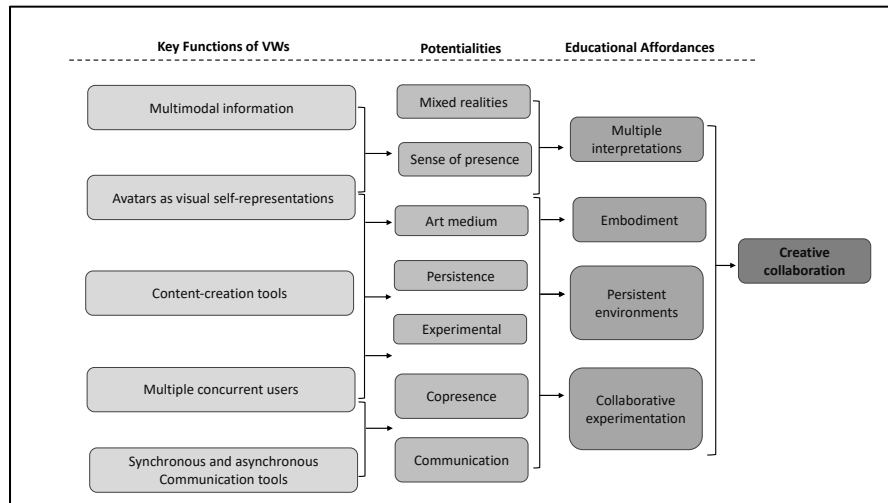


Figure 3. Virtual worlds' affordances for fostering creative collaboration in literature

2.3.4. Constraints of virtual worlds for collaborative learning

Despite VWs' potential for creative collaboration, several studies have revealed the constraints of using the platform's resources to create effective collaborative learning scenarios. Warburton (2009), for instance, listed technical obstacles, identity confusion and discomfort, isolated cultural experience, scaffolding persistence for collaboration, time issues, and the cost of incorporating SL as barriers to the deployment of SL in postsecondary education. Similarly, Pfeil et al. (2009) discovered that the challenges of teaching and learning in VWs stemmed from (1) the time issues in getting all students signed up and set up for learning; (2) the navigation and orientation difficulties for first-time users; (3) the identification of students and the difficulty to track individual learning progress in teamwork; (4) the increased cognitive load when switching communication channels; (5) a lack of clear purpose of using VWs for teaching and learning; and (6) the accessibility and cost issues. However, Pfeil et al. found that a critical study of the prominent challenges to the implementation SL as an educational tool revealed multiple opportunities to address these challenges across VWs in general. In recognizing the steepness of the SL learning curve, De Leon (2011) emphasized that students' frustration with their technological use of the platform was a common factor in their decreased confidence. The author urged teachers to provide students with continuous practice and exposure, reviews of fundamental technological background and skills, peer learning, and an appropriate scaffolding to reduce the learning curve, thereby

maximizing the VWs' potential for collaborative learning and boosting students' confidence. In the case study of collaborative design learning in VWs, student participants indicated that their design projects lacked visual details and rendering quality (Koutsabasis et al., 2012). However, the authors concluded that this was to be expected due to the dynamic, real-time nature of VWs. Overall, the review of each highlighted constraint associated with the use of VWs for collaborative learning presents a challenge that demands careful consideration of a variety of pedagogical possibilities. The following sections examine social semiotic multimodality (Kress, 2010) as an alternative pedagogical approach based on the complex notion of modal affordances and constraints for making meaning, leveraging the creative potential of VWs for collaborative learning and designing.

2.3.5. Multimodal pedagogy for the virtual worlds-integrated art and design education

Multimodal virtual design processes

Even though prior literature reviews have illustrated VWs' educational potential to foster creative practice and collaboration, few studies have focused on art and design education or examined the VW-integrated design processes in which students make decisions while using different VW functions according to the situations. Rather than studying the perceived or actual properties of VW technology, this research investigates students' "situated choices" (Jewitt, 2013, p. 2) regarding VWs' available and recognizable affordances during their creative design processes. Therefore, the conception of multimodality (Jewitt, 2013; Kress, 2010), which emphasizes the situated semiotic actions rather than the technological system of available resources, can be utilized as a pedagogical approach. According to Jewitt (2013) and Kress (2010), a multimodal lens-filtered affordance is no longer a matter of perception; instead, it is a complex concept related to wider material, social, cultural, and semiotic uses of a mode. In his 2010 book *Multimodality: A social semiotic approach to contemporary communication*, Kress adapts the concept of affordances to describe the potentialities and constraints of semiotic modes that shape today's increasingly complex forms of communicative modes—*multimodal ensembles*. According to Kress' conception, what one mode can express is apt for some semiotic tasks but may be less well-suited or even impossible for other tasks, and this mode is constantly shaped and reshaped in

everyday social semiotic work. Kress also states that meaning is made in socially shaped, culturally available material resources— modes. Each mode offers particular affordances of the material stuff that occur during the work performed in social life with that material over a lengthy period of time. This explains how the same materials may be used differently in different kinds of “social work performed ceaselessly by members of social groups” (p. 80). For example, sound can be utilized as material resources in different modes, such as music and speech. Although each mode may eventually express the same “cultural reality” (Van Leeuwen, 2015), the modes differ in what they can offer from culture to culture, which Kress (2010) conceptualizes as *modal affordances*. Differences in modal affordances *prompt* meaning-makers to engage the modes differently, asking which conceptual resources may be realized in a specific mode, resulting in constant expansion and transformation of modes and their resources by creating new meanings. Because signs are always made in particular semiotic modes and always appear as ensembles, each mode makes a partial contribution to the overall meaning. The sign makers can meet their interests through the designed sign complex in modal ensembles (Kress & Bezemer, 2015)

In this study, Kress' (2010) multimodal perspective allows me, the teacher–researcher to recognize the range of VW modal resources that prompt meaning-making engagements. Furthermore, I can benefit from this investigation of how students—as meaning-makers in socially constructed virtual environments—continuously make creative modal choices to make their meaning materially evident in their collaborative designs. Consequently, this research highlights both VWs’ power and limits to appropriate this technology for pedagogical use in the art and design classroom.

Multimodal assessment for creative collaboration

The previous sections highlight VWs’ potentials for creative collaboration and the possibility of multimodality as a pedagogical approach. However, they also call attention to a problem in the debate about the assessment of creativity in collaborative art and design practices: the intangible outcomes (e.g., interests, experiences, and engagement) are difficult to evaluate, while the success criteria depend significantly the identifiable information and measurable skills evident in the student’s final design project or portfolio presentation. According to Danvers (2003), this utilitarian assessment may work effectively in data-based or information-accumulated learning, but it minimizes the

uncertain and open-ended nature of knowledge and practices in design learning. Thus, it cannot fully recognize and value students' efforts and capabilities in addressing the fundamental uncertainty of meaning in many of their design activities. Furthermore, a number of design education studies (Belluigi, 2016; Dineen & Collins, 2005; Mann, 2001) have confirmed that students' intrinsic motivation and sense of self or agency decrease significantly when their input is validated only by the pre-defined measurement of grades or marks. With lower levels of motivation and self-perception, their desire and interest in engaging with the knowledge and the learning context diminishes, leading to conformity and uniformity, which are detrimental to creativity.

In considering the debate, Kress's (2010, 2013) social semiotic account of multimodality also appears to be a suitable and reliable form of assessment that provides appropriate and workable tools to recognize these crucial but often unnoticed creative outcomes for learners during their collaborative learning processes. In Kress' conceptualization, the multimodal social semiotics moves beyond the contemporary, narrow view of knowledge and provides descriptive and analytic means to recognize students' learning as they make meaning across a broad spectrum of socially and culturally shaped resources. These resources comprise various communicative modes, such as speech, movement, gesture, gaze, and more. Some of these resources may be unknown to learners at the moment of meaning-making or unprescribed by curriculum. However, they reveal the learner's interests and agency in engaging with the different modes of learning environment, demonstrating their learning.

To elaborate on this approach, Kress (2013) and Kress and Bezemer (2015) conceptualize the tools of recognition in a theoretical frame of communication and meaning that encompasses two fundamental foci. First, from a social semiotic aspect, learning is viewed as both an instance and a result of sign- and meaning-making, allowing educators to perceive learners as sign-makers' agency through their choices of signs, which are shaped by the social, semiotic, and material environment. Second, the notion of multimodality recognizes all the modes of the communicative environment through their distinctive affordances, which offer specific potential for the sign- and meaning-making with different social effects. From this perspective, learning no longer applies to the sender-receiver model of communication wherein the educator, as the only authoritative holder of knowledge, transmits the knowledge to learners. Instead, the learner—who was previously a passive receiver—becomes an interpreter of the

message (which is supplied by the educator and/or the learning environment) and views the message as a prompt, which influences the approaches that the learner undertakes to engage with his/her learning as interpretation. Therefore, in a social semiotic view of multimodality, learning as communication happens (a) in complex social environments; (b) in interaction with the environment, prompting engagement as interpretation according to the available semiotic resources and the learner's agency and interest; and (c) in interaction through which the learner constructs knowledge and makes meaning by iteratively connecting the affordances of the material mode, the affordances of the socio-cultural environment, resources, motivations, and knowledge that they encounter (Jewitt, 2013; Kress & Bezemer, 2015). Furthermore, Kress and Bezemer (2015) state that,

Every sign made is new, an 'innovation'; its making is an act and sign of 'creativity'. The ongoing, unceasing process of transformative engagement, of integration in 'inner' transformation, with a constantly new resultant state, constitutes learning. (p. 158)

Through the social semiotic view of multimodality, students' creativity during collaborative learning processes is seen as the ordinary and constant process of making and re-making signs. Nevertheless, meticulously tracing of students' various semiotic works allows the educator to interpret students' agency in exercising their "resourcefulness" (Bezemer & Kress, 2016; Mavers, 2007), circumventing various constraints, and creatively selecting modal resources to create meaning. Concurrently, interpreting students' meaning-making processes guides the educator to engage in discussions with students about their choices, and then the educator reflects on the semiotic possibilities of the designed learning environment that was taken as a prompt. This leads the educator to redesign the next prompt to better engage students in response to their interests (Kress & Selander, 2012). Hereby, the educator also becomes a designer who uses students' principles to analyze the teaching and learning activities as communicative and sign-making processes, consequently shaping the students' paths toward an epistemological proximity to the curriculum's aims (Kress, 2013).

This emphasis on the theoretical understanding of design as a way to configure both communicative resources and social interaction in educational settings (Bezemer & Kress, 2016; Kress & Selander, 2012) has been a focus in various studies across different disciplines (Boy, 2013; Kalantzis & Cope, 2010a; Osmond & Tovey, 2015;

Selander, 2008; Sheridan & Rowsell, 2010). These studies have demonstrated that the changing role of a teacher as a designer and interpreter allows the teacher to embrace a designer's mindset and adopt a human-centred design approach to develop empathy about students' needs and learning processes while achieving a deeper understanding of components of learner-centred learning environments. Consequently, the teacher becomes more sensitive to the principles brought by students and tailors the learning environments in ways that empower students to become autonomous, creative designers of their own knowledge and interaction as they continuously influence their environments.

2.3.6. Summary

I began Section 2.3 by reviewing the existing literature on the definitions and characteristics of VW technology. Then, I investigated the most significant educational affordances of VWs, including multiple interpretations, embodiment, persistent environments, and collaborative experiments, which suggested their potential for fostering constructivist-based creative collaboration in art and design education. In addition, I examined studies that highlighted the constraints of employing VWs for collaborative learning and teaching. Considering both affordances and constraints of the pedagogical use of VWs, I then examined the multimodal social semiotic theory that could be used to leverage the VW potential to harness a powerful pedagogy and an alternative assessment for supporting students' creative collaboration and recognizing their creative actions as resourcefulness at different design stages.

This resourcefulness also indicates the students' "capacities for semiotic initiative" (Mavers, 2007, p. 160), which is the foundation of art and design education. This is because one of the primary goals of design education is to transform students into self-directed and autonomous agents who can assume professional responsibility and pursue collaboration across disciplines with autonomy and consciousnesses initiate to solve the "wicked problems" (Buchanan, 1992) of everyday design in an era of uncertainty and complexity (Gale, 2020). For the transformation to occur in the design classrooms, there need to be transformative practices characterized by iterative processes, such as exploration, collaboration, trial and error, design risks, and

incubation of concepts, that result in intensive reflection, questions, and exploration, as well as the applications of creative solutions (Bull, 2016). In the remaining sections of this chapter, I examine O'Neill's (2012a, 2014) TAE framework as the transformative pedagogy that can be used to achieve transformative learning and teaching, expanding the scope of art and design pedagogy.

2.4. Transformative Arts Engagement

Frequently, studies on Internet-based educational interventions have emphasized the material change in the mode of teaching, such as MOOCs—massive open online courses (Glassman, 2019). However, it is more important to understand how new types of technology influences the thinking of both students and educators, expands their horizons, and transforms existing educational process (O'Neill & Peluso, 2013; Tilak et al., 2020). My research engaged postsecondary junior design students in a creative pursuit, which transformed their perspectives and empowered them with the necessary capacity for broader design contexts of complexity and uncertainty. Before examining the key aspects of the TAE framework for constructing a holistic pedagogy in this research, I will investigate transformative learning theory and its diverse perspectives.

2.4.1. Transformative learning theory

Transformative learning has been an important conceptual model for developing adult, postsecondary, and lifelong education since Jack Mezirow proposed it over 40 years ago; it continues to be the most researched and discussed theory in adult learning. Mezirow (1978) formulated his theory based on a study of adult women who returned to complete their higher education after an extended time away. His initial research led him to theorize that adults do not apply their initial assumptions and beliefs to new situations. Instead, they must transform their previous perspectives into new ones as they change. Drawing on Habermas' (1971) work on the kinds of knowledge—instrumental, communicative, and emancipatory—Mezirow (1991) articulates his comprehensive theory of transformative learning in his book *Transformative Dimensions of Adult Learning*. In his view, transformative learning represents a cognitive, rational process whereby adults reconstruct their sense of self in relation to the world by critically

reflecting on instrumental and communicative knowledge (Mezirow, 2000). The concept of critical self-reflection is therefore characterized as the signature feature of this process.

As the scholarship evolves on transformative learning, various theoretical conceptions have emerged, one of which is the extrarational perspective, which focuses on the affective, imaginative, intuitive, and emotional dimensions of the learning process and aligns the transformation with the Jungian concept of individualization (Cranton & Taylor, 2011). Design is a “transformative, socially engaged practice” (Mendoza & Matyók, 2013, p. 215) that requires both logical and intuitive thinking (Cross, 2006). For transformative learning to occur in the design classroom, educators must investigate these perspectives to integrate them into a holistic pedagogical orientation.

Rational and social transformation

According to Mezirow (1994), transformative learning involves “being constructivist, an orientation which holds that the way learners interpret and reinterpret their sense experience is central to making meaning and hence learning” (p. 222). In other words, transformative learning theory includes constructivist assumptions of learning as a reflective “process of assessing the grounds (justification) for one’s belief” (Dewey, 1933/1985, p. 9). Learners in such a process are active participants rather than passive recipients (Cranton & Taylor, 2011), interpreting and constructing knowledge based on their life experiences. Thus, the purpose of transformative learning is to empower learners to become “autonomous, socially responsible thinkers” (Mezirow, 2000, p. 8). Furthermore, in transformative learning, learners encounter new concepts or ways of thinking to actively evaluate their prior knowledge and experiences while making moral decisions (Mezirow, 1997), subsequently “constructing and reconstructing personal meaning” (Dirkx, 2006, p. 24) of being in the world. This view surpasses common types of learning, such as acquiring knowledge and learning new skills, for it dives into the unique ways in which learners see every day experiences and social situations differently: they develop an increasingly critical and ethical lens that empowers them to become “active agents” (O’Neill, 2012a) to change the status quo.

This change includes individual and collective dimensions and occurs when individuals, groups, or a significant social unit change in noticeable ways (Cranton & Taylor, 2011). This change of consciousness dramatically and profoundly transforms

“problematic frames of references—sets of fixed assumptions and expectations (habits of mind, meaning perspectives, mindsets)—to make them more inclusive, discriminating, open, reflective, and emotionally able to change” (Mezirow, 2003, p. 58). From this perspective, transformative learning is also a process of “problem-solving by defining a problem or by refining or reframing the problem” (Mezirow, 1991, p. 20), thereby achieving transformative insights through a critical reflection of one’s own and others’ assumptions. This concept of critical reflection is fundamental to effective collaborative problem-posing and -solving (Mezirow, 1997), which is fostered in a democratic discourse or dialogue (Mezirow, 2003). Essentially, democratic participation in such a discourse involves Habermas’ (1984) instrumental and communicative learning as the key propositions of transformative learning theory (Mezirow, 1991, 2000). According to Mezirow’s (1991) description, instrumental learning emphasizes learning through deductive reasoning and determination of cause-and-effect relationships. Conversely, communicative learning involves analogical-abductive reasoning and understanding of the assumptions, intentions, and qualifications of the person communicating. Both instrumental and communicative learning are represented below as 10 phases of perspective transformation:

(1) a disorienting dilemma; (2) self-examination with feelings of fear, anger, guilt, or shame; (3) critical reflections on assumptions; (4) recognition that one’s discontent and the process of transformation are shared; (5) exploration of options for new roles, relationships, and actions; (6) planning a course of action; (7) acquiring knowledge and skills for implementing one’s plans; (8) provisionally trying on new roles; (9) building competence and self-confidence in new roles and relationships; (10) a reintegration into one’s life on the basis of conditions and one’s new perspective. (p. 22)

Through these 10 phases of transformative learning, Mezirow (2003) recognizes Habermas’ rational and cognitive approaches for engaging in discourse and achieving democratic judgment. In educational contexts, this involves creating participatory environments with “more equitable and collaborative opportunities for exchanging knowledge and understanding on topics that matter and make a difference to the lives of those personally affected” (O’Neill, 2012a, p. 173). Learners in such environments are free agents who are more tolerant of differences and utilize ideological exchanges to add critical and deep meaning to their common purpose (Dewey, 1916/2021).

Participatory environments for critical reflection are an important goal for postsecondary education. However, they are difficult to achieve in traditional,

hierarchical classrooms in which the teachers are authority figures who impart knowledge to students and define assessment standards (Tilak et al., 2020). Drawing from Dewey (1933) and Habermas (1971, 1984), Mezirow (1991, 1996, 2003) argues that transformative learning is also concerned with the creation of public knowledge within a participatory and democratic context of discourse that improves human conditions. As Cranton and Taylor (2011) state, Mezirow's perspective emphasizes the cultivation of Freire's (1973) "ontological vocations" in individuals who continually reflect and act to transform their worlds into a more socially equitable place to live for all. Transformative learning from this perspective is an emancipatory experience wherein learners become more conscious of their states of being based on power and social structures; consequently, they develop the ability to construct their own meaning of the world (Cunningham, 1998). Essentially, Habermas's rational approach and Freire's sociocultural perspective particularly informed Mezirow's (1991) initial transformative learning theory. Central to this teaching approach is the problem-posing and -solving method, which is rooted in praxis as well as rational and social processes of critical reflection and actions. This approach is included in the democratic participation in discourse as a social learning process. Additionally, transformative learning theory stresses on developing authentic and transformative relationships between students and educators through a foundation of self-awareness, respect, delineation of constraints, and critical reflection (Cranton, 2006).

However, there has been considerable debate in the literature on whether Mezirow's transformative learning theory focuses excessively on rationality and cognition while overlooking the role of expressive, emotive, unconscious, and intuitive dimensions in critical reflection, especially in the understanding of the faulty assumption people hold about themselves. Thus, scholars have argued that the preference for the rational and cognitive process of inquiry associated with this approach limits humans' ways of perceiving and being in the world (Boyd & Myers, 1988; Dirkx, 2006; Taylor, 2001; Yorks & Kasl, 2006). According to Kotter and Cohen (2012), "people rarely change through a rational process of analyze-think-change" (p. 11). Instead, "they are much more likely to change in a see-feel-change sequence" (Brown, 2006, p. 732). This point is particularly noteworthy for developing creativity needed in art and design education, wherein the intuitive way of thinking is inherent in the design thinking process (Cross, 2011). Bull (2016) argues that greater participation in intuitive and emotional experiences during

transformative learning practices may lead design students to acquire heightened artistic sensibility, a better understanding of diverse user-groups' needs, an openness to different ways of thinking, and an awareness of visual cultural forms and their responsibilities, which has the potential to produce increased social activism through creative art expressions. Thus, as a complementary perspective to the rational process of transformative learning, extrarational transformation is reviewed in the next section.

Extrarational and holistic transformation

Many adult education scholars and practitioners have discussed transformative learning from an extrarational perspective based on Jung's (1923) psychological concept of individualization, which refers to a continuous process of self-formulation towards wholeness (Boyd & Myers, 1988; Cranton & Roy, 2003; Dirkx, 2001, 2006; Yorks & Kasl, 2006). In these discussions, attention is focused on the roles of the unconscious, emotions, affect, intuition, and imagination in transformative learning. In contrast to Mezirow's reflection, Boyd and Myers (1988) conceptualize discernment as the central learning process that leads to personal transformation—the feelings, images, and symbols generated by small, supportive social groups are the archetypal elements that conjointly enable the individual to bring awareness to an unresolved dilemma, thus resulting in “greater personality integration” (Boyd, 1989, p. 459).

This theoretical turn also reflects the emphasis on the imaginative and intuitive dimensions of transformative learning. Dirkx (2001) argues that fostering imaginative engagement with emotion-evoking images encourages learners to intuitively explore their inner stories and establish a more conscious dialogue with the unconscious aspects of themselves, thereby entering a profoundly transformative relationship with others and the world. As Dirkx (2006) states, “conscious participation in this process directs our psychic energy toward creative, constructive, and potentially transformative activities” (p. 19). Similarly, Yorks and Kasl (2006) discuss the process through which the expressive way of knowing in adult educators becomes whole and develops “an affective, intuitive, thinking, physical, and spiritual self” (p. 46) in the classroom.

Additionally, Cranton and Roy (2003) offered a more holistic perspective of transformative learning to allow educators to understand themselves and integrate their sense of self into their teaching in order to foster authentic relationships with students. For Cranton and Roy,

When people transform a habit of mind, surely, they are engaged in becoming more authentic. Transforming a habit of mind involves separating one's own beliefs from the beliefs of others just as it does when a person sets out on the journey of becoming authentic. (p. 95)

Therefore, authenticity, individualization, and transformation are inextricably intertwined; the rational and extrarational perspectives should be employed side by side to develop a more holistic view of transformative learning. Recently, O'Neill (2012a, 2014) developed a pedagogical framework based on a holistic view of transformative learning that specifically promotes young people's engagement in today's technology-driven, complex, and multimodal art learning environments. The next section explores this framework to construct a holistic, transformative pedagogy for this research.

2.4.2. Key aspects of transformative arts engagement

Art and design educators have increasingly hoped to prepare their students for the complex, uncertain future through collaboration, communication, and innovation. They have aimed to embrace a culture of lifelong learning to foster students' growth mindset, outlook, and skills so that they can continuously develop their creative capabilities and apply them in various fields with diverse teams throughout their lives. To promote such learning, an increasing number of design scholar-educators (Bull, 2016; Danvers, 2003; Osmond & Turner, 2010) have challenged the long-established atelier model of teaching and learning within traditional art and design studio environments, wherein students merely mimic the actions of professional designers and teachers to acquire knowledge and skills. These educators have called for a transformative approach to design learning that is strongly committed to developing "a whole person" (Dall'Alba & Barnacle, 2007, p. 689) who can function amidst unpredictable flux. The following section reviews O'Neill's (2012a, 2014) ideas on TAE, which provides a transformative learning framework and requisite principles for fostering art and design students' capacity to navigate complexity.

TAE is a pedagogical framework derived from transformative music engagement (TME) which was also developed by O'Neill (2012a). According to O'Neill, TME alters our orientation to music learners from "deficit versus talent/expertise" (p. 166) and proposes that every music learner has the potential and capacity to positively engage in all artistic development. Building upon the key principles and features of TME, O'Neill

(2014) expands this framework from the musical world to the realm of arts and labels it as *TAE*. The concept encourages educators across the art disciplines to adopt a critical approach and re-evaluate what it means to be an art learner in the 21st century, seeking to understand how aesthetic and artistic engagement can be seen as a part of creative meaning-making and knowledge construction in art learners' daily life through their artistic representations within the world of multimodal media and participatory culture. From this perspective, TAE is well-suited for this action research, which focuses on VW-integrated multimodal art and design learning to enhance students' creative collaboration. It also enables art and design educators to recognize students' individual and group engagement with multimodal virtual learning environments, as a process of creative meaning-making that may result in changes in design processes, products, and even individual perspectives.

TAE provides a “dynamic, transformational, and multidimensional” (O’Neill, 2012a, p. 164) conceptual framework that is grounded in sociocultural and ecological systems and provides relatively new opportunities for the learner’s artistic creativity (O’Neill, 2014). It comprises three theories to conceptualize purposeful and meaningful arts engagement—psychodevelopmental or lifelong learning perspectives on transformative learning (Mezirow, 2000), the complex nature of social learning contexts, and relationships that are facilitated through critical transformative pedagogies (Kincheloe, 2008; McCaleb, 2013)—and engages learners in an art activity that empowers them with a sense of relevance, purpose, and fulfillment by developing positive changes (O’Neill, 2006). Specifically, TAE focuses on the online participatory learning environments that provide art learners with expansive opportunities for fostering collaborative creativity and autonomous thinking distinct from traditional art learning. It recognizes today’s increasingly multimodal and participatory forms of digital art learning as well as the importance of demystifying what constitutes an “expert” art “knower” (O’Neill et al., 2011, p. 27) to create an “informal learning” (Gee, 2005) space in which young art learners are encouraged to support each other through dialogic inquiries and to share their user-generated, multimodal digital content or expertise for creative collaboration and critical reflection (O’Neill & Peluso, 2013). By creating a space that is more democratic, supportive, participatory, collaborative, reflective, and dialogic, art learners may better understand the purpose of their involvement in the specific technology-mediated art activity, feel valued by their peers and teachers, and

consequently construct their identities by establishing robust social relationships within the learning community. Such a learning experience can become a source of empowerment, increase learners' engagement and motivation to persistently practice art with greater autonomy, and become more capable of recognizing the opportunities within their capacities to generate more creative insights. O'Neill (2012a) conceptualizes and characterizes this TAE framework across three key dimensions of learning capacity (Figure 4), which include prominent experiential, temporal, spatial, relational, and transformational aspects.

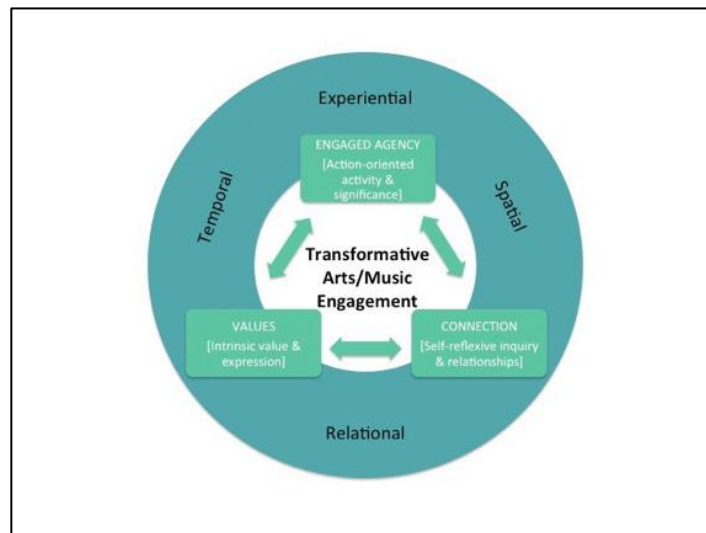


Figure 4. Three key dimensions of the transformative arts engagement framework

Figure: O'Neill (2012a), reproduced with permission

Engaged agency

The first TAE capacity is engaged agency. According to O'Neill (2012a), agency involves individuals or groups acting upon, modifying, and assigning significance to their worlds in purposeful ways to impact, create, and transform themselves and the conditions of their lives. It is founded on a capacity for critical reflective self-awareness and intrinsic motivation to pursue untapped possibilities. In art education, O'Neill (2012b) uses agency to refer to a "positive understanding of, and commitment to, art learning that keeps learners meaningfully engaged" (p. 10). They feel empowered and autonomous in their ability to direct their own learning processes and create art forms that speak from their own "authentic voice" (O'Neill & Peluso, 2013, p. 4). O'Neill (2006) argues that an important aspect of empowering art education involves valuing learner

agency as both the outcome of TAE and as a critical contributor to the generative art learning process that transforms one's sense of self, others, and their learning community.

Fostering a sense of an engaged agency requires more than transmitting the power to the learner. O'Neill (2012a) suggests that it involves action-oriented activities in which art learners are actively involved in their learning and well-being. In developing these activities, educators consider the learners as active agents whose interests, emotions, cognition, and the reflective awareness are enhanced by participating in an experiential, learner-centred, emergent, and safe learning context (O'Neill, 2012a). Providing these kinds of learning opportunities fosters a sense of empowerment among students and increases their belief in their ability and motivation to shape their activity systems in that specific learning context (Engeström & Sannino, 2017). Subsequently, they may undertake their engaged praxis by reflecting upon, questioning, and challenging their beliefs, values, and learning situations (O'Neill, 2015). They may also become more aware of their unrealized opportunities and generate creative ideas for reaching goals with personal meaning and significance (Vygotsky, 1978) regardless of the constraints and difficulties in their learning. As a crucial component of the TAE framework, action-oriented activities reflect the activity theory in which agency in learning involves learners' actions and motivation rather than merely their reactions (Miettinen et al., 1999). Agency is closely connected with and mediated by identity. In turn, identity is continually shaped through social practices (Holland et al., 1998). Thus, TAE provides art learners with "expansive learning" (Engeström & Sannino, 2017) opportunities to enrich, diversify, and transform their selfhood and self-identity for positive change (O'Neill, 2012b, 2017). This view has important implications for art and design education, as design learning is typically conducted through a collaborative and participatory process of negotiation, investigation, and design. Art and design educators must create a space in which students can continuously expand their identities and exert their agency through peer learning, student-teacher collaboration, and critical reflection within an exploratory space. Within such a space, they become empowered to autonomously explore themselves by connecting with others and to widen their social experience by making moral decisions and undertaking responsible actions that are not only creative but also transformative for their worlds.

Connection

The second capacity of TAE is connection. Art and design learning is more than simply learning content. It combines learning content and developing skills to think critically about the design content, and purposefully effecting change by applying one's critical awareness of the design in the light of the potential consumers and their contexts (Bull, 2016; Bull & Tovey, 2010). O'Neill (2014) refers to this as a sense of connectedness and emotional engagement with a capacity for reflective self-awareness. Drawing on Bronfenbrenner's (1979) conceptual framework of family ecology, O'Neill (2012a) claims that art learning is nested within multiple interconnected learning contexts, including the learner's family, school, and community. Any changes or conflicts in any one system can have a ripple effect on other systems. Therefore, O'Neill suggests that educators must become critical and contextualize art learning within "zones of complexity" (Kincheloe, 2008) that connect the learners with diverse learning circumstances. Thereby, when problems arise, learners can critically scrutinize their ideas and utilize their real-world knowledge to become more capable of exerting their agency, thus producing creative solutions that are responsible for their "figured worlds" (Holland et al., 1998).

One technique to construct zones of complexity is through agentive art learning ecologies within particular contexts (e.g., home, school, and Internet) that cultivate an intense connectedness between positive relationships and learning experiences (O'Neill, 2017). According to O'Neill, young people's artistic lives both shape and are shaped by their artistic selves, which develop over time within specific learning ecologies. These learning ecologies enable learners to view themselves as active agents in relation to the lives of others. O'Neill maps three types of art learning ecologies—segmented, situated, and agentive. Segmented ecologies are primarily associated with recurring events, such as formal art lessons, which often offer little or no sense of connectedness between the young learners and their learning activities. Conversely, situated learning ecologies focus on the situatedness of the art activities within particular places and relationships that make them meaningful for the learner. Situated art learners usually collaborate with like-minded peers from different social groups, making solidary and new expressions that challenge their old artistic perspectives, thereby leading to holistic and transformative experiences. Situated art learners approach and participate in a group that values their artistic contributions, makes them feel cared for, and provides them with

common goals. Consequently, there is a strong sense of connectedness that keeps their learners' artistic selves dialogical and relational to art activities, non-art activities, and others who may or may not be involved in their social art world. However, O'Neill states that the sense of connectedness in situated learning ecologies may not necessarily be empowering but is usually intense and enduring in agentic art learning ecologies.

In O'Neill's (2017) conceptualization, agentic ecologies emphasize the intentional and intense process of art creation, experimentation, and innovation that opens up possibilities to achieve personally meaningful artistic goals. This process involves constructing "communities of practice" (Lave & Wenger, 1991) that foster a strong sense of connectedness within positive relationships and experiences with others and motivate art learners to learn the art and engage in artistic activities. Nevertheless, this connectedness does not necessitate that learners must seek conformity in their art-making; instead, learners in these communities intentionally "compare and contrast differences that act as a vehicle and a catalyst for growth and change, identity constructions, creative process, and artistic expression" (O'Neill, 2012a, p. 167). These intentional actions illustrate the learners' engaged agency in shaping decisions regarding their artistic lives, including how they manage challenges to expand their knowledge and skills. Therefore, art activity within agentic learning ecologies is "more than a transformative experience (identified in situated learning ecologies), but a transformative journey" (O'Neill, 2017, p. 19).

This transformative journey of agentic artistic life has important implications for postsecondary art and design education, wherein design creations have evolved from handcrafted forms to digital technology-mediated expressions. For design educators, this profound change implies the urgent need to foster the design learners' abilities to "actively deal with digital information and media and communicate effectively with others using online digital applications or services" (OECD, 2012, p. 17). O'Neill (2017) states that "although technology is not an essential feature in agentic art learning ecologies, it did feature prominently" (p. 20). Specifically, the participatory affordances (Kress, 2010) of online technologies provide preconditions for establishing online "affinity spaces" (Gee, 2005) and "participatory culture" (Jenkins, 2006). Within these affinity spaces, learners "voluntarily" (O'Neill, 2017, p. 20) engage in art-related activities to support each other's growth, artistry, and creativity (O'Neill, 2012a)—they participate in experimental learning and knowledge sharing, critically reflecting on their own

perspectives to accommodate various perspectives not necessarily arising from the same cultural or geographical location. By creating such a social connectedness without barriers, art learners develop a critical awareness of the impact of their decisions and actions on the environment and others. Consequently, they become the actual “agentive beings who develop through embeddedness in sociocultural contexts and within relations to others” (Stetsenko, 2012, p. 3), and consciously producing artistic expressions that have creative and responsible impacts on the world. Design creations and expressions are becoming increasingly multimodal, complex, and innovative because digital technology is involved; therefore, agentive learning ecologies appear to foster a sense of empowerment and connectedness that have a reciprocal relationship with the learners’ artistic selves, creating a sense of agency with which they are more capable of navigating and negotiating new learning opportunities (O’Neill, 2017).

Values and beliefs

The third dimension of the TAE framework includes the development of students’ values and beliefs, which are inherent to the “enjoyment or pleasure one gets from engaging in an activity” (Eccles et al., 2005, p. 239) and are necessary for the self-expression and self-direction that result from the learners’ positive art engagement (O’Neill, 2006). According to O’Neill (2012a),

Values have an odd life cycle, one that transcends the dichotomy between individual and social. Values can only thrive (or fail to develop) within relationships between individuals. They contribute to the way that knowledge is constructed, used, and exchanged in the present and the future. (p. 174)

For art learners to enjoy and deeply engage, their artistic activities should occur in the context in which both they and their educator can participate freely and fully in an “appreciative and dialogical inquiry” (O’Neill, 2015) to identify “more comprehensible, authentic, and morally appropriate ways of valuing and engaging in art practices” (O’Neill, 2012a, p. 175).

Despite its merits, the traditional achievement-oriented learning framework also limits educators’ expectations and the possible pedagogical approaches that may fix or solve art learners’ achievement-related problems instead of fostering their potential (O’Neill, 2012a). Conversely, appreciative inquiry is “the art and practice of asking questions that strengthen a system’s capacity to apprehend, anticipate, and heighten

positive potential—linking people, as it were, to the positive core of their past, present, and future capacities” (Cooperrider & Barrett, 2002, p. 59). TAE operates within this appreciative inquiry framework, enabling educators to listen to and honor art learners’ voices through constant critical and reflective discourses (O’Neill, 2015). Both the educator and learners strive to develop an appreciative and critical eye in the “assessment of assumptions and expectations that support beliefs, values, and feelings” (Mezirow, 2003, p. 60). Therefore, the appreciative dialogical inquiry may serve as a catalyst for art learners’ sense of self, desire, and motivation for positive art engagement, empowering them to develop their tolerance, acceptance, and respect for the diversity of artistic practices in their world (O’Neill, 2006).

In considering today’s art learning activities that largely involve digital technology, O’Neill (2005) states that young art learners are already active agents in constructing their artistic lives since they have considerable autonomy in choosing their engagement in art activities. Consequently, art educators must consider not only the opportunities for teaching and learning offered by the specific technology but also the extent to which these opportunities motivate young tech-savvy learners to self-direct and commit their learning to their own long-term development. Therefore, O’Neill (2015) suggests that positive art engagement, as a form of appreciative and dialogical inquiry within collaborative technology-mediated artistic activities, provides art learners with opportunities for self- or social empowerment by valuing their voices. Young art learners and educators must purposefully collaborate to share, reflect, expand, and express diverse voices to enable the development of a deep level of empathy and positive engagement that values each other’s efforts. Such experiences can become a source of empowerment that fosters art learners’ capacity to change their beliefs, values, and attitudes toward taking creative risks, experimenting, and imagining. Ultimately, these experiences transform their identity from a position of aspiring to be an artist to becoming a fully confident artist with a “growth mindset” (Dweck, 2008) for achieving enduring motivation, persistence, and resilience despite adversity and uncertainty.

2.4.3. Transformative pedagogy

O’Neill (2012a) suggests that one prominent feature of TAE involves the creation of expansive learning opportunities that are facilitated through transformative pedagogy. However, “transformative pedagogy is not a method of teaching but rather a set of

principles that guide teaching and learning interactions” (p. 177). While these principles may vary across different epistemologies and perspectives, O’Neill lists several key elements that share common features:

- Teaching begins with the students’ knowledge. Opportunities for expansive learning are provided that enable learners to manipulate or interact within their own artistic and cultural ecologies in a way that helps them make meaningful connections.
- Skills, knowledge, and voices develop from engagement. Learners are asked to create, express, or display their own representations of a particular issue, event, or phenomenon.
- Teaching and learning are both individual and collaborative processes. The role of the instructor is one of facilitator, organizer, leader, and source of knowledge on the topic but not the primary source of learning.
- Teaching and learning are transformative processes. Learners share their creative representations with others and engage in a process of dialogue, shared meaning making, and sociocultural and sociopolitical associations. (p. 177–178)

2.4.4. Summary

Briefly, the three interrelated dimensions of the TAE framework and key features of transformative pedagogy illustrate the potential of art educators to foster a sense of empowerment among art learners; however, art educators need to scrutinize their expectations of what it means to be an art learner, how these learners construct knowledge in their critical agentic consciousnesses and their knowledge-construction processes. Through these efforts, educators can truly and meaningfully engage art learners, nurturing their autonomous and responsible agency to connect different perspectives and explore new possibilities. Therefore, art learners can produce practical, creative, and responsible ideas that not only enact positive social changes but also enable them to develop a transformative perspective of themselves in connection to their aspirations, others, and the world.

Chapter 3. Theoretical Framework: Toward Transformative Engagement in Virtual-World-Based Collaborative Design Practices

3.1. Overview

As discussed in the literature review, the increasingly complex and uncertain design challenges necessitate that art and design education adopts a transformative learning approach to iteratively develop students' competence and capacity through collaborative practices so that they can transform into autonomous, confident, resilient collaborators, communicators, and innovators who continuously navigate complexity and uncertainty (Bull, 2016; Crosby et al., 2019; Osmond & Tovey, 2015). I propose that the purposeful implementation of VW-based multimodal collaborative design within a TAE pedagogical framework might be capable of fostering creative collaboration among junior design students, potentially leading to this transformation for advanced design learning. In this chapter, I explain in three sections how I utilized aspects and elements of the interrelated theories presented in the literature review to develop the theoretical framework that guided my research and the development of a design foundational course centred on the design thinking model.

3.2. Alignment of Design Thinking, Virtual World Affordances, and Features of Constructivist Collaborative Learning

First, considering the critical aspects of design thinking, educational affordances of VW technology, and constructivist learning, I propose that the IDEO design thinking model may serve as a potentially appropriate pedagogy for usage in a VW-integrated design course because the model leverages VWs' affordances by establishing a frame with which to balance the tension between freedom and structure in constructivist-based collaborative learning (Figure 5). Second, from a social semiotic account of multimodality, each mode of the learning environment, through its affordances, offers possibilities for making meaning and learning (Bezemer & Kress, 2016). I employed this concept as a pedagogical approach to support students' creative collaboration by

recognizing their transformative engagement with VWs in modal forms as “multimodal ensembles” (Jewitt, 2009; Kress, 2013), such as drawing, talking, writing, moving, and building, thus positioning their collaborative VW design experiences. Finally, employing the TAE framework that is coherent with multimodality and design thinking created a more holistic pedagogy to foster students’ creative collaboration in their VW-supported design learning, which may transform their perceptions of themselves in relation to design learning, thereby preparing them for the next stage of their design learning (Figure 6). Following is a detailed explanation of the theoretical framework construction process:

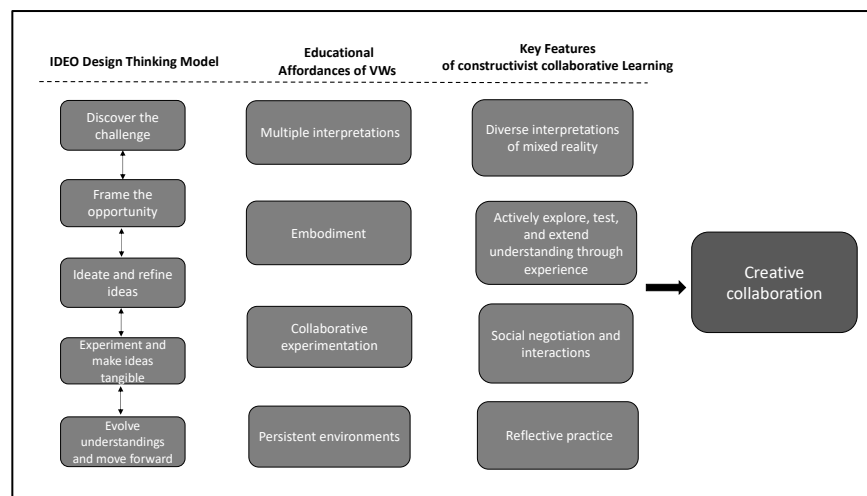


Figure 5. Alignment of design thinking, virtual world affordances, and features of constructivist collaborative learning

Figure 5 illustrates the first step of employing IDEO design thinking model to structure VW-integrated constructivist-based collaborative learning activities. According to Jonassen (1994), “constructivist learning environments provide multiple representations of reality, thereby avoiding oversimplification of instruction by presenting natural complexity of the real world” (p. 35). Stapleton and Hughes (2006) posit that virtual environments provide students with a mixed reality of physical (e.g., real-world surroundings), virtual (e.g., media simulations), and imaginary realities (e.g., users’ cognitive perceptions of the environment) within which they may be deeply immersed. The first design thinking stage involves developing an empathetic understanding of the design challenge concerning its contexts to discover the hidden needs (IDEO, 2012); consequently, the activities in this design thinking stage can be organized around exploring VWs’ mixed reality to realize this constructivist learning experience. By being

immersed in the mixed reality, students receive opportunities to actively interact with a wide range of VW communicative modes, such as visual, aural, audio, and spatial, to collect relevant information and inspiration, hence producing diverse interpretations of the challenge and its context.

Constructivist learning environments also allow students to actively explore, test, and extend their understanding through experience and communication with persons, objects, and situations (Bredo, 1997; Papert & Harel, 1991). This experience can be organized around the second design thinking stage—framing the opportunity—through activities that incorporate VW affordances—multiple interpretations, embodiment, and collaborative experiments. According to IDEO (2012), the purpose of the second design thinking stage is to utilize the information gathered in the first stage and condense it into a clear direction for ideation. The embodied social presence, the synchronous and asynchronous collaboration, and the experimentation afforded by VWs embrace student-users' intensive and playful participation and engagement (Jung, 2011; Ondrejka, 2007). Therefore, it is reasonable to believe that organizing activities in this stage can leverage these VW affordances to encourage students to explore, share insights, extend their understanding, and hence frame inspiring and actionable opportunities for their designs.

Furthermore, constructivist-based collaborative learning environments facilitate purposeful knowledge construction in which students engage in authentic activities, negotiate meanings with others, and develop an identity as a member of the community of practice (Jonassen, 1994; Lave & Wenger, 1991; Vygotsky, 1978). These social interactions and negotiations can be facilitated by providing students with opportunities to collaboratively generate and refine ideas. Thus, the third design thinking stage—ideation—can be organized as brainstorming sessions leveraged by the affordances of embodiment and collaboration. When both students and teachers simultaneously embody various avatars to participate in brainstorming sessions, everyone creates an “alternative persona or identity” (Gilbert et al., 2011, p. 214), which can be utilized as a “protective shield” (Alahuhta et al., 2014, p. 9) to provide a sense of safety and comfort. Concurrently, the shared place and copresence for rich real-time interactions virtually connect students and teachers as a team (Gaimster, 2008), thereby encouraging social negotiation of meaning to produce more wild and visionary ideas.

Moreover, constructivist-oriented collaborative learning environments provide students with an opportunity for reflection (Jonassen, 1994; Jonassen & Land, 2011). The final two design thinking stages—experimentation and evolution—support this reflective practice by using VW affordances in persistent environments and by collaboratively experimenting. Specifically, created objects and environments remain persistent in VWs despite the absence of their creators (Weiley & Pisan, 2008). Students, therefore, are always able to share their design progress with their team members and reflect on the problematic design situation for refinement. More importantly, VWs afford real-time communication while avatar-mediated users are codesigning in the environment. This affordance effectively supports Schön's (1984) reflection-in-action in which the prototypes could be reviewed and tested by navigating avatars through the content (Koutsabasis et al., 2012) while communicating to identify problems and experimenting with solutions.

In short, these design thinking stages follow an iterative and collaborative process from exploring the knowledge domain to experimenting, co-constructing knowledge, reflecting, and achieving an evolving understanding, which aligns with a wide range of affordances inherent in VWs as well as critical features of constructivist-based collaborative learning environments. Educators can emphasize activities arranged around design thinking stages according to the specific affordances of the VW platform; consequently, the educational potential of this technology can be leveraged. Furthermore, the tension between freedom and structure in constructivist learning can be balanced and hence can produce unique opportunities for enhancing creative collaboration in design education, which may not be easily offered in other forms of learning.

3.3. Social Semiotic Multimodality as a Pedagogical and Assessment Approach to Support and Recognize Students' Creative Collaboration

As discussed in Section 2.3.5, multimodal social semiotics is grounded in communication theory, whereby learners' creativity is revealed in their transformative engagement with their social worlds (Bezemer & Kress, 2016; Kress, 2010, 2013; Kress & Bezemer, 2015; Kress & Selander, 2012). This perspective was adopted in this research as a pedagogical approach and alternative assessment to support and

recognize students' creative collaboration as they resourcefully select, combine, and transform multiple semiotic modes of VWs into new, creative multimodal ensembles.

As discussed in the literature review, creativity's success criteria depend on the identifiable information and measurable skills evident in the student's final presentation while ignoring the intangible creative outcomes in the learning process, such as students' interests, experiences, and engagement. Educators who utilize this utilitarian assessment may not fully recognize students' efforts and capacities, which may negatively impact their learning motivation and self-perception, leading to conformity and uniformity that is detrimental to creativity (Belluigi, 2016; Dineen & Collins, 2005; Mann, 2001). However, from a multimodal social semiotic perspective, students' design practices are inherently creative, as they constantly select different VW modes and ensembles for engagement and then collaborate with team members to design and redesign these ensembles into new forms of meaning.

Furthermore, according to Bezemer and Kress (2016), no two team members make the same choices or have the same levels of interest, the same set of cultural resources, or the same value. Therefore, the modal ensembles reflect the division of semiotic work completed by each team member, which is visible in the commonality and differences in students' chosen semiotic resources. In addition, these "situated choices" (Jewitt, 2013, p. 2) demonstrate the student users' different types of engagement with VWs' material resources, illustrating how they are motivated by VWs' multimodal affordances, such as visual, aural, embodied, and spatial aspects, to convey creative meanings despite their potentially conflicting interests of group members. Concurrently, these engagements reveal the students' challenges in crystallizing particular aspects of meaning due to the modes' specific constraints and students "semiotic resourcefulness" (Bezemer & Kress, 2016; Mavers, 2007) in jointly and iteratively circumventing technological and social constraints as they transform these constraints into opportunities. By interpreting students' creative collaboration as socially transformative and semiotically resourceful, their motivating interests in specific modes and affordances of VWs become apparent. The educator can then use this interpretation to engage in discussions with students about their modal choices and then to reflect on the possibilities and limitations of the designed VW learning environment. This insight then serves as the prompt for further enhancing the learning environment to be more based on student agency and interests (Kress & Selander, 2012).

3.4. Fostering Transformative Engagement in Virtual-World-Based Collaborative Design Learning

Design education concerns the “transformation of design learners from aspiring to be design practitioners and recognize their own skills and capabilities within a board design industry to become fully confident members of their professional community of practice” (Bull & Tovey, 2010, p. 124). In my research, the iterative design thinking processes entailed in VW-integrated collaborative design learning evoke several phases of Mezirow's (1991) transformative learning: discovering disorienting dilemma; critically reflecting on assumptions; exploring options for new roles, relationships, and actions; building competencies and developing autonomous thinking; and subsequently transforming frames of reference. This evocation indicates the transformative potential of design thinking-framed multimodal collaborative VW design practices, which may challenge students to explore, undergo trial-and-error processes, and undertake design risks, resulting in dialogues, reflecting, questioning, envisioning, and applying additional alternative, creative solutions. To bring about this transformation, I also integrated the TAE framework to create a more holistic pedagogical model to engage students in their multimodal collaborative VW design learning that builds upon and expands their knowledge and capacities to foster their own and others' creativity in navigating complexity (Figure 6).



Figure 6. Pedagogical model for virtual-world-based collaborative design practices

The core of this model constitutes a provision of holistic and transformative learning education that invites the interaction of design thinking, multimodality, and the TAE framework within VW-based collaborative design practices. Through tactful use of these approaches and perspectives, I see a significant potential to foster students' creative collaboration in design learning, thereby empowering them to develop three key TAE learning capacities—engaged agency, connection, and values and beliefs—as a result of transformative engagement (O'Neill, 2012a, 2014). The TAE framework, whose hallmark is a combination of action-oriented learning, experiential learning, peer learning, student-teacher collaboration, reflection, and student agency within a participatory multimodal space, aligns with VW affordances and the design thinking process. Carefully employing this pedagogical framework in the human-centred design thinking process allows both students and the teacher to collaboratively define learning pathways by continually reflecting on their efforts and capabilities according to the specific learning goals and personal achievements in each design thinking stage. For junior design students with little or no digital design experience, the inherently complex and multimodal VW design practices often lead to disorienting dilemmas (Mezirow, 1991) regarding design difficulties and problems. Therefore, employing TAE in the design thinking process enables the teacher to be more prepared to empower students to address the complex challenges of each stage and thus become more motivated in utilizing these approaches to realize further constructivist learning. Such a learning process offers students the necessary and specific support to engage with their VW-based design practices more deeply and purposefully, thus fostering their design thinking skills and TAE-related capacities.

Within this theoretical framework, various elements and concepts were adopted to foster students' creative collaboration in their VW-based group design practices, which creates conditions for transformative engagement to expand the scope of the long-established atelier style and apprenticeship teaching in design education (Bull, 2016). This pedagogy is built on the synergy of the three aforementioned interrelated concepts to provide a transformative space for fostering junior design students' creativity through repeated collaborative design practices in VWs, which affords them expansive opportunities to become more aware of their own and others' potential and achievements. With increased awareness, students are more likely to develop an enhanced sense of engaged agency, connect to their learning and others, and transform

their values and beliefs to manage their design challenges with greater creative confidence and resiliency. Such a practice has a considerable potential to foster transformative engagement, leading to students' reconstruction of their identities as "what they know, how they act, and who they are" (Dall'Alba & Barnacle, 2007, p. 689) to navigate this era of complexity and uncertainty.

Based on my scholarly interests and the theoretical framework, which is built upon the relevant existing literature, my research addresses the following questions:

1. How might the purposeful use of multimodal pedagogy leverage the affordances of VWs to foster creative collaboration among junior art and design students?
2. How might the multimodal pedagogical approach in conjunction with the TAE framework create transformative learning opportunities through a VW-based collaborative design processes?

Chapter 4. Research Methods

4.1. Course Design

4.1.1. Objectives and methods

This study employs a practical action research design that includes a VW-integrated course and a study conducted in the Department of Art and Design at Zhengzhou University in China. According to Mills (2007), practical action research enables teacher researchers to reflect on a problematic situation and experiment with new ideas in their own classroom contexts to improve learning and teaching. To test the new pedagogical idea of integrating VW technology for creative collaboration, the course, which was developed based on the department's required course I taught—Design Fundamentals—was conducted in the 2018 fall term.

As indicated earlier, my concern based on my previous experience teaching foundational-level art and design classes was that junior design students often struggled with creativity when confronted with complex design collaborations. I used the Dialectic Action Research Spiral Model to develop and facilitate the VW-integrated Design Fundamental course. This model includes the responsive, dynamic, and repeated processes of identifying an area of focus, collecting data, analyzing and interpreting data, and planning action (Mills, 2007), as depicted in Figure 7. In 2017, I redesigned the Design Fundamental curriculum to accommodate the newly adapted course incorporating VW technology for this research, based on a preliminary process of reflecting on the course's initial aims and shortcomings, obtaining advice from my department colleagues, and gaining insights during my doctoral studies. I also developed strategies to foster creative collaboration among junior design students by facilitating their group design activities and conducting continuous multimodal analyses of the students' collaborative design processes and completed group projects to recognize their creative actions and engage them in an ongoing discussion for pedagogical refinement.

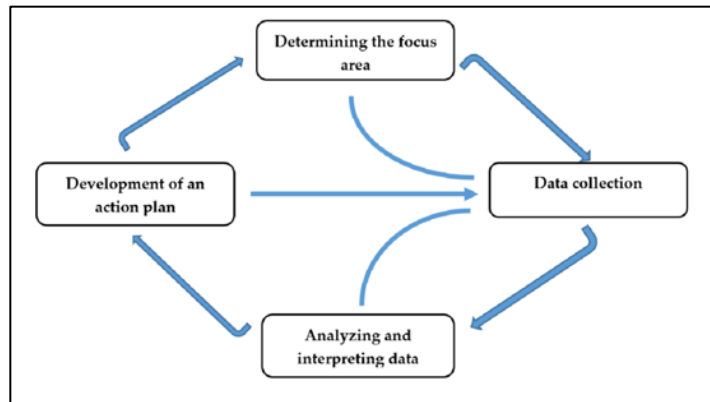


Figure 7. Mills' Dialectic Action Research Spiral Model

Figure 7: refers to Mills (2007, p. 19).

As part of the study, post-pre surveys and formal interviews were conducted at the end of the course to capture students' perceptions of change and reflection on their experience of design learning and creative collaboration in VWs. Through the iterative and responsive action research process, I became "a learner" (Mills, 2007, p. 2) in the newly designed course concerned with what my students were learning collaboratively and how they collaborated throughout their VW design processes. I also experienced the classroom as a "collaborative venture" (Pine, 2009, p. 242) in which students' continuous feedback assisted in validating my interpretations of significant problems and opportunities when teaching and learning in VWs for creative collaboration. Although this research only completed the first spiral cycle, its methods were founded on the understanding that the reflections and insights emerging from this research would be applied to the refined planning of action in the subsequent deliveries.

The following sections describe the development of the VW-integrated course, including the course learning goals, anticipated learning outcomes, and the application of VW technology.

4.1.2. Course learning goals

As the comparative chart in Table 1 indicates, the elective course learning goals were developed based on the original goals of the Design Fundamentals course but aimed to foster students' creative collaboration and transformative engagement with their VW-supported design learning that are associated with aspects of TAE. The learning goals of the required course are general and broad, as the course is a

foundation for learning the art and design vocabularies, concepts, and principles of abstract and representational 2D design. The VW-integrated elective course encourages students to utilize the design thinking process as a tool kit to collaboratively solve specific, complicated problems that are positioned in their 3D VW-based designs. While the learning goals of the required course are detailed and defined, the goals in this research remained open and flexible to support the emergent and generative nature of the collaborative design processes and student-led design projects.

Table 1. Course learning goals comparison chart

Design Fundamentals	VW-integrated Design Fundamentals
<p>Students will ...</p> <ul style="list-style-type: none"> • Utilize the basic elements and principles of design as they solve design-based assignments • Understand what constitutes the design thinking process, thinking forms, and functions • Explore aspects of aesthetics and craftsmanship in 2D designs • Practice critical reflective skills, including learning to apply art and design knowledge to assess the strength of individual visual solutions through analysis and evaluation • Define, use, and apply the appropriate terminology and research materials to specific design-related compositions • Use appropriate tools to achieve desired results 	<p>Students will ...</p> <ul style="list-style-type: none"> • Utilize the elements and principles of design as they solve VW-based design problems • Work in Groups to develop a VW-based project in both a physical and virtual settings • Research and experience various aspects of visual design, such as aesthetics, design concepts and content, the user experience, and culture factors in VWs • Demonstrate aesthetic sensibility and technological skills in VW-based 3D designs while considering the potential user's experience • Work in a group and with potential users to test the tentative solutions through reflection and feedback • Investigate the various elements of visual design (including content, psychological connections, and sociocultural characteristics of potential users)

4.1.3. Anticipated learning outcomes

Six anticipated learning outcomes were student-focused, which informed the affordances of the VW-integrated Design Fundamentals course. In other words, they state which learning experiences were provided by this course and which creative capacities students were expected to develop at the end of the course:

- Explore and utilize the elements and principles of visual compositions, including balance, unity, hierarchy and emphasis, harmony, contrast, variety, rhythm and

repetition, alignment, and proximity, to tell correct stories to the appropriate audience in multimodal ways.

- Complete self-initiated VW group design projects, practicing the design thinking process with group members and the potential audience to ensure human-centred design development.
- Apply experimentation, exploration, analysis, reflection, evaluation, and synthesis to an iterative and collaborative design thinking process of discovering problems, framing questions, ideating solutions, creating prototypes, and improving ideas.
- Define roles and develop dialogical relationships within a group, determining which meaning presented in a mode is appropriate and creative.
- Develop VW design projects that not only express the group's decision-making but also present a suitable and creative experience to the audience in a social context.
- Match the affordances of different tools (non-digital and digital) to design projects to develop organization, aesthetic sensitivity, and craftsmanship skills in representing ideas and achieving desired results.

4.1.4. Course development (virtual world technology)

The design of the VW-integrated Design Fundamentals course involved two types of VWs that allow students to engage in different stages of design thinking for transformative outcomes. In the early design thinking stages, SL, the world's largest and most popular virtual environment, was employed to develop students' interests in working in VWs and to enable them to discover and frame the design problem. After students became familiar with the SL user interface, a similar virtual platform—VCER—was introduced for the student-led group design project. Compared with the cost to play SL, VCER is a free virtual learning environment for education and research purposes only and is supported by UBC. Drawing on the original curriculum of Design Fundamentals as well as VW affordances and the theoretical framework, I refined and developed this new Design Fundamentals course, integrating VW technology. At the beginning of the spring 2018 term, the new course content was sent to the dean of the

Department of Art and Design for review and approval. Upon receiving the dean's permission, I registered this newly developed course as an elective course named as *3DVWs Exploration: Design Fundamentals* for the fall 2018 term in the Academic Affairs Office of the Department of Art and Design.

4.1.5. Course structure and pedagogies

The VW-integrated design course began in October 2018 with a cohort of undergraduate art and design students in the Department of Art and Design. The course was conducted over 8 weeks with class twice each week on Monday and Thursday (16 sessions in total) for 2 hours each session. A hybrid learning method that involved students' presence simultaneously in class and in VWs was applied in this course. Two VW applications (SL and VCER) were installed in the department's computer lab before the course started. Students' tasks were to explore fundamental design elements and principles by participating in collaborative design projects in VCER based on their group's interests. In the final session of this course, all students were expected to participate in a 20-minute group presentation of their completed design projects followed by a post-pre survey and a reflective interview. If students were willing to share their designs with others outside the classroom, then they were encouraged to sell any of their project items in the SL marketplace. In this research, I integrated a design thinking pedagogy, the multimodal approach, and the TAE framework to develop a holistic pedagogical model to foster students' transformative engagement in their VW-integrated design learning and their creativity related to the TAE key learning capacities: engaged agency, connection, and values and beliefs.

In Weeks 1 and 2, I focused on developing students' engaged agency by practicing activities that were organized according to the first two stages of the design thinking process in SL, including discovering and understanding the challenge and framing the opportunity. These exploratory activities motivated students' different semiotic actions to approach various virtual environments in SL (e.g., avatars' physical interactions, verbal and written communication, design, and movement). In turn, these activities offered insights into which VW multimodal affordances attracted the students' interests, hence providing guidelines that enabled me to continuously design (Kalantzis & Cope, 2010a) the space to better engage students in their collaborative multimodal design practices.

During the first two weeks, students gradually developed their navigation skills and interests; consequently, in the following six weeks, I focused on the activities framed around the remaining three stages of the design thinking process, which were conducted in VCER, a virtual platform similar to SL. Students engaged in action-oriented activities to ideate and refine concepts, experimented to make ideas tangible, and analyzed and progressed through collaborative participation utilizing different VCER modalities.

To support students' interactive and iterative design processes, my role within the VW-based design learning was "one of facilitator, organizer, leader, and source of knowledge on the topic, but not the primary source of learning" (O'Neill, 2012a, p. 178). As VWs offer flexible opportunities for remote learning, my role as the instructor was to lead students through their challenging activities and rigorous learning both inside and outside the classroom. Additionally, as the group design project was driven entirely by students' interests, I worked alongside with each group to solve their unique problems, facilitate their reflective dialogues, organize engaging tasks to build community, and nurture connections and positive values among these groups. In such a learning community, I was no longer an "authoritative holder of knowledge" (Kress & Selander, 2012, p. 267). Instead, each group member became an autonomous and self-directed learner, and peer mentoring as well as peer learning became predominant in class. Overall, this VW-integrated course, which was framed around the design thinking model and the use of multimodal and TAE frameworks, created conditions with a significant potential for transformative design engagement as part of the design processes and design products, thus promoting students' creativity in navigating complex design challenges. A brief description of the 8-week VW-integrated design course content follows.

Week 1

Session 1: Design awareness, VW tutorial, and discovery. Design issues within a cultural, historical, and global context were discussed in class. Then, a 1-hour VW tutorial was conducted to support students in registering their SL and VCER accounts, editing their avatars, and mastering basic navigation skills in VCER (the two

VWs have similar user interfaces). During the virtual field trips, I guided the students to visit two interactive art environments in SL³.

Later, the students and I entered the multimodal design learning centre (Figure 8) that I previously created in VCER to prompt discussion. Since we were in the same physical class, we did not utilize the in-world chat tools for communication. Nevertheless, we engaged in an in-world conversation as we used our avatars to demonstrate VW elements to each other. Students expressed their feelings about the VW-integrated design learning and their understanding of today's technology-driven designs.



Figure 8. Multimodal design learning centre in Virtual Commons for Education and Research

Video source: <https://youtu.be/VMYz9JUG64Q>

Session 2: First design fundamentals exploration, VW tutorial, and discovery. A continued VCER tutorial was offered in the first 1-hour of the second 2-hour session. Then, students were asked to explore the design element of shape and the principle of harmony by visiting two or three virtual environments in SL based on their own interests. The following SL discussion occurred in the train station in a virtual environment called Berlin1920s. Students discussed the virtual designs in SL, utilizing the elements and principles mentioned previously. At the beginning of the session, students were taught how to capture VW screenshots. Many students shared screenshots of the virtual designs or environments that were personally resonant.

³ Appendix C contains web links to all virtual field trips that were undertaken in the course.

Following the conversation, a 40-minute hands-on practice session occurred in Sandbox (a parcel of VCER land set aside for experimentation and building practice). Each student learned to use the content-creation tools by designing one to three simple objects. To close the session, I assigned the course design task—a collaborative VW design project—and provided them with printed navigation instructions and video tutorials. I also asked them to form four equal-sized groups to develop their designs according to their interests and design preferences. Additionally, I distributed weekly journal templates with guided reflective questions⁴ to encourage students to chronicle their ideas, issues, meetings, design processes, critical analyses, and anything else that pertained to their design work. Due to the collaborative nature of the virtual design project, a systematic record of the design process effectively verified each student's due diligence.

Week 2

Session 3: Second design fundamentals exploration and discovery.

Students spent 40 minutes individually exploring the design element of line and the design principles of repetition and rhythm in two or three virtual environments within SL. Then, we held an in-world discussion in a virtual Chinese ink painting gallery in SL. While there, we spent around 20 minutes sharing our experiences in various VWs and discussing the designs that used repetitive and rhythmic lines. In the following 60-minute hands-on practice session, four groups of students first discussed what to create for their projects and drafted rough plans. Then, they were asked to continue experimenting in VCER's Sandbox to practice their navigation and building skills.

Session 4: Third design fundamentals exploration and problem-framing.

Students first spent approximately 50 minutes exploring two digital art environments within SL, focusing on the design element of texture and the design principles of gradation and contrast. Then, they reflected on their exploratory experiences and shared their design progress within an ethereal, abstract architectural virtual environment in SL. Four groups of students spent approximately 1 hour sharing their group decisions on group composition as well as the design topics documented in their first design journals

⁴ Appendix D contains student weekly journal questions.

entries. A significant contribution to the overall design process emerged from this session as students demonstrated a relatively deep understanding of their design topics.

Each group also alternated in sharing how their self-initiated design topics related to the VW exploration and practices they had experienced. Uniformly, students stated that they wanted to create magical or surreal environments in VCER. The names or concepts of the four virtual projects are displayed in Table 2, including Pan's Labyrinth (Group P), Ancient Chinese Immortal Town (Group A), Magical Land Park (Group M), and Chinese Sky Courtyard (Group S, who later changed their design topic into iCloud City). Additionally, students also defined each member's role within the group, the target users with whom they wanted to engage, and their plans for the project. Once the presentations were completed, the whole class immediately engaged in discussing any assumptions that may have arisen from the previous group's design topic. Although each group expressed their design challenges generally, these broad views were a solid foundation for discovering new opportunities and inspiration for new discussions and actions, which resulted in reframing the design challenges, adjusting the group structure, and changing the design plans.

At the end of the session, I distributed informal surveys to students, asking them to complete the survey and return it in the next session. Three general questions in the survey asked for students' feedback on utilizing VWs for design learning and their expectations from this course. The survey responses remained entirely anonymous to encourage students to fully express their views without worrying about any consequences.

Week 3

Session 5: Fourth design fundamentals exploration and problem-framing.

In Session 5, a group-led exploration of design elements and principles emerged. Group A suggested that each group should find some virtual spaces in which they were interested ahead of each session and then guide other groups in class to discover the particular design elements and principles within these environments. Group A further explained that discovering attractive virtual environments to share could assist them in collecting information and evaluating the environments from user perspectives, which contributed to the refinement of their design challenges. The whole class agreed that the

group-led VW exploration concept would become the primary method through which design elements and principles were explored in VWs for the remainder of the sessions. However, the exploration of the design element of typography and the design principles of direction and alteration remained individual field trips in this session. The after-trip discussion occurred in a motorcycle racetrack environment in SL.

Session 6: Fifth design fundamentals exploration and ideation. Group A was the first to lead the class in exploring the design elements of colour and value in SL. Group A was interested in building an ancient Chinese architectural fantasy environment, so they shared two traditional Chinese-culture-oriented virtual environments that were resonant with group members. Students used their avatars to move and interact with the objects in these virtual environments; however, they communicated verbally in class about the design of the environments and elements during their visit.

After approximately 40 minutes, Group A members shared their feelings regarding exploring the Chinese virtual environments in class, indicating their disappointment at seeing their cultures being inappropriately utilized or redesigned. Other group members also reflected on their in-world experiences and exchanged ideas about how to create environments that represented authentic Chinese cultures and aesthetics. The discussion provided Group A with valuable insights for developing their project. Nevertheless, because the discussion was extended from 30 minutes to 50 minutes, this session ended before in-world practice could occur. I assigned the weekly tasks, which included refining the design challenge and writing in their design journals.

Week 4

Session 7: Sixth design fundamentals exploration and ideation. This session started with a Group S-led VW exploration of the design element of texture and the design principle of variety in VWs. Group S was interested in creating a magical environment that included aspects of traditional Chinese cultures, so they shared two relevant virtual spaces. The first space was an elven fantasy environment. We followed the group member Leah, climbing through different levels of castles and reaching the top of a waterfall, where we watched dragons circling overhead. The second guided field trip

was to a virtual Chinese island where we tried different interactive tasks to experience everyday Chinese cultures.

Additionally, we moved around to observe the different objects while commenting about designs until approximately 40 minutes in class had elapsed. During the remainder of the session, students continued enthusiastically discussing their in-world experiences, brainstorming ideas to assist Group S to develop their design project, regardless of whether they were in the same group. However, all students asked for my help developing scripts, and some were struggling with the language (English) utilized in VWs. This session was extended by 30 minutes, as students were willing to remain in-world to see my demonstrations of basic scripting skills and to continue experimenting in VCER.

Session 8: Seventh design fundamentals exploration and ideation. In the final exploratory session for design elements and principles, Group M firstly offered a 30-minute guided field trip to explore the basic concepts of size and opposition. The exploration was led by Group M members Quin, Parker, and Sarah; we visited an ancient European architectural garden that featured numerous classical art forms with a modern symbolic twist. Later, Raiden and Tamara led us to visit an online store that sells Gothic, post-apocalyptic, Victorian, industrial, and rustic furniture. In the second 30-minute session, Group P members guided us to visit two social gathering places to explore the design elements of space and plane. One was the Japanese Sakura (cherry blossom) resort; the other was a virtual simulation of Miami Beach. I did not teach students how to use the poseball (a scripted object that can play a series of animations on an avatar in synchronization); however, Group P members Caleb and Daisy learned by themselves before this session and demonstrated this skill for the class. All students danced in world for approximately 20 more minutes after field trips ended.

In the final 50-minute session, students shared their understandings of the use of design elements and principles in the environments we visited and shared their design briefs, including design draft drawings for our feedback and comments. Group P presented an early but representable prototype in VCER and invited us to walk through their environment for a review and evaluation. We flew over and walked through the spaces to acquire overviews as well as detailed observations of the design concepts from the first- or third-person view while students exchanged comments about the

project. The chat tools were not used in the discussion. However, they were occasionally used to display scripted messages.

Week 5

Sessions 9 and 10: Prototyping. Starting in Week 5, practical sessions became the course's primary focus. In both sessions of this week, students first spent approximately 80 minutes working on their group projects. They were encouraged to move around the room to discuss relevant issues with anyone in the class. As the teacher-researcher, I provided any help whenever students needed it during their practice. In the following 40-minute discussion session, I encouraged each group to share their challenges or exciting moments from their previous design stages. Additionally, I asked students to share their creative ideas even if the ideas were still underdeveloped and fresh in their minds. This week, both Groups A and P decided to develop their original design topics further. Group S found it challenging to develop their concept of the Chinese Sky Courtyard. However, they decided to continue this uncertain topic until they found something new and creative.

As indicated in Section 4.2.2, three Group M members withdrew from the course. Therefore, I omitted this group from the remainder of this research to ensure that data for the course's evaluation is conducted fairly.

Week 6

Sessions 11 and 12: Prototyping and evolution. This week, students focused on experimenting and building prototypes to make their ideas tangible. Each session started with an 80-minute in-world practice time and a 30-minute prototype-review conversation. To facilitate constructive conversation, I not only asked students to share their weekly design journals that captured the evolution of their prototypes but also encouraged them to organize their ideas according to the following structure:

- Share initial thoughts about the design concept.
- Ask for specific feedback about the idea.
- Be open to others' ideas.

- Archive the ideas that matter to the project.

With careful preparation and structured questions, students and I utilized our avatars to effectively review and critique each group's prototypes in their virtual environments while providing feedback and comments to improve the solutions. The session ended with a 10-minute individual group reflection; I asked each group to revisit these reviews as well as the critiques they received from other groups and enact plans to incorporate valuable feedback and insights into their project in their next iteration.

Week 7

Session 13: Prototyping and evolution. In this session, students continued prototyping and exchanging ideas within their design groups and with their peers outside their groups.

Groups A and P progressed significantly in developing their projects. Notably, after experimenting for more than 5 weeks, Group S abandoned their initial design concept—the Chinese Sky Courtyard—and changed their project topic to iCloud City. Therefore, I hereafter refer to this group as Group I.

Session 14: Prototyping and formal in-world critique session. Design is the process that forces the designer to encounter and confront audiences (McDonagh et al., 2011). Due to the time and resource constraints, I did not develop an authentic VW project that involved actual clients in this research. However, I organized a remote critique session to promote a review of prototypes from users' perspectives. In this session, students and I visited each group's designed virtual environments in VCER for reviewing activities only. We first spent 60 minutes (15 minutes on each project) collaboratively evaluating each group's project by walking, flying around, and performing actions while communicating fruitfully and producing solutions from users' perspectives. A number of the problems would have been identified and solutions would not have been proposed if we remained in the physical classroom. After the review, each group returned to their own environments, reflected on the feedback they received, and planned to improve their projects. Since this session was entirely remote, both voice and texting chatting tools were utilized.

Week 8

Session 15: Prototyping and evolution. The entire session was devoted to students to refine their group projects for their final presentations. As the teacher-researcher, I was available to provide help whenever needed.

Session 16: Presentations and research. Initially, the group presentation was intended to be a public exhibition in SL. However, due to the time and expense of displaying students' complex designs, the final presentations took place within the classroom. Each group spent 15 minutes presenting their project and 10 minutes interacting with their peers. In the final 40-minute session, post-pre assessments of students' own learning experiences and engagement were distributed. I asked students to utilize their current knowledge and understanding to compare their learning and creativity related to the TAE capacities before and after the VW-integrated design learning. The semi-structured reflective interviews were arranged over three sessions after completing this course and were based on students' scheduling preferences.

4.1.6. Ethical procedures: Reciprocity and reflexivity

Constructing reciprocal relationships within y VW-integrated classroom was essential to the ethics of this action research. As the teacher-researcher, I created this VW-integrated design course not only to generate research findings but also to incorporate these findings into improvements and innovations in my classroom. Therefore, the process of constructing is simultaneously a knowledge-developing practice and a practice of developing knowledge that establishes the foundation for empowerment and reciprocity to be achieved in my research. Therefore, I actively sought reciprocal relationships with students as praxis through an "inquiry-based dialogue" (O'Neill, 2011) that involved teacher-student collaboration and a continuum of reflective discourse, which led to mutual meaning negotiation and allowed all individuals involved in this research to reflect on their practices.

As previously discussed in Section 2.2.3, although teacher-student collaboration and reflective discourse are the fundamental forms of social interaction in design education, these concepts have not been appropriately developed due to the stressful and competitive critiquing tradition in the design learning process (Webster, 2006). With an inquiry-based dialogical approach, I was empowered to be a reflective problem solver, an agent of change, and a generator of my own knowledge by continually

examining my own understanding of art practice (O'Neill, 2011). In this course, this approach encouraged the critical dialogue between my students and me as well as occasional avatar-mediated others outside the classroom to identify the driving questions (O'Neill, 2011, p. 12) about students' understandings of a particular design problem, such as the condition of the ill-defined design problem and the feasibility issue of the solution. Once a driving question was established, students became more aware of the fundamental issue that needed to be investigated to achieve a new understanding or perspective for innovation instead of merely focusing on solving that problem. By continuously promoting dialogue and inquiry, I guided students to develop a learning community, thereby creating a knowledge democracy in which a shared understanding and appreciation of common design approaches were built around students' sense of engaged agency and identity development. Therefore, reciprocity was maximized through a simultaneous process of developing knowledge and practice for my own and for students' mutual growth. Additionally, these processes emancipated the relationship between me as the researcher and my students as the researched participants, resulting in a practice of reflexivity that transformed all members of this research community.

O'Neill (2011) provides a set of principles that promote inquiry-based dialogue in art education. I have therefore adapted them to develop reciprocity as an integral part of my action research to promote creativity through perspective and learning transformations:

- Design groups should be encouraged to view themselves as a collaborative community of learners.
- Design activities should be purposeful, involve the lived experiences of the whole person, and contributes to the development of individual identities.
- Design activities are situated in place and time; each encounter offers unique "contact zones" (Hermans, 2001) of interaction.
- Design activities are a means, not an end, to achieving cultural diversity in education.
- Design activities' outcomes are both aimed for and emergent.
- Design activities must allow for diversity and originality. (p. 14)

4.2. Study

4.2.1. Research site

The research received approval and was undertaken as an elective course for second-year design students within the Department of Art and Design at Zhengzhou University. Located in Henan Province, the university is a major comprehensive research-oriented university in China with an enrollment of exceeding 80,000 students. The Department of Art and Design is the largest academic unit of the School of Fine Arts, comprising 95% Chinese students from various cities and provinces and 5% international students. The admitted students are characterized by their advanced skills and knowledge in drawing and painting, as they must achieve a comparatively higher score on the provincial university entrance art exams to be accepted into Zhengzhou University. The department provides two major areas of study: animation and graphic design. Each area of study consists of a series of required and elective courses from foundational to advanced levels, which are provided systematically to students.

4.2.2. Participants

This research was intended for junior-level design students with little or no prior digital design experience; the goal was to engage them in collaborative on VW design projects. Concurrently, I also attempted to foster learning opportunities to expand their creative capacities and transform their personal and professional outlook for moving to the next stage of learning and navigating complex design challenges. In the spring 2018 term, a faculty administrator (who had no influence or authority on students' decisions regarding courses) and I advertised this course and described the research study in a meeting with all first-year art and design students. During the meeting, I explained the study and the course, informing students that their participation in the elective course and the study were completely voluntary. Before the upcoming fall term, the students who were interested in taking this elective course enrolled through the university's online course registration system and participated on a first-come, first-served basis until the required number of places for an elective course (20) was achieved; this included seven males and 13 females between 18 and 20 years of age. The participating students came from the two different areas of study and enrolled in courses based on their personal interests and schedules; therefore, many of them had little acquaintance with each other.

In Session 2 of the course, these student participants formed four groups of equal sizes to develop their collaborative design projects according to their design interests. Table 2 provides a summary of the participants' personal information (the group names or projects were developed later during the participants' design processes). I assigned each participant a pseudonym to protect anonymity in the research.

However, all Group M participants' data were excluded from this research due to three members' withdrawals. Two members, Quin and Raiden, left this course in Week 5 because of a scheduling conflict. Tamara had been absent from time to time due to an illness, and she officially left this course in Week 5. The two remaining group members, Parker and Sara, chose to remain in the course and expressed their willingness to continue working as partners on their virtual design project. I excluded Parker and Sara from this research to promote equality of the data collection for the assessment of this course.

Table 2. Participants' information

Name (pseudonym)	Gender	Major	Group name
Anna	Female	Graphic design	Pan's Labyrinth
Ben	Male	Graphic design	Pan's Labyrinth
Caleb	Male	Animation	Pan's Labyrinth
Daisy	Female	Animation	Pan's Labyrinth
Effie	Female	Animation	Pan's Labyrinth
Finn	Male	Animation	Ancient Chinese Immortal Town
Gena	Female	Graphic design	Ancient Chinese Immortal Town
Halley	Female	Graphic design	Ancient Chinese Immortal Town
Ivy	Female	Graphic design	Ancient Chinese Immortal Town
Jessica	Female	Graphic design	Ancient Chinese Immortal Town
Kaden	Male	Animation	iCloud City
Leah	Female	Graphic design	iCloud City
Megan	Female	Animation	iCloud City
Nina	Female	Graphic design	iCloud City
Olivia	Female	Graphic design	iCloud City
Parker (excluded)	Male	Graphic design	Magic Land Park
Quin (excluded)	Male	Animation	Magic land Park
Raiden (excluded)	Male	Graphic design	Magic Land Park
Sarah (excluded)	Female	Graphic design	Magic Land Park
Tamara (excluded)	Female	Graphic design	Magic Land Park

4.2.3. Data collection procedures

The VW-integrated Design Fundamentals course lasted more than 2 months and included 16 sessions. In the research, I adopted a qualitative method to collect data from three of the design groups to utilize as case studies; data collection was conducted from Session 1 through 16. The purposes of the data collection were, on the one hand, to develop an in-depth and descriptive account that documented the groups' complexity in multimodal forms of creativity as demonstrated in their VW-mediated design thinking processes and completed design projects. On the other hand, I aimed to examine and improve the VW-supported design course to meaningfully engage students in their design thinking processes, thus fostering transformative engagement to creative improvement. Consequently, I employed two different techniques (observational and narrative techniques as well as non-observational, interview, and post-pre assessments) to collect data for triangulation (Stringer, 2007), which increased the reliability and validity of the case studies in this action research. Informed consent was obtained from the student participants before the data were collected.

Observational and narrative techniques

The observational and narrative-based data included the following data sets: my in-world and in-class observations, my field notes, students' VW screenshots of their design processes, students' weekly design journals that accompanied their VW screenshots, and video recordings of students' VW showcase presentations. Throughout each of the 16 sessions, I engaged students' design learning activities in both virtual and physical settings as a "participant-observer" (McKernan, 1996) to capture students' design processes and relevant events as they occurred naturally. I also entered VCER frequently to observe students as they designed and occasionally engaged in conversations with students who worked on their projects outside the class. Additionally, observational field notes and VW screenshots were employed alongside my observations to describe important details or interesting events during students' design learning. Another narrative data collection technique I employed was asking students to maintain weekly design journals as personal documents to chronicle their 8-week design activities, progress, reflections, and feelings that had importance to them. In the journals, students often expressed feelings and thoughts that they were not comfortable verbalizing publicly. Therefore, journaling surpassed any digital or electronic method of

recording students' design learning processes, as it provided emotional indicators of students' changes in values, beliefs, and actions.

In Session 16, I used the in-world video recording technique to document each group's project presentation. With the students' permission, a computer screen capture recorder was installed on my laptop and was invisible as a research device; consequently, students performed naturally during their group presentations. Taken together, these five unobtrusive approaches allowed me to collect observational and narrative data to interpret a continuous stream of witnessed events, which facilitated the concept of action research as a "naturalistic inquiry" (Willems & Raush, 1969).

Non-observational, post-pre assessments and interview techniques

Post-pre assessments

The non-observational data collection techniques include "post-pre assessments" (Hiebert et al., 2011) and semi-structured interviews, which were conducted after the course was completed. In traditional educational research, the separate before- and after- measurements of changes in students' perceptions of their learning have been widely employed. Despite their merits, the critical problem with utilizing these measures is that students have not yet experienced the learning activity and do not know what they do not know at the time of pre-assessments, so their measuring stick is more likely to change as they develop greater knowledge or understanding after they experience the activity. Consequently, students often rate their level of knowledge higher in the before assessment than they do at the end of the learning activity; the assessment scores after the activity are usually lower than the pre-assessment scores although positive changes have occurred (Hiebert et al., 2011). To address this problem, Hiebert et al. (2011) developed a post-pre assessment that combines a decision-making approach with retrospective assessment to determine the changes in students' self-perceptions of their knowledge, skills, and personal attributes that resulted from a particular learning intervention. Specifically, the assessment asks students to use their current level of knowledge to create a "consistent measuring stick" (p. 9) for before-learning and after-learning assessments. Furthermore, the post-pre measurement is employed only after the completion of a course, course, project, or unit of learning; therefore, it saves time by collecting data in only one session rather than two.

According to Hiebert et al. (2011), developing the post-pre assessment involves two steps that begin with an explicit specification of intended outcomes of the learning intervention (e.g., the goals, objectives, and capacities). Hiebert and Magnusson (2014) suggest that the assessment items should measure three types of changes related to the following learning outcomes:

1. Competencies, such as knowledge and skills that participants learned.
2. Personal attributes, including attitudes (e.g., beliefs that change is possible or internal focus of control); intrapersonal factors (e.g., confidence, motivation, self-esteem, stress, or depression); and independence (e.g., self-reliance and initiative, as well as independent use of tools and knowledge provided).
3. Future impacts, including benefits of positive changes in participants' lives, behaviors, or future aspirations.

After carefully crafting the measuring items, Hiebert et al. (2011) recommended a two-step procedure to design the post-pre assessment:

Step A (Figure 9)—Decide whether the change in the competency is “not true for me” or “true for me”

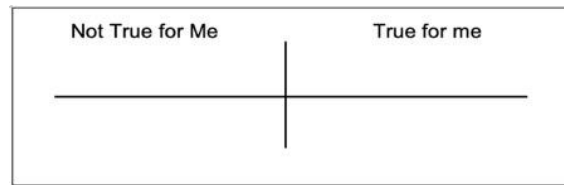


Figure 9. First step of designing the post-pre assessment

Step B (Figure 10)—If the level of competence is not true for the participant, then the participant must decide whether it is:

- “Not at all true for me” (= 0)

or

- “Not very true for me” (= 1)

If the level of competence is true for me the participant, then the participant must decide whether it is

- “Sort of true for me” (= 2)
- “Mostly true for me” (= 3)
- “Very true for me” (= 4)

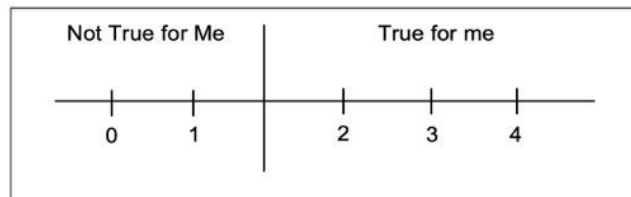


Figure 10. Second step of designing the post-pre assessment

The complete assessment (Figure 11) asks students to repeat Steps A and B to consider before and after the learning intervention, thereby deciding whether the features in these items are true or not true and then selecting the appropriate ratings:

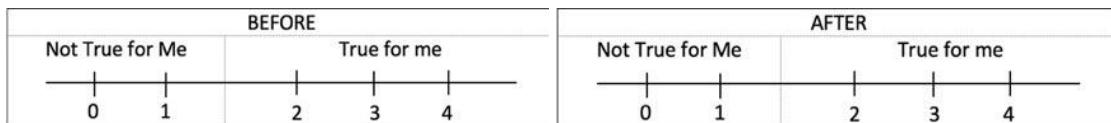


Figure 11. The complete post-pre assessment design

In my research, the design students’ creative actions during their collaborative design processes are perceived to be transformative and critical, a stance that is closely linked to TAE’s three key learning capacities. The post-pre assessments were developed to measure students’ changes in their perceptions of the three TAE capacities resulting from the VW-supported design learning. The following explains how the post-pre assessment relates various elements and concepts in creative development to the three TAE capacities.

[Engaged agency](#)

For students to experience a strong sense of engaged agency, they must feel empowered and autonomous in their ability to direct their own design learning process and to create design forms that mirror their “authentic voice” (O’Neill & Peluso, 2013, p.

4). My students actively engaged in the collaboratively VW design activities that were framed around the design thinking model by communicating, reflecting, questioning, and challenging their beliefs, values, and learning situations, thereby recognizing novel opportunities and generating creative ideas to achieve goals that were personally meaningful (Vygotsky, 1978) regardless of the constraints of the VW technology and difficulties in their design learning.

As discussed in Chapter 3., adopting the TAE framework provided action-oriented and inquiry-based learning opportunities that aligned with VWs' inherent affordances that foster design thinking, such as collaboration, embodiment, experimentation, multiple interpretations, and persistent environments. Students progressed through each design thinking stage with their peers within the collaboration-friendly VWs, and the learning became a source of motivation and empowerment that allowed them to think in "designerly" ways and creatively engage in the "solution process" (Cross, 2006). Such a creative process inevitably involves an ongoing and mutually understood discourse that develops the foundation for "a community of learning relationships" (O'Neill, 2011, p. 25). Within such a caring community, design learning is not only the accumulation of knowledge and skills but also the process of exploring and enriching the creative and critically minded self by engaging with others, which offers significant potential to transform one's selfhood and self-identity for positive changes and new possibilities (O'Neill, 2012b, 2017).

Connection

In *The Reflective practitioner: How Professionals Think in Action*, Schön (1984) defines design as a reflective conversation with kinds of variables (e.g., moves, norms, and interrelationships) in a situation, arguing that a competent designer "shapes the situation in accordance with his initial appreciation of it, the situation talks back, and he responds to the situation's back-talk"(p. 79). Similarly, the primary goal of the TAE framework is to develop art learners' capacity to critically connect with their social experiences and others to increase their self-awareness. Derived from TAE, the VW-integrated design course focused on promoting students' sense of connectedness and emotional engagement with their design learning, peers, the teacher, and their critical VW friends within agentive ecologies (O'Neill, 2017) to empower students to become reflective practitioners who can navigate a complex and uncertain future.

Although today's media technology has generated substantial grassroots creativity from amateurs and hobbyists (Jenkins, 2009), it may not meet the need to build agentic ecologies, which require a connection between the students and the complex learning circumstances across educational, personal, social, and artistic domains. Using VW affordances, the design activities in the VW-supported design course unite students with interconnected layers of personal reflection and engagement in both formal and informal design learning through "reciprocal interaction" (O'Neill, 2017, p. 14) with their peers, the teacher, and avatar-mediated others across physical borders. Providing design students with opportunities to move between formal and informal learning and to enjoy the collaborative forms of design-making and knowledge-sharing enhances the likelihood that they will experience an intense sense of interconnectedness and empowerment from their learning community, which "act[s] as a vehicle and a catalyst for growth and change, identity constructions, creative process, and artistic expressions" (O'Neill, 2012a, p. 167).

Values and beliefs

In the VW-integrated collaborative design learning context, the design-thinking-oriented activities were facilitated through "appreciative and dialogical inquiry" (O'Neill, 2015), which contributed to promoting students' intrinsic value and self-beliefs to ensure long-lasting motivation, persistence, and resilience in the face of challenges. The ultimate goal of my research was to transform the junior design students' outlook on the future and equip them with creative capacities to progress to the next stage of their learning. However, such a transformation cannot be achieved instantly but requires iterative practice, skill development, experimentation, and the trial-and-error method. As previously discussed, VWs' dialogical and social nature not only supports and extends the "interactions between individuals and groups, but also the interactions between individuals and the space they co-construct around themselves" (Freitas & Veletsianos, 2010, p. 5). Therefore, adopting an appreciative and dialogical inquiry aligns with the VWs' social affordances, thereby extending the opportunities for students to remake and develop their multifaceted roles and identities as they negotiate their personal meaning while collaboratively designing and socially interacting within the fluid VW-based learning community. Students of such a community may engage in cycles of design thinking stages through reflection, analysis, actions, dialogue, and creative collaboration, and thus are more likely to unite as a group and feel a sense of values and belonging

(O'Neill, 2011, p. 2). Consequently, they may persistently work toward their shared goal despite the uncertainty and complexity of the challenge, which ultimately leads to changes and transformation of their identities and learning.

Drawing on this conceptual understanding and engaging Dr. O'Neill's assistance, the assessment items pertaining to the three TAE learning capacities were crafted into one survey with 27 items to measure students' engaged agency, connection, and values and beliefs related to the VW-supported design learning outcomes. The items were also carefully translated into Chinese to ensure that each student understood the text. Table 5 offers sample items that appeared in the survey. The key concepts are marked alongside each item in this sample. However, they were hidden and randomly dispersed throughout the official survey (see Appendix A for the complete survey).

Table 3. Sample items in the post-pre assessment

I feel inspired and willing to explore ideas when working in a group. (Engaged agency)
I can find out connections with other learning and design experiences when I am designing. (Connection)
I feel confident about learning new technology to design in the future. (Values and beliefs)

Semi-structured interviews

In addition to the post-pre assessment, student participants were asked to participate in a semi-structured interview after completing the VW-integrated design course to gain additional insight into the indicated positive changes. There were 26 pre-designed questions in each interview (See Appendix B for the interview questions). However, I decided not to strictly follow the list of questions to allow for natural responses throughout the interview (McKernan, 1996). After the pre-determined questions had been asked, the open-ended questions were often raised to probe students' implicit issues from the previous questions. For example, I asked, "Compared with your previous design experience or design learning, do you think the 3DVW technology allows you to be more creative? Why do you think this?"

Before conducting the post-pre assessments and interviews, I informed students that participating in the two research activities was completely voluntary. They could

refuse to participate or withdraw from the activities at any point without any consequences to their grades. Nevertheless, all students voluntarily participated in the two activities, which resulted in more than 150 pages of transcripts. Due to the omission of the three students from Group M after Week 5, I narrowed the research focus to include three case studies based on three equally sized groups' VW collaborative design processes and their completed VW group design projects.

4.2.4. Data analysis methods

In this research, which is grounded in sociocultural theories of learning (Dewey, 1938/1997; Vygotsky, 1978), I aim to foster junior design students' creative collaboration through VW-mediated multimodal design practices. I attempted to gain critical insights into how these participants creatively utilized particular VW affordances to co-construct meaning, so I employed a multimodal analysis that was filtered through the lens of TAE to identify students' creative acts exhibited in their VW collaborative design processes and completed design projects.

Moreover, a constant comparative method (Maykut & Morehouse, 1994) was utilized to examine participants' responses to the post-pre assessments and reflective interviews to obtain a more holistic and in-depth understanding of students' perceptions of changes in how much they valued the VW-integrated course for promoting creative collaboration associated with three TAE learning capacities.

By combining the two primary analytical lenses, I explored and understood the participants' individual and collective creative actions that emerged in their group design practices, both within and across the design thinking stages, as an outcome of the ongoing process of transformative engagement with VWs, which led to students' reconstruction of personal and professional identities for the next stage of design learning and more complex challenges.

Multimodal analysis for case studies

As in Chapter 2, I draw on two positions of social semiotic multimodality (Bezemer & Kress, 2016; Kress, 2010) to understand learning and the learner's creative acts. First, learning as communication, as sign-making is always multimodal. Second, through their affordances, signs are always made in a particular mode and are always

new and innovative. Therefore, sign-making is as an act of creativity and an unceasing process of transformative engagement with the sign maker's world (Kress & Bezemer, 2015). From this perspective, social semiotic multimodality provides concepts, methods, and a framework not only for applying as a pedagogical approach but also for analyzing situated meaning-making through different uses of affordances of multimodal ensembles. In other words, meaning is understood as being made in an iterative connection between the affordances of a material-semiotic artifact; the affordances of the sociocultural environment; and the resources, intentions, and knowledge that the sign maker brings to the encounter (Jewitt, 2013).

In this research, I employed social semiotic multimodality as an approach to perform a fine-grained analysis of how students used their creativity in what Kress (2003) calls *multimodal ensembles* of image, layout, music, movement, speech, 3D compositions, and embodiment that incorporated their interests and meaning potentials through all VW modes. In Kress's (2003) conceptualization, each mode has a set of distinct affordances and always combines other modes' affordances to produce meaning collectively rather than individually. Analyzing the ensembles, therefore, can point, on the one hand, to each group member's "semiotic resourcefulness" (Bezemer & Kress, 2016) in utilizing VWs' multimodal resources as developed in their transformative engagement with VWs and accumulated in their groups over time. On the other hand, analyzing these ensembles can reveal group members' "dispositions" (Bezemer & Kress, 2016) through their uses of these resources according to their collective interests and attention to VWs. Both reveal VWs' potential to foster students' individual and collaborative creativity and innovation in design.

However, according to Bezemer and Kress (2016), although the concept of a coherent ensemble has implications for effective communication, it does not necessarily mean an equal or balanced orchestration of multimodalities. In many communicative contexts, some modes are prominent or prioritized. For example, a textbook page lends prominence to a diagram through its size and centred position over other modes, such as a photograph or text. Such an unequal positioning of modes not only illustrates how meanings are realized through other modes that interact within the communicative ensembles but also reflects the division of labor in a design team and the power relations between those involved in the textbook's design. For instance, the design team may be led or dominated by illustrators and their drawings. Therefore, through the lens

of multimodality, educators may find helpful to consider the effectiveness and the coordination of a design team, due to the potentially conflicting interests of individual members.

Drawing upon the three common principles (framing, selecting, and highlighting) of semiotic work (Kress, 2010), I analyzed the multimodal ensembles in three iterative stages using three different formats to transcribe three different units of “multimodal data” (Flewitt et al., 2009). This analytical approach was based on the social semiotic perspective of transcriptions, which foregrounds the agency of the transcriber in making significant representational choices while acknowledging the potentials and constraints transcription modes in the social context (Bezemer & Mavers, 2011). By drawing attention to the meaning-making principles, I produced multimodal transcripts that are not merely descriptive or mere translations but are transduced modes of representations that provide “gains and losses” (Kress, 2010) in analytical insights into the VW design pedagogy’s affordances for students’ transformative engagement, and thus into students’ creative acts throughout their collaborative design processes.

Framing transcripts

The first stage is framing transcripts, which provides a momentary view of the researcher as a sign-maker’s interest, concern, or purpose at a particular level (Kress, 2000). For this research, student participants’ VW screenshots, their weekly design journals documented their design processes, and the completed design projects were framed as demonstrations of students’ creativity exhibited in the multimodal ensembles of avatars’ appearances, gestures, talking, movement, and designing that comprised their VW design experiences. Through this framing, I aimed to acquire two fundamental aspects of multimodal ensembles. First, I wanted to investigate which specific virtual environment contents, through their affordances, prompted students to engage as well as how they interacted with other avatars during the collaborative design process. Second, I wanted to examine students’ completed design projects to distinguish their motivating interests in VW modes with which they chose to engage would become apparent. Overall, through a social semiotic perspective of multimodality, the visual mode (students’ VW screenshots) and the written mode (students’ weekly design journals) were selected and framed by the research aim, which necessitated graphic demonstrations and textual descriptions of the original interactions in the VW-integrated

course. Each mode of presentation pointed to different meaning potentials and relationships, which were examined to achieve the research aim—the framed semiotic interest. Therefore, the three characteristics of signs—environment, affordances, and motivated signs (Bezemer & Kress, 2016)—which align with the foci of the VW-supported design thinking stages, were employed to frame three units of a fine-grained multimodal analysis. The detailed framework of three units of analysis is as follows:

Virtual environments. The multimodal analysis stems from the first characteristic of the sign. According to Bezemer and Kress (2016), “a sign is always shaped by the environment in which it is made, and its place in that environment” (p. 9). This characteristic allows analysis of different semiotic resources that sign makers choose in their environments to create meaning, and the interactions between these resources provide prompts. I considered the embodied nature of experiences within VWs and the characteristics of the design-thinking-oriented VW activities; therefore, this unit of analysis focused on the two following VW embodied resources:

- Avatar-to-world (SL) engagement (e.g., self-presentations, identity, style; movement; actions, gestures; and gaze directions via camera)
- Avatar-to-avatar (including student to student or student to avatar from outside the classroom) engagement (e.g., speech, texts, movement, actions, and gestures, and gaze directions via camera)

By framing two resources that encompass two types of embodied VW engagement, this unit of analysis allowed me to recognize two types of sign makers. First, VWs, as the initial sign makers, provide different prompts for students who engage with or within them to interpret them according to their interests and semiotic resources. As the second sign makers, students act as “agents” (Kress, 2013) who creatively use their avatars and the materials artifacts to interact with other avatars and explore the virtual space, making new signs from the initial signs in that environment.

Virtual worlds’ affordances. The second characteristic of the sign, according to the social semiotic theory of multimodality, is that each mode offers a unique potential for making meaning, as each has a different range of affordances and constraints (Bezemer & Kress, 2016). Signs are always made in a specific mode, which necessitates the central role of the sign-maker’s interests and focus of attention through the choices

and interpretations of the particular modal resource and its recognized potentials. This concept could be valuable in framing the examination of the VW-based collaborative design, as VWs are characterized by a plethora of affordances for creative team interactions (Alahuhta et al., 2014), some of which can attract students' interests. Concurrently, such a concept can be suitable to investigate the ideation and prototyping stages of the design thinking process since, by meticulously tracing students' choices of VW modes, it offers an inroad into their process of resourcefully using VW multimodal affordances to make meaning, thus demonstrating their creativity and innovation. Therefore, by framing the VW affordances as the analytical focus, this unit of analysis allowed me to gather evidence for grasping students' attention through the available VW resources and VWs' possibilities for fostering sign makers' resourcefulness in the collaborative design process.

Motivated signs—completed VW design projects. The third characteristic of a sign is that “signs are constantly made anew, and are motivated in the apt combination of form and meaning by the sign-maker’s interest” (Bezemer & Kress, 2016, p. 132). In other words, some features of the form are appropriate means for the sign maker’s desired communication, which allows others to recognize the sign maker’s agency and interests in the world by the choices of available semiotic resources. This notion of the motivated sign has direct implications for assessing students’ completed VW group projects and therefore was employed to frame the third unit of analysis. Specifically, this analysis highlighted how groups of students exerted their creative agency in a constant transformation and transduction of VWs’ available modes and multimodal ensembles to optimally communicate with a particular audience, especially when considering the potentially conflicting motivating interests. Furthermore, through a multimodal lens, this unit of analysis allowed me to acquire more insights to deepen the understanding of the creative affordances of the VW design pedagogy to engage students around specific design thinking skills, issues, and ways of knowing and creating conditions for transformative engagement.

Selecting multimodal data

The second stage includes selecting the multimodal data as the components of the framing and how they should be introduced, which is typically guided by the rhetorical purposes of the sign maker (Kress, 2010). Based on my framed analytical

aims, I selected the students' VW screenshots that depicted their interactions with other avatars and the VW contents and design artifacts that represented significant features of their design thinking activities. After engaging with these VW screenshots in an incremental refinement process, I chose one to three of most representative screenshots from each student per week and their weekly design journals for 8 weeks. This approach was grounded in Walsh's (2007) research that demonstrates that the multimodal ensembles of students' website designs and related narratives of critical incidents represent a valid research method to access these students' views of their digital design experiences. Once the 8-week screenshot samplings were selected, I created eight extensive tables for each design group in Microsoft Word, each as a separate document, and inserted each group's individual participants' names below one another in each table. Then, I pasted each selected screenshots next to the appropriate student's name in horizontal rows, so that students' journals of narratives and code categories spread to the right of each screenshot.

As previously stated, the foci of the three framed units of analysis aligned with the emphasis of the design thinking stages, which were conducted as activities within this VW-integrated design course. The student-captured VW screenshots and their weekly design journals documented these activity stages and therefore were organized into three units of analysis. The first analytical unit emphasized VW environments, which was performed in students' VW design activities that were organized around the first stage of the design thinking process—discovery. I only examined the first design thinking stage in this unit to gather insights into which modes and modal ensembles immediately drew their attention and curiosity, which contributed to framing their initial impressions and engagement of VWs. Consequently, each groups' students' first 2 weeks of VW screenshots and design journals were selected for transcription, as they documented the activities that were framed around the first stage of design thinking: exploring different virtual environments of SL to discover design challenges and aspirations.

The second unit of analysis focused on how each design group of students continuously utilized VWs' multimodal affordances to define, review, and improve their initial assumptions and understanding of the design challenges, thereby creating new ideas for their design projects. These activities were organized around the middle stages of the design thinking process, including interpretation, ideation, and experimentation,

which were conducted from Weeks 4 to 7 of the course. Consequently, students' VW screenshots and design journals from this period were selected for investigation.

The motivated signs were framed as the focus of the third analytical unit, which indicated that I should examine students' completed VW design projects as the transformative outcomes of their learning to reveal their interests and creative agency. Therefore, students' Week 8 screenshots, design journals, and final presentation recording screenshots that documented their finished VW design projects were chosen for this unit of analysis.

Highlighting multimodal transcripts

The third meaning-making principle is highlighting, which concerns assigning salience in the transcripts or the prominent remade features (Bezemer & Kress, 2016). At this stage of transcription, I drew on multiple concepts in the multimodal analysis (Burn, 2013; Burn & Kress, 2018; Kress, 2010; Kress & Van Leeuwen, 2006; Stenglin, 2009) to create three templates to highlight elements and concerns within the three units of analysis. Consequently, the transcripts gradually focused on responding to the issue of transformative engagement for which the VW screenshots, design journals, and final presentations were selected.

[The first unit of analysis — virtual environments.](#)

As explained in the first analytical stage, the first unit was framed to analyze the virtual environments of SL, wherein three different groups of students participated in exploratory activities to discover aspirations and design opportunities through two types of embodied engagement (avatar to world and avatar to avatar). To seek evidence of students' VW engagement in their screenshots, I combined Kress's (2010) multimodal social semiotics and Burn's (2013) kineikonic mode into a hybrid frame, which allowed me to highlight the distinctive embodied VW modes that contributed to students' engagement through time, space, and scene. Specifically, the kineikonic theory proposed by Burn (2013) stems from a multimodal theory of the moving image developed by Burn and Parker (2003), named *kineikonic mode*, which is a portmanteau of the Greek words for "to move" (*kinein*) and "image" (*eikon*). This theory employs a multimodal approach that not only investigates the interplay of all the modes of the moving image but also attends to the grammar of the moving image at the level of the

individual frame and the shot. In Burn's conceptualization, the modes of filming and editing are perceived as the orchestrating modes, which occur in both spatial and temporal dimensions and have a close relationship to the moving image. All other modes are identified in three categories of contributory modes, which can be further divided into progressively smaller elements in the analysis. For example, the embodied modes can be disassembled into action and speech, auditory modes can be disassembled into music and sound, and visual modes can be disassembled into lighting and set design.

Although the VW screenshots were not extracted from a digital video, they document students' real-time engagement with virtual environments or others as animated avatars by utilizing various action menus. Each screenshot was constructed and edited by students utilizing a virtual camera. Thus, these VW screenshots cannot be simply understood as static 2D photographs, but as individual scenes or shots of the moving image designed by students that provide insights into the interplay between a selection of orchestrating and contributory modes, which constitutes the two types of students' engagement with and within VWs. Furthermore, in the VW screenshots, each avatar's appearance was designed or edited by students, which added another layer of analysis of students' "aesthetic strategies" (Burn & Kress, 2018) across a variety of modes of engaging with VWs, which I later integrated into the design thinking process.

Overall, in a social semiotic account, the two types of engagement reflect students' interests in selecting VW modes with which they were motivated to engage. Therefore, creating a hybrid multimodal frame also allowed me to explore how specific VW modes engaged students in multimodal meaning-making; their resulting production of engagement/interpretation then became matter of "design" (Kress & Van Leeuwen, 2001). The following provides a detailed description of the code categories that were adapted from Burn (2013, 2016), Burn and Kress (2018), and Kress (2010) to foreground the key elements of the two types of students' engagement with and within VWs:

Screenshot: This category provides the number and timing of each VW screenshot were taken. To the right of the students' names (see Table 4) are thumbnail(s) that illustrate their avatar-mediated interactions with VWs.

Scene description: Some straightforward narrative is offered in this category to explain the screenshot, providing a non-biased and detailed account of each step the students took in designing the virtual projects.


Avatar design: This category presents embodied modes within avatar-to-world engagement and refers to the revelation of students' interests, identities, and "aesthetic value" (Burn & Kress, 2018, p. 8) that are provided by the students' stylistic choices for the avatar's appearances within different VWs. Additionally, this category contributed to students' ways of being present and the interpersonal copresence in the shared virtual environments (Schroeder, 2006).

Actions or gestures: This category identifies students' choices of particular forms of actions and gestures, including the avatar's bodily movements, hand gestures, facial expressions, speech, and sound when engaging with the specific content of virtual environments or other avatars.

Camera and framing: This category describe how students manipulated the virtual camera to change the point of view (e.g., shot distance and perspective) and decided which elements to frame in the screenshot to represent their actions in the virtual environment.

In addition to these five code categories, I added Student Design Journal as Narrative as a code category to this template. This approach was grounded on multimodal research that suggests that students' digital website designs and related narratives represent a valid research method to access students' views and experiences (Walsh, 2007). Therefore, adding this code allowed me to access the participants' interpretations of their engagement or critical incidents as illustrated in the screenshots and their framing choices in capturing these screenshots. The example of the transcript template for this unit is as follows:

Table 4. Transcript template sample for the first unit of multimodal analysis—virtual environments

Pan's Labyrinth (Group P)	
Week 1 Activities: SL exploration and discovery	
Caleb	<p>Screenshot</p>  <p>Screenshot description</p> <p>Time: Week 1 Virtual location: Miami Beach Dance Club Description: A long shot with Caleb's avatar dancing at a ball, which is located on the beach</p>
<p>Avatar design (identity, style, or aesthetics)</p> <p>An establishing shot locates Caleb's avatar as separate and distinct from the other avatar in front of him as they dance at a ball. He is a well-suited White man wearing a gray vest, pants, white shirt, and bowler hat. His stylistic choices for the avatar's appearance echo the theme of this virtual environment — a Western culture-oriented dance club. It announces the relationship between the two avatars — both are dancing as ball participants.</p>	
<p>Actions or gestures</p> <p>Caleb is gesturing around the circle with both arms raised. The other avatar in front of Caleb is moving with the music.</p>	
<p>Camera and framing</p> <p>The long-distance shot features Caleb's avatar facing the other dancing avatar in the distance.</p> <p>Framed elements include the beach at sunset, palm trees, a beach umbrella, a formal dance on the beach, musical instruments, a vinyl record as the stage, and a dancing avatar (not from his class).</p>	
<p>Student design journal as narrative</p> <p>"It was fun to dance with other avatars, especially as the dancing ball is located on the beach...I went surfing afterward, and I found it interesting to see some people sunbathing on the beach."</p>	

Cross (2006) asserts that sketches are essential in the second interpretation stage of design thinking because they enable designers to discover the unforeseen consequences and surprises that prolong the inquiry and lead to "the reflective conversation with the situation" (Schön, 1984). Following the explorations in SL, two groups immediately sketched their initial project concepts on paper and the digital tablet, which fundamentally aided their process of thinking about the problems and their solutions. Due to the significance of these sketches in the design thinking processes and

their semiotic relationships with the previous SL explorations, I decided to include them as a part of students' multimodal ensembles in this unit to investigate how the groups of students were motivated by specific content in virtual environments that they chose to interpret to generate creative and transformative meaning.


The second unit of analysis— VWs' affordances

The second analytical unit focused on examining VW affordances that fostered resourcefulness in each team to utilize different modes during the middle design thinking stages; they constantly interpreted and reinterpreted meanings, framed opportunities, and produced innovative prototypes as transformative types of engagement. To highlight the focus of this unit, I continued combining the analysis of the student-captured VW screenshots and the associated design journals during this stage (from Week 3 to 8) to seek evidence of each group's choices of modes that were shaped by the affordances of the virtual environments in which they were made. These techniques were based on the social semiotic theory of affordances — the second characteristic of signs, which significantly impacts what can be communicated and what is actually communicated within an environment (Bezemer & Kress, 2016). This foregrounding of the affordances allowed me to recognize VWs' possibilities for cultivating the semiotic resourcefulness of each group of students as sign makers. In other words, their creativity and innovation at each point of the design thinking stages—finding existing or potential signifiers in the different modes, distributing apt meaning over available modes, and demonstrating sensibility to their potential audience in their social environment.

Nevertheless, according to Bezemer and Kress (2016), one critical step of multimodal analysis is to analogously distinguish between material and conceptual resources regarding affordances. Therefore, I considered not only which material affordances of the specific mode drew students' attention for interpretation, but also which conceptual resources were materialized in that specific mode. For example, when considering the traditional Chinese aesthetic forms utilized in Group A's project, I noted that each mode received salience by the groups' choice of colour, shape, texture, and pattern that were seen throughout the virtual temple. Furthermore, when considering the social relationships of Group A members in interactions, I recognized that they were materially realized through the modes of the image, dialogue, gesture, and space via avatars in relation to the virtual environment. Moreover, each group had significantly

different themes for their design projects and different social dynamics within their teams, and the conceptual resources were therefore distinct from one another. Consequently, in addition to continuing the analysis of each group’s engagements with the virtual environments while constructing their design projects, I added Semiotic Affordances of VWs as a new code category. This category was designed to highlight the potentials, limitations, and prompts of each VW mode or modal ensembles that shaped each student’s semiotic choices, revealing aspects of the interested engagement, autonomy, collaboration, agency, and resourcefulness of each team. The template example for the second unit of analysis follows:

Table 5. Transcript template for the second unit of multimodal analysis—virtual worlds’ affordances

Ancient Chinese Immortal Town (Group A)	
Week 4 activities: Ideation and experimentation in VCER	
Ivy	<p>Screenshot</p>  <p>Scene description</p> <p>Time: Week 5 Virtual location: Group A’s private land in VCER Description: Ivy is flying above the palace to change the temple top</p>
	<p>Avatar design (Identity, style, and aesthetics)</p> <p>A long-distance shot features Ivy’s avatar turning her back to the audience, flying above the temple. She appears as a swordswoman from an ancient Chinese kung fu novel, wearing a long, dark purple skirt with a checked pattern, a long-sleeved black shirt, a bronze belt, and a large straw hat. Her aesthetic shaping of the avatar’s appearance echoes the central theme of her group project — Ancient Chinese Immortal Town.</p>
	<p>Actions and gesture</p> <p>Ivy’s avatar circles in the sky, facing the temple. She raises left hand. Her right-hand holds a sword. Her actions and gestures indicate that she is building the roof.</p>
	<p>Camera and framing</p> <p>An establishing long shot frames Ivy’s design responsibility in Week 5 that she wished to present to the audience. Ivy’s responsibility for sign-making is seen in the screenshot in the re-designed temple top: she changed the one-level flat roof into a two-level sloped roof with four beams on the sides. This stylistic articulation borrowed from and transformed elements of the hip roof design, which is part of the ancient Chinese grand temples and royal palaces she visited previously, suggesting that her cultural experiences informed her interest in this particular aesthetic.</p>

	<p>Student design journal as narrative</p> <p>“Zoe and I took responsibility for improving the design of the temple top this week. We talked about our experiences of visiting the ancient Chinese grand temples and royal palaces, discussing the roof designs in detail. Both of us agreed that the hip roof could represent the signature architectural style of ancient China.”</p>
	<p>Semiotic affordances of virtual worlds</p> <p>Sensory modalities are used different modes, such as visual design of the avatar, action, texture, colour, and 3D forms.</p>

The third unit of analysis—completed virtual world group design projects as motivated signs

In the third unit, I aimed to examine the motivated signs — the completed VW group design projects to recognize students’ interests and agency that highlighted their creativity and innovation. Therefore, I examined evidence of modal transformation and transduction by combining the analysis of the final presentations of the completed VW projects, students’ narratives that accompanied these projects (recorded by digital videos), and their final week design journals. However, design is a process that describe how sign makers use available semiotic resources to construct social products or environments for themselves and for their audience (Bezemer & Kress, 2016). Hence, in this unit of analysis, I also studied how each group assumed the audience roles to interact with the other two groups’ virtual projects during the final presentations, thereby recognizing each group’s creativity in bringing the three distinctive aspects of design into coherence (Kress, 2006).

In each visit, the participants became the audience to travel to different areas and participate in activities via avatars that were supported by virtual spatial representations. These real-time interactions with design contents were facilitated by the “communicative functions—ideational, interpersonal, and textual” (Halliday, 1978)—in the 3D virtual spaces that were intentionally designed by the groups. Therefore, in addition to the category codes of the second analytical unit, I adapted several of Stenglin’s (2004, 2008, 2009) social semiotic codes of 3D space to discuss the virtual environments’ communicative functions that constructed audiences’ visiting experiences and revealed the designers’ interests, agency, and creativity (Table 6).

Table 6. Codes employed in the third unit of multimodal analysis—motivated signs

Social semiotic codes adapted from Stenglin (2004, 2008, 2009)
Ideational function: The ways of construing representation of human experience (Stenglin, 2009).
Field: The purpose the virtual space has been designed to fulfill. Field-related activities: The activities that expected to fulfill the specific purposes of the field. Objects: The design elements that are involved in these activities. Structure: The patterns and interrelated parts of the virtual space that is designed to direct visitors' activities.
Interpersonal function: How the spaces are designed to make people feel (Stenglin, 2009).
Binding: How the virtual spaces are designed to evoke different feelings. For example, a space that is constructed to make visitors feel comfortable and safe (as bound); a free open dark natural space that makes the visitors feel exposed and vulnerable (as unbound). Ambience: The design elements that shape the binding relationship between the virtual spaces and visitors Bonding: Visitors' affiliation in relation to the designed virtual spaces Bonding icons: The symbolic signs that are used to create sharing meanings
Textual Function: The organization of information as a meaningful whole (Stenglin, 2009).
Theme: The guiding information in the designed virtual space Framing: The composition of the designed virtual space Path-venue: The routes that the virtual space scaffolds for visitors and the elements that attract the visitors' attention as they walk the paths.

Writing and analyzing transcripts as transduction of modes

By remaking the VWs screenshots as multimodal transcripts, I arrived at the stage of reconstructing and writing a selection of the transductions. Admittedly, when image as a mode of transcription is transduced into the mode of text, some analytical insights are gained and certain details are lost (Bezemer & Mavers, 2011). Thus, it was crucial to make those gains and losses transparent in my transcripts to render a vision of the modes and multimodal ensembles in the VW designs that the students utilized to express their specific interests.

I considered the distinctive material affordances of different modes of transcription (avatar designs, actions, gestures, framing, gaze, and communicative functions of the virtual space), and then I transduced them into pieces of interpreted narratives according to the foci of three units of analysis for each group. Then, the interpretations were examined using grounded content analysis to inductively define codes that revealed each group's repetitive "patterns of attention"(Bezemer & Kress,

2016, p. 43) to modes in and across the virtual environments, which led to prompted multimodal choices in constructing their collaborative designs. By relating students' patterns to their choices, I gained insights into the effect of the engagement between each group's attention and VW affordances on their shaping of modal ensembles. From the various semiotic features of these patterns, I extracted themes for three units of analysis and sub-themes for different design thinking stages as signifiers for the meanings that each group, considering their situations, employed in their VW design projects; these depicted students' agentive actions in the three unique and creative collaborations throughout the design thinking process.

Overall, the interpretations reflect my subjective view of students' VW design experience. However, they nonetheless provide reconstructed representations of those "original observed activities" (Bezemer & Mavers, 2011, p. 196) through my professional lens, which allowed me to recognize students' potentials and capacities as well as VW affordances for creative collaboration in design education.

Analysis of post-pre assessments and interviews

The participants' responses to the post-pre assessments were analyzed using Excel (Statistical Package for the Social Sciences). It aimed to understand each group of student participants' perceptions of changes in valuing the VW-integrated design course to enhance their creative collaboration in relation to the three TAE learning capacities, including engaged agency, connection, and values and beliefs. Using this approach, I first determined individual change by calculating each group member's before-and-after responses to each item. Then, within each group, I added each participant's "before" response to a single item and divided the sum by the number of scores to obtain the group's overall mean score. I also calculated the overall mean score of the group's "after" responses to the same item. Next, I subtracted each group's "before" mean score from the "after" mean score of each of the 27 items to obtain the mean difference scores and then created three different overall means scores graphs for each group, indicating the positive changes in the overall perceptions of three individual TAE learning capacities after the VW-integrated design course. Finally, I reported the largest mean difference that indicated the most significant change in each TAE capacity within each group, resulting in the three highest overall means for each group.

To gain additional insights into indicated positive changes in each group, I conducted the analysis of reflective interviews to foreground students' voices or perspectives by investigating the shifts in viewpoint of their VW-based design learning, experiences, engagement, and creative collaboration. Therefore, the data analysis involved an inductive reasoning process adapted from Glaser and Strauss' (1967) constants comparative method, which is described by Maykut and Morehouse (1994) to identify emergent themes by establishing and coding units of meanings from interview transcripts that were filtered through the TAE perspective.

The first step involved transcribing the 15 formal interviews. The second step was to establish units of meaning through open coding. I utilized the raw data of the transcripts and divided them into individual snippets on the Post-it notes; each participant was assigned a different colour of Post-it note. Then, I practiced the constant comparative method by comparing the snippets, which led to the discovery of common words and concepts that became the preliminary codes to connect snippets. After the open coding, I imported all the transcripts into NVivo (Qualitative Data Analysis Software) and created an interview analysis project with the preliminary codes and the code descriptions. Then, I continued seeking the connections between these codes through a more detailed interpretation of emergent codes; I then created multiple second-level categories that connected codes. The final step involved selective coding. Through the TAE lens, I compared categories with categories and created four core categories: building design thinking skills, learning avatar-based multimodal design, transforming from team-based communities to a class-based community, and developing a sense of empowerment. Each core category includes several sub-themes that indicate creative collaboration associated with the TAE learning capacities, which are described in Chapter 6.

4.2.5. Reflexivity and trustworthiness

By employing the concept of transformative engagement to understand communication and learning for my research, I recognized the importance of creating “dialogic encounters” (Lather, 1986) to achieve reciprocity between me—the teacher-researcher—and student-participants. Such engagement is the foundation for the ultimate achievement of reflexivity and trustworthiness in designing, conducting, and reporting this action research, which leads to coconstructing knowledge.

Engaging in reflexivity

One of the first challenges I encountered when I began this research was representing a visible classroom reality to facilitate and articulate a particular professional view. Multimodality and social semiotics together allowed me to ask questions about meaning-making in my research, including how and by whom the reality is constructed and shaped in different modes (Kress, 2011). This idea led to the notion of reflexivity in qualitative research, which according to Powell (2012), is “a conscious use of reflection to examine one’s own personal biases, views, and motivations and to develop self-awareness in interaction with others” (p. 36). Kress (2011) also mentions this awareness, as a move from one mode to another characteristic of the transduction of transcriptions, indicating the transcriber’s own interest (at the time of responding to the prompt) in being aware of the social characteristics of the environment in which this interaction occur. This entails that the construction of social reality could be ideally achieved through an interactional approach for the development and self-awareness of both researchers and participants (Eisner, 1998), who mutually transform each other in the co-construction of knowledge, thus leading to reciprocity and reflexivity. Therefore, I move beyond merely acknowledging my dual role as a teacher-researcher who was studying in my own teaching context. I also intentionally included the participants in many aspects of the research to heighten their awareness of their roles and predispositions. For example, whenever I had doubts about my understanding of the participants’ assumptions, ideas, and design processes as reflected in their weekly design journals, I questioned them to confirm my interpretations.

Furthermore, I acknowledged that my presence and personal biases could affect my interpretations of a familiar research context. To mitigate these effects, I kept reflection diaries, held discussions with my supervisor Dr. O’Neill, and reread relevant literature to decide on appropriate actions. The efforts committed to the continual dialogues transformed my understanding of myself in relation to the research context, resulting in a critical awareness of my dual role and the reciprocal relationships that serve as the basis of this research. In coming to this self-awareness, I became more resonant with O’Neill’s (2012a, 2014) TAE framework, which not only promotes student-led participatory inquiry and critical reflection in art learning but also shifts art teachers’ thinking about art learning. Therefore, I also became a learner in the classroom, concerned with what and how my students were learning. Furthermore, I developed a

responsive mode of teaching in which I asked the “driving questions” (O’Neill, 2011, p. 12) in students’ reflective journals to encourage them to actively investigate and co-construct knowledge with me. Within such a learning environment, the students benefited from inquiries and dialogues before the research was completed, as I addressed issues and problems specific to them. It was partially for this reason that, despite many students being somewhat skeptical about the research interviews and the post-pre assessments at beginning of this course, they eventually consented to be interviewed and complete the assessments because we built trust and developed caring relationships within a learning community.

The interpretative nature of multimodal transcripts utilized in this research allowed me to appreciate that reflexivity is a “valuable analytical tool” (Robertson, 2000) when employed to interpret the reality of the participants’ design processes, assumptions, and ideas in this VW-based course. My interpretation of the classroom reality was a transduction of semiotic modes from negotiations with the participants, the contexts, and myself. Therefore, I openly acknowledged my bias, beliefs, and influence on the participants, settings, and transcripts by inviting them to verify my interpretations of the research findings. I also produced a reflexive statement of my role and any unexpected results on the findings, which is provided in Chapter 7.

Building trustworthiness

The second challenge I became aware of once I started this action research was building trustworthiness during my inquiry. According to Lincoln and Guba (1985), trustworthiness refers to the believability of a researcher’s findings. They also propose several steps to increase four aspects of trustworthiness: credibility, transferability, dependability, and confirmability. When conducting my action research, I found these four steps to be helpful and applied them throughout the research.

Guba and Lincoln (1989) state that the credibility of research is determined by the participants, who are the co-constructors of the multiple realities being studied. I sought to increase the credibility of my action research by triangulating multimodal analyses, interviews, post-pre assessments, and reviews of my reflective diaries and field notes. Constant comparison and convergence of core categories and significant themes from different data resources led to the solid credibility of the findings. Moreover, utilizing member checks confirmed that my interpretations were not heavily dependent

on my own assumptions, values, and beliefs, which increased the credibility of the findings. Although listening to the participants does not mean changing the results, I have found that offering my students opportunities to comment on the multimodal analyses, interview transcripts, and reflective journals allowed me to see or emphasize if I missed something.

Transferability, Lincoln and Guba's (1985) second aspect of trustworthiness, refers to the generalizability of inquiry and is concerned with a case-to-case transfer in qualitative research. In my action research, I sought to achieve transferability by developing "thick descriptions of the context" (Geertz, 1973), as described by Guba (1981). Specifically, I utilized different data resources and methods mentioned previously to create detailed accounts of students' VW design processes, completed project presentations, and all contextual factors that impacted my inquiry. Consequently, any researcher who wishes to compare the findings of this context to another context can judge the transferability.

In qualitative research, dependability involves data consistency and substitutes for the scientific term of reliability (Lincoln & Guba, 1985). In my action research, I found that dependability could be improved by employing members checks and triangulating data resources and analytical methods.

According to Guba and Lincoln (1989), the fourth aspect, confirmability, can only be established when credibility, transferability, and dependability that have been achieved. Confirmability refers to the degree to which the research interpretation and findings can be validated. To achieve this aim, I established a permanent audit trail that comprised the research data documentation and a running account of the research process in reflective diaries. Therefore, I can "walk people through [my] work, from beginning to end, so that they can understand the path [I] took and judge the trustworthiness of [my] outcome" (Maykut & Morehouse, 1994, p. 134).

Chapter 5. Research Findings: Fostering and Recognizing Students' Creativity in Their Transformative Engagement with Multimodal Collaborative Virtual World Designs

This chapter presents the case study findings of three different groups' VW design processes and completed design projects⁵ to answer the first primary research question: How might the purposeful use of multimodal pedagogy leverage the affordances of VWs to foster creative collaboration among junior art and design students?

As detailed in Chapter 4, each case study includes three units of multimodal analysis that focus on how the virtual environments and their affordances affected, via each group's individual and collective interests and attention, the creative shaping of multimodal design ensembles to demonstrate transformative engagement, as illustrated by VW screenshots and design journals. By conducting fine-grained units of multimodal analysis, I recognized each student's different types of transformative engagement with VWs in the design processes and the completed group design projects. This pointed to different kinds of creativity in each group member who resourcefully made the modal choices to represent what each group wanted to convey. Tracked over time, these choices revealed each group's unique "patterns of attention" (Bezemer & Kress, 2016) to the virtual environments, which eventually emerged as themes that facilitated the understanding of which specific VW affordances can be utilized to foster a continual and transformative process of multimodal design. This iterative process involves exploring, evaluating, envisioning, reflecting, collaborating, and evolving, which are essential components of design thinking for creative collaboration in design education and evoke the essential steps to transformative learning.

5.1. Pan's Labyrinth Group: Design to Recontextualize

By exploring Group P's case study vignettes, all the five participants (Anna, Ben, Caleb, Daisy, and Effie) were identified as creative agents who engaged in their

⁵ Three completed VW group projects video link: <https://youtu.be/Gigg3iWsMI0>

multimodal designs, using the representational modes of VW technology to recontextualize the Spanish fantasy horror movie—*Pan's Labyrinth*—for their interests. The virtual labyrinth garden design was multimodal, drawing on a wide range of designs and digital proficiencies as students transformed different semiotic modes into a unique ensemble that could only be afforded in VWs. This multimodal design ensemble also reflects the creative collaboration of Group P, through which they discovered design opportunities, framed goals, shared opinions, and resourcefully circumventing constraints of VW technology to distinctively engage with their audience. Through the lens of multimodal social semiotics, Group P members were rendered as reflective and creative meaning-makers in a continuous process. They were also recognized as an efficient and coordinated team, with each member's unique contributions evident in their design choices of the available and representational VW modes.

5.1.1. Virtual environments: Defining the goal in avatar-mediated social and multimodal virtual worlds






Sub-theme 1: Embodied engagement with virtual worlds as a transformative way of collecting information

Screenshots description

The snapshots below illustrate Group P students' exploration of the virtual environments in Weeks 1 and 2, during which they attempted to formulate their design goal by searching for inspirations in SL. In Screenshot 1, Anna, mediated through her avatar, visited a Japanese-culture-oriented virtual environment, where she saw cherry blossoms, shopping malls, and galleries, and heard people speaking Japanese beside the swimming pool. However, due to the unstable Internet connection, her avatar was not displayed properly in this environment and appeared as red smoke spiralling in the air. Screenshot 2 presents Ben appearing as a Black, short-haired female avatar wearing a green ball gown while visiting a virtual space named Man Cave. In this dark and gloomy environment, cars, gears, construction tools, and a large old warehouse are present. In Caleb's first snapshot (Screenshot 3), he appears as a vampire with long ears and wings, wearing a black robe while communicating with the other avatars in a hall. In a virtual space named *AnesTezi Club* (Screenshot 4), Caleb becomes a fantasy knight with long red-and-white hair. He wears black armour, iron gloves, red pants, and combat boots while standing on a sunny beach. In Screenshot 5, Caleb becomes a well-

suited avatar dancing with other avatars on a dancing floor beside a beach. Daisy appears as a Brown girl with short hair sitting on a stone stool in front of a traditional Chinese house on a mountain (Screenshot 6). Effie appears as a short-haired, Black female avatar wearing a dark red ball gown walking on a red wooden bridge in a virtual space named *Greenhouse* (Screenshot 7). She then becomes the same female avatar as Daisy, dancing with a group of avatars in a virtual Japanese park in the evening (Screenshot 8).

Table 7. Group P members’ virtual world screenshots from their Weeks 1 and 2 journals

Design-thinking-oriented activities in Weeks 1 and 2: SL exploration and discovery			
Anna	 Screenshot 1		
Ben	 Screenshot 2		
Caleb	 Screenshot 3	 Screenshot 4	 Screenshot 5
Daisy	 Screenshot 6		



Patterns of attention⁶

Avatar redesign, avatar-mediated physical explorations, gaze, movement, social interactions, inspiration discovery, and information collection

Interpretation

After five students voluntarily formed their group in the first week, Daisy, who had experience in life-simulation video games, proposed that they re-contextualize the Spanish movie *Pan's Labyrinth*, which she had seen previously. However, since the other members did not have similar experiences, they were not convinced by Daisy's idea. Therefore, I encouraged them to explore SL for inspiration. Through their design journal snapshots, I identified Group P's agency and creativity through three types of modal choices made in their exploration of the virtual environments. These choices had a significant role in assisting them as they formulated their team goal.

The first common choice was utilizing SL's appearance-editing function to redesign their avatars. Although I did not provide detailed instructions on the SL user interface, each Group P member acted autonomously, making creative choices by combining various modes, such as hairstyle, skin colour, body shape, facial features, clothing, and accessories, into multimodal ensembles as their distinctive and unique avatars. In the first virtual class, all the students wore the clothing that pre-existed on the platform. They learned to change their avatar's clothes and modify their appearance by using the appearance-editing tools, and Group P students displayed their enthusiasm

⁶ According to Bezemer and Kress (2016), the learner's interest shapes his/her attention to a part of the social world and serves as the motivation for principle of selection. Thus, by tracking the learners' patterns of attention to various modes of virtual environments over time, it is possible to reveal their interests in specific modes, their semiotic resources, and the affordances of the modes for motivated selection (design).

and abilities in changing and designing their appearance on their visit to SL. Ben appeared as an avatar of the opposite sex (Screenshot 2). Other team members chose avatars that were either fantasy creatures or ethnically different from themselves (Screenshots 3 through 8). In these experiments, their avatar creations resulted partially from their interests and partially from the affordances of the multimodal VW. With every modification they made, the students created meaning by engaging with a selection of VW modes that attracted their attention, thus transforming their understanding of the environments into something new and innovative. Such meaning-making processes were embodied, which not only enhanced their emotional attachment to their avatars but also approximated their knowledge about the virtual environments to gather useful information to frame their goal.

The second type of choice was related to Group P's avatar-mediated physical explorations of different virtual environments in SL, including avatars' gazes and movements. Specifically, short-distance rear views were the first snap shots by Ben (Screenshot 2) and Daisy (Screenshot 6), long-distance rear views were provided by Caleb (Screenshots 3 through 5) and Effie (Screenshot 7), a bird's-eye view was Anna's snapshot (Screenshot 1), and a front view was Effie's snapshot (Screenshot 8). These different views indicated Group P students' engagement as interpretations of different VWs: they first interpreted the interface of camera angles to adjust their avatars' gaze directions and virtual environments. The effect of these interpretations changed their inner resources, which was seen in their subsequent actions: they made purposeful choices in selecting specific content in the environments that motivated them to capture snapshots from different angles. While creating the snapshots, they made signs that indicated different resources and different means of embodied knowledge, which continuously transformed their future actions of choosing to define their goal.

In the aforementioned snapshots, the avatars' movements, such as sitting, walking, running, flying, and dancing, further indicated how this VW mode offered unique opportunities for Group P students to engage with different environments. Specifically, Screenshots 5 and 8 reveal that Caleb and Daisy's avatars danced in two different virtual spaces, which signified their VW interpretations. First, to be able to dance in VWs, both Caleb and Daisy learned how to find the poseball in the dancing area and activated it so that the dancing mode implied their interpretation of the environment, producing specific forms of available knowledge and structuring particular ways of engaging with a

part of the virtual environment. Second, once they activated the poseball, the dancing mode offered them a unique physical experience of interacting with other users in real time. With every move they made, the two members learned more about the VWs, and thus transformed their previous interpretations for making meaning in their subsequent actions. Consequently, both Caleb and Daisy indicated in their journals that they enjoyed dancing with other avatars and that they wanted to add some interactive effects as fun elements to their collaborative design project.

Third, the repeated choices found in Group P students' avatar-mediated social interactions suggested that unique modal resources in the virtual environments offered a creative route to engagement and meaning-making. For example, Screenshot 3 illustrates that Caleb talked to another avatar in the Social Island VW. However, to communicate in VWs, Caleb learned to use the nearby voice chat function by interpreting its interface on the screen. He also learned to move his avatar toward the male avatar in the black suit and aimed to press the speak button in the viewer interface to talk to him (mode of movement). When both avatars arrived at apt locations, they could engage in the conversation they wished to have (mode of voice). As portrayed in Screenshot 3, two avatars were present in the same place simultaneously. Therefore, the mode of proximity likely fostered a sense of shared space, which may have facilitated their discussion to some extent. Similar choices were also apparent in Anna and Effie's experiences. According to their journals, both were invited to participate in conversations with other avatars through voice- and text-based communication. As Caleb reflected in his journal,

Once I entered the grand hall, some avatars came to say hello. One from Portugal kindly reminded me that my pants did not show properly and taught me how to fix the problem. Instead of feeling embarrassed, I was very pleased to learn something from someone from another country.

This interpretation demonstrates that the social affordances of virtual environments provided Group P students with the unique choices to synchronously engage with other avatar-mediated participants for embarrassment-free explorations through which they made meaning. As they explored these environments to discover inspirations and collect information, such interactive and enjoyable meaning-making processes likely transformed this groups' VW interpretations. In other words, the definition of their ultimate group project goal involves entertaining factors.

By analyzing Group P's explorations, I learned that VWs offer students social, multimodal, and embodied resources to represent personalized selves and to physically engage with the environments and other VW users; these are unique and creative ways of collecting information at the early stage of design processes. Concurrently, I recognized the students' agency through their choices in the information-gathering process, which were shaped by the modal affordances of these virtual environments. These choices reflected Group P students' different meaning-making processes using different modes, gradually increasing their "approximation in interpretations" (Bezemer & Kress, 2016) toward their goal as a team. Consequently, all Group P members expressed their interest in the magical and entertaining characteristics of the VW platform. They approved Daisy's proposal to recontextualize the mysterious, fantasy labyrinth as their collaborative project during the in-class meeting at the end of Week 2.

Sub-theme 2: Re-collecting information for transformation and transduction

Screenshots description

After defining the goal in the previous week, all of the group members returned to SL to re-collect relevant information. However, only Effie included three snapshots that documented her return visit to the virtual labyrinths. Within these environments, she appears as a Black girl with short hair wearing a patterned, dark blue gown with purple gloves. Screenshot 9 illustrates that Effie's avatar is standing in an oval hall in which three gates point to three different routes. A skeleton is sitting on the ground, and a female image is hanging on the wall. Screenshot 10 depicts Effie standing on a narrow brick path that is surrounded by two gray partition walls. On both sides of the walls, there are reflections of images and digital table charts. At the end of the path, a ladder leads to somewhere above. In Screenshot 11, Effie is flying above a forest, and a red-roofed farmhouse is located at the centre.

Table 8. Effie's virtual world screenshots from her Week 3 journal



Patterns of attention

Transduction, transformation, and information re-collection

Interpretation

Effie's screen captures (Screenshots 9 through 11) reflect her ability to make conscious choices to explore specific virtual environments to regather information as a critical step in her design thinking processes. In the previous week, Group P established its goal of representing *Pan's Labyrinth* in the virtual environment. Because they defined their objective loosely, everyone in this group knew that they needed to gather additional relevant information to clarify the goal. These snapshots document Effie's attempt to search for inspiration and information. Specifically, she consciously chose to visit particular virtual environments with the same labyrinth theme, thus following her interests. Within these environments of semiotic resources, her attention was drawn by specific elements, such as the three different routes, the sitting skeleton, the ladder, the tall partition walls, the forest, the farmhouse, and the dusty gray air. These observations were confirmed in the completed group project, which featured similar elements that Effie and her group members designed.

These findings suggest an essential step in the early stages of the design thinking processes—regathering information about the design goal. The critical aspects of this step can be interpreted as the semiotic processes of transformation (changes in the arrangement within one mode) and transduction (changes in entities), which were realized through Effie's engagement with the virtual environments. First, the main idea of the movie was transduced from the visual and auditory modes (what Group P saw and heard from the movie) to the mode of sound and text (what Group P discussed about the

goal in class and their journals). Later, by choosing what to frame in the snapshots, Effie was prompted to engage by the VW elements. She transduced and transformed the aforementioned modes through her inner resources into images she captured in VWs.

Although other members did not include any visual information in their journals, they all mentioned their explorations of SL to gather relevant information. Therefore, as I interpreted Group P's process of collecting information from a multimodal social semiotic perspective, I noted their interests in engaging with particular semiotic VW resources, which highlighted unique VW affordances for design learning. Concurrently, their engagement revealed Group P members' agency, with which they committed themselves to continue transforming and transducting the modes into something new, enabling them to derive creative ideas for workable and practical solutions.

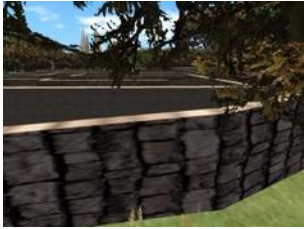








5.1.2. Virtual world affordances: Prompting a constant process of recontextualization

Sub-theme 1: Prototyping directly to preview the solutions

Screenshots description

The snapshots below from Group P members document their attempts at solutions in VCER during the stage of ideation and experimentation stages, which began around Week 4. Screenshots 12 and 13 reveal that Anna built some parts of the labyrinth walls. Screenshots 14 and 15 present Ben as a tall, bald male avatar, wearing a dark yellow cape and planting trees outside the labyrinth. Caleb was also in charge of creating the forest outside the labyrinth in Weeks 4 and 5. Screenshot 16 is a bird's-eye view of the forest after he worked on it for these two weeks. His second screen capture (Screenshot 17) is a near-distance view in which Caleb appears as a knight-like male avatar in a black cape and hat, planting in the forest around the labyrinth. Effie's first snapshot (Screenshot 18) depicts her appearance as a pink-dressed, red-haired fairy creating a transparent handrail for the staircase in the pond. In her second screen capture (Screenshot 19), she hovers in the air, building the labyrinth walls. The third snapshot (Screenshot 20) documents the moment when she resized the rocks using the content-creation tools to decorate the forest. Daisy did not provide any visual information in her design journal. However, she mentioned in her journal that she also contributed to the construction of the labyrinth walls and constructed the labyrinth gate.

Table 9. Group P members' virtual world screenshots from their Week 4 and 5 journals

Design-thinking-oriented activities in Week 4 and 5: Ideation and experimentation in VCER			
Anna	 Screenshot 12	 Screenshot 13	
Ben	 Screenshot 14	 Screenshot 15	
Caleb	 Screenshot 16	 Screenshot 17	
Effie	 Screenshot 18	 Screenshot 19	 Screenshot 20

Patterns of attention

Prototype creation, synchronous and asynchronous collaboration, iterative design, constraints management, and pre-existing resources redesign

Interpretation

These snapshots illustrate that VWs encouraged Group P to prototype their ideas directly, autonomously, and collaboratively, which allowed them to identify the practicality of their solutions by transforming and transducing VW available modes into

newly designed ensembles. In many modern design societies, creating typically begins only after the design process is completed. However, the snapshots and accompanying design journals demonstrate that this group of junior design students started creating the labyrinth by working directly in the virtual environment without first sketching or drawings the labyrinth. This suggests a significant affordance of VW technology for design education: VWs provide technologically inexperienced students with relatively simple visual information (such as shapes, textures, and script models) for collaborative experimentation.

With little guidance concerning the content-creation tools, Group P members explored the problems and solutions together. They employed primitive geometric shapes, such as cubes, spheres, and cylinders, to create new meanings through transformations and transductions. Through the interpretation and assessment of the VWs, Anna worked autonomously to transduce the group discussion and transform the constructs of the original labyrinth from the movie to the virtual labyrinth walls by using the cube shapes and applying brick texture. Later, she resized the walls into the desired size and copied and positioned them to form different paths as ensembles (Screenshots 12 and 13). The same semiotic processes occurred within Daisy and Effie's designs in building the labyrinth walls (Screenshot 19). Notably, the socio-technological nature of VWs allowed these three members' individual design actions to synchronously alter the stimuli in the virtual space, which initiated a modifiable cycle of actions that were performed in their designed virtual environment. With each interpretation of the semiotic ensembles, they iteratively transformed the virtual environment as the newly designed sign complex to develop an increasing approximation of a shared understanding of the optimal solutions.

Ben, Caleb, and Effie also performed a similar modifiable cycle of design actions. With constant synchronous and asynchronous communication, they collaboratively designed the virtual forest within their labyrinth project (Screenshots 15 through 17, 20), which resulted in the iterative codesign of the virtual forest reaching somewhere unknown. This unique VW affordance continuously approximated the interpretations of each other's designs, consequently contributing to the development of the problematic areas and the production of the creative solution space as a team.

In their design journals, all five members mentioned that their technical difficulties in utilizing the content-creation tools to create complex objects led to the overuse of simple geometric shapes and pre-existing objects (such as trees, grass, and brick texture) in their collaborative project. However, each worked resourcefully around these constraints by relocating their semiotic tasks using available VW modes to push their project toward recontextualization. For instance, Effie claimed that because she could not create a more realistic handrail, she utilized the cube shapes to create a transparent handrail to prevent users from falling off the stairs, which she also felt added an aesthetic appeal (Screenshot 18). As such, by interpreting their design activities as semiotic processes of transformation and transduction, I understand that VWs offered both individual and collaborative opportunities to initiate and experiment their ideas synchronously and asynchronously, thereby producing meaning that met the needs of Group P students' interests. Furthermore, these students demonstrated their agency in overcoming the VW constraints resourcefully and made purposeful and creative meanings by utilizing whatever modes they could find in the VW.

Sub-theme 2: Refining the goal in a continuum of multimodal redesigns





Screenshots description

The snapshots from students' Week 6 design journals illustrate that Group P continued to refine their objective in the experimentation stage in VCER. In Anna's first snapshot (Screenshot 21), a pottery is halfway hidden in the forest soil. Her second screenshot (Screenshot 22) presents that a bonfire and a wooden trolley in the forest near the outer labyrinth wall. Ben's avatar is seen constructing the forest by adding, reducing, resizing, and positioning different plants and rocks (Screenshots 23 and 24). Caleb, the forest's codesigner, is seen editing the terrain in the forest, where the selected area had been turned into water as well as uneven bumps and hills (Screenshot 25). Screenshot 26 illustrates that Caleb planted specific kinds of trees and shrubs around the water to make the environment more harmonious and aesthetically pleasing. Caleb's third snapshot (Screenshot 27) is a long-distance view of the forest after he changed the land's shape and elevation: in Screenshot 25, there are three or four hills with running streams; whereas Screenshot 27 portrays five hills that tower into the clouds; outside the forest (in the foreground of Screenshot 27), there are many small bumps and natural slopes on the ground.

In Screenshots 28 and 29, Effie utilized pre-existing objects (a firepit and haystacks) and the script teleporter to create three hidden tricks for visitors who meet dead ends. Screenshot 30 illustrates that her avatar creating some fluorescent spheres and making them float around the flower trolley. If the visitor happens to touch these objects, then they may choose to be teleported to the front gate of the labyrinth without knowing where they will be sent at that moment. Effie also employed the same teleporter script for three pieces of the labyrinth wall that partially enclose the pond (Screenshot 31).

Daisy still did not provide any visual information in this week’s design journal. However, comparing Ben’s Week 6 snapshot (Screenshot 23) with Effie’s Week 5 snapshot (Screenshot 19) reveals that Daisy progressed on the design of the front gate she had designed. She created colourful glowing balls and positioned them on the ground around the front gate. She also created a translucent glowing red ball, which was embedded in the gothic crown-like sculpture on the top of the gate.

Table 10. Group P members’ virtual world screenshots from their Week 6 journals

Design-thinking-oriented activities in Week 6: Experimentation in VCER		
Anna	 <p>Screenshot 21</p>	 <p>Screenshot 22</p>
Ben	 <p>Screenshot 23</p>	 <p>Screenshot 24</p>

Caleb	 <p>Screenshot 25</p>	 <p>Screenshot 26</p>	 <p>Screenshot 27</p>
Effie	 <p>Screenshot 28</p>	 <p>Screenshot 29</p>	 <p>Screenshot 30</p>
	 <p>Screenshot 31</p>		

Patterns of attention

Recontextualizing, framing, continuously designing and redesigning, arranging, interacting, creating multimodal ensembles, collaborating, and assuming responsibilities

Interpretation

Week 6's snapshots illustrate that VWs' creative affordances prompted Group P to refine their goal by exploring the tentative ideas in a continuum of multimodal ensembles that they jointly produced and reproduced. In the prototyping stage, each group member constantly utilized VWs' material resources to create modal combinations of shape, colour, texture, size, sound, animation, and placement to achieve their goal of representing the movie to an imagined audience. However, their social roles were not necessarily fixed and changed from situation to situation, which shaped the division of labor within the design group and the relations between the members throughout the design processes. Screenshot 21 indicates that Anna switched her responsibility of building the labyrinth walls in Week 5 to constructing the forest in Week 6. Screenshot 22 illustrates that Anna made distinct choices by selecting two pre-existing objects—a wooden trolley and a bonfire—and positioned them together in the outer space of the

forest. She purposefully hid the pottery halfway under the ground in the deep forest to create a wild and mysterious atmosphere. In Week 6, Ben maintained his role as the forest's codesigner and made conscious choices of certain plants (mainly autumn-coloured dark or yellow trees) and rocks, adapting them to achieve a sense of primitiveness and mysteriousness (Screenshots 23 and 24). These actions demonstrate Anna and Ben's autonomy and collaboration in the incremental development of the interim ideas and solutions, resourcefully utilizing the VWs' affordances to produce connected and integrated interpretations of the original movie scene.

Daisy, with the affordances of the content-creation tools, incrementally developed her modal ensembles by designing different modes, such as gothic crown-like sculptures with spikes, pointed cone shapes, bright and glowing colours, floating spheres, and brick texture. The coherence of the ensembles reflects her creative autonomy and personal commitment to gradually melding the semiotic work with her interests (recontextualizing the labyrinth from the movie) and shaping her rhetorical intention (creating a spooky and mysterious virtual atmosphere for visitors) that not only fits with the co-generated digital content but also carries apt meaning for the audience. As Daisy reflected in her design journal,

As we continue to build, the hardest thing for me is team coordination because even if you are just planting a tree or grass, you must consider its effect on the overall arrangement.

By analyzing each Group P member's semiotic works during this week, I learned that Caleb led participation in the collaborative design processes in Week 6. Caleb began his semiotic work by marking out a space in the centre of the forest, which defined the domain of his interests. Next, by utilizing the content-creation tools, he selected a set of terra-forming techniques, such as flatten, raise, size, strength, and direction, to create several hills with different heights, slopes, and sizes. To distinguish between the labyrinth and forest elements, Caleb intentionally created a ditch at the side of the hills to bring the constituent elements into the frame. He continued to redesign the plants, ridges, bumps, and ditches, arranging them for their imagined audience (Screenshots 25 and 26). In the design journal, Caleb reflected as follows:

The design responsibility I took this week was almost the same as before, but I knew only planting trees was not enough, and there was still one thing missing in the forest design—the roughness of the ground. I just want our visitors to feel present in the forest...just like Ofelia, the

leading actress of the movie, lost in the forest in Pan's Labyrinth. So, I raised the land to create hills and bumps and lowered it to make water... The terrain editing was not that hard, but it required much time to achieve what I wanted. The whole environment looks more like a real forest now.

This is clear evidence that Caleb acted as an autonomous agent, exploring the problem within the joint design task. Through an iterative process of framing, selecting, designing, redesigning, and arranging the modal resources, he made semiotic changes of transformation and transduction, which not only resulted in the unique recontextualization of the original forest from the movie, but also matched the multimodal ensembles produced by Anna and Ben, thereby shaping the visitors' potential engagement with the environment.

As the design progressed, Group P members discovered more problems and issues, one of which related to the playfulness and interactivity of their labyrinth. During an in-class group meeting, they expressed that their designed environment was dull because they did not take advantage of the interactive nature of VWs to create playful atmosphere and they placed excessive emphasis on the visual elements. As a result, they reallocated their semiotic tasks to further investigate the interactivity functions of VWs further in order to make their labyrinth more entertaining. Effie's VW snapshots (Screenshots 28 through 30) suggest that she assumed this design task to produce interactive elements for their group project. She consciously chose three pre-existing objects (flower trolley, haystack, and bonfire) in a rustic style that matched the desired genre. After adjusting them into appropriate sizes, Effie placed them in three particular positions at three dead ends. After that, she employed a sophisticated combination of scripting techniques, including applying the teleporter script to the object's content and then modifying vector positions within the script. Effie also tested the script multiple times to confirm that it operated properly and re-adjusted the vector positions to ensure that visitors would be teleported to a particular location around the front gate. Additionally, she created several colourful, glowing spheres and made them float around the trolley to attract visitors' attention.

As Screenshot 31 illustrates, the teleporter script was applied a second time to three wall pieces to teleport visitors who may be stuck in the labyrinth and cannot find the goal. Again, Effie made a conscious decision to select three walls that partially enclose the pond (the goal of the labyrinth). Next, she employed the script on the walls.

To contrast the selected walls with the normal walls, she increased the degree of the selected walls' transparency. Effie explained this in her design journal:

The most difficult thing this week was being creative, but I didn't want to only copy and paste the pre-existing objects from the inventory to build our labyrinth. I wanted to do it by myself, even just little by little, piece by piece. However, I had to give up some interactive effects I wanted to achieve because I did not know how to script. What I could do was to utilize what I could find to create little tricks to increase the playfulness in our labyrinth. Now, it is no longer just a boring visual project on display, and we can interact with it.

The two examples illustrate Effie's repeated undertaking of significant responsibilities as the leader and acting as an autonomous agent in making her specific and deliberate semiotic choices utilizing specific VW affordances. This process was constant and iterative, which resulted in meaningful and creative modal ensembles for the group design content and the audience.

In summary, although interactivity is a unique creative VW affordance, achieving this effect requires relatively sophisticated scripting skills, which became a constraint on Group P's making-meaning. When the group members wanted to create animated objects, their options to achieve interactivity were limited by this technique. However, with the outsourcing accommodated by VWs, Effie resourcefully utilized the open-source script to overcome the constraints and demonstrated her creativity in accomplishing her interests.

Sub-theme 3: Making novel modal choices by recontextualizing semiotic interests







Screenshots description

Week 7 screenshots document Group P students' design activities in the penultimate week of the course. Screenshot 32 reveals that Anna continued to organize the plants that she created. She also utilized a script that I provided to create a rain effect at the labyrinth entrance (Screenshot 33). Caleb created a dozen semi-transparent glowing spheres with birds-chirping sound effects and placed them in multiple locations in the forest (Screenshot 34). Snapshot 35 illustrates Caleb's other design task: heaven. Glowing objects, including clouds, light spots, and colourful shapes of planets with particle effects are visible. His avatar appears in front of a long, cylindrical light beam that he designed, which emits its glow from the bottom of the pond (Screenshot 36). In

Screenshot 37, Effie’s avatar is standing in front of a glowing white stela with a skeleton at pond’s bottom.

Ben did not submit his design journal, so I was unable to determine what he designed during this week. Daisy again did not include any visual information in her journal. However, she mentioned in her journal that she and the other members continued to create additional glowing spheres for the front gate scene, and she continued to seek applicable open-source scripts.

Table 11. Group P members’ virtual world screenshots from their Week 7 journals

Design-thinking-oriented activities in Week 7: Experimentation and evolution in VCER			
Anna	 Screenshot 32	 Screenshot 33	
Caleb	 Screenshot 34	 Screenshot 35	 Screenshot 36
Effie	 Screenshot 37		

Patterns of attention

Recontextualizing semiotic interests, making stylistic choices, implementing genre-framing devices, selecting, arranging, foregrounding, a rapid succession of engaging, synchronously assessing, evolving existing design

Interpretation

These examples illustrate that Group P members made novel design decisions and continued testing, elaborating, and developing their ideas during the experimentation and evolution stages. Again, these stages suggested in analysis are neither separate nor linear but are iterative and sometimes mixed.

Toward the end of the course, all Group P members worked more intensely in reassessing and redesigning the ensembles created during prototyping. Anna continued her task of representing the mystery and fantasy genre of the original labyrinth. She made deliberate stylistic choices of VW modes, including plant types, sizes, and spatial arrangements. According to her journal, as her engagement increased, the idea of creating a rain effect at the entrance of the labyrinth emerged. After discussing with the gate designer, Daisy, they identified the animated rainy effect as a distinctive mode to enhance the mysterious atmosphere by simulating visitors' tactile sensation. Therefore, Daisy enabled the adjust content permission function for her group members, and then Anna applied the rain effect script to the front gate. From a social semiotic view, Anna acted as a "semiotic resourceful" (Bezemer & Kress, 2016) sign maker: she continuously developed the resources by engaging in a transformative process with VWs and accumulating them over time, which prompted her to work across a wider range with attention on different facets of the goal and tentative ideas. As she became more sensitive to the social and material VW environment in which she participated, a creative decision—the rain effect—emerged in the process.

Caleb's design work featured several instances in which he made novel design decisions. As mentioned previously, Caleb appeared to be decidedly engaged in various design tasks in the VW, and these engagements between modes in rapid succession led him to achieve more creative ideas. For example, he chose to design an ambient sound for the forest (Screenshot 34). While a vast number of sounds are available online, he consciously selected the sound of birds to meet the group's rhetorical intention. He then downloaded the sound in MP3 format. However, issues with the sound's format and length prevented Caleb from uploading the sound file to VCER. After seeking guidance, Caleb employed a series of editing techniques, including converting the MP3 to a WAV file (the only sound files that can be uploaded in VWs) and dividing the longer sound into 10-second blocks (a sound file longer than 10 seconds cannot be uploaded). Then, he

uploaded the file and created several glowing balls as the sound-emitting objects to match the style of other sign complexes produced by other members. To ensure that visitors could hear the sound from anywhere in the labyrinth forest, he intentionally selected particular forest locations to arrange these ambient sound generators. Instead of assuming that the sound effect was central in Caleb's semiotic tasks, I believe that the VW affordances and limitations motivated Caleb to make a specific sign that contributed distinctively and significantly to the sign complex he created and the development of the multimodal design project.

Caleb's second creative choice was creating heaven in the sky within the labyrinth garden (Screenshot 35). Caleb stated that the idea of building heaven came from regathering and sharing information with team members. In his journal, he mentioned that he rewatched the movie, and the golden room where Ofelia's parents wait for her to return to after her death inspired him to make a similar space. When his teammates heard this information, they determined that the characteristics of heaven should include peace, spirituality, and happiness. Accordingly, Caleb recontextualized the golden room in a new modal configuration. He first marked a space in the sky above the virtual labyrinth, which framed the domain of his interest and conveyed the specific meaning (heaven is in the sky in his interpretation) to potential visitors. Then, using a range of VW content-creation tools, Caleb made a stylistic choice to create several glowing white spheres as the "framing devices" (Bezemer & Kress, 2016, p. 77) to mark the boundary between heaven and the labyrinth. Concurrently, he intentionally created signifiers within the frame, such as clouds with particle effects, glowing golden halos, planet-like shapes, and a transparent, walkable floor that jointly created apt meaning and style to represent the golden room. He continually designed and redesigned these semiotic entities in the airspace. He consciously chose to arrange the cloud in the centre of the framed space and placed the three glowing golden halos as well as planets above the three edges of the cloud. Consequently, the vertical spatial "arrangement" (Bezemer & Kress, 2016) of signs was utilized not only to create a temporal reading path to engage visitors but also to "foreground" (Bezemer & Kress, 2016) the elements (the three glowing golden halos and the planets) above to represent a sacred and spiritual atmosphere. In Caleb's third snapshot (Screenshot 36), he revealed another creative choice by creating a long light beam that emits from the pond and connects with heaven. According to his journal,

The glowing cylinder is an indication of where the labyrinth's destination is. I made it tower into the sky because I wanted it to represent one particular plot of the movie: Ofelia sacrificed her life to return to her parents and her kingdom. Therefore, I created the light beam to symbolize heaven's light and guide the visitors to the journey's end.

In interpreting Caleb's VW design process as a semiotic realization of recontextualization, I recognized Caleb's creative autonomy and agency in transforming and transducing the "meaning-material" (Bezemer & Kress, 2016) from the movie to the virtual environment, from the mode of TV-based picture to the mode of virtual reality, and from the Spanish cultural context to the mixture of Chinese and Spanish cultural contexts. Each semiotic change requires social semiotic remaking, which entails four semiotic principles (framing, selection, arrangement, and foregrounding) that sign maker Caleb utilized to redesign the golden room in available VW modes to suit the audience and his interests. Such design processes represented varying divisions of the sign maker's semiotic works that connected to his different abilities and demonstrate learning and creativity.

Effie's first screenshot (Screenshot 37) portrays her avatar near a stela. In her journal, she explained that she was about to create a second stone stela with the teleporter script under the pond. Effie reflected in her journal as follows:

Initially, the destination of this virtual labyrinth was designed to be the bottom of the pond where the stela was located. The idea came from the movie. However, as we continued to design, we found it a little simple to end the labyrinth tour here. Caleb has been building "heaven" this week, so I created the first stela with the teleporting function. When visitors arrive at the pond's bottom, they may touch the stela and be teleported to heaven as a surprise...Now, I want to create the second one so that visitors can be teleported to the forest in the back of the labyrinth. It might be fun for our visitors.

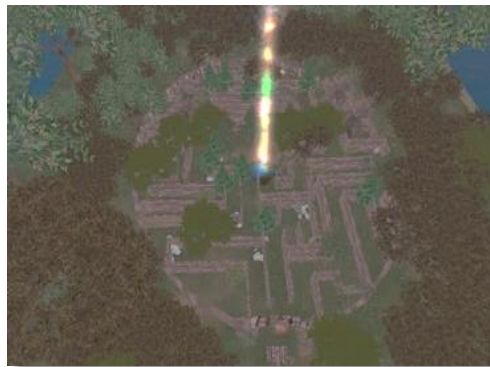
Effie recontextualized some aspects of the movie through meaningful and creative expressions shaped by VW affordances. The synchronous and evolving nature of VWs allowed Effie to be aware of any changes in the design project as it was being developed. As Effie interpreted Caleb's design, she was prompted to evaluate whether the specific modes of her design met the interests of visitors and her group. As signifiers, her sequential actions of extending the goal to two different spaces within the designed environment were motivated and the semiotic result of her interpretation, demonstrating the creative potential of VWs for design learners.

5.1.3. Completed project as motivated signs: Materializing interests through coherent multimodal design ensembles

Sub-theme 1: Asserting creative agency by framing the semiotic entities

Screenshot description

Screenshot 38 reveals a horizontal layout of Group P's labyrinth garden in the final presentation. The circular structure includes a collection of convoluted paths to different destinations, only one of which is the final destination. The beam of light emitting from the centre of the labyrinth (the pond) points to the labyrinth's vertical destination.



Screenshot 38. Laybrinth Birdview

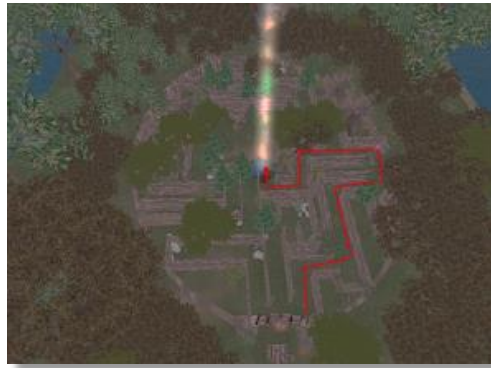
Patterns of attention

Recontextualizing, designing layout, creating a spherical structure, making ideational and textual meaning, and designing paths

Interpretation

Using various VW content-creation tools, Group P members Anna, Daisy, and Effie collaboratively designed and arranged specific semiotic entities in a spherical structure to recontextualize the labyrinth in the movie (Screenshot 38). As Screenshot 39 reveals, the goal is in the centre of the structure, which means that visitors must walk inside the labyrinth to reach the goal. To engage with visitors in a more challenging way, Group P participants made creative choices to design only one path that leads from the beginning to the goal and many repeatedly dividing paths that lead to dead ends or

return to a previous path. Consequently, this structure fulfills its ideational meaning: it presents a spatial pattern that organizes the interconnected spaces of the labyrinth.



Screenshot 39. Labyrinth structure

In addition to designing activities in the labyrinth, the group members employed a combination of VW design techniques to create objects that may be involved in these activities. For instance, Caleb employed the modes of shape and colour to design a long beam of light that emits from labyrinth's centre to attract visitors to the goal. All group members participated in planting trees, bushes, grass, and flowers that were selected from the pre-existing system. Then, through a process of modification, they purposefully arranged them into particular positions within the labyrinth to frame the space. This structural design, along with other elements in the space, created barriers on the paths to the goal, establishing a semiotic relationship that shaped visitors' engagement with the labyrinth.

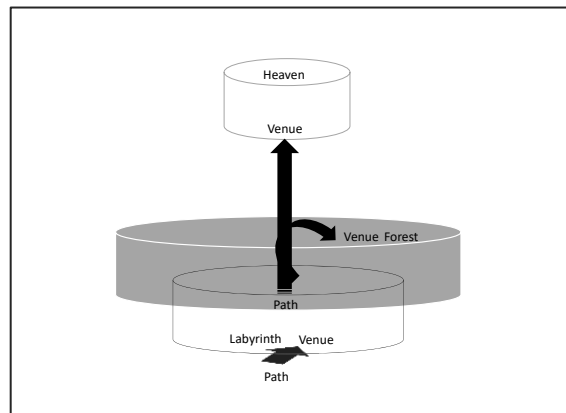


Figure 12. The path-venue design of the virtual labyrinth garden

Group P students constructed three main paths—horizontal, vertical, and moving—to organize the virtual labyrinth garden (Figure 11). The horizontal path was designed to channel visitors into the labyrinth. The vertical path simulates heaven’s light from the movie that teleports visitors to heaven. Visitors can also reach heaven by flying if they follow the light beam as a cue. The third path is a moving route to the forest via teleportation, which was motivated by Group P students’ interests in recontextualizing the magical channel to the surreal world in the movie. Therefore, the three main paths achieved particular textual meanings in the virtual labyrinth garden: they were a “path-venue” (Stenglin, 2009) to scaffold and attract visitors’ attention as they stroll the paths. The path-venue design was the semiotic remaking that motivated and was completed by Group P members. Therefore, I conclude that VWs encouraged students to assert their agency and interest in achieving some textual meanings in specific modes that were framed in ways unique to VWs. These meanings recontextualized some aspects of the *Pan’s Labyrinth* movie, reflecting the transformative and innovative nature of the students’ design.

Sub-theme 2: Designing interests, virtual worlds’ modal resources and audience characteristics into coherence

Screenshot description

Screenshot 40 depicts the design of the virtual labyrinth entrance. It is an arched gate made of old brownstone bricks. On the top of the gate, a gothic crown-like sculpture features spikes and a glowing red ball in the centre. Two conical sculptures are fixed on each side of the gate. Through the gate, three divided paths are made of the same material as the gate and the sculptures. Additionally, a glowing beam of light emits from the labyrinth’s centre. Outside the gate, two irregular areas of brick pavement lead to the entrance where the rain drizzles. Some rocks, weeds, and withered trees are scattered around this front gate. Multiple semi-transparent glowing balls emit bird-chirping sounds as they float in the dark and dusty air around the front gate.



Screenshot 40. The front gate of the labyrinth garden

Patterns of attention

Creating modal ensembles, producing coherence, designing ambience, recontextualizing, transforming and transducting, and combining three meaning functions

Interpretation

The design of the front gate area reflects Group P members' creative agency and interest in utilizing specific VW modes to convey a complex, coherent, and interrelated meaning. Specifically, three activities occurred in the front gate area in final presentations, suggesting its ideational effects. First, the front gate (designed by Daisy) segregated the labyrinth from its external environment so that visitors could distinguish the resources inside and outside the labyrinth. Second, the style of the front gate (as magical, ancient, and Western-culture-oriented) was a prompt for visitors to interpret. Finally, the gate was not only for display in the space but also for encouraging visitors to enter the labyrinth. The gothic crown-like sculptural object with a glowing red sphere atop the arched gate was designed to attract the visitors' attention for further engagement. The strong light beam (created by Caleb) coming from the inside of the labyrinth was also intended to create a strong lure for the visitors.

The front gate area had an interpersonal function, which was demonstrated by how visitors were addressed by the designers. During the final representation, many student visitors reported that they felt "too bound" (Stenglin, 2004, 2009) when they arrived in this virtually built, dark and natural environment. More precisely, the dusty weather, the rain, the birds' sounds, the heavily wooded area, and the arched gate with

its old, dilapidated wall texture created an abandoned ambience throughout the labyrinth garden. Concurrently, the floating glowing balls (created by Daisy and Effie) and the strong beam of light worked with the members' semiotic choices for a deserted ambience to make the space feel mystical and magical. Atop of the arched gate, the sculpture referenced the original gate top (a sculpture of a gothic crown shape) from the Spanish movie, which pointed to Western culture and symbolizes a social power. With the glowing red sphere positioned in the sculpture's centre, these bonding icons created a strong Western-culture-oriented, magical atmosphere.

In the final showcase, the front gate and the three divided paths inside the gate comprised the "theme" (Stenglin, 2009, p. 57), orienting the student visitors to the virtual labyrinth. Together with other sign complexes, such as the pavement in the front of the gate and the conical sculptures on each side of the gate, the entire front gate area functioned as multimodal ensembles that offered visitors way-finding information with textual effects, reflecting Group P students' motivation and agency.

The design of the front gate area yielded rich insights into how the signs were made coherently in the mix of the three meaning functions across multimodal ensembles to address the visitors and Group P members' motivating interests. This coherence not only reflects the students' creative agency in utilizing VW modes to transform and transduct certain aspects of the movie into newly designed ensembles but also suggests that VWs can effectively support user-centred design activities to develop students' design thinking skills.

Sub-theme 3: Students' interests and underdeveloped meanings

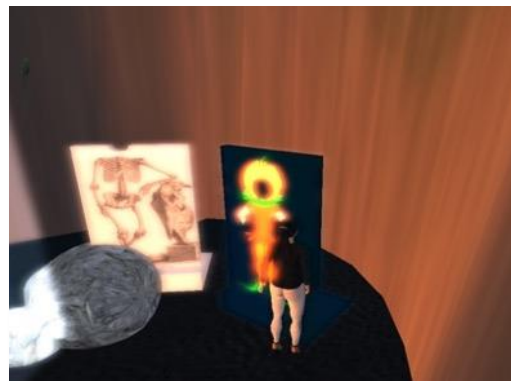
Screenshots description

Screenshot 41 depicts the design of the virtual labyrinth's goal from an edge-of-the-pond perspective. A few trees and rocks are arranged along the walls. In the centre, a transparent beam of light arises from a round pond where lotuses float on the surface. In the corner, a dark brown wooden staircase descends from the ground into the pond. In Screenshot 42, the soil defines the vertical edge of the bottom of the pond, and it is bright due to the beam of light extending from the water. A visitor stands before the two glowing posters; the poster on the left features a skeleton and the poster on the right

features a clown figure with a pumpkin head. Two large rocks are on the ground beside the poster.



Screenshot 41. The pond design (above water)



Screenshot 42. The pond design (under water)

Patterns of attention

Binding, bonding, addressing the visitors, collaboratively designing, managing VW affordances and constraints, and underdeveloped meanings

Interpretation

As depicted in Screenshot 41, Group P students produced coherence across the labyrinth's goal by employing constituent modes that conveyed distinct domains of meaning, demonstrating their abilities to make transformative and innovative meaning. In

terms of interpersonal meaning, when student visitors arrived at the centre of the labyrinth, many reported that they felt relaxed, as the wall plane receded to a more distant point (designed by Anna, Daisy, and Effie) and the ground transformed into a pond (designed by Effie), thus extending the vertical space. This design choice came from the movie's design of the labyrinth goal (an underground space); from this, Effie redesigned the goal into a pond using VW affordances. She also transduced the original stone staircases from the movie into a virtual wooden staircase that descended from the ground into the pond, and she selected two pre-existing lotuses and arranged them on the water for ambient purposes. Consequently, the staircase, flowers, and pond together created a feeling of openness, prompting the visitors to explore the water underneath. In addition to Effie's semiotic remaking, Caleb's beam of light emitting from the pond was an important factor in luring the visitors to explore what was underwater.

Screenshot 41 additionally reveals that the elements were arranged as a complex of coherent modal ensembles through Group P members' textual choices. Specifically, Anna, Daisy, and Effie created old brick walls (modes of texture and colour), while Caleb adjusted the environment to be dark and dusty (mode of colour). Effie designed the pond and staircase in the centre of the wall plane (mode of space), while Caleb created an intense beam of light coming from the centre of the pond (mode of space). In each of these ensembles, signs were made with specific modal features shaped by VW affordances, and each contributed to the textual function of this space as the labyrinth's goal (theme). Particularly, considering the framing effect of the walls, beam of light was assigned for "saliency" (Kress, 2006), which directed visitors' attention to the water in the presentation. Overall, these interconnected and interrelated signs were organized and operated as a multimodal ensemble, which became a navigational prompt to attract and orient visitors to this space. However, the interpersonal and textual meanings in this area constantly lead to the ideational meaning. Therefore, I conclude that Group P may have intentionally developed the ideational meaning more than others in this design, indicating their interest in how they designed the space to address the visitors.

The modal ensembles of the labyrinth's goal (underwater) in Screenshot 42 carry more textual than ideational and interpersonal meanings. As I examined the modes separately, I noted that the posters, rocks, light beam, and stairs were organized loosely within the bottom of the pond and were framed by the surrounding soil. As the sole

entrance, the staircase-oriented visitors to the bottom of the pond, which functioned as the end of the goal. The two glowing posters, which were arranged near the staircase, attracted visitors' attention. All the underwater elements visually connected to the goal above the water and the labyrinth, thus producing coherent textual meaning.

The design also had interpersonal effects. Caleb utilized the beam to lighten the impenetrable space, while Effie designed the staircase to provide permeability. She employed the glowing effect on the two figures (the skeleton and the clown) to evoke negative feelings. These semiotic binding choices provided student visitors with a sense of horror and fantasy with which many explored this space during the final showcase.

However, I observed that many student visitors had no idea what to expect from the space until Group P members told them to touch the posters to teleport. Therefore, the posters' communicative functions were underdeveloped because there was no ideational signifier. This suggests that the signs made with the modal features were not properly arranged and operated in the ideational meaning that Group P intended to present to visitors.

Studying the labyrinth's goal (underwater) reveals a display of Group P students' transformed virtual design, which produced coherence across their semiotic choices in interpersonal and textual meanings. However, the posters at the bottom of the pond were entirely devoid of any ideational meaning, which necessitates a rethinking of VW affordances in shaping junior designers' interests, purposes, and intentions. In this instance, VW technical constraints impeded these students' achievement of these purposes in a fully developed modal complex.

Sub-theme 4: Recontextualizing additional interpersonal meaning across the multimodal ensemble

Screenshot description

Screenshot 43 illustrates the heaven design in the final presentation: a visitor is standing on a large, pinkish cloud surrounded by glowing spheres, and two objects resemble planets (one is golden, and the other is bright yellow).



Screenshot 43. The heaven design

Patterns of attention

Making binding choices, recontextualizing, building modal ensembles, and developing interpersonal relationships

Interpretation

This multimodal communication (Screenshot 43) was recontextualized by Caleb, and the interpersonal meaning was carried mainly by his binding choices for comfort and joy. These choices were present in a unique arrangement of modes, such as colour, texture, light, space, and animation, which were afforded by the VW platform. As previous analysis has indicated, Caleb referenced the golden room from the movie to create the virtual heaven in the sky. He, therefore, made conscious choices to establish a feeling of security by enabling visitors to feel free, gentle, and spiritual. According to Group P's final presentation, Caleb purposefully designed a holy and magical environment, including pinkish clouds, luminous spheres, and bright golden planets with particle effects. Consequently, when the student visitors were teleported from the labyrinth's goal (the bottom of the pond) to the walkable clouds, they immediately felt free and joyful in this boundless space, in contrast to the restricted space of the labyrinth. When gazing at the overhead plane, student visitors found it magical, as the space was articulated through semi-transparent materials that outline the sky, such as glowing spheres and planets with moving and scattered particles.

These specific materialized modes were Caleb's binding choices to construct the interpersonal relationships between this virtual space and visitors' emotions and to recontextualize conceptual resources from "the originating site" (Bezemer & Kress,

2016)—the golden room of the movie. However, according to the final showcase, the textual effect was subtle, as many student visitors who did not watch the movie beforehand could not interpret the exact theme or purpose of the space. Additionally, student visitors had no idea what other specifically field-related activities they could perform in the space.

Overall, the textual and ideational meanings were not clearly distributed in Caleb's multimodal design, which may have been caused by VW technical constraints and the time issues. However, his design produced interpersonal effects that evoked playful and magical feelings for student visitors. Thus, Caleb demonstrated remarkable agency and resourcefulness in selecting specific VW modes and recontextualizing them into an innovative ensemble for his audience.

Sub-theme 5: Smooth coordination of the design team

Screenshot description

Screenshots 44 and 45 depict the design of the forest that was built behind the labyrinth. As Screenshot 44 portrays, the space is divided into two parts by the ditch. On the left side, there are dark green trees, brownish shrubs, and natural slopes. On the right side (Screenshot 45), mountain spikes were created to enclose the forest. A park with recreational facilities was added on the right side of the bridge; the park includes a white summer house and an arched garden gate with yellow-green flowers.



Screenshot 44. Forest design (Part 1)



Screenshot 45. Forest design (Part 2)

Patterns of attention

Coordinating, producing coherence, combining two communicative functions, managing VW affordances and constraints, and redesigning

Interpretation

The coherence of the multimodal ensemble was evident in the three distinctive domains of meaning, which reflects the smooth coordination of Group P, considering the individual members' motivating interests. As previous analysis has revealed, all Group P members participated in creating this forest by reworking and arranging a selection of pre-existing objects from the VCER inventory. Specifically, Caleb and Effie collaboratively assumed the primary responsibility of designing the centre area of the forest. Caleb first employed a sophisticated combination of terrain-editing techniques, including raising, lowering, roughening, and smoothing, to dig a ditch around the ground where he was motivated to create a park. Thus, the ditch was utilized as the framing device to mark the boundary of the field space. Caleb also applied similar terrain-editing techniques to create mountain spikes around the inner edge of the ditch to strengthen the park's outline. After that, Caleb shared his semiotic interest with other group members, and Effie volunteered for this design task. She purposefully selected some specific objects from the inventory, including a white summer house, a white garden gate, a white wooden bridge, a picnic blanket, and a small boat. Then she resized and arranged them in a particular spatial presentation within this framed space. Although Effie did not originally design these objects, she carefully selected and redesigned them to cohere with the elements created by Caleb and other members. Such a coherent multimodal ensemble produced considerable ideational meaning, as these modes jointly constructed visitors' experience in which field-related activities could occur here.

Additionally, Caleb made more creative choices in designing the park's location within their virtual environment. Specifically, he designed the park in the forest behind the labyrinth to produce a surprise for the visitors. During the final presentation, when student visitors found this park either by walking from the dark forest or by teleporting from the pond in the labyrinth, many of them were surprised and amused (interpersonal meaning) because they had just experienced intense and horrifying feelings in the other two locations. Concurrently, the elements in this space directed visitors to notice the key artifacts that Effie designed (as mentioned previously), thus presenting the textual function of the space as a recreational park.

By analyzing the forest design as a multimodal ensemble, I found that Group P members collaboratively created integrated, coherent, and creative meaning through their transformative engagement with VWs. Furthermore, I understood how the VW constraints, such as the sophisticated techniques for creating complex virtual artifacts, played a vital part in preventing these students from developing additional original ideas. However, in analyzing Group P students' collaborative design processes multimodally, I recognized their creativity, agency, knowledge, and learning in all means of meaning-making that would be difficult to identify based only on their final summative projects.

5.2. Ancient Chinese Immortal Town Group: Design in Style

The three units of the multimodal analysis revealed that the VW codesign practice enabled Group A students to creatively co-employ various unique VW affordances to design a Chinese culture-oriented environment with a distinct style drawn from their collective cultural experiences and identities. The data analysis also indicated that the multimodal affordances of VW technology sufficiently facilitated the design-thinking-oriented group activities, such as gathering and sharing information, framing opportunities, and reflecting and transforming the elements of earlier designs. These activities comprised the multimodal ensembles of a VW-integrated design classroom communication, which created a conducive space for students to explore, experience, interpret, analyze, and distribute their aesthetic strategies across various modes of their collaborative design-making process.

5.2.1. Virtual environments: Embodied avatars reconcile different semiotic interests









Sub-theme 1: Embodied virtual world explorations enable a shared understanding

Screenshots description

The snapshots illustrate how Group A students attempted to gather relevant information to define their goals through mediated avatars in the early stages of the collaborative design processes. Finn’s first snapshot (Screenshot 46) presents his avatar in a virtual medieval fantasy role-play environment, named *Avilion*, as a short-haired Black girl wearing a medieval purple gown. In this environment, Finn visits an ancient Greek temple shrouded in the dark mist and located in the desert. In Screenshot 47, Finn rides on a pumpkin carriage pulled by two unicorns outside the temple under luminous, sparkling trees. Screenshot 48 illustrates that Gena explores a Halloween-themed environment. In Screenshot 49, Gena’s avatar, a Black female avatar wearing a blue gown, rides a deer-like animal in a beach-themed environment. In Screenshot 50, Halley wears a pink skirt and a cloak while pushing a green spaceship through the sky above a dark, futuristic city. In Screenshot 51, Halley sits on a recliner on a sunny beach. Ivy explored a beach in the nighttime by gliding and surfing (Screenshots 52 and 53). Jessica made a virtual journey to ancient Greece, where she became a blond-haired girl wearing a pink skirt who visited grand Greek temples and palaces beside the sea (Screenshots 54 and 55).

Table 12. Group A members' virtual world screenshots from their Weeks 1 and 2 journals

Design-thinking-oriented activities in Week 1 and 2: SL exploration and discovery	
Finn	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Screenshot 46</p> </div> <div style="text-align: center;">  <p>Screenshot 47</p> </div> </div>

Gena	 <p>Screenshot 48</p>	 <p>Screenshot 49</p>
Halley	 <p>Screenshot 50</p>	 <p>Screenshot 51</p>
Ivy	 <p>Screenshot 52</p>	 <p>Screenshot 53</p>
Jessica	 <p>Screenshot 54</p>	 <p>Screenshot 55</p>

Patterns of attention

Utilizing embodied interactions and communication, redesigning avatars for self-presentations, gathering information, reaching a shared understanding

Interpretation

The snapshots presented confirm the conclusion reached in the first unit of analysis regarding the social effects of virtual environments on Group P's design

processes. In other words, the virtual environments provided Group A with embodied meaning-making opportunities in the early design stages, which resulted in a shared understanding and interpretation of the goal. Unlike Group P participants, who constructed their design challenge from a particular perspective (recontextualizing the Spanish movie *Pan's Labyrinth*), Group A members could not immediately define their goal because of individual members' different interests. Consequently, I encouraged the group to seek concepts in SL. The snapshots captured by Group A members demonstrated that they conducted some unplanned explorations in SL through their avatars in Week 1 and 2 of the course.

Similar to Group P, each Group A member chose avatars that were different than their actual identities in real life. This similarity in choice corroborates my Group P analysis: students were able to create meaning by redesigning the avatars to achieve their desired self-images. More importantly, utilizing avatars for self-presentations was a crucial part of enabling Group A students to gather a wide range of embodied semiotic resources to define their collective goal. Finn, for example, visited the virtual environment of Avilion, where he intentionally chose three modes (visual, gaze direction, and movement) to materialize his interests. In the mode of visual, he selected an avatar of the opposite gender and wore clothing suited to a medieval community. In the mode of gaze, he viewed the virtual spaces by continuously adjusting his avatar's perspectives via camera between third-person near and far views. In the mode of movement, Finn navigated the space by making his avatar teleport, walk, and sit. Therefore, his avatar was located and derived a part of its meaning as a sign from that location (Bezemer & Kress, 2016). The sign can, in turn, embody Finn's role-playing identity, which offers unique potential for an unceasing process of engagement within that virtual environment, resulting in transformative and creative changes in actions and meaning-making.

Gena's embodied VW explorations were not limited to the aforementioned modes but extended to the mediated social interaction. She explained in her Week 1 journal:

I sensed the spooky and scary atmosphere once I teleported into this virtual space. There was a vast and bottomless hole in the centre of this world. A few costume shops around the hole drew my attention, and I bought a witch costume using the SL dollars offered by my teacher. As I am a newbie to SL, the shop owner from New York taught me how to put on the costume. Even though my English is not so good, it felt fantastic to talk to another avatar from a different part of the world.

By choosing to purchase a costume and converse with another avatar, Gena was prompted to see, feel, experience, and reflect on the virtual environment through the modes of movement, gesture, image, speech, and space. Each of these shaped her mediated social and semiotic actions as well as the possibilities of her sign-making in response to prompts. These embodied interactions and communication exemplified virtual environments as social and multimodal, leading her to entirely different selections of relevant information in her transformative engagement.


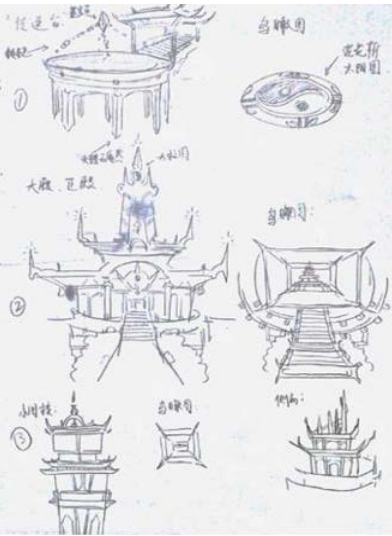
The remaining team members also made conscious choices to make signs in various modes, to recreate themselves and gather information based on their interests. As all of these signs were made by digitally mediated avatars, these embodied meaning-making processes provided Group A members with unique opportunities that transformed their inner resources for the subsequent sign-making as creative acts in their future design actions. In an in-class meeting at the end of Week 2, Group A members shared their gathered information from SL and reached a consensus on the design objective despite their different interests. The next section investigates this goal-framing process in detail.

Sub-theme 2: Interpretations of virtual worlds lead to goal-framing

Screenshots description

The two scanned images presented are the design drafts sketched by Finn. Figure 13 is the overall conceptual design proposal, which illustrates a group of traditional Chinese temples hanging on a cliff. Figure 14 portrays the individual parts of the design, including a pedestal base, the main temple from both front and bird's-eye views, and a pavilion from front, side, and bird's-eye views. A traditional Chinese yin-yang pattern with lotus flowers was drawn on the pedestal base's border.

Table 13. Finn's design draft from his Week 3 journal

Design-thinking-oriented activities in Week 3: Interpretation	
Finn	 <p style="text-align: center;">Figure 13. Finn's design draft (part 1)</p>
	 <p style="text-align: center;">Figure 14. Finn's design draft (part 2)</p>

Patterns of attention

Interpreting VWs, framing goals, choosing media, and choosing an aesthetic style

Interpretation

As the semiotic result of the first 2 weeks' VW explorations, the design draft sketched by Finn embodied his group's collective interests. In the in-class meeting, all Group A members expressed that they were impressed by the simulated ancient European fantasy cities that were impossible in the real world; they felt immersed when participating in the cities' events with other unfamiliar avatars as a group. However, concurrently, they were somewhat disappointed that they did not find any virtual environment that represented authentic Chinese culture. In a class meeting, these students reflected on their past Chinese cultural experiences and finally reached a decision as a team: an imaginary, traditional Chinese architectural environment that represented aspects of Taoist thinking. As the group leader, Finn assumed responsibility to sketch the design draft. He explained the design concept in his journal:

Achieving immortality has always been the highest pursuit of the ancient Chinese. In the Taoist thoughts, a man can ascend to heaven and become immortal through continuously cultivating vital energy. Deriving from this concept, we want to represent Taoist immortality and heaven by building a temple on a big dangling rock in the air.

Therefore, as illustrated in Figures 13 and 14, Finn sketched the design draft, including all the resources described above—VW explorations, previous cultural knowledge, and the meeting notes comprised Group A's definition of their goal. By choosing to explore SL's virtual environments via avatars, they were prompted by the embodied modal resources that grasped their attention; simultaneously, the different modal choices prompted different types of engagements with the virtual environments, which led to a process of integration in the group's inner resource transformation. The choices of signifiers that initiated the goal, including ancient Chinese hanging temples, the yin-yang-patterned pedestal, and lotus flowers, were the new sign complex that was transformed and transduced from the earlier VW signs that appealed to them, which were combined with their expanded inner cultural and aesthetic resources. The choice of medium (using sketching to illustrate the goal) also indicated an "epistemological implication" (Bezemer & Kress, 2016). Finn told me that, compared with other means of producing the representation, such as a crayon or a marker pen, utilizing a roller pen afforded a degree of graphic detail by allowing him to vary the fine lines.

Tracing and analyzing Group A's early design stages from a social semiotic view of multimodality demonstrated that the virtual environments fostered students'

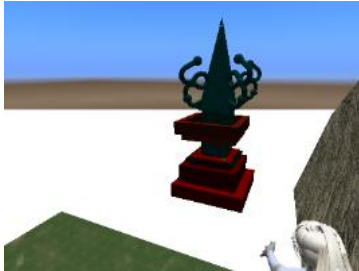




engagement, which enabled new meaning-making possibilities for goal framing. As Group A's goal was to construct a fantasy traditional Chinese architectural space, the design style derived from the virtual, digital form and meaning became prominent in their design processes. Therefore, in following sections, I focus on how Group A students' interests shaped their stylistic choices of meaning and form as motivated signs. I also analyze how VW affordances and constraints shaped this group's aesthetic strategies that were creatively distributed across various modes.

5.2.2. Virtual world affordances: Initiating ideas by making stylistic modal choices

Screenshots description

Gena's design journals include two snapshots documenting a work-in-progress incense burner that she designed during Weeks 4 and 5. Screenshot 56 presents a dark green cone shape with four curved lines as the burner's top. The incense burner bottom is made of a stack of multiple dark red squares in different sizes. Screenshot 57 reveals that the incense burner evolved into a relatively complex shape consisting of a sloping roof, a chest, and a base with a glowing blue cone shape. Halley's two snapshots illustrate the group's design tasks during the 2-week period. In Week 4 snapshot (Screenshot 58), an inverted triangle-shaped boulder (designed by Halley) is suspended above a grassland. A house-like structure with a two-layer red roof and two rectangular-shaped floors is floating above the boulder, and a bluish rock is floating in front of the house-like structure (designed by Ivy and Jessica). Surrounding the boulder, multiple cone-shaped rocks hang in the air; some are semi-transparent blue and shine brightly (designed by Halley). In the Week 5 VW snapshot (Screenshot 59), the boulder's edges are rounded, and its texture is evident. The house-like structure is now an architectural complex. The small bluish rock has become a mountain at the back of the architectural complex. The floating cone-shaped rocks have become glowing blue diamonds. A hanging bridge with luminous lights floats at the bottom of the architectural complex, connecting the boulder to something offscreen, and the original grassland is now a blurry green pattern. Ivy's snapshot, Screenshot 60, documents that she changed the temple top into a hip roof style (a traditional Chinese architectural design). Additionally, Gena's incense burner is floating right above the temple.

Table 14. Group A members' virtual world screenshots from their Weeks 4 and 5 journals

Design-thinking-oriented activities in Weeks 4 and 5: Ideation and experimentation in VCER		
Gena	 <p>Screenshot 56</p>	 <p>Screenshot 57</p>
Halley	 <p>Screenshot 58</p>	 <p>Screenshot 59</p>
Ivy	 <p>Screenshot 60</p>	

Patterns of attention

Making stylistic choices, changing frames of reference, collaborating, reflecting, producing coherence, managing constraints, reallocating design tasks, and redesigning

Interpretation

Unlike Group P, who initiated their ideas in the VCER in the early design stages, Group A students encountered building difficulties due to the complicated structural design in their draft sketch. However, these VW snapshots demonstrate that they worked around the constraints to make a creative leap in expressing their stylistic ideas collectively and coherently by utilizing particular affordances of the VW technology.

By gathering and sharing information in SL, Group A reached a shared understanding of their goal despite the different individual interests in the group. Finn assumed responsibility to concretize their collective interests in a sketchbook. These steps exemplified Group A members' creative autonomy and collaboration in deciding what they wished to present. However, after experimenting with these ideas for a few days in the VCER Sandbox, Group A students soon realized that they were overly optimistic about their VW design skills when they approved Finn's complicated design draft. Several of them reflected in their journals that the initial design concepts could only be fully elaborated in VCER if they could overcome considerable technical difficulties in building complicated 3D models with specific aesthetic details.

Although the building tools constrained these junior designers, some other VW modes prompted them to creatively reallocate their semiotic tasks. Ivy and Jessica were the first to learn how to creatively use specific VCER resources to serve their interests. After failing to produce the complex temple conceived in the design draft, these two sign makers chose a pre-existing house from the VCER inventory. They constantly disassembled, resembled, modified, and edited the house utilizing the content-creation tools, gradually transforming the house into a grand temple with a selection of colours, textures, shapes, structures, and styles that signify traditional Chinese architectural features (Screenshots 58 through 60). Specifically, Ivy redesigned the house roof into a two-level sloped roof with beams on the sides. This stylistic choice echoed the hip roof design she saw during her visits to the ancient Chinese grand temples and royal palaces (described in her journal), suggesting that her cultural experiences informed her interest in this particular aesthetic. This cultural interest provided the two sign makers with resources and then shaped their designs according to a particular style. Therefore, although Jessica and Ivy could not realize the complicated original design draft, utilizing the affordances of content-creation tools, they creatively chose to redesign a pre-existing virtual object to present characteristics of traditional Chinese architecture.

VWs allow users to change their frames of reference that alter the environments around them (Alahuhta et al., 2014). In Weeks 4 and 5, the impact of Ivy and Jessica's changing frame of reference inspired Halley to modify a range of modes in a pre-existing bridge by utilizing VW building techniques she had at hand. She enlarged the bridge's size (mode of size), connected the bridge to the temple's entrance in the air (mode of space), changed the original white colour to an earthy brown (mode of colour), extended

the length of the bridge piers (mode of length), and designed stone-textured triangular pyramids with glowing effects and then added them to the bottoms of the bridge piers (modes of shape and texture). Halley also applied a glowing blue effect to the floating cones to match the fantasy style of the bridge she designed (Screenshots 58 and 59). This changed frame of reference also caused Gena to refine her incense burner design to cohere with the genre and style of their collaborative project (Screenshot 57). She stated in her journal that she borrowed the stylistic concepts from ding (鼎, a bronze vessel utilized in ancient Chinese sacrificial ceremonies) and transformed the signifiers—rectangular, green-blue vessel, and cloud patterns—into her stylistic choices of the shape (rectangular) and colour (green) of the incense burner chest and four curved lines (patterns). Furthermore, she applied the same red colour as Ivy and Jessica's temple roof for the incense burner's base and copied the glowing blue cones (with Halley's permission) to the incense burner's base to match the elements produced by Halley (Screenshot 57). Consequently, this collaborative design project was initiated through an iterative and transformative process of designing and redesigning the modes of the virtual environment. In each of these modes, signs were made with specific modal features that signified the group's desired cultural aesthetics and fulfilled specific functions to match the signs produced by other members, thus constructing the coherent and interconnected meaning they wanted to achieve. Ivy explained in her design journal:

The challenges this week are not only the initiation of our design in the VW but also conveying a coherent meaning as a team. In other design classes, it is sometimes hard to collaborate with other classmates because some are reluctant to share their work-in-progress designs until they are satisfied. Even if they are willing to share their designs within the group, it is always challenging for other members to rework these designs because they are only for display. However, the VW allows us to observe other members' design processes in real time. More importantly, we can directly interact with each other's designs by copying, editing, and reassembling.

Overall, these inexperienced student designers were overly optimistic in estimating the difficulty of their defined goal, which resulted in their struggle to implement their ideas in the virtual environment. Nevertheless, after they had spent a relatively long period engaging with different VW modes, the affordances and constraints of this digital platform prompted them to explore their previous cultural experiences and knowledge and make creative choices. Ivy and Jessica were the first to act autonomously, reallocating their semiotic tasks to redesign the pre-existing objects in the

digital platform. By changing the frames of reference of their virtual environment, these inexperienced designers made a creative leap that allowed them to collaboratively initiate the actual design while embracing its reflections on each other's semiotic works and the surrounding virtual environment. These tasks demonstrated Group A students' agency as creative, collaborative, and reflective design learners; therefore, I expected a coherent design project with their desired style in the following weeks.

5.2.3. Completed project as motivated signs: Codesigning a coherent style by continually transforming modal ensembles

Screenshot description

Finn's Screenshot 61 illustrates a cyan-coloured lotus flower with many glowing, floating particles and a cone-shaped boulder floating on the water. Gena's first snapshot (Screenshot 62) presents the temple gate she designed during Weeks 6 and 7. It is similar to the classic Chinese resting hill roof with two curving sides. Under the roof, a golden plaque with the word *welcome* hangs from the gray beams. Underneath, a dark red beam is supported by two pillars of the same colour. Two textured, yellowish-green metal lanterns hang from each side of the roof, and an iron chain with many small, shining balls is draped between the two pillars. Taken from Gena's journal, Screenshot 63 utilizes a near-distance view to reveal the lantern details: multi-coloured particles float around the lantern.

Halley's first VW snapshot (Screenshot 64) documents her design tasks during the 2 weeks: a pedestal base and a hanging ladder. The pedestal base is set upon a relatively small conical rock directly below the temple. It contains four circular patterns in three colours: green, dark red, and yellow. In her second VW snapshot (Screenshot 65), which is another near-distance view, a ladder in the same colours is positioned directly above the pedestal base and connects to the bridge. Warm lights hang from the bottom pillars and the railings of the bridge. Halley's third snapshot (Screenshot 66) depicts her avatar hovering above the Chinese-style lamp she designed. The lamppost is the same dark red as the ladder and the bridge. On its top is a cylinder in the same yellow colour as the base pedestal. A round-shaped warm light hangs from the dark red rack with dark yellow, geometrically patterned structures.

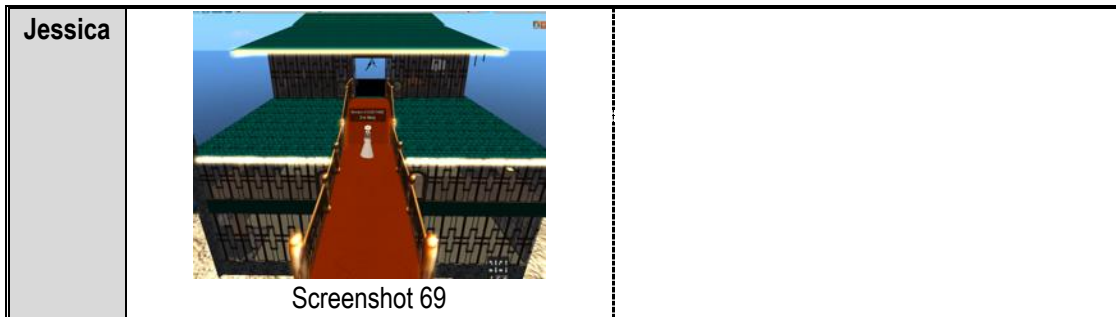
Ivy's first screen capture (Screenshot 67) reveals the changes she and Jessica made to the temple: the dark brown roof is now green, the second floor is now heightened, and the hollow triangle-shaped rooftop is now filled in with dark gray bricks. Ivy and Jessica also added another roof between the triangle rooftop and the second-floor roof. Furthermore, they designed three glowing golden strips inlaid around the three roofs' edges. Her second snapshot (Screenshot 68) presents the interior design of the temple's second floor: a podium and a whiteboard are arranged in front of a few golden benches, the windows are geometrically patterned, and a red bridge connects to the open door.

In addition to Ivy's snapshots, Jessica's journal also documents her individual design: a bridge connects to the temple's gate on the second floor. Jessica's avatar walks toward the second floor on a red carpet-covered bridge with golden railings (Screenshot 69).

Overall, these snapshots illustrate that Group A members quickly progressed in their designs, which led to the early completion of their project around Week 7. Consequently, the project they presented in the Week 8 final showcase did not significantly differ from that previewed in Week 7. Therefore, I selected eight virtual design artifacts from their completed design project displayed in their final presentations and combined these artifacts with the screenshots from their journals for Weeks 6 and 7 for the third unit of analysis. In doing so, I hope to gain critical insights into how this group creatively and collaboratively distributed their aesthetic strategies across various modes that were gradually integrated into coherent modal ensembles according to the group members' complex and sometimes conflicting motivating interests.

Table 15. Group A members' virtual world screenshots from their Weeks 6 and 7 design journals

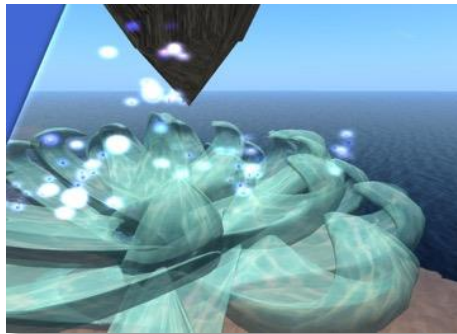
Design-thinking-oriented activities in Weeks 6 and 7: Experimentation and evolution in VCER	
Finn	 <p>Screenshot 61</p>
Gena	 <p>Screenshot 62</p>  <p>Screenshot 63</p>
Halley	 <p>Screenshot 64</p>  <p>Screenshot 65</p>
	 <p>Screenshot 66</p>
Ivy	 <p>Screenshot 67</p>  <p>Screenshot 68</p>



Sub-theme 1: Foregrounding the provenance of the signs

Artifact

The lotus flower (also see Screenshot 61)



Screenshot 70. The lotus flower in the final presentation

Patterns of attention

Engaging in collaborative design, foregrounding cultural provenance, redesigning, making aesthetic and stylistic choices, realizing interests and identities, and configuring multimodal ensembles

Interpretation

Led by Finn, all Group A members participated in creating the lotus flower. Although this object did not appear on the initial design draft, the group members made a collective choice in-class discussion to create a lotus under the floating boulder. Two sources of signifiers offered opportunities with which students could work. The first is common to all team members—shared cultural experiences. Finn explained in his journal: “In almost all the Chinese folktale and childhood fairy stories, there is always a

lotus flower either being used as decorations of the temple or the name of the celestial being.” Gena reflected on the classical Chinese mythological TV series, *A Journey to the West*, which she had watched many times as a teenager. Gene described one scene vividly in her journal: When Guanyin (the goddess of mercy), who sits on a beautiful lotus throne, descends from the sky into the mortal world. Ivy stated that the lotus flower is associated with Buddhism. Therefore, when these students became interested in visually connecting the temple to the floating boulder and the water, their shared and diverse cultural experiences foregrounded the “provenance” (Kress & Van Leeuwen, 2001) of the lotus flower from their childhood memories, and this reservoir of past knowledge prompted a collective design choice. Simultaneously, as these experiences were oriented around Chinese culture, this provenance also provided the students with aesthetics that shaped the style of the lotus flower they wished to craft, evoking the genre of traditional Chinese fantasy that they strived to construct.

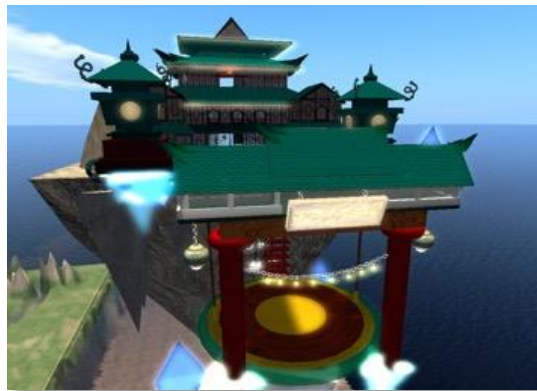
The second source of signifiers with which Group A worked is the VWs’ unique modal resources, which provided students with creative opportunities to materially realized the interests, identities, styles, and aesthetic values they wanted to pursue. Specifically, Group A decided to redesign a pre-existing object due to the difficulty of constructing a scripted, complex lotus shape on their own. After assessing all the available modifiable objects, Finn chose an animated mountain waterfall and then disassembled the object into different parts. By enabling the group editing function, all members participated in different design activities: they twisted and tapered a water stream into the shape of a lotus flower petal, changed the original colour into cyan, and duplicated the petal multiple times, rotating and configuring the redesigned water stream into a modal ensemble that reflected the style of the lotus flower they had seen previously. Gena also chose to redesign the sparkling purple particles she had designed for the lantern (Screenshot 63). She duplicated these particles, formed them into a round shape, and placed them to the right above the lotus flower. For her, these particles—made in the modes of colour, shape, texture, and animation—not only created a magical atmosphere appropriate to the group’s fantasy genre but also coherently echoed the style of the lantern within the multimodal semiotic entities. Concurrently, the particle editing functions (such as glow, burst radius, and pattern) and the 3D construction (as the VW’s embedded semiotic resource) also contributed to shaping a distinctively styled lotus flower that exists only in the VW platform.

Overall, these multimodal configurations reflected Group A students' ability to collaboratively shape a style they aspired to achieve. This ability was partially dependent on their reservoir of cultural experiences and knowledge to transform these ideas and partially due to the affordances and constraints of the VW technology. In particular, the affordance of allowing the group to simultaneously design enabled them to address some VW limitations and contributed to their creative autonomy and collaboration.

Sub-theme 2: Exploring unknown territories and returning with a creative and coherent ensembles

Artifacts

Temple's gate, incense burners, and lanterns (also see Screenshots 62, 63)



Screenshot 71. The front gate of the temple in the final presentation

Patterns of attention

Solving the conflicts and uncertainties, creating style and genre, addressing the audience, utilizing VW affordances, engaging with embodied semiotic resources, and re-collecting information

Interpretation

Screenshots 62, 63 and 71 illustrate how Gena capitalized on the VW affordances to explore unknown territories and return with creative and coherent designs, despite the conflicting interests of individual members. After completing the construction of the incense burner in Week 5, Gena immediately began the next design task: the temple's grand gate. In the original design drafts (Figures 13 and 14), the gate was separate but attached to the temple. However, before Gena started her task, Halley

and Jessica had built two suspension bridges connecting the temple's front and back doors without informing Gena, leaving no space for her to place the attached grand gate. In a meeting, the other group members agreed that re-constructing the front gate would jeopardize the construction they had already completed. Consequently, even if Gena preferred a new gate, her priority task was to resolve the conflict and achieve a constructive outcome. Gena wrote in her design journal:

I started to re-explore SL to find more helpful information. I visited many historical and cultural spaces, such as France, Japan, and England. I was especially amazed by a virtual environment called the 1920s Berlin Project, where a wide range of historical buildings made me feel the 1920s Weimar culture...I saw modern Bauhaus-style houses where a dancing event took place in a luxurious hotel. I also saw dirty and narrow streets with tiny apartments. I accidentally went into a bar in a damp basement where a few avatars were drinking beers. Such an engaging cultural experience inspired me to design a gate that can interact with the audience in a meaningful cultural way.

Returning with this valuable semiotic information from another virtual environments, Gena began to create the gate in the sky outside the temple within her group's land. Her sophisticated iterations of VW design techniques shaped the key features of the gate, including 3D object modeling, colouring, texturing, sizing, and applying particle effects. While Gena was not a student of Chinese architecture, she grew up around this type of cultural aesthetic, which offered her specific semiotic resources to integrate into the design. For instance, she purposefully chose signifiers, such as the dark red pillars, the dark green tiles, and the resting hill roof, to represent typical features of traditional Chinese architecture. Utilizing her past knowledge (as described in her journal), Gena intentionally chose even numbers that are favored in Chinese culture (such as 2, 6, 8, 10, and 12) to design the numbers of beams, lanterns, and incense burners, thereby conveying the traditional Chinese aesthetic value of symmetry. In her gate design, Gena used the signifiers of glowing, animated, and colourful particles to express this traditional Chinese fantasy cultural genre. She also repeatedly adjusted the gate's placement near other elements to achieve a spatial arrangement that optimally represented the desired style and genre for the assumed audience. In the end, she creatively placed the gate in front of all other constituent elements in their environment, which established its textual meaning to frame the space by creating a boundary between semiotic entities of the same kind and level. During the final presentation, this grand entrance with its distinctive Chinese style provided visitors

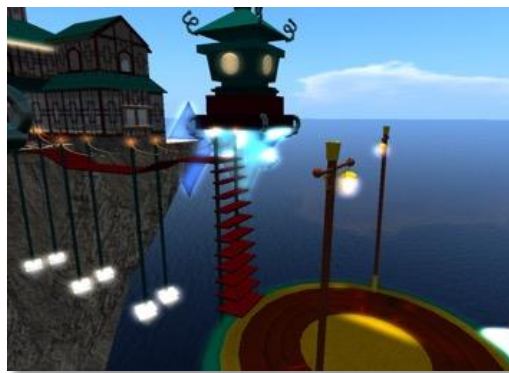
with ideational meaning and a strong interpersonal theme (Stenglin, 2009), unfolding their pathways and immersing them in the particular cultural space.

This analysis provides evidence that Gena's creative semiotic actions primarily resulted from her engagement with the VW platform. First, the virtually simulated Berlin in SL afforded her rich and embodied semiotic resources and potential to make meaning, suggesting imaginative and appropriate solutions to solve conflicts and uncertainties. Second, affordances, such as the content-creation tools and the ability to change the frames of reference, provided her with unique reflective opportunities to continually make stylistic choices that brought coherence to the contradictory interests among individual members, design purposes, and the assumed audience. Therefore, the VW design experience fostered her sense of agency as a creative and autonomous problem solver and team player.

Sub-theme 3: Solving problems by choice of ordering

Artifacts

The pedestal base, the suspension bridge and landing, and the lamp (also see Screenshots 64 through 66)



Screenshot 72. The side view of the temple

Patterns of attention

Prompting interpretations, utilizing avatars as visual and spatial references, transforming, producing a coherent and consistent style, ordering, and collaboratively developing and solving problems

Interpretation

The screenshots 64 through 66 and 72 reflect that VW affordances allowed Halley to turn problems into opportunities, bringing creative and coherent meanings into the semiotic entity. In the experimentation stage, as all the group members were continuously exploring possible solutions simultaneously, no concrete representation remained the same for long. For example, Gena was adjusting the placement of her incense burners while Jessica and Ivy were changing the angles of the temple to enhance the arrangements of Gena's incense burners and the gate. One of the problems that emerged from this ever-changing digital content was the lack of "ordering" (Bezemer & Kress, 2016) within the semiotic 3D virtual space. This problem did not become apparent until Halley attempted to solve it.

Halley spotted Gena's work-in-progress gate in front of her bridge while working on her design tasks. She interpreted that Gena's gate was composed of the modes of shape, colour, and spatial placement (Screenshot 64). Consequently, Halley's interpretation expanded her inner resources and prompted her to explore possible solutions. Specifically, although the initial design draft included a yin-yang-patterned pedestal base, it did not explain how to achieve it nor where to place it. Utilizing the VW content-creation tools, Halley selected a primitive geometrical shape (sphere) to create the pedestal base.

Moreover, in considering a coherent style for their project, Halley decided to abandon the original yin-yang pattern (commonly portrayed in black and white) and selected three colours (green, red, and yellow) to match the colours of other elements. By utilizing her avatar to ensure that the design was to scale, Halley purposefully placed the pedestal base in the lower space between the suspension bridge and the front gate (Screenshots 62 and 64), promoting an interconnected relationship between these two elements in the spatial composition. Halley also designed a wooden ladder in dark red and green colours and placed it above the pedestal base under the bridge to connect all the elements within the temple's entrance area, establishing a path to regulate visitor flow (Stenglin, 2009). Additionally, Halley continued to refine the entrance area by designing two lamps, utilizing the traditional Chinese wooden geometric patterns in dark red colour (Screenshot 66) and placing the lamps on each side of the bridge. She explained in her journal:

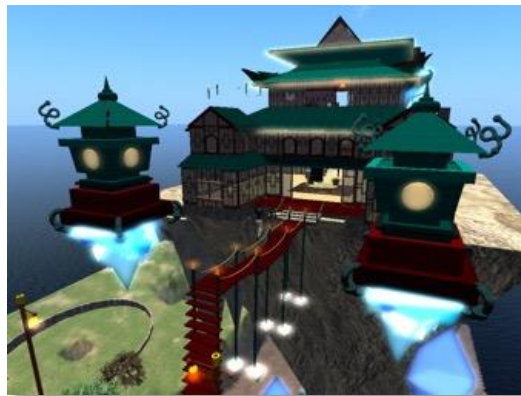
One of the great things about designing in the VW is I can literally walk and fly around my designs and other members' designs. I used my avatar as visual and spatial references to make a scale and create the pedestal base to order the front gate and the bridge in a more connected way.

Therefore, this demonstrates that the VW affordances provided Halley with unique opportunities to assert her creative and autonomous agency, prompting her to contribute coherence and consistency of style to the overall meaning through a process of semiotically selecting, transforming, evaluating, and ordering the signs in specific ways. This process also allowed her to explore a new understanding of what it may mean to be a problem solver in a collaborative design environment.

Sub-theme 4: Continual refinements lead to transformation

Artifact

The temple (also see Screenshots 67 through 69)



Screenshot 73. Overview of the temple in the final presentation

Patterns of attention

Continually refine and assess designs, simultaneously collaborating on design, transforming and transducing cultural aesthetic values, and producing multimodal ensembles of coherence

Interpretation

The VW Screenshots 67 through 69 and 73 illustrate that the VW affordances supported Ivy and Jessica's continual refinements and improvements, leading their meaning-making process to distinct transformations and transductions. The temple

design was substantially developed Weeks 6 to 7 compared to previous weeks, although these two group members did not stop adjusting their current design. This personal commitment primarily resulted from their design interests, which were supported and motivated by the VW affordances. For instance, Ivy made deliberate stylistic choices of particular colours to craft a convincing traditional Chinese temple. She explained in her journal: “We need to construct the temple of red walls and green tiles because many of the ancient Chinese palaces and temples look like this.” Jessica’s creative autonomy and collaboration were also empowered by the VW content-creation tools. Based on what Ivy had constructed, Jessica stretched both ends of the roof into curved lines to signify a cornice, a traditional Chinese architectural element. Jessica reflected in her journal:

I do not know what type of traditional Chinese architecture we are building as none of us are experts or students studying architecture. Nevertheless, we are happy that we wound up with a style that is pretty Chinese from our point of view.

In addition to the roof design, the other stylistic choices of the temple’s key features also demonstrate their autonomous and collaborative creativity as Jessica and Ivy progressively refined and evaluated their goal to create a meaningful and coherent multimodal construct (Screenshots 67 and 68). Specifically, Ivy made significant changes to the pre-existing, European-style, arched-top windows. She applied a series of sophisticated VW design techniques, including traditional Chinese geometric patterns, texture editing, and 3D structural design. She also filled in the window frames with glass that emphasized the dark red geometric patterns. Concurrently, Jessica heightened the second floor and added another roof on top of the two existing roofs to emphasize the grandness of the temple. Ivy later designed three luminous golden strings to trim all the roofs’ edges and applied a similar golden colour to the benches and stairs on the second floor, which added a fluent fantasy element to the stylistic organization. Additionally, Jessica constructed a dark red, floating wooden bridge with glowing golden railings that connected to the gate on the second floor, which provided coherence to the colour scheme and the fantasy genre. In Screenshot 69, we see her avatar walks on the bridge to examine what has been completed so far. Ivy reflected in her journal:

I employed the ancient Chinese emperor’s colour—gold—and designed the glowing effect on all the roofs’ edges and the second floor’s interior to represent a sense of sacredness and fantasy. Because I had not got better ideas for developing the second floor yet, I just kept

experimenting with it bit by bit in case a good concept emerged from the construction process. Luckily, Jessica located some problems and made improvements later on.

Through continual refinement, the two sign makers, Ivy and Jessica achieved the goal of conveying their semiotic interests in shaping a temple in the traditional Chinese architectural style. During this process, the signifiers utilized by the two members derived both from their cultural knowledge and the VW technology. Although the original design drafts did not provide any specifications for a solution, they prompted the subsequent engagement and explorations. The first prompted action was Group A members' recalling cultural memories of aesthetics, which offered Ivy and Jessica the resources (such as red walls, green tiles, the resting hill roof, geometric window patterns, and golden colour) to design the style for which strived. The second prompted action was a process of innovatively transforming and transducting their cultural aesthetic values into new forms of sign complex, which was shaped by their engagement with the VW affordances, including changing the frame of reference and the simultaneous design collaboration.

With each sign created, Ivy and Jessica utilized their avatars as visual and spatial references to make embodied assessments of the aptness of each other's semiotic works, and those assessments shaped their subsequent requests for the semiotic realization of the particular stylistic virtual composition. With each request-and-response iteration, Ivy and Jessica innovatively responded through the signifiers of integration in inner and technological transformation, thus prompting future semiotic actions. Concurrently, with each cycle, their inner resources were expanded and transformed. They learned more about each other, which eventually prompted them to engage in creative meaning-making interaction. This iterative and modifiable cycle of action and response provided the freedom to experiment with their ideas. Together with the spatial and visual awareness afforded by their avatars, the VW design practices empowered these students' creative agencies at both the individual and team levels, transforming their monomodal stylistic articulations into multimodal ensembles of coherence.

5.3. iCloud City Group: Design to Win

The findings derived from the Group I case study demonstrated a relatively bumpy VW design process in which student members were challenged by multiple difficulties, such as an infeasible design draft, a design concept similar to another group's idea, technical proficiency, and the pressure of maintaining pace with the other two groups. However, the multimodal analysis revealed the remarkable resourcefulness of these students in creatively toggling between designers, collaborators, critics, audiences, and interpreters to produce new and coherent forms of meaning. These multiple role participations were prompted by both VW multimodal affordances and constraints, which were enhanced by the design-thinking-oriented group design practices and TAE pedagogies, providing expansive opportunities to foster creative, agentive autonomous, collaborative, and reflexive design learners.

5.3.1. Virtual environments: Embodied modal resources for conjectures





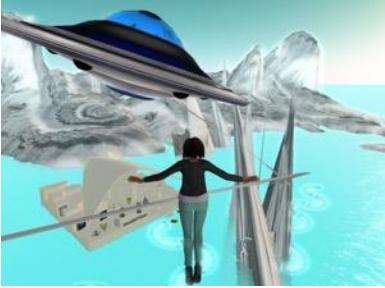
Sub-theme 1: Embodied engagement with virtual worlds transforms students' semiotic resources

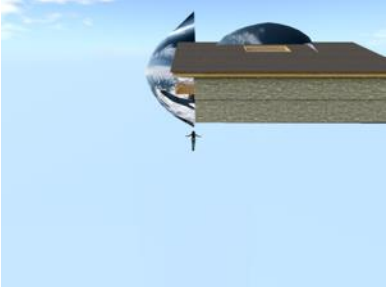
Screenshots Description

The snapshots illustrate Group I students' exploration in SL during Weeks 1 and 2. In Screenshot 74, Kaden appears as a female avatar with a bobbed haircut walking toward a gated garden in a fantasy-themed virtual environment. The garden is dark, and the flower-patterned lamps scatter purple light on the shrubs while wisps of smoke floated around. Screenshot 75 presents that Leah's avatars visiting a virtual space called *Unicorn Forest Sanctuary*. She uses the same avatar as Kaden, floating toward a dragon statue on the edge of a high cliff. In her second snapshot (Screenshot 76), Leah's avatar sits relaxing on a beach, arms outstretched with her elbows resting on her knees, as she turns her head to watch a herd of unicorns galloping on the horizon. Megan also documented her visit to a surreal virtual environment named *InterstellArt*. Her first VW snapshot (Screenshot 77) illustrates a silver spaceship-like object with round purple patterns and four white spires hovering above the water as icebergs float in the background. Screenshot 78 features Megan's avatar (same as Kaden and Leah) flying toward a spaceship, which is above an ocean, icebergs, and some irregularly

shaped buildings. In Screenshot 79, Nina’s avatar is a fairy dressed in pink and wandering on a quiet forest path at night. The garden is full of flowers and lights. Screenshot 80 presents that Olivia’s female avatar with bobbed hair, similar to her teammates. She is in a space where a chalet floats in the sky. In this snapshot, she is flying near the back of the chalet, finding that the snowy landscape, when seen from inside the chalet, is an illusion created with curved surfaces.

Table 16. Group I members’ virtual world screenshots from their Weeks 1 and 2 journals

Design-thinking-oriented activities in Weeks 1 and 2: SL exploration and discovery	
Kaden	 <p>Screenshot 74</p>
Leah	 <p>Screenshot 75</p>  <p>Screenshot 76</p>
Megan	 <p>Screenshot 77</p>  <p>Screenshot 78</p>

<p>Nina</p>	 <p>Screenshot 79</p>	
<p>Olivia</p>	 <p>Screenshot 80</p>	

Patterns of attention

Engaging with embodied resources, gathering information, framing the goal, and prompting interests

Interpretation

The SL exploration snapshots taken from Group I students' journals are similar to the other two groups' explorative activities. In other words, they collected various VW modal resources through their mediated avatars and then transformed the resources into the design draft. At the beginning of the course, when these inexperienced design students knew that they would need to self-initiate a group virtual design project and complete it by the end of the course, most of them had no idea what to design or what to expect from VWs. Therefore, I encouraged all students to explore virtual environments in SL for inspiration. Unlike the other two groups, the snapshots from Group I students do not indicate significant enthusiasm for designing their avatars. The majority chose to utilize the basic avatars to signify their presence. However, the avatar-mediated nature of VW explorations provided these students with a special lens for embodied engagement with the virtual environments, which constantly transformed their inner resources and hence their subsequent actions to define their goal. For instance, all members explored different virtual environments via their avatars and a modal mixture of

gaze, movement, gesture, sound, and animation. Kaden (as a Black female avatar) and Nina (as a fairy) applied a third-person, near-distance view that moved in a specific direction to indicate what captured their attention (Screenshots 74 and 79). Moreover, Leah, Megan, and Olivia chose the same Black female avatar (Screenshots 76, 78, and 80) and employed a third-person, long-distance view while flying toward specific objects that embodied their interests to tell the audience (their group members and me) where to look. Furthermore, Leah's avatar is seated with her arms resting on her knees as her head tilts in a near-view direction; she is listening to birds chirping to express her interests in this particular space (Screenshot 76). In Screenshot 78, Megan's avatar's hair is frozen. She utilized a first-person, far-distance view of the spaceship to suggest her focus of attention during her exploratory activities.

In each example, through their avatars, these students consciously chose from specific modes that were uniquely afforded by the specific virtual environment to make signs with different modal features derived from that environment. Each mode they chose provided distinct semiotic resources, which allowed an increasing approximation in their interpretation (Bezemer & Kress, 2016) and understanding of that virtual environment. Leah reflected in her journal: "Sitting on the beach listening to the birds singing made me feel refreshed, and at the same time seeing those unicorns flying by, make me feel even surreal." Megan also explained in her journal:

Once I stepped into this world, I was surprised to find that my hair had turned into ice... in this world, I felt like I was an alien taking a spaceship to outer space...I really like it here because it is completely different from the real world.

Therefore, these modal complexes created by Group I students provide compelling evidence that VW environments offer unique and embodied modal resources for engagement based on the agency of the sign makers, which prompted their knowledge expansion and transformation toward framing their design goal. Consequently, when Group I members shared their gathered information with other group members in an in-class meeting at the end of Week 3, they efficiently clarified their goal: creating a modern version of a traditional Chinese quadrilateral courtyard in an imaginary multi-gravitational space. Kaden explained in the group's creative brief:

Before exploring SL, our group thought of building a traditional Chinese quadrangle courtyard to represent some aspects of our culture. However, these virtual environments blew our minds. We do not want

our audience to feel that our virtual quadrangle is the same as the real world. So, when Olivia reflected on her virtual experience in a vacuum space, I immediately shared my explorations in an imaginary stimulated space of London, where glass-made skyscrapers were everywhere. Other members also spoke about how they directly interacted with the objects in the immersive imaginary worlds through their avatars. Therefore, we quickly achieved consensus in defining our goal of creating a modern-style Chinese quadrangle in a multi-gravitational space.

Sub-theme 2: Engaging with a repertoire of recourses to frame the goal

Screenshot description

In Week 3, Olivia used a digital drawing tablet to sketch a series of lofts on a mountain in the traditional Chinese architectural style for her group. On the left side of the sketch, we see the Chinese characters 玻璃 (glass) annotates the picture.

Table 17. Olivia's design draft from her Week 3 journal

Design-thinking-oriented activities in Week 3: Interpretation	
Olivia	 <p>Screenshot 81</p>

Patterns of attention

Creating a style, choosing media, and utilizing a repertoire of semiotic interests and cultural experiences

Interpretation

Olivia assumed responsibility to externalizing the group's idea onto a design draft utilizing her digital drawing tablet (Screenshot 81). By choosing to draw the resting hill

roofs, Olivia prompted herself to identify the signifier—traditional Chinese resting roofs—as an essential part of the houses. Different choices, such as the organizational structure of the houses (a clustering structure), the placement of the houses (above trees), the use of colour for trees only, the arrangement of flying birds at the top margin, and the Chinese connotations (glass walls for the houses), could have prompted her to engage differently with a repertoire of her group’s interests, her VW experiences, and cultural knowledge for transformation and transduction. Furthermore, her choice of utilizing a digital drawing tablet as the medium to produce the representation also provided Olivia with a unique opportunity to engage with its stylistic instruments, thus achieving a degree of graphic details for future sharing and building in VWs.

Although Group I did not follow this proposal in the subsequent design process, Olivia’s creation of “something may be” (Cross, 2011, p. 34) is an appropriate starting point for a journey of exploration and is central to its design. Why did Group I not follow their original design draft? How did the VW affordances prompt this group of students to make creative choices in producing modal ensembles that developed both problems and solutions? The following two units of analysis explore these two questions.






5.3.2. Virtual world affordances: Unleashing students’ competitive urge to negotiate challenges through a continual meaning-making process

Sub-theme 1: Working around the constraints in negotiation with others

Screenshot description

The snapshots present Group I members’ ideation and prototyping processes during Week 4. In Screenshot 82, Kaden appears as a king-like avatar wearing a golden crown and a red cloak. His avatar hovers in midair to build a stone-textured foundation as he arranges buildings in specific patterns. Screenshot 83 suggests that Leah’s responsibility for Week 4 was planting trees. In Screenshot 84, Megan becomes a blond female avatar who wears a white crop top and jeans. Her avatar is redesigning the terrain with a lake and mountains with Leah’s participation. In Screenshot 85, Nina appears as a black-haired female avatar who wears a blue blouse and a black skirt and hovers in the air to design the buildings, rocks, and trees. Screenshot 86 illustrates Olivia’s design task for Week 4: building a floating pavilion.

Table 18. Group I members' virtual world screenshots from their Week 4 journals

Design-thinking-oriented activities in Week 4: Ideation and experimentation in VCER			
Kaden		Leah	
Megan		Nina	
Olivia			

Patterns of attention

Redesigning, interacting in real time through avatars, transforming and transducing, collaborating, and managing technical difficulties and the uncertainty

Interpretation

The ever-changing multimodal ensembles created in the VCER during the prototyping stage reveal how this digital platform provided Group I with opportunities and constraints to construct meaning in members negotiations, which enhanced the team coordination and creative interaction. Similar to the other two groups, the difficulties in producing complex 3D shapes soon emerged when Group I began their VW design

tasks. They realized that the initial expression of their goal was not technically feasible since the forms drawn on the tablet would be overly complicated to be developed in the VW platform within an 8-week course. However, Group I inventively worked around the constraints of the platform to redesign these modal resources to serve their interests.

As the Week 4 snapshots suggest, four group members participated in building the main structure. Kaden made a design choice by using the content-creation tools to build a rectangular, stone-textured foundation at a particular level in the air to establish a space that frames the elements to be created. While constructing, Kaden's avatar flew around the foundation to gain direct visual and spatial references to achieve the representation that served his interest (Screenshot 82). By interpreting Kaden's semiotic work, Leah and Nina shared the responsibility to jointly construct buildings, rocks, and trees on the foundation made in this synchronous, multi-user virtual environment. Although they did not originally create these elements, the two members consciously selected a range of VW modes, such as contemporary buildings (style), gray rocks (texture), and green trees (colour), and redesigned them into different sizes and shapes as they wished (Screenshots 83 and 85). Leah and Nina's avatars are seen in these images flying around the foundation, arranging these elements to optimally represent their group's interests—creating a multi-gravitational architectural space. Concurrently, Olivia utilized the content-creation tools to construct a floating pavilion that connected to the foundation through stairs. She also chose the design for the roof, matching the gray stone and the colour and textures of the elements produced by other group members (Screenshot 86). In the original design brief, Group I intended to build a modern version of a traditional Chinese mountainside quadrilateral courtyard. The modal ensembles portrayed in Screenshot 84 reflect Leah and Megan's active and collaborative agency in assuming responsibility to transform the terrain into hills, bulges, and a lake. They also chose a pre-existing white wooden bridge and placed it over the lake.

With this modal ensemble, an imaginary multi-gravitational environment of the Chinese quadrangle was remade in a VW simulation with elements that served the needs of Group I students at the moment of their meaning-making. These needs were temporal and ambiguous since they did not know what design they would achieve by the end of the course, as they had yet to manage their technical difficulties and the uncertain nature of the design processes. As Kaden explained: "I don't know where we are heading to since we only reworked on the pre-existing objects." Nina also reflected in her

journal: “There was no breakthrough this week. We have not solved the problem of creating the script for the multi-gravitational space. We just copied these houses, trees, and rocks and redesigned them a little bit.”

Although the VW constraints of limited Group I’s means of creating their design in Week 4, the description of their semiotic works reveals the commitment and smooth coordination in the design group. Each group member was an active agent who, in negotiation with others, continuously contributed partial meaning to the final result. This negotiation process involved transformations and transductions of the design draft into a VW simulation by framing, selection, and arrangement, which were supported by the VW affordances, such as real-time, avatar-mediated activities, multimodal communication, and the changing frame of reference. Such a process promoted students’ creative team interaction as they jointly sought opportunities to advance their project during the design processes.

Sub-theme 2: Maintaining parallel meaning-making for sudden enlightenment

Screenshots description

In Screenshot 87, Kaden’s avatar is seen creating a new foundation in the air. Additionally, he adds new buildings on various sides of the foundation and places them in an intricate pattern. Screenshot 88 illustrates that Leah also participated in creating and arranging the buildings with Kaden. In Screenshot 89, Leah appears as a female avatar wearing a red crop top and a miniskirt; the image portrays her disassembling a pre-existing animated mountain for future use. Screenshot 90 presents Megan’s avatar placing a waterfall on the mountain that she and Leah previously designed. Screenshot 91 displays two cartoon characters that Nina created: a Doraemon (from a Japanese manga series) and SpongeBob (from a U.S. animation series).

Table 19. Group I members virtual world screenshots from their Weeks 5 and 6 journals

Design-thinking-oriented activities in Weeks 5 and 6: Ideation and experimentation in VCER		
Kaden	 <p>Screenshot 87</p>	
Leah	 <p>Screenshot 88</p>	 <p>Screenshot 89</p>
Megan	 <p>Screenshot 90</p>	
Nina	 <p>Screenshot 91</p>	

Pattens of attention

Experimenting ideas, collaborating in a shared space, competing, maintaining parallel work, interpreting, reflecting, and reformulating the goal

Interpretation

The snapshots for Weeks 5 and 6 revealed certain VW affordances urged the students to persist in producing modal ensembles to experiment with ideas, resulting in sudden enlightenment for the reformulation of the design challenge. As mentioned previously, designing in VWs is significantly different from designing on almost every other kind of graphic design platform. This is because VWs support synchronous and asynchronous avatar-based design collaboration in shared virtual spaces. Although competition was not the intention of this course, Group I members reflected in their journals that they felt competitive to win after learning that Group A had already made substantial progress on a virtual project with a similar theme. They also felt pressured when members of the other two groups repeatedly flew into their group's land for a quick peek at what they were constructing. This reflection demonstrates the VWs' affordances in prompting Group I's interpretations of Group A's working progress and the other two groups' interactions with their project, which transformed Group I's inner resources and subsequent actions. For instance, with Leah's help, Kaden removed all the designs he had previously built and then constructed a new foundation on which the buildings were intricately arranged (Screenshots 87 and 88). In his journal, Kaden wrote:

I deleted all the designs I created before. I then built a new foundation, selected a few buildings, and rearranged them into different positions to emphasize the concept of multi-gravity. We want to distinguish our design from Group A's.

This is evidence of how the shared space, as a VW mode with unique affordances, created a competitive atmosphere that motivated Kaden and Leah to make new meaning to improve their current design.

A similar example was found in Megan and Leah's collaborative meaning-making processes. As the designer of the ground, Megan intended to design an anti-gravity waterfall. However, due to the difficulties of building a scripted object, she redesigned a pre-existing object by extracting all relevant elements from the inventory and placing them in the VCER Sandbox for screening. Megan invited Leah to join her design task. After the class, both members entered the same virtual space from different real-world locations. Utilizing the voice and text communication tools, they cooperated and selected a mountain with animated waterfalls. They then disassembled the mountain, removed one waterfall, and redesigned it to the desired shape. To emphasize the design concept

of anti-gravity, the two members placed the newly made waterfall upside down at a particular position on the hill they had previously built (Screenshots 89 and 90). Megan explained in her journal:

The pressure from our peers became intense. We have to develop something new and interesting to catch up with the other groups. We have not given up on our initial goal yet; we are just keeping our design activities going. We hope to come up with some creative ideas quickly.

Therefore, although Group I still continually alternated between the solution concepts and problem explorations, this relentless pressure caused by VWs enabled every Group I member to bravely manage this uncertainty by maintaining a “parallel working” (Cross, 2011) process of sign-making as continually made improvements at different levels. Notably, Megan and Leah’s design practices also highlighted VW affordances, such as copresence and multimodal communication, in facilitating real-time interpretations of each other’s embodied semiotic actions, which also enhanced team-level creativity in the collective meaning-making processes.

Nina also maintained parallel working by continuing her quadrangle codesigning task. However, she concurrently began experimenting with some new ideas in the VCER Sandbox (Screenshot 91). She reflected:

We have been continuously adjusting and developing the quadrangle this week, and I think we will not build traditional Chinese architecture and only keep the concept of fantasy ... I created two cartoon characters in Sandbox, and I also found a script for spinning on a website and added it to my Doraemon so that he can fly with his propeller.

It may seem that Nina’s designs—the two cartoon characters (Doraemon and SpongeBob)—came from flashes of inspiration. However, in a social semiotic account, her expressions of new concepts were expanded and transformed insights or “prompts-as-signs” (Bezemer & Kress, 2016, p. 37). Amid a competitive atmosphere, all Group I members made continual improvements according to their motivating interests. Therefore, the design processes were not static but were ongoing, unceasing processes of meaning-making. They intensively engaged with the VWs to explore the solutions and the problems, and every group member, including Nina, experienced her knowledge base being continually renewed and transformed, which eventually led Group I to abandon the traditional Chinese architecture and reinterpret their goal. Nina’s designs were the semiotic results of such an interpretation. The fictional cartoon characters,

Doraemon and SpongeBob, were the signifiers she utilized to satisfy her group's interests in building a modern virtual environment, which was achieved as a sign of creativity through the multimodal affordances of the VW technology.




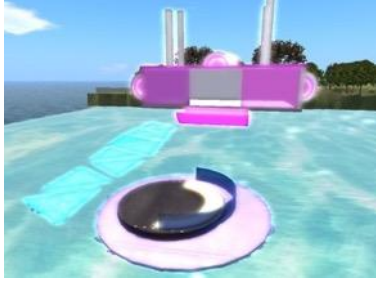

Nina's experiments quickly attracted the attention of other group members. The two cartoon characters simulated their childhood memories of watching the cartoons in which the characters featured. This recent aesthetic of the computer animations not only connected to previously created elements of the genre (digital imaginary stories) but also offered the potential for meaning-making with a social effect. This effect was evident when Group I re-visited SL and examined modern fantasy virtual environments for inspiration. Consequently, the sudden enlightenment occurred when the whole group found a futuristic world in SL. In other words, they reached a consensus to create an iCloud City to represent an everyday digital lifestyle. Megan reflected in her journal: "We felt excited, and our passion was instantly rekindled when we stepped into a futuristic sci-fi world in SL." This critical and creative decision was the turning point for Group I to finally refine their goal of arriving at feasible and meaningful solutions, which may not have been achieved without the group's transformative VW engagement.

Sub-theme 3: Transforming the newly established goal through detailed implementation

Screenshots description

These snapshots document Group I's new cycle of prototyping progress during the final 2 weeks of the course. In Screenshot 92, we see Kaden's avatar hovers in the air in front of his design, which includes a cloud-shaped foundation that has a bouncing effect; three pink boards; purple stairs; blue carpet, a small, black-and-white round base; and a few buildings on the top of the cloud. Leah's snapshots (Screenshots 93 and 94) present her avatar standing before the texts (*welcome to you*) that she designed on the two pink boards. Screenshots 95 and 96 illustrate Megan's design outcomes during Week 7. They include a flowing sea; a bouncing pink-and-white spaceship; and a round, black lifting stage. Screenshot 97 displays Nina's black-and-white robots with an animated bouncing effect as they float around the cloud foundation.

Table 20. Group I members' virtual world screenshots from their Week 7 journals

Design-thinking-oriented activities in Week 7: Experimentation and evolution in VCER		
Kaden	 <p>Screenshot 92</p>	
Leah	 <p>Screenshot 93</p>	 <p>Screenshot 94</p>
	Megan	 <p>Screenshot 95</p>
Nina	 <p>Screenshot 97</p>	

Patterns of attention

Producing semiotic change, encouraging transformative engagement, making stylistic choices, producing coherent modal ensembles, resourcefully managing constraints, implementing details

Interpretation

In the VW snapshots for Week 7, significant semiotic changes appear across the modes of Group I's project, which were directly related to the students' transformative engagement with the VW affordances. After reformulating their goal, every group member worked intensively in their virtual environment to compensate for the lost time. For instance, Kaden utilized the content-creation tools to entirely remove his previous designs for a second time. Then, he redesigned a bouncing foundation in a cumulus cloud shape with a low front and a high back. By utilizing the VW spatial affordance, Kaden concretized the original design concept of multi-gravity by stacking the buildings and trees randomly at the high back end of the foundation. He also arranged a rectangular board on each side of the low front and created stairs that connected with the carpet behind the boards and the small round base in front of the building so that they could unroll a pathway for visitors. As stated previously, Group I's design goal changed to represent a futuristic and cheerful ambience. Therefore, Kaden consciously utilized the digital semiotic resources of fluorescent neon colours: ultraviolet for the stairs, bright magenta for the boards, electric indigo for the carpet, and glowing white for the cloud foundation to increase vibrancy and contrast (Screenshot 92).

In Leah's VW snapshots (Screenshots 93 and 94), her avatar stands before the white glowing texts, which she created on Kaden's two bright magenta boards. The text was grammatically incorrect because Leah was not proficient in English; however, they revealed Leah's creativity in circumventing the VW constraints to work with Kaden in designing an entrance that also filled a "way-finding function" (Stenglin, 2009) for visitors.

Several robots are moving up and down around the cloud foundation (Screenshot 97). Nina utilized the VW content-creation tools and the script editing function to create these animated figures. Notably, her semiotic construct, including contrasting fluorescent neon colours, conjoining basic geometric shapes, and the bouncing effect, was similar to Kaden's designs, which echoed the stylistic choices made by many recent science-fiction computer animations. Kaden reflected:

The course is approaching the end, and we are working very hard to catch up with other groups. Since our goal was finally defined, we are now trying to express our idea with our visitors in mind...We created a

bouncing effect and used bright neon colours for almost every object to make our environment look more vibrant and futuristic.

Another effort was the semiotic transformation from Megan. Screenshots 95 and 96 indicate that she transformed the visual information she gathered from a virtual science-fiction environment in SL in the initial design stage—the spaceship and the flowing sea (Screenshot 77)—into the same mode, yet with distinct realizations. She changed the original colour of the spaceship into semi-transparent neon pink and added a bouncing effect to the redesigned spaceship. She also edited the pre-existing grass ground into a sea with a flowing motion. Additionally, Megan designed some bright teal triangles that were placed underwater to produce eye-catching patterns with a monochromatic colour scheme. However, she settled for four white cylinders on the spaceship, as she could not create animated icicles with the scripts. Megan also constructed a bouncing platform utilizing similar fluorescent colours. She wrote:

I was inspired by InterstellArt, the sci-fi space in SL. However, while constructing the terrain in our land, I found another group also transforming their land into a sea. Therefore, I created some triangles of the neon teal colour to distinguish our sea from theirs. Unfortunately, I could not figure out how to create a freezing animation in our world.

As stated previously, Megan’s spaceship and sea designs borrowed stylistically from the elements of another virtual environment. However, she innovatively deployed signifiers afforded by VWs, such as neon colours and the bouncing effect, to transform these elements by adding new meanings and aesthetic values to match the style of other group members’ semiotic works. Although the VW constraints circumscribed Megan’s designs, she demonstrated her resourcefulness by utilizing other affordances to create meaningful expressions in a competitive atmosphere.



As every group made significant weekly progress in their designs, this analysis provides evidence that Group I members were driven by a competitive spirit to transform their newly defined goal through detailed implementation, arriving at a coherent modal ensemble with a distinct style that focused on their interests and potential audience. This transformation was the inevitable outcome of their engagement with different modes of VW technology, which suggests students’ creativity in all of these design instances of sign-making.


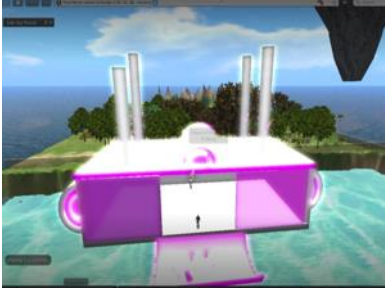

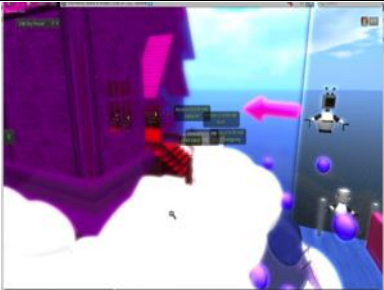
5.3.3. Completed project as motivated signs: Continuous improvements through coherent ensembles

Screenshots description

These snapshots illustrate the design of Group I's iCloud City in the showcase at the end of the course. Screenshots 98 through 100 document improvements Kaden and Leah made in Week 8. Screenshot 98 reveals that the colour of the main building on the cloud foundation changed from dark gray into bright magenta. Screenshot 99 exhibits bouncing houses, minibuses, tables, desks, and sofas that were piled up against each other on the sides and the rear of the main house. Screenshot 100 portrays the bright red and magenta interior design of the main building; pianos bounce ups and down here. Screenshot 101 indicates that Megan added a pink particle effect to the four pillars on the top of the spaceship. She also created a transparent water curtain flowing behind the cloud foundation from the top of the main building to the sea below (Screenshots 98 and 99). In Screenshot 102, avatars stand on a bouncing platform created by Nina. This black circular platform has a neon pink border and floats by the side of the cloud foundation. Additionally, Nina designed some fluorescent purple balls and a neon pink arrow with a bouncing effect and arranged them around the front area of the main building (Screenshot 103).

Table 21. Group I's completed virtual world project screenshots from their final presentation

Design-thinking-oriented activities in Week 8: Final presentation in VCER	
Kaden and Leah	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">  <p>Screenshot 98</p> </div> <div style="text-align: center;">  <p>Screenshot 99</p> </div> </div>

	 <p>Screenshot 100</p>	
<p>Megan</p>	 <p>Screenshot 101</p>	
<p>Nina</p>	 <p>Screenshot 102</p>	 <p>Screenshot 103</p>

Patterns of attention

Continuously transforming, integrating coherent forms and meaning, utilizing multimodal and embodied means, freely make meanings, collaborating, and circumventing VW constraints

Interpretation

Group I's consistent motivation to create their iCloud City was seen in their constant meaning-making processes throughout this VW-integrated design course. As previously described, the challenges in framing feasible problems and solutions caused Group I to fall behind in their design schedules. With the other two groups significantly progressing, Group I felt the time pressure to develop a detailed design to showcase in the final session. The snapshots chosen from their presentation indicate that all group members devoted their time to continuously improving and adjusting the main exhibition

area—the cloud foundation design. Kaden continued to refine his designs by changing the colour of the main building from dark gray to bright magenta to cohere with the semiotic entities produced by other group members (Screenshot 98). He and Leah collaboratively selected particular pre-existing objects from the inventory, such as modern houses, sofas, desks, and minibuses, redesigning each piece to desired sizes, painting them with different neon colours, applying animated bouncing effects, and organizing them in a disorderly fashion on the sides and rear of the main building (Screenshot 99). In addition to designing the exterior, Kaden assumed the responsibility of independently changing the original interior colours of the main building into a fluorescent neon colour scheme that included bright red, magenta, and ultraviolet. Furthermore, he added the bouncing scripts to the musical instruments—pianos and a drum set—and arranged them in two rows on either side of that room for visitors to play (Screenshot 100). Nina utilized the content-creation tools to create bright purple balls that moved up and down above the cloud foundation. She designed a large, bouncing magenta arrow that pointed to the main building (Screenshot 103). Megan made her effort by redesigning a pre-existing mountain waterfall into a transparent water curtain behind the main building to frame all the elements on the cloud foundation (Screenshots 98 and 99).

These different design tasks resulted in motivated signs that were shaped by these sign makers' interest in combining the forms and the meanings of each design. These forms, such as the shapes, colours, sizes, textures, and animations, were the signifiers created in VW modal complexes to ideally express the meaning and style the group wished to communicate. In other words, Group I shaped a futuristic and cheerful virtual environment for an audience. Their signs were continuously redesigned and reshaped by engaging with different VW modes to satisfy their collective interest and the potential audience's needs. Therefore, I conclude that the VW platform continuously motivated Group I members to dedicate themselves to their semiotic works, enabling their creative agency to constantly improve, even at the end of the course. As Leah wrote, "In VCER, we can destroy and reconstruct our designs, no longer worry about the cost, and no longer worry about deconstruction being irreversible. We can try different materials and methods again and again until we are satisfied."

To convey an integrated and coherent meaning, the sea designer Megan added the pink particle effect to the four white pillars on the spaceships to cohere with other

neon pink elements in their iCloud City (Screenshot 101). She and Nina also wished to create a UFO stage that could transfer visitors from the sea to the front gate of the cloud in the sky. Therefore, after class, these members spent days and nights building the stage that would perform their desired function. However, due to the technical and time constraints, they settled for teleportation from the spaceship to the bouncing stage floating in front of the cloud (Screenshot 102). As Megan reflected in her journal:

We kept building our project in our free time. Although we constantly stayed up late, it did not feel like a burden. Everyone was at the computer and turned on our microphones to work together. It did not matter if we were in our pajamas or eating meals. In VCER, we were always ready and in a good mental state. We were immersed in designing our very own world of imagination. Even though we did not achieve exactly what we wanted in the end, we all felt we became closer to each other and our teacher.

This is another example of how the VW technology motivated and engaged this group of students throughout the collaborative design processes, allowing them to maneuver autonomously and imaginatively while collaborating within the limits of the resource. Although the final project deviated from their original objective, Group I students demonstrated their collaborative creativity by continuing to leveraging the VW designing constraints into opportunities, producing coherent meaning that was transformative and innovative.

5.4. Summary

In Chapter 5, I applied a multimodal social approach to analyze the VW processes and completed design projects of three different groups. The design processes were documented in each student's VW screenshots and the accompanying weekly design journals, while the completed design projects were recorded in each group's final presentation VW screenshots. For each group, I employed the concept of three characteristics of a sign—environments, affordances, and the motivated relation of forms and meanings—to frame three units of a fine-grained multimodal analysis. Each analysis served as a case study to examine each group of students who creatively and collaboratively worked through the design-thinking process, exploring the virtual environments, exploiting VW affordances, and developing their multimodal codesign projects as motivated signs.

The findings indicate that multimodal analysis constitutes an effective approach and a student-centred alternative assessment for recognizing and analyzing each group of students' varied semiotic processes of transformative engagement with multimodal VW codesign practices. Those diverse forms of transformative engagement revealed diverse types of creative collaboration among students, who resourcefully made modal choices to represent what each group wanted to convey. Each multimodal analysis identified one prominent theme for each group: (a) design to recontextualize (Group P), (b) design in style (Group A), and (c) design to win (Group I).

The first theme—design to recontextualize—that emerged from the Group P case study demonstrated how the members—Anna, Ben, Caleb, Daisy, and Effie—acted as creative agents who co-employed VWs' available modes to recontextualize the Spanish fantasy horror film, *Pan's Labyrinth*, into a new digital multimodal ensemble. According to Bezemer and Kress (2016), the concept of recontextualization involves “the re-presentation of the meaning-material in a mode apt for the next context, in the light of available modal resource” (p. 75). By examining the codesign processes and the completed project of Group P as recontextualized multimodal ensembles, I recognized their diverse types of creative collaboration as they jointly exploited the distinct meaning potentials of modes available in VWs for design opportunities, compared the semiotic resources of the two mediums, and redesigned the resources from the original medium of a movie production into a new virtual medium.

The process of recontextualization constitutes an ongoing semiotic practice of transformation and transduction of signs and sign complexes, which occurred throughout their multimodal codesign stages. With each sign transformed or transduced, the meaning-making possibilities of VWs for Group P students vastly expanded, which motivated them to continuously explore, interpret, communicate, and codesign their VW.

The second theme—design in style—demonstrated that the VW design practice encouraged Group A students to use their creativity to codesign a virtual environment centred on Chinese culture, derived from their collective cultural experiences and identities. Using distinctive VW multimodal affordances, the students made collaborative modal choices to produce modal ensembles with a style appropriate for the traditional Chinese mythological film culture and their childhood folktale narrative, from which they drew inspiration. The complex multimodal ensembles comprising the lotus flower, the

temple, the podium, the floating boulder, and other artifacts reflected the concept of the social semiotic principle of *provenance* developed by Kress and Van Leeuwen (2001).

That concept provided sign makers with semiotic potentials to be constantly remade as new signs, indicating VW affordances for Group A students to creatively foreground that provenance they strive to achieve in collaboration. In addition, the three units of the multimodal analysis revealed that the VW codesign practice was able to engage Group A students in several of IDEO's (2012) design thinking activities, such as information gathering and sharing, opportunity framing, and reflecting on and modifying design aspects from previous iterations. Those activities provide user-centred, accessible structures and collaborative approaches that are widely used to address complex and uncertain design challenges in a creative manner (Cross, 2006; Lawson, 2006). Consequently, this analysis captured the affordances of a VW-integrated design classroom for creating a safe and enjoyable environment for students to experiment with, evaluate, analyze, and develop the aesthetic style they claimed during the collaborative design-making processes.

The third theme—design to win—derived from the multimodal analysis of the Group I case study indicated that their VW collaborative design processes that were riddled with obstacles, such as an impractical design draft, a design concept similar to another group's design goal, a lack of technical proficiency, and the pressure to keep up with the other two groups. Particularly, Group I students felt pressured when they realized they needed to reconstruct their design, while at the same time observing other groups' rapid design progress via avatars.

The analysis, however, revealed the remarkable resourcefulness of the students in circumventing those material and social constraints to create an iCloud City that represented their creative capacity to codesign a preferred virtual environment through their motivated choices of VW semiotic modes. Drawing on Kress's (2003) multimodal literacy, Walsh (2007) illustrated how groups of students were able to use their various creative capitals to showcase their web-based multimodal designs as their new practices of literacy, thereby transforming their existing understanding as they engaged in a continuous process of personal and social development. Similarly, the analysis showed that with VW affordances, Group I students were able to creatively shift between being designers, collaborators, critics, audiences, and interpreters throughout their codesign

processes. Those multiple roles of participation prompted Group I students to persist in experimenting with ideas and to share and reevaluate knowledge with their peers and the teacher. That ultimately resulted in sudden enlightenment for reformulation of the design challenge as they engaged in an ongoing transformative process in which the changes they made contributed to their individual and collaborative development.

Chapter 6. Research Findings: Transformative Engagement in Virtual World-Integrated Collaborative Design Learning

6.1. Overview

My aim in Chapter 6 is to answer the second main research question: How might the multimodal pedagogical approach in conjunction with the TAE framework create transformative learning opportunities through VW-based collaborative design processes? Utilizing the second research question as a guide, I examined student participants' responses to the TAE-framed post-pre assessments and interviews regarding their VW-supported collaborative design learning experiences. Each emergent category and theme that developed clearly connected to the research question. The data, based on participants' responses to post-pre assessments, revealed students' positive perceptions of changes in valuing the VW design pedagogy to learn design fundamentals and promote their creative collaborations in relation to the three TAE learning capacities: engaged agency, connection, and values and beliefs. Utilizing the constant comparative method (Maykut & Morehouse, 1994), the data, based on participants' open-ended interviews, portrayed four dominant themes that offered additional insights into students' views of VW-based design learning, engagement, and creative collaboration. Many aspects and elements of the four themes connected to the three primary TAE learning capacities. Therefore, I listed each theme to the right of its accordant capacity to demonstrate students' transformative engagement, as experienced in their VW design practices (Table 22).

Table 22. Themes that emerged from the analysis of participants' reflective interviews

Key TAE learning capacities	Emergent themes
Engaged agency	<ul style="list-style-type: none">• Building design thinking skills• Developing avatar-mediated multimodal designs
Connection	<ul style="list-style-type: none">• Transforming from team-based learning communities to a class-based learning community
Values and beliefs	<ul style="list-style-type: none">• Developing a sense of empowerment

Particularly, In Section 6.1, I first provide an overview of the descriptive statistics derived from the average means of the post-pre assessments to demonstrate each group's perceptions of changes in three intended TAE learning outcomes after completing the VW-integrated design course (Figures 15 through 23). In Tables 24 through 32, I offer each group's mean and standard deviation (SD) of their before- and after-course ratings in the specific TAE learning outcome to understand the group's score variables. Next, I present the top means scores for each group demonstrating the greatest difference in three TAE learning capacities and interpret them separately (Figures 24 through 26), suggesting the most significant perceived impact of the VW-integrated design course on creative collaboration associated with each TAE learning outcome. Filtered through the TAE framework, in Section 6.2, I interpret the four dominant emergent themes from the semi-structured interviews and explains how they relate to the three fundamental TAE capacities needed for creative development. Then I summarize and compare the interview findings to the post-pre assessment results to achieve a more complete and holistic understanding of students' perceptions of changes in valuing VW-based design learning for creative collaboration.

Overall, the iterative comparison of the two data sets revealed all students reported positive changes in valuing VW-integrated design learning for fostering an engaging environment, developing their design thinking skills, facilitating creative collaboration, and increasing critical awareness of their own and others' abilities and achievements. These elements are closely linked to TAE's key learning capabilities, which empowered them to advance to the next level of design learning and manage more complex design challenges.

6.2. Groups' Mean Scores for the Key Transformative Arts Engagement Learning Capacities

All items in the post-pre survey revealed various levels of increases that reflected participants' perceptions of changes in their design learning and TAE capacities, indicating a successful implementation of VW technology in art and design education. As demonstrated in Table 23, the three groups' average scores of mean differences derived from their responses to the engaged agency items were similar (0.6 for Group P, 0.7 for Group A, and 0.8 for Group I). The average scores of each group's overall mean differences in connection items were 0.4 for Group P, 0.7 for Group A, and 0.8 for Group

I. As for the values and beliefs items, the average scores of each group’s overall mean differences were 0.3 for Group P, 0.5 for Group A, and 0.9 for Group I.

Table 23. Each group’s mean differences in three key transformative arts engagement learning capacities

Groups	Engaged agency items	Connection items	Values and beliefs items
Group P	0.6	0.4	0.3
Group A	0.7	0.7	0.5
Group I	0.8	0.8	0.9

6.2.1. Engaged agency items

The greatest difference between the before-and after-course means in engaged agency items scored by all three groups was Item 4 (Figures 15 through 17): “I have developed a working knowledge of concepts and technical skills needed to facilitate my understanding and creation of effective and artistic visual compositions.” For this item, both Groups P and A had a mean score of 2 before (“Sort of true for me”) and a mean score of 3.4 after the course (between “Mostly true for me” and “Very true for me”), resulting in a mean difference of 1.4. Although Group I had a lower mean score of 2.4 (between “Sort of true for me” and “Mostly true for me”) after the course, their mean score of 1.2 (“Not very true for me”) before the course made Item 4 have the highest mean difference score (1.2) in their group and the second-highest difference in the total participant mean scores for the engaged agency items.

Furthermore, as shown in Tables 24 through 26, each group’s after-course mean score on engaged agency items was higher than its before-course mean score, and each group’s after-course SD value was lower than its before-course SD value. More specifically, Group P had a mean score of 3.07 on the before-course items and a mean score of 3.65 on the after-course items. This group’s before-course ratings had an SD of 0.72, whereas their after-course ratings had an SD of 0.28. The significant difference between the two SD values revealed Group P students had more consistent ratings on the after-course items than the before-course ones. In addition, Group A students had a mean score of 2.75 on the before-course items and 3.45 on the after-course items. Moreover, their scores on the before- and after-course items produced SDs of 0.53 and 0.33, respectively, suggesting Group A students scored more consistently on the after-course items. In Group I, students’ average after-course ratings exceeded 0.83,

compared to their before-course ratings. The SD results (0.47 for the after and 0.68 for the before) indicated Group I had slightly more consistent scores than their before-course ratings for the engaged agency items.

Overall, all groups had higher mean scores on the after-course items than on the before-course items, indicating positive changes in students' perceptions of the impact of the VW-integrated design pedagogy on their development of O'Neill's (2012a, 2014) engaged agency, a key TAE learning capacity for creative collaboration. The SD results showed all three groups' after-course scores were more tightly clustered around their respective after-course means, indicating each group had a similarly shifted understanding of the development of their engaged agency capacity for creative collaboration. Notably, the three group's post-pre ratings of the engaged agency items indicated their collaborative creativity in resourcefully utilizing VW affordances to coconstruct their preferred designs, despite having no prior learning experience with digital design technology. They engaged deeply with their knowledge and skills within the VW-integrated design course and purposefully transformed their existing design knowledge and skills into their own design practices. Through the continuous process of transformative engagement with their multimodal designs, these participants became empowered to exert their agency and make creative meanings that had personal significance for them and addressed the interests of others as members of a learning community.

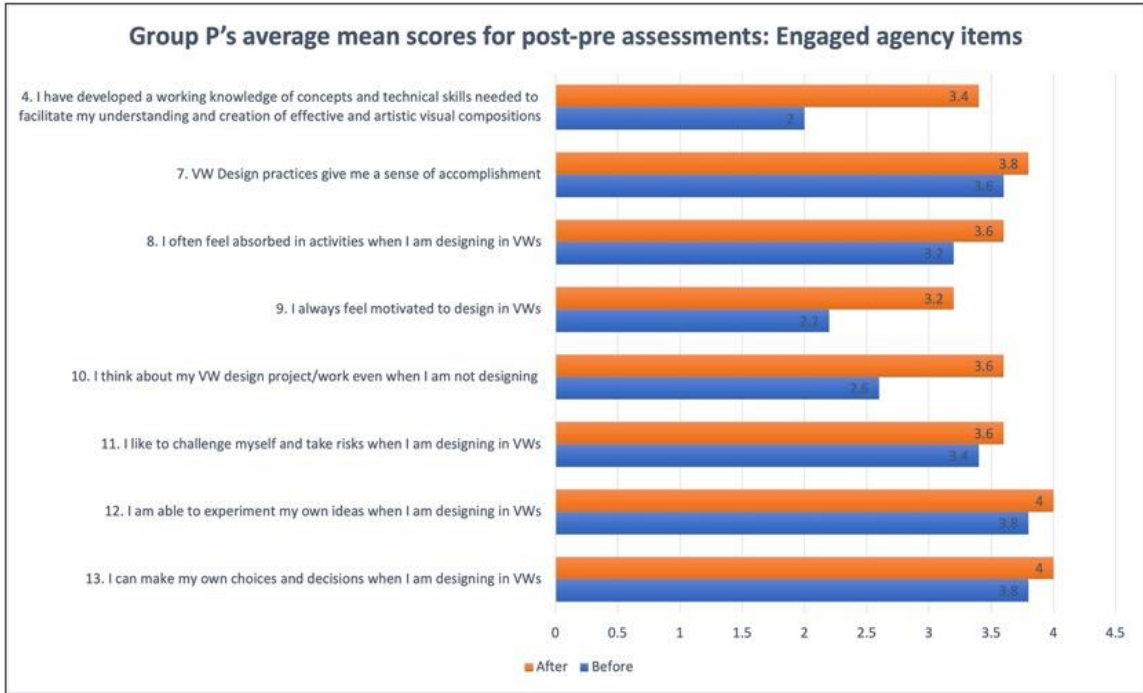


Figure 15. Group P's means for post-pre assessments: Engaged agency items

Table 24. Group P's means and standard deviations for engaged agency items

Engaged agency (Group P)	n	Mean before	SD before	Mean after	SD after
	5	3.07	.72	3.65	.28

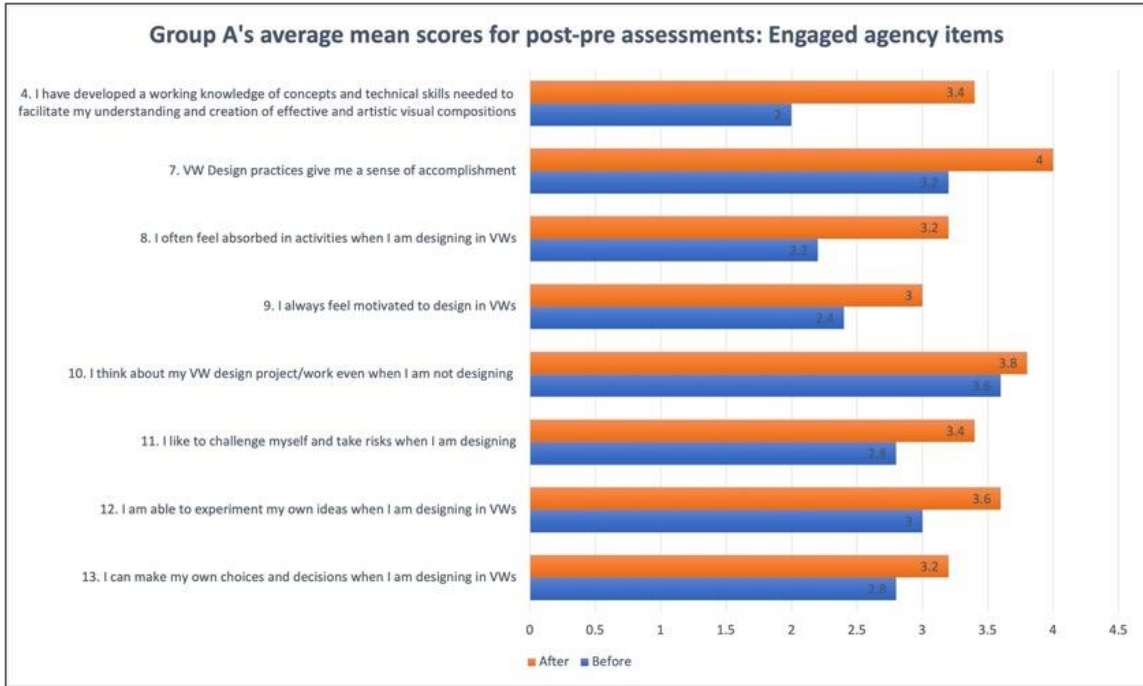


Figure 16. Group A's means for post-pre assessments: Engaged agency items

Table 25. Group A's means and standard deviations for engaged agency items

Engaged agency (Group A)	n	Mean before	SD before	Mean after	SD after
	5	2.75	.53	3.45	.33

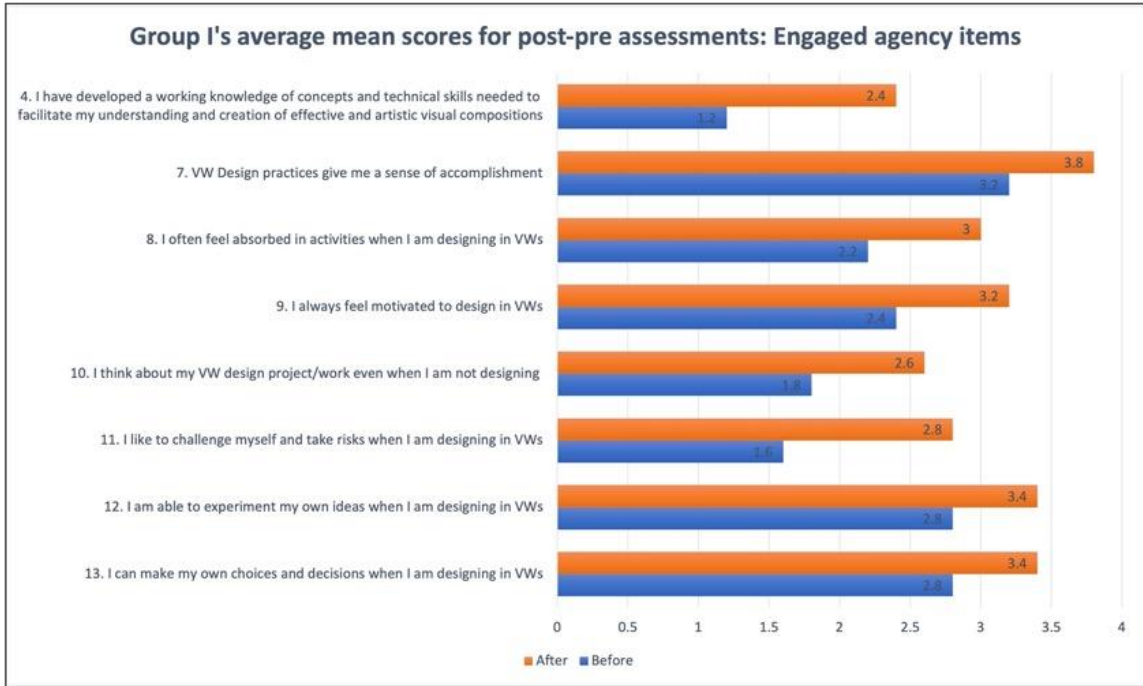


Figure 17. Group I's means for post-pre assessments: Engaged agency items

Table 26. Group I's means and standard deviations for engaged agency items

Engaged agency (Group I)	n	Mean before	SD before	Mean after	SD after
	5	2.25	.68	3.08	.47

6.2.2. Connection items

The highest mean difference score found in connection items was for Item 1: “I think it is interesting to explore design principles and elements through VW design practices” (Figures 18 through 20). For this item, Group I had a mean score of 1.8 before the course and a mean score of 3.4 after the course, resulting in a difference of 1.6 (Notably, this was also the highest mean difference score in all three TAE capacity items). Group A had a mean score of 2.8 before and 3.8 after the course, which is a difference of 1.0, making it the highest difference from Group A participants’ means in the connection items. Although Group P had only 0.6 for the mean difference score for Item 1, this value was the highest in connection items within their group.

The mean scores and SD results yielded from the three groups' post-pre responses to the connection items are comparable to those derived from their answers to the engaged agency items (Tables 27 through 29). More exactly, Group P's after-course mean score (3.78) was 0.35 points higher than their before-course mean score (3.43). This group's before-course ratings had an SD of 0.29, whereas their after-course ratings had an SD of 0.20. The small difference between the two SD values suggested Group P students rated consistently on before- and after-course items. In addition, Group A's mean score on the before-course items was relatively low, at 2.98, compared to their after-course mean score (3.68). Moreover, this group had SD values of 0.39 and 0.25 on before- and after-course items, respectively, indicating Group A had marginally more consistent scores on the after-course items. Similarly, Group I had a relatively low mean score (2.81) on the before-course items but a high mean score (3.57) on the after-course items. The slightly lower SD value of 0.27, derived from after-course ratings compared to 0.55 produced from the before-course ratings, demonstrated Group I students scored more consistently on the connection items after the course.

As noted in the literature review, VW technology was not initially developed for design. In this research, I purposefully employed design thinking, multimodal, and TAE pedagogical approaches that leveraged various VW affordances to design (Kalantzis & Cope, 2010b; Kress, 2010) an environment that facilitated student creative design collaboration. According to the findings presented above, all students' perspectives on the influence of VW collaborative practices on the development of their sense of connectedness changed positively and consistently as a result of the connections they were able to make between design learning, other learning across disciplines, peers, and the teacher changed consistently. The findings also provided formative feedback that assessed the effectiveness of the VW design pedagogy to foster a community of practice (Lave & Wenger, 1991) in which students experienced a strong sense of connectedness within positive relationships and experiences, and learning became a source of motivation and personal and social significance (O'Neill, 2017). Within such a community, students were more motivated to exploit VW multimodal affordances for innovative solutions and felt more valued and supported. Consequently, they gradually "[found] themselves at the centre of the learning process" (O'Neill, 2012a, p. 173) and developed their collective learning identities and agency, which encouraged more expansive and creative

multimodal choices for not only achieving their goals but also reformulating themselves with a growth mindset.

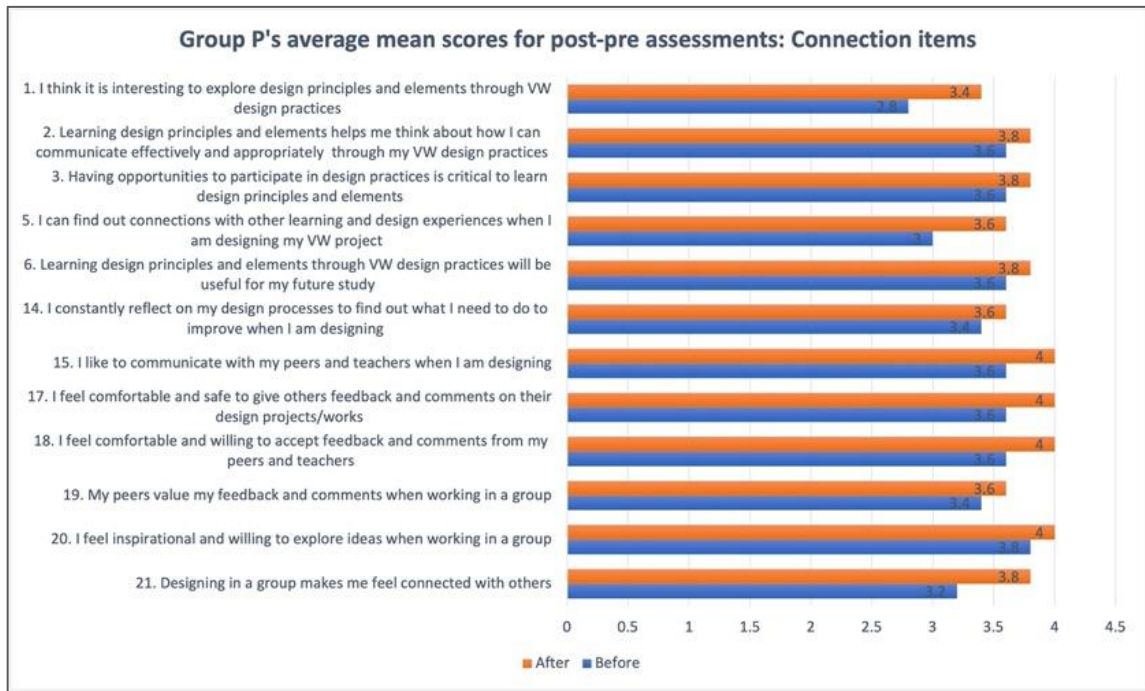


Figure 18. Group P's means for post-pre assessments: Connection items

Table 27. Group P's means and standard deviations for connection items

Connection (Group P)	n	Mean before	SD before	Mean after	SD after
	5	3.43	.29	3.78	.20

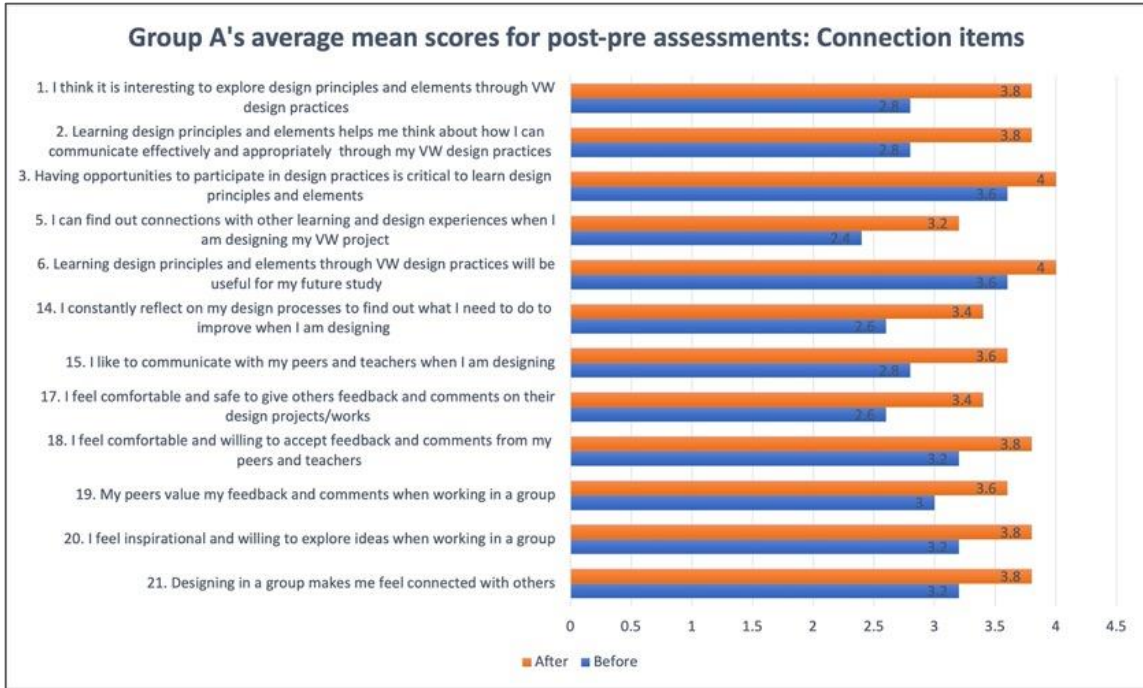


Figure 19. Group A's means for post-pre assessments: Connection items

Table 28. Group A's means and standard deviations for connection items

Connection (Group A)	n	Mean before	SD before	Mean after	SD after
	5	2.98	.39	3.68	.25



Figure 20. Group I's means for post-pre assessments: Connection items

Table 29. Group I's means and standard deviations for connection items

Connection (Group I)	n	Mean before	SD before	Mean after	SD after
	5	2.81	.55	3.57	.27

6.2.3. Values and belief items

Among seven values and beliefs items (Figures 21 through 23), the highest difference from the total participant means was identified for three items (Items 22, 24, and 26), with a difference of 1.4, all of which were achieved by Group I. In Item 22, “When designing in a group, being able to collaborate with others is important,” Group I participants had a mean of 2.4 before and a mean of 3.6 after the course. Their mean was 1.6 before the course for Item 24 (“I think I am good at designing”) and 2.8 after the course. For Item 26, “I feel my VW design project/work is creative,” they reported a mean of 1.8 before the course and a mean of 3.0 thereafter. The findings revealed Group I students’ perceptions of themselves and others as creative individuals changed the most after participating in the collaborative VW design practice, indicating a transformative learning experience may have occurred. For the other two groups, the highest difference from Group A participants’ means was found for Item 16:

“Communication with peers and teachers is an important part of designing”; the mean difference was 0.8. Moreover, Group P participants mainly rated values and beliefs items as true for themselves on all before-course assessments (from 2.8 to 3.8), resulting in small changes in mean scores for all values and beliefs items (from 0.2 to 0.4).

Tables 30 through 33 exhibit the mean scores and SD results of the three groups' post-pre responses to the values and belief items. Specifically, Group P obtained a mean score of 3.31 before the course and 3.65 after the course. The SD result for this group was 0.38 before the course, whereas, after the course, it was 0.32. The slight difference (0.06) between the two SD values revealed Group P students scored consistently on before- and after-course items. In addition, Group A's before-course mean score was comparatively low, at 2.91, compared to their after-course mean score, which was 3.37. Interestingly, this group's after-course SD (0.39) was greater than the before-course SD (0.25), indicating Group A's after-course ratings were more widespread around the after-course mean of 3.37. Therefore, Group A students' after-course understanding of the impact of VW collaborative learning on the development of their values and beliefs as a learning outcome was more varied than their understanding before the course. However, their after-course mean score was 0.49 points higher than their before-course mean score, suggesting Group A had a more positive perceptions of VW design pedagogy after completing the VW-integrated design course. Moreover, Group I had a low mean score (2.4) on the before-course items but a high mean score (3.29) on the after-course ones. The higher before-course SD value (0.71) and lower after-course SD value (0.45) in this group indicated students had consistent responses to the after-course values and beliefs items.

The findings demonstrated all three groups of students experienced an increase in self-awareness of their values and beliefs after the VW-integrated design course. The values and beliefs developed by the students reinforce what O'Neill (2012a) described as a fundamental TAE capacity for today's art learners who are already tech-savvy enough to become self-directed and committed to their long-term learning and effect positive change through providing expansive opportunities for appreciative and dialogical inquiry for their self- and social empowerment. As a result, students' responses provided an important indicator of VW design pedagogy's effectiveness in providing these opportunities that appreciate and encourage dialogue, reflections, diverse voices, and collaborations. Through the iterative and continuous VW design practices, with

increasing awareness of personal and others' efforts and achievements, students developed positive engagement (O'Neill, 2015), which empowered them to expand their knowledge and ultimately view themselves differently as more passionate, collaborative, skilled, creative, and confident individuals able to face more complex design challenges.

In the section that follows, I present each group's top three means scores for the three TAE learning capacities with the most significant differences, and then I interpret these scores to understand how the three groups' perceptions of their learning outcomes changed during their VW collaborative design practices.

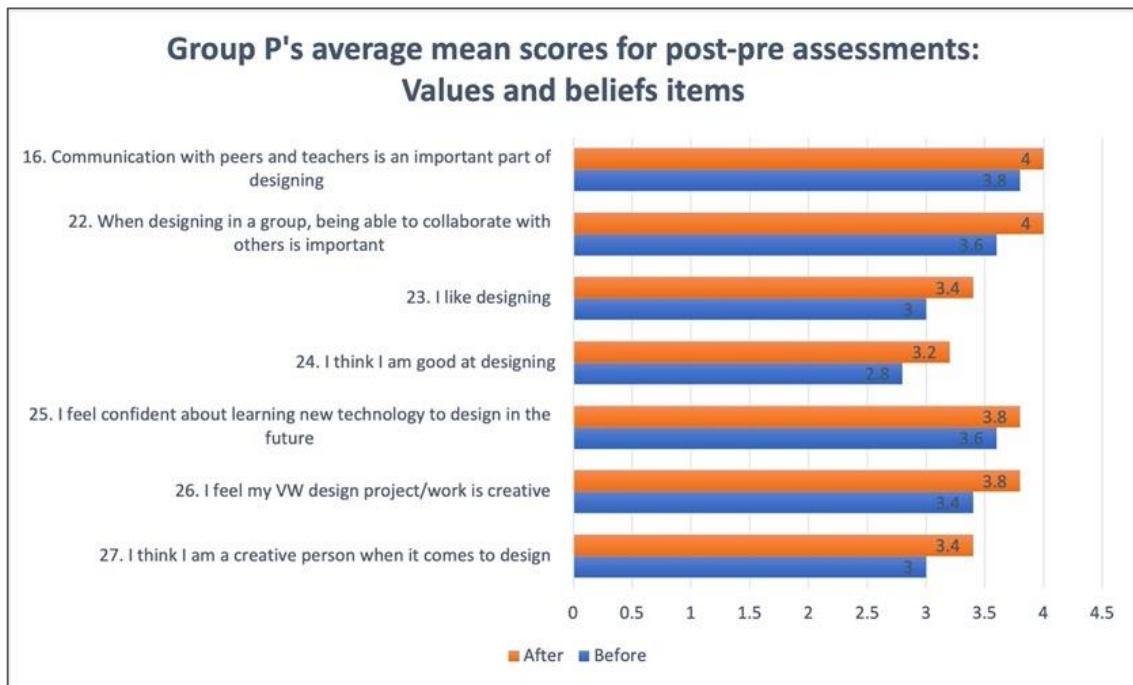


Figure 21. Group P's means for post-pre assessments: Values and beliefs items

Table 30. Group P's means and standard deviations for values and beliefs items

Values and beliefs (Group P)	n	Mean before	SD before	Mean after	SD after
	5	3.31	.38	3.65	.32

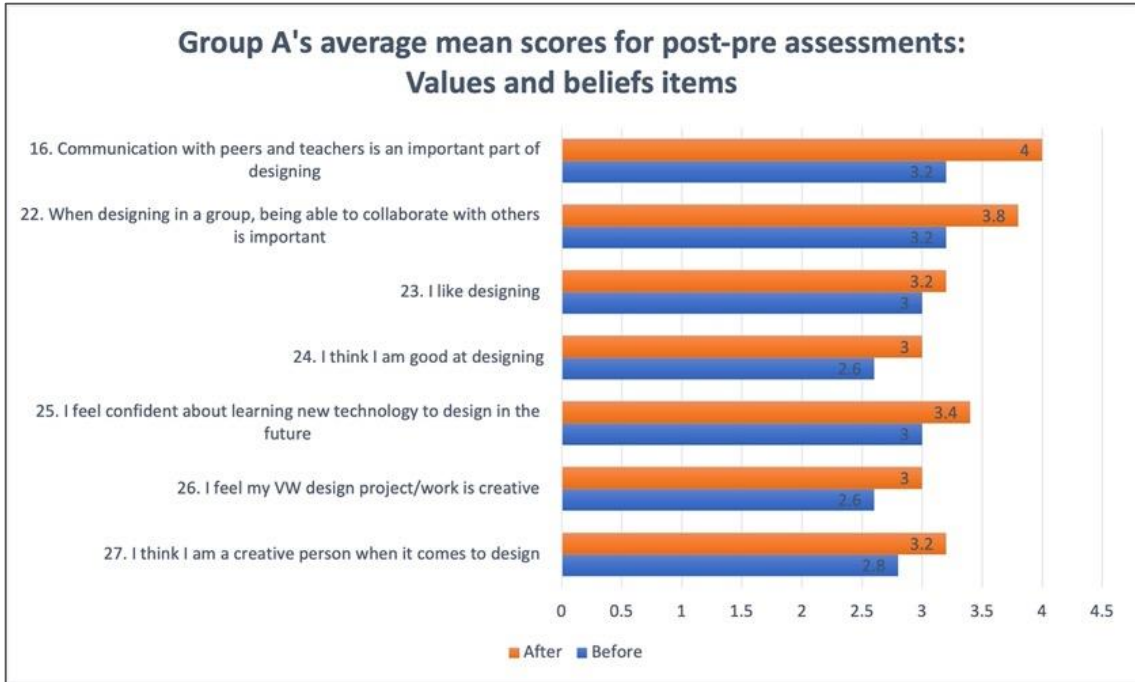


Figure 22. Group A's means for post-pre assessments: Values and beliefs items

Table 31. Group A's means and standard deviations for values and beliefs items

Values and beliefs (Group A)	n	Mean before	SD before	Mean after	SD after
	5	2.91	.25	3.37	.39

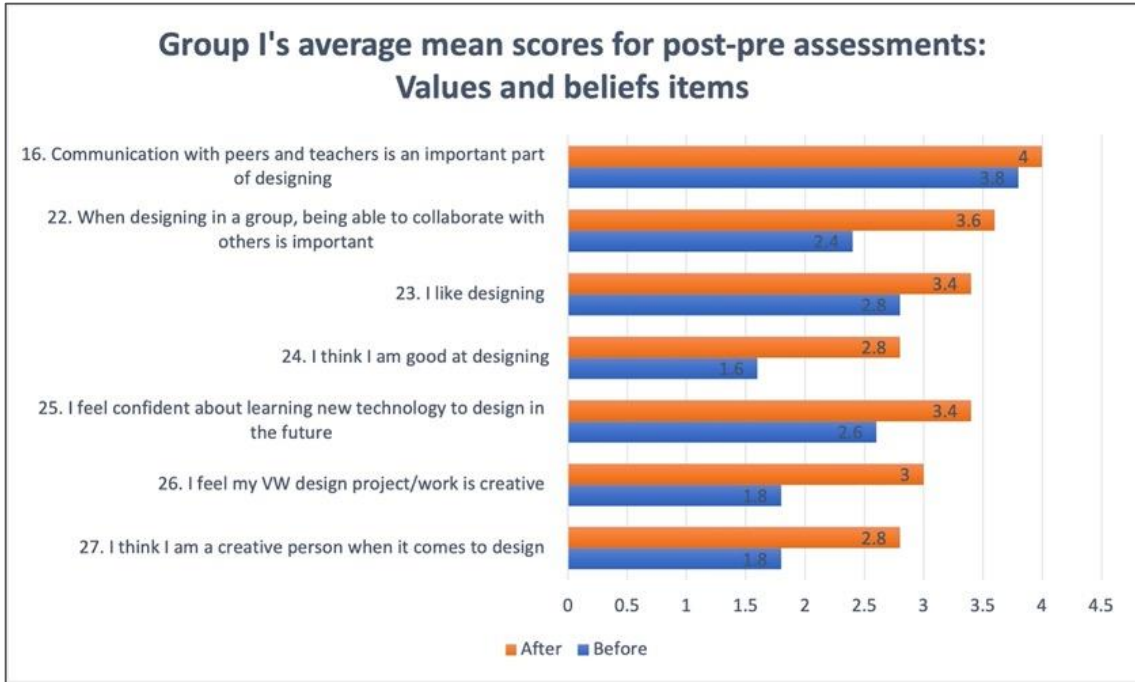


Figure 23. Group I's means for post-pre assessments: Values and beliefs items

Table 32. Group I's means and standard deviations for values and beliefs items

Values and beliefs (Group I)	n	Mean before	SD before	Mean after	SD after
	5	2.4	.71	3.29	.45

6.2.4. Each group's top three means for TAE learning capacities

Group P

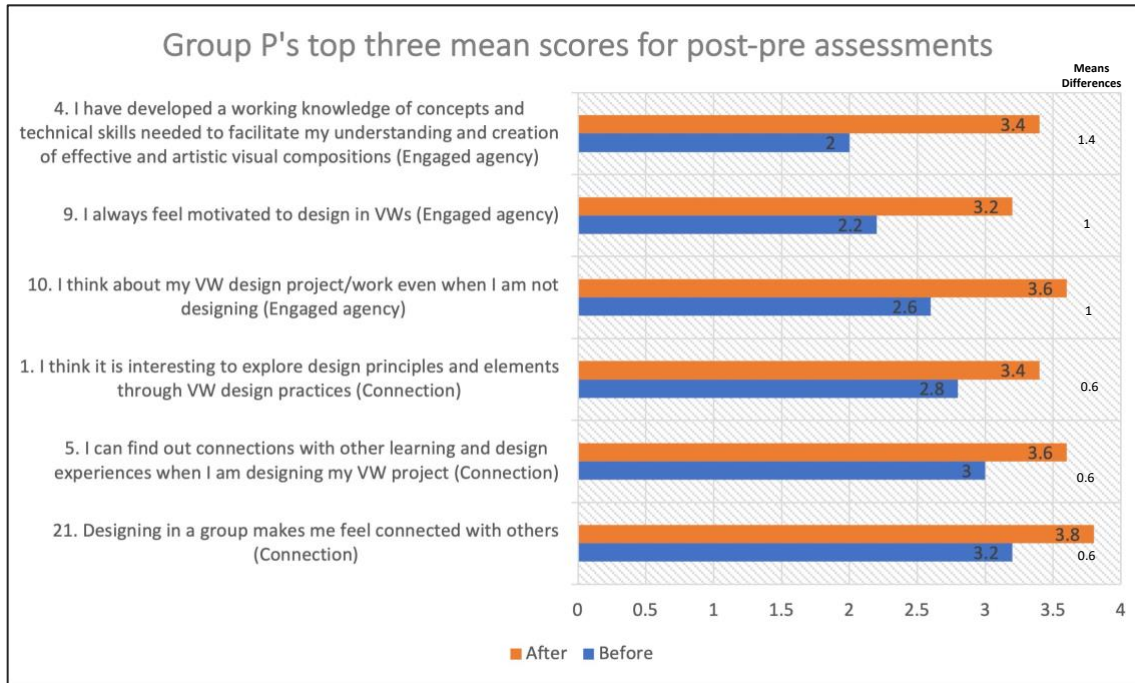


Figure 24. Group P's top three means for post-pre assessments

As displayed in Figure 24, the top three highest differences from the total Group P participant mean scores were found in two types of items associated with TAE learning capacities—engaged agency and connection. As mentioned previously, the mean difference of 1.4 for Item 4 was not only the highest value from Group P participant means scores but also from total participant means scores, which suggests that they experienced a strong sense of engaged agency through their actions in developing their VW project.

The second-highest difference (1.0), which appeared in Items 9 and 10 (“I also feel motivated to design in VWs”; and “I always think about my VW design project/work even when I am not designing”), also provides evidence of the TAE learning capacity of engaged agency. In other words, Group P participants experienced positive changes in their motivation to coconstruct their VW project, which resulted in a deeper level of engagement in design learning activities as well as a sense of identity. At the beginning of this course, some Group P participants were skeptical about utilizing VW technology

to learn design fundamentals. They were not motivated to work on their group project. However, with the principles of the TAE framework in mind, I fostered “student-led participatory inquiry and critical reflection” (O’Neill, 2006) to develop collaborative, formal, and informal design learning opportunities by using the participatory affordances of VW technology. With limited knowledge of the content-creation tools, Group P students collaboratively and rapidly prototyped their ideas in real time while being virtually copresent. Using the avatars, Group P participants and I interacted informally in various virtual environments during and after classes. We flew over the mountains, rode horses, visited art exhibitions, sunbathed on the beach, and more. As we spent more time together, we began to develop more trusting and positive relationships, which led Group P participants to engage in collaboratively developing prototypes and to share them in more reflective and appreciative discussions, resulting in improvement and refinement of ideas. This relatively low barrier to artistic expressions and positive relationships are the key features of online participatory cultures (Jenkins, 2009), which enabled Group P participants to become more motivated to engage with this unfamiliar technology by exerting their agency in their codesigning processes. Ultimately, this engagement allowed these participants to gain confidence and a sense of identity, thereby motivating them to produce more creative solutions that transformed their understanding of self through positive perceptions of changes.

The third highest difference (0.6) from the total Group P participant mean scores was identified in three connection items that relate to the previously mentioned top two highest mean differences for the engaged agency items. The three connection items are Item 1: “I think it is interesting to explore design principles and elements through VW design practices”; Item 5: “I can find connections with other learning and design experiences when I am designing my VW project”; and Item 21: “Designing in a group makes me feel connected with others.” These relatively high differences in means reconfirm the affordance of VW technology as a “shared medium” (O’Neill & Peluso, 2013, p. 120) for avatar-mediated interactions and collaborative designs. This technology enabled Group P participants to develop a sense of engaged agency by making “embodied connections” (O’Neill, 2017, p. 16) between themselves, their design learning, and others in an interesting and challenging process. In my observations, I noticed Group P participants collaboratively examining their rough prototypes by utilizing their avatars to fly over, walk through, and trigger an animated effect while exchanging

immediate ideas, all of which led to further reflection for new and creative solutions. Such an embodied and responsive learning experience was distinctively provided by VW technology, which encouraged anxiety-free collaborative design and user experience-centred design as a critical aspect of design thinking. As most participants voluntarily entered VWs for their group design after classes, their motivation to codesign and test prototypes while utilizing an unfamiliar technology demonstrated their engaged agency that resulted from “agentive learning ecologies” (O’Neill, 2017), which were fostered by the VW design practices. These junior design students deeply engaged in these challenging codesigning tasks in playful environments with the continuing support of positive relationships, and they gradually recognized the value of contributions made by themselves and other team members, thereby developing an intense sense of identity, connectedness, and empowerment that motivated them to experiment and innovate.

Group A

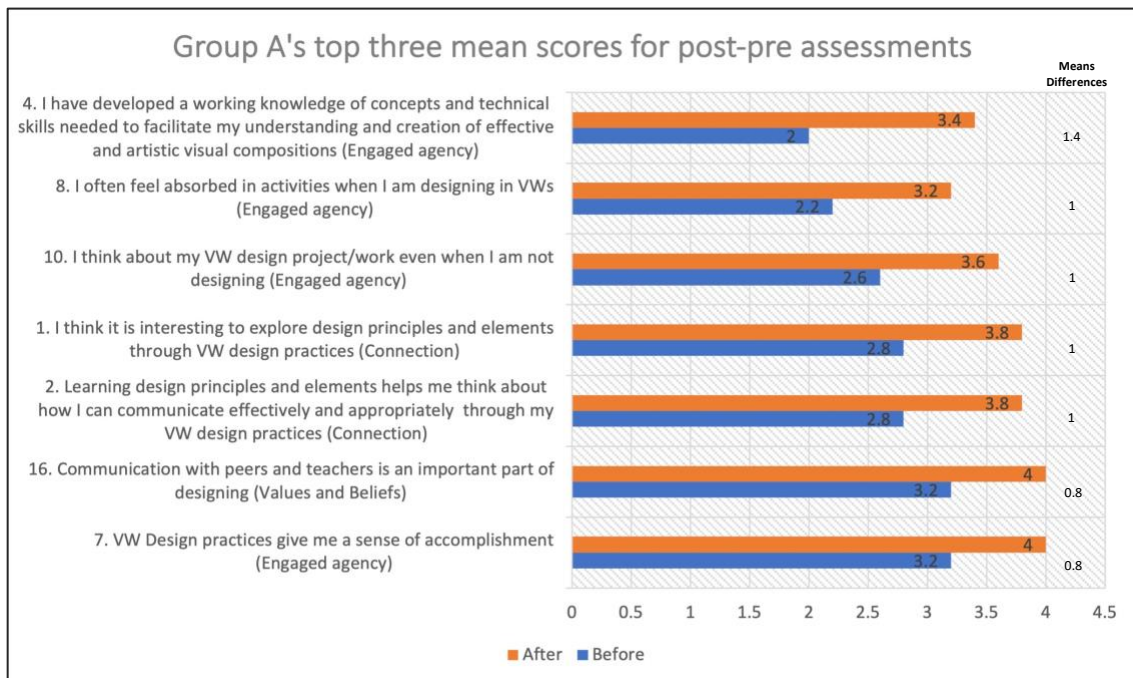


Figure 25. Group A's top three means for post-pre assessments

In Figure 25, the top three highest mean differences from the total Group A participant mean scores showed that the positive post-pre rating shifts were primarily associated with two critical TAE capacities—engaged agency and connection. The engaged agency items include Item 4: “I have developed working knowledge...”; Item 8:

“I often feel absorbed in activities when I am designing in VWs”; Item 10: “I think about my VW design project/work even when I am not designing”; and Item 7: “VW design practices give me a sense of accomplishment.” According to the results, Group A participants experienced positive changes in their appreciation of the VW design practices for learning and motivating their drive for creative work. Notably, the mean difference for Item 7 implied a distinct affordance of the VW design experience: Group A participants felt a sense of satisfaction and achievement as they overcame the complex design problems to produce innovative solutions by continually expanding the strengths of each participant within their group.

As discussed previously, VW-based design embraces interdisciplinary knowledge and practices—from graphic design to 3D animation, from gaming to computer science, from digital visual culture to multimedia literacy and everything in between (Han, 2019a; Liao & Sweeny, 2010; Stokrocki, 2014b). Therefore, Group A participants found it challenging to codesign a virtual environment that represented a particular architectural style and elements of ancient Chinese mythology within an 8-week course. The purpose of the transformative practice-based VW course was to foster these junior design students with the necessary creative capacity to navigate complexity. Therefore, the collaborative experimentation, dialogical inquiry, and solution-oriented activities leveraged by VW affordances became the key contributor to Group A participants’ engagement with the complexity and uncertainty of the boundaries between multiple disciplines within their VW design practices. During the codesign processes, they were unable to achieve some specific complicated effects in the final project in the ways they had initially planned. However, Group A participants reported collective feelings of pride and accomplishment in making the challenges of every design stage an exciting opportunity for creative output. As a result, when these novice designers collectively engaged in the reflective process of finding and solving problems within the VW codesign practice, they made connections not only between their VW project and learning design fundamentals but also with a group of trusted collaborative partners. Consequently, all Group A participants provided relatively high ratings for the after-course assessment for Items 1: “I think it is interesting to explore...” and 2: “Learning design principles and elements helps me think...,” each of which earned a mean difference of 1.0, indicating that their TAE learning capacity—connection had been strengthened.

Overall, the tactful use of the multimodal VW affordances stimulated Group A students' collaborative engagement in their design project and challenged them to seek new opportunities. Collectively, these approaches allowed Group A participants to build a "caring community" (O'Neill, 2006, p. 9) that encouraged respectful and appreciative communication among members, thereby contributing to their development of self-awareness in relation to others during the meaning-making process. Therefore, Item 16: "Communication with peers and teachers is an important part of designing," also received a relatively high score in values and beliefs.

Group I

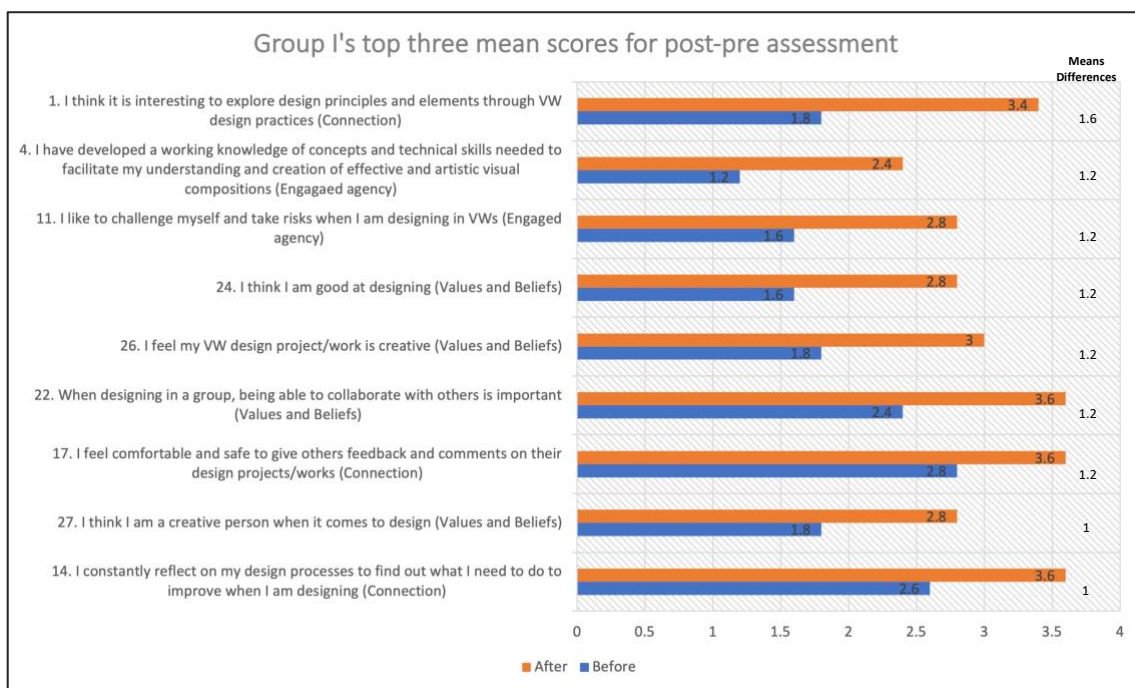


Figure 26. Group I's top three means for post-pre assessments

As illustrated in Figure 26, Group I experienced positive changes in all three TAE learning capacities. As with Groups P and A, Group I's top two highest mean differences were also found in Items 1: "I think it is interesting to explore design principles and elements..." and 4: "I have developed a working knowledge of concepts and technical skills...", with mean differences of 1.6 and 1.2, respectively. The substantial increase in the two items indicates that Group I participants developed an intense sense of engaged agency and connection by designing and learning together in VWs. The other engaged agency, Item 11: "I like to challenge myself and take risks when I am in VWs," also

achieved a significant increase, with a mean difference of 1.2. This strong result was primarily due to their risky choice of reformulating their design problem near the end of the VW design course. As presented in Section 5.3.1, Group I members spent over 5 weeks constructing their original VW design concept (a Chinese quadrangle courtyard in an imaginary multi-gravitational space). However, they reformulated the design goal, as they recognized the infeasibility of their initial design idea with their current VW design skills. Reframing the design problem as they neared the course's completion was a risky and usually unrewarded decision, although Group I participants' agentic actions to undertake risks implied their motivation to persevere in the effort (Csikszentmihalyi, 2014).

Furthermore, their recognition of the ill-defined initial design idea indicated that Group I participants engaged in their VW design as a "reflective conversation with the situation" (Schön, 1984). With the support of the "participatory affordances" (Kress, 2010) of VW technology, these junior design learners collaboratively and continuously examined and reflected on their prototypes and actions while designing from a user perspective via avatars. This avatar-mediated examination and reflection reduces anxiety in design learning, which has long been recognized by scholars (Gaimster, 2008, Han, 2019a). Together with TAE pedagogical approaches, these aspects of VW design learning context created a safe and playful space in which Group I participants reported feelings of comfort to offer genuine opinions to their peers (indicated in the connection capacity statement in Item 17: "I feel comfortable and safe to give others feedback and comments on their design projects/work". When Group I participants were able to freely and reflectively engage in the "conversation" with their problematic situation, the situation "talk[ed]" back," and they responded by "developing renewed understanding and making new moves" (Schön, 1984, p. 79) to change the situation. Consequently, Group I participants reported significant changes in the connection capacity statement in Item 14: "I constantly reflect on my design processes to find out what I need to improve when I am designing," with a mean difference of 1.2.

Despite the challenges Group I has encountered, the mean differences in scores for engaged agency and connection provide evidence of these novice designers' deep and positive engagement with their complex and uncertain VW design processes. This engagement transformed Group I participants' perceptions of their design project and self-identities as innovative and creative, which led to a growth mindset (Dweck, 2008)

that could produce enduring changes. Therefore, Group I participants rated relatively highly the three items associated with the TAE learning capacity of values and beliefs. The three items include Item 24: “I think I am good at designing”; Item 26: “I feel my VW design project/work is creative”; and Item 27: “I think I am a creative person when it comes to design.”

6.2.5. Summary of post-pre assessments

The analysis of the three group’s overall means scores and the top three mean difference scores of the post-pre assessments provides a strong indication of VW design pedagogy’s positive impact on students’ perceptions of the improvement of their creative collaboration associated with TAE learning capacities.

According to the results, Group I experienced substantial changes in how they perceived the impact of VW codesign practices on fostering engagement and collaboration in their design learning process and on transforming their perceptions of themselves as creative designers with three key TAE capacities. Although Group P and A students reported an increase in all after-course mean scores in all three TAE capacities items, the top mean score differences were only identified in their ratings on engaged agency and connection items. However, given the small mean differences between each pair of before- and after-mean scores, it is not possible to draw the conclusion that Groups P and A had the smallest changes in valuing their VW design pedagogy for creative collaboration concerning TAE capacities. Another concern was highlighted by Group P students, who demonstrated remarkable creativity in codesigning their multimodal virtual environment of *Pan’s Labyrinth* (Chapter 5) but exhibited only the slightest increase in rating their after-course items in all three TAE capacities.

The next section provides interpretations of the open-ended interviews with all student participants, which were conducted following post-pre assessments. The main purpose of the interviews was to address the aforementioned concerns and obtain additional comments and feedback from students that were difficult for them to describe in the post-pre assessments. By doing this, I hoped to gain a more in-depth and holistic understanding of their perspectives regarding the impact of VW codesign learning on their creative collaboration related to TAE capacities.

6.3. Participants' Themed Reflection on Their Virtual-World-Integrated Collaborative Design Learning

The responses from the 15 students who volunteered to participate in the semi-structured interviews at the end of the VW-integrated design course are provided as follows. The participants responded to 26 open-ended questions about their perceptions of their engagement with their collaborative design learning, agency, connections, values, and self-beliefs as they experienced in their VW design practices. Many participants from the three groups critically reflected on their contributions to the VW codesign projects, their group collaboration during the design processes, and their final VW presentations. Additionally, they expressed that their participation in the VW-integrated course broadened their awareness of creative potential of design across disciplines, which allow them to focus on particular disciplinary areas that align with their professional aspirations. As O'Neill (2012a) states, the aim of TAE is to develop a sense of empowerment among art learners with a "reflexive capacity to reflect inwardly about connections between self, art, and their sociocultural understandings" (p. 178). The findings confirm O'Neill's concept: the VW design pedagogy fostered students' creative collaborations through developing their transformative engagement with their multimodal VW designs, leading to an increased level of engaged agency, connectedness, reflective self-awareness, and belief empowerment for advanced design learning and challenges.

Sections 6.3.1 to 6.3.4 explore four main themes that emerged from the analysis of the open-ended interviews regarding the three TAE learning capacities. Together with students' responses to the post-pre assessments, this research could provide a more holistic and in-depth understanding of students' views of their VW design learning experiences and their creative collaborations in relation to the TAE capacities, indicating the transformative potential of the VW design pedagogy.

6.3.1. Theme 1: Building design thinking skills as engaged agency

In O'Neill's (2012a) TAE framework, fostering art students' sense of engaged agency requires art educators to consciously provide action-oriented, experiential learning opportunities to encourage students to reach goals that have personal significance. By analyzing all participants' responses, I witnessed the emergence of building design thinking skills emerged as the first theme regarding engaged agency.

These critical skills include empathy, reflection-in-action (a detailed explanation is provided later in this section), continuous experimentation, and collaboration and facilitation. They reflect how each group of design students became creative agents who collaboratively engaged with and accomplished a series of tasks in each design thinking stage within VWs to achieve their group design project as a collective goal. Many of the responses overlap regarding developing design thinking skills. However, I categorized them into sub-themes to offer a sense of how students described their participation in VW design as engaged agency.

Empathy

Many participants developed an empathetic understanding of the potential audience⁷ and the context in which the design challenge was situated. According to McDonagh et al. (2011), innovative designs that meet the users' functional or emotional needs reveal designers' creative ability to empathize with the users' worlds. In the early design thinking stages, all participants were asked to conduct empathic design research activities in SL to collect potential users' information and inspiration for discovering and framing design opportunities. Group A member Finn and Group P member Caleb reflected upon their improved skills of developing empathy, understanding, experiences, insights, and observations, which they utilized to build their VW projects. Finn explained that they were deeply immersed in the "simulated virtual galleries museums, interactive art installations, and other imaginative and playful virtual spaces created by people worldwide." After immersing himself in various multimodal VWs, Caleb stated that the experience was "not just eye-opening but also gave him a good understanding of the issues, needs, and design challenges involved." Other participants also expressed that they were engaged in visiting the different virtual environments and felt inspired to create their own worlds that do not exist in the real world. Group P member Daisy explained:

At first, I was just impressed by those beautiful virtual environments. However, as I visited and interacted with more environments, I started to think about the purposes of creating these environments, the avatar user's experience, and what we can do to enhance the user's experience while expressing our ideas.

⁷ At the beginning of the course, I informed students that I would organize an exhibition in SL to showcase their completed virtual projects. Due to the time constraints of the course, the exhibition was limited to student participants only. However, several students uploaded their projects or parts of their projects to SL for display or sale after the course.

In addition to the rich and immersive multimodal content, Group I member Megan felt that the avatar-mediated VW communication system enabled her to “consider a broader spectrum of people who were possibly relevant to the design challenge.” Specifically, Group A member Jessica reflected upon her communicative experience in developing empathy:

In a virtual environment of Athens in SL, I met an avatar from New York, and she took me to see exhibitions about ancient Greek architecture that I would never experience in the real world. These architectures were not presented through 2D pictures or stand-alone static 3D models as we usually see in real-life exhibitions but through animated and interactive virtual simulations...We walked through and flew over the buildings while sharing our presence with each other. We played designed games in these buildings while making comments from visitors’ perspectives through instant messages (as my oral English skill was not good). As I gradually felt comfortable communicating with this new friend, I shared our group’s initial design concept—the ancient Chinese fairy palace and discovered some unfamiliar and exciting ideas from her. This was how I got inspired to create a hidden second floor in our palace so that the visitors might have a game-like experience when they found this mystery space.

These responses reflect participants’ perspectives in valuing VWs for developing their ability to empathize with their potential users and understand their design challenges, thus building foundations to envision new ideas. This ability was fostered through avatar-based exploration and communication in the early design thinking stages of discovery and interpretation, which aligned with the affordances inherent in VWs. Therefore, through transformative approaches in the VW-based design project, the design-thinking-oriented activities stimulated these design students’ sense of agency to actively engage with numerous unfamiliar concepts, artifacts, and technical skills, which empowered them to prepare sufficiently and subsequently generate ideas to accomplish their design projects.

Reflection-in-action

According to Schön (1984), reflection-in-action is the ability to continuously reflect on the approaches to strategies to handle a design situation while the situation is occurring. In this VW-integrated design course, learning to reflect-in-action during the different VW design stages and activities is the second improved design thinking skill related to participants’ increased sense of engaged agency. This kind of “reflective conversation” (Schön, 1984) proceeded from participants’ real-time identification of

problematic design situations and communication in evaluating and reconstructing the solutions in the same designed virtual space. Group P members Anna, Ben, Caleb, Daisy, and Effie reflected upon their enhanced design thinking skills of reflection-in-action in the VW design project. Specifically, Anna felt that she could “focus more on identifying the problem areas when coevaluating with other members in the same space.” Daisy reflected upon their collaborative design process, stating that it was “more efficient and easier to locate the problem and come up with new solutions while other members were collectively examining the prototypes.” Effie further explained their reflective practices in relation to navigating the avatars:

In real-life design classes, although we produced prototypes, it was hard to evaluate if we told the right stories or presented appropriate experiences to the right audiences. When in a VW-based classroom, we had chances to ask other team members, our teacher, and sometimes avatars outside our classroom to review and assess our prototypes by navigating their avatars through the content and interacting with it. For example, our group didn’t design any guiding signs in our labyrinth garden initially. We didn’t notice this problem until other groups and our teacher walked through each area of our labyrinth and got lost because of the lack of signs. Our avatar-mediated classmates immediately pointed out the specific problematic places and offered us feedback while in the same space. This problem would never have been exposed if we didn’t have the in-world review and evaluation. As a result, we had a reflective discussion about our ill-designed environmental signs and generated some creative solutions emphasizing the user experience.

Similarly, Group A member Gena stated that:

Constantly inviting peers and the teacher to review our project in VCER and provide instant feedback was critical for our group members to reflect on our project while it was being designed. Through their user perspectives, we obtained some degree of understanding of the potential audience’s needs, which helped us develop a more empathic virtual environment.

Megan, from Group I, not only reflected upon the user-experience-oriented evaluation of the VW design projects but also expressed that the avatar-mediated virtual evaluation engaged them in a more reflective process that motivated them to find and solve problems independently and collaboratively throughout their design process. Megan explained:

Compared with other forms of design I have experienced, I expressed my own ideas more in the VW design project. Because we reviewed and evaluated each group’s projects through avatars, I felt like there was no

expert in this classroom, and we were equal, so I talked to everyone, including my teacher, like a friend. When anyone from our group or other groups pointed out the problem of our project, I didn't feel unhappy or embarrassed. Instead, I was very pleased and motivated to discuss with my peers, looking for solutions. In VWs, I believe that everyone became more genuine and open-minded. We just worked alongside each other to achieve our collective goals.

O'Neill (2015) explains that "TAE operates within an appreciative inquiry framework that encourages youth and educators to work deliberately and collaboratively on creating the best condition possible within their own educational contexts for promoting positive change" (p. 9). These participants' responses reflect that the implementation of VW technology harnessed a culture of appreciation whereby they became engaged in reflective dialogue and learned to recognize their own and peers' "authentic voice[s]" (O'Neill & Peluso, 2013, p. 4), contributions, and abilities. Within such an appreciative culture, the shared reflection became a source of motivation and inspiration that empowered these design students to become "reflective practitioners" (Schön, 1984) in their actions, exerting their agency in active testing and feedback loops for continuous improvement.

Continuous experimentation

When participants were asked to reflect on their prototyping stage, Group I members Kaden, Leah, Megan, Nina, and Olivia spoke fondly of their design experiments in addressing their particular design challenge. Kaden reflected:

Even though we gradually realized that our initial design goal was not technically feasible due to its complexity, we didn't know how to redefine or change our design challenge at that time. Therefore, we had to tolerate and keep working with this uncertainty to research solution conjectures...Given the open-ended virtual environment, I challenged myself to prototype at least three versions of each of my ideas and manipulated them instantly to test the aspects of possible solutions.

Nina further described their VW collaborative management of uncertainty as engaging and motivating. She explained,

I enjoyed watching my teammates' avatars experiment with their ideas. They flew around and ran through the buildings and even jumped from the top of the mountain...I also found that real-time changes that appeared on our project were inspiring, encouraging me to reflect on my existing designs with respect to their contributions and conjecture more ideas...Sometimes, I came over to my teammates designing in VCER for discussions.

Expressing a similar sentiment, Megan described:

Although our group was in a hurry with the final workload due to the feasibility problem of our initial design concept, the great thing was that we made several breakthroughs together even under pressure...In VCER, I could destroy and redo the designs I was not satisfied with. I was no longer worried that the destruction was irreversible, and I no longer felt afraid of failure... In order to create a distinctive sea surface, I boldly hollowed out the ground. However, it was not what I expected, so our group had multiple times of meetings while continually improving it. We tried different methods and materials again and again until we were all happy about it...It was an inspiring experience.

Group I members' responses reflected that VWs support playful experimentation and prototyping while sharing the world with others in a worrying-free environment, thus contributing to the team's agency and resiliency in engaging with challenges. The other two groups' participants also expressed that they became more willing to experiment with their ideas in VWs. Finn, a Group A member, stated:

While in VWs, I felt like it was my world. I could create light, mountains, rivers, and everything I could imagine. Learning in these places gave me a sense of freedom and confidence. It's amazing that learning design can be so joyful.

Despite various challenges in the prototyping stage, Group P members Anna, Ben, Caleb, and Effie reflected that "seeing their own and other members' avatars in a third- or first-person view" or "flying around" their design project inspired them to continually derive fascinating ideas, leading to some "unexpected solutions" that offered them "a sense of achievement."

Design thinking is about "learning by doing" (Dewey, 1938/1997). The responses confirmed Dewey's experiential, hands-on learning: with significant freedom, real-time awareness of the results of their works, and immediate feedback provided by VWs, the participants' motivation to play and experiment was increased. With positive motivation, these participants demonstrated confidence and resiliency to overcome design uncertainty as a team, thus highlighting the pedagogical alignment with the affordances of VW technology.

Collaboration and facilitation

Participants expressed that engaging in the VW group design encouraged them to be open to and positive about collaboration. Group P member Effie explained:

In the past, I would not say I like communicating with my classmates or teacher during the design process. However, my participation in this VW-based design course changed me fundamentally...I no longer felt uncomfortable communicating with my peers and teacher in VWs, and I had become more active and willing to engage in our collaborative design activities.

As Group P's leader, Effie also commented that she had become more "empathetic to diverse thinking and facilitate crucial conversations" within her group. Concurrently, she had become more "decisive to lead efficiently" when her group members "didn't have their answers yet."

Group A participant Halley reflected that their "VW project was meaningful," as they "conquered various challenges to achieve a common goal." Additionally, Jessica stated that their "design workload was heavy due to the complexity of building an animated Chinese traditional palace as the goal," but they persisted as they "enjoyed working together in the VW for achieving the collective goal." Finn, Group A's leader, related their achievement of the goal to the enhanced relationships within his group:

Building and scripting in VCER were challenging, given our current digital design skills. However, the game-like environment made our design learning and collaboration amusing. Throughout the process, when encountering scripting or design difficulties, we constantly took breaks from our work to visit SL and other groups' VW projects, observed their progress on their projects, and came back to reflect and redesign the scripted objects...We always made mistakes in scripting and had undesired or unexpected results. However, we never expressed negative comments, and sometimes we laughed at our mistakes.

Group I participants commented positively about their emotional design experience in the VW. Specifically, Megan described the time when her group members attempted to solve the feasibility issue of their initial design project:

We flew over, though, and went in and out of our designs in VCER, just as we communicated with them, which made us attached to our project and encouraged us to spend significant time designing in our world even after the class.

The responses provide evidence that VW design practices offered each group expansive learning opportunities to collaborate with their peers and teacher in both the virtual and real worlds. The core of design thinking is collaboration (IDEO, 2012), and with improved collaboration, these participants felt empowered by others' diverse views

and the enhanced relationships to exert their agency in their creative abilities and their process to circumvent difficulties.

6.3.2. Theme 2: Developing avatar-mediated multimodal designs as engaged agency

Participants stated that interacting with numerous VW communicative modes via personalized avatars increased their sense of agency and collaborative engagement with their projects, leading to creative problem-finding and -solving. Participants expressed some negative feedback about VWs' technical constraints and building challenges. However, they also described how they were motivated by certain VW aspects to transform these constraints and challenges into design opportunities. This feedback, therefore, deepened my understanding of both VW limitations and affordances when implementing this technology in art and design education. The following sections present three sub-themes that emerged from the participants' reflections on their customized avatars, multimodal choices, and constraints and challenges within their VW codesign practices.

Customized avatars as social self-representations

All participants expressed that designing in VWs via their personalized avatars facilitated their individual and collaborative design processes. Group I participant Leah reflected that "trying on different characters through modifiable avatars encouraged me to imagine all kinds of wild ideas that I wouldn't be able to come up with in the real classroom." Nina also commented:

Driving different customized avatar bodies in performing a wide range of tasks enabled me to put myself into the characters that acted out my real-life roles...I felt a sense of ownership and engagement in different role-playing virtual environments, which encouraged me to express myself imaginatively and produce more alternative solutions for constructing our project.

Megan echoed Nina's sentiment, expressing that she also felt a strong sense of engagement and agency via avatars:

I felt like an observer when designing on professional design platforms like 3ds Max and Photoshop. However, when designing in VCER, I felt immersed as I was, like, in that place, interacting with the environments and other avatars... I could become whatever I wanted and not be

restricted by rules and standards, and I was not affected by others' views and opinions and felt free to design there.

Participants also identified the collective identity within a team that promoted creative collaboration and a feeling of connectedness as a hallmark of the avatar-mediated design experience. Group A member Jessica described that during the first 2 weeks of SL discovery, her team's role-playing experience in a European Middle Ages-themed virtual environment inspired them to redesign their appearances for the rest of their collaborative design activities. She said:

We all had to change our clothes into the gowns of that period and behave in specific ways to attend the ball. At first, we were a little confused about the purpose of wearing specific clothing. However, as soon as we put on the gowns, danced to the music, and saw other avatars in the same space, we tuned in to our roles. In the follow-up group meeting, we decided to change our avatars' appearances to match our project theme and to create clothing shopping options for potential visitors to role-play in our Ancient Chinese Immortal Town.

Due to technical constraints, Group A participants failed to redesign their avatars into traditional Chinese characters and create shopping options for role-playing. However, all five Group A members edited their avatars to some extent after the first 2 weeks of classes. For the remainder of their design process, they appeared as avatars with similar physical features and similar styled clothes that expressed their collective identity as a group. According to Ivy, "seeing my look-alike avatar teammates appear in our world made me feel connected with them and more attached to our project...We felt safe and comfortable collaborating as a team of imaginary avatars to pursue our collective goal."

Additionally, Group P members Anna, Caleb, Daisy, and Effie reflected that the real-time manipulation of the objects and co-construction while being aware of each other's spatial positions and actions in a synchronous manner were invaluable to their creative collaboration and coordination. Caleb explained:

In the previous courses, I found it challenging to collaborate with other classmates in the group projects, as it was hard to track down the group members' progress to propose suggestions and feedback. In our VW design project, I can see our group members' activities and the instant progress of their designs while closely observing the details or even walking through their designs for review. This ability to be aware of other members' actions while interacting with their designs allowed me to understand their concepts better and create a coherent project.

Regarding the communication tools, Effie commented, “We felt like we were together in our world, and we always made sincere comments and propose creative alterations and ideas that were built on each other’s designed solutions.”

Multimodal choices

Participants reflected that the VW platform provided rich choices to create the multimodal design of their interests, allowing them to develop a critical understanding of design knowledge that would not be possible in other digital applications. Group P members Anna, Ben, and Effie explained that the relatively straightforward user interface and various VW interactive functions supported them to prototype the ideas quickly for exploration and initial evaluation. Anna commented that “compared to other professional digital design applications, it was fairly simple to experiment with our ideas using the basic geometric building blocks.” Ben stated, “The interactions with our environment while it was being designed allowed me to gain direct visual and spatial references, which allowed me to develop more accurate and practical solutions to achieve our goal.” Effie further explained, “Through my avatar, I sat on the bench I created and walked through the exterior of the maze I built...This unique experience allowed me to detect some functional issues that I had not thought of while designing these prototypes.”

Group A participants reflected on their decisions on how to represent the coherence of their collaborative design due to the persistent virtual environment. Jessica described:

The most creative thing I did was the interior design of the palace because it was coherent with other teammates’ works, highlighting our design concept. At first, I was initially concerned that my design would not fit our environment, as everyone focused on their own tasks at the same time. However, I found it easy to constantly return to our collaborative project and review other teammates’ progress in the persistent virtual environment. With this help, I was able to work on my own designs while constantly adjusting them with reference to my teammates’ tasks regarding the colours, forms, styles, structures, and layout.

Halley also expressed that the persistent VW platform allowed them to design a “stylistically coherent” environment. She commented:

We were very much aware of each other’s progress throughout the design process...We enjoyed discussing the problems while walking around our designed place. Although we did not achieve visual details

in the end, we did present an ancient Chinese architectural style using specific colours, forms, and structures.

Group I participants Kaden, Leah, Megan, Nina, and Olivia reflected on their challenges when they had to reformulate their design problem and redesigned the whole project near the end of the course. All five members related their motivation to work harder to the persistent virtual environments. Kaden, Group I's leader, stated:

We were impressed when we flew over to Group A's world and discovered that they had made significant progress on their project. Meanwhile, we felt pressured because Group A was also building an ancient Chinese architectural environment, which was a similar theme to ours.

Leah commented, "The other two groups of members constantly flew into our world for a quick peek at what we were constructing, which motivated us to solve problems and develop something new and creative quickly." Although the intention of this course was not to create competition, the real-time awareness of the situation afforded by VWs unleashed Group I members' competitive drive. Nina and Olivia made similar comments, expressing their desire to win. Consequently, when asked about their rebuilt environment—the iCloud City—Megan spoke fondly:

Learning design fundamentals through VW design practice is better than simply relying on design textbooks and doing individual prototyping projects. Through engaging in the VW design, we learned 3D modeling, architectures, physics, math, scripting, and visual design through collaboration, risk-taking, and working under pressure to achieve our goal...I think our project is creative in every aspect because we put much effort into it, and it is meaningful to us.

According to the responses, the VW design practices offered students rich multimodal choices, such as a straightforward user interface; avatar-based, real-time navigation, persistent environments for deep engagement; multimodal experimentation; creative risk-taking; collaboration; and critical reflection, which may transform students' understanding of design practices and learning.

Constraints and challenges during virtual world collaborative design practices

Although no participants stated that their VW collaborative design practices were unfavorable, many expressed that the unstable Internet access to VWs was the primary technical obstacle they encountered. Group P member Anna described that the "biggest

bug was the fluctuating Internet connection to the VW application.” She stated, “When our Wi-Fi was lagging, it took me hours to get into VCER...After a few minutes of creating, I was logged off suddenly.” Similarly, Caleb expressed that “our Internet became slow when using the VW application.” Daisy and Effie cited the unsteady Internet connection to VWs as their least favorite part of the design process. Specifically, Daisy described her experience of losing her objects and buildings in VCER due to the Internet issue, explaining that “it was frustrating to rebuild them all over again.” Finn, Ivy, and Kaden also described the “sudden VW application crash” as the most significant technical constraint, as it sometimes caused content loss.

Moreover, a number of participants reflected that the English user interface of VWs created challenges in their design processes. Group P member Anna described that she was occasionally forced to “try out every building option to achieve the specific effect” she desired because she could not understand the English terminology on the user interface. Ben elaborated on his feelings of English inadequacy within the VW design practice, saying, “I could not transform the rock into the form I wanted it because I was confused about some of the building functions in English.” Caleb and Daisy cited English as the most significant challenge during the VW design process, stating that they frequently consulted the dictionary while working on the project. Ivy and Jessica from Group A reflected that “the language barrier limited their ideas.” Group I member Leah commented, “I wish they could add Chinese into their user interface.”

Additionally, participants reflected that constructing a sophisticated project required considerable programming efforts with the VW scripting language, which became a significant obstacle during the design process. Group P member Anna expressed, “Although we had a lot of interesting and new ideas, it became difficult to evolve and develop our project further because we didn’t know how to script.” Caleb also reflected, “I think we would have expressed more of our ideas in our project if we were good at scripting.” Group A member Ivy particularly expressed her disappointment at the lack of interactivity in their project, stating, “We wanted to create an interactive movie theater on the second floor of our palace. Unfortunately, we didn’t achieve it due to our limited scripting skills.” She continued to reflect on the resolutions they derived to work around this constraint, stating:

We didn't want to use the pre-existing resources in VCER's inventory, but we couldn't achieve the specific effect we wanted...Eventually, we took the chairs, tables, sofas, and stage from inventory. We changed their colours, textures, and sizes and arranged them into a theater-like environment. We were happy about the visual result, but we could have done better if we had known how to script.

Group I members Kaden, Leah, and Megan expressed their regret, as they failed to use the VW scripting language to create a multi-gravitational space. Kaden described:

The most challenging part for us would be figuring out how to code for our multi-gravitational space. Yi recommended some websites that assisted people in creating scripts for VW objects. However, we couldn't achieve our desired results using these sites. We also asked for help from our classmates and searched for solutions in SL and related websites. Unfortunately, we had to give up this concept and reformulate our goal because it was not feasible given our current scripting skills.

Consequently, when asked if VWs allowed them to express their own ideas, Megan said, "We can certainly express our own ideas and concepts with our VW project, but if we knew more about the scripting language, we would be able to turn more of our wild ideas into reality."

Another constraint that emerged from participants' reflections was that the VW platform in this study could not adequately support detailed design artifacts. Group P member Effie stated that "in comparison to professional 3D modeling applications, VW designs lacked visual details and rendering quality." Kaden, from Group I, expressed that "the simulation quality, such as texture was not sophisticated enough and low-resolution." Despite these disadvantages, they commented that the VW designs were appealing and immersive in the available forms, structures, and interactivity.

Participants' responses reflect the constraints and challenges they experienced during the VW collaborative design practices. The problems of unstable access to the VW application and the language barrier were unique to this study because all participants were Chinese and lived in dorms on campus where the Internet was localized and restricted. The problems of low-resolution simulation and the scripting language are related to the VW characteristics of being dynamic, operating in real time, and offering interactive environments (Koutsabasis et al., 2012). In the TAE-framed design learning context, students' reflections provide the basis for grasping their

experiences with the VW platform and identifying the particular constraints and limitations of this technology to guide course refinement.

6.3.3. Theme 3: Transforming from team-based learning communities to a classed-based learning community

According to participants' interview responses, the emergence of learning communities within teams occurred in the early stages of VW design processes when these junior design students became acquainted with each other. By developing VW projects together over time, a larger, class-based learning community emerged among all participants in the remainder of the VW design stages. The transformation from team-based communities to a class-based learning community suggests that the VW design practices created opportunities to connect oneself with peers and the teacher in collaborative learning. These connections were critical for fostering "equitable and respectful engagement" (O'Neill, 2006, p. 12) in design learning activities. Through a deepening process of participation in this a "community of practice" (Lave & Wenger, 1991), design learning can become a source of motivation and protection that fosters not only students' skills and knowledge but also positive attitudes and resiliency in the face of challenges and obstacles.

Team-based design learning communities

Most participants were slightly acquainted at the beginning of this course because these junior design students came from two different academic programs (graphic design and animation) and enrolled in classes according to their plans and schedules. However, when asked about the collaborative process, participants expressed feelings of warmth, support, and connectedness, which began soon working together in VWs. Group P member Caleb reflected on his positive experience of sharing frustrations of with his teammates regarding utilizing this new technology, stating:

At first, I felt a struggle to learn all these functions, especially in English. Soon, it became reassuring to discover that other team members were also struggling, as we shared and laughed about our silly mistakes in VWs.

Effie also mentioned described her positive experience in overcoming technical difficulties in the early VW design stages, saying:

I used to be kind of shy around people, and I didn't communicate much with my teachers and classmates about my ideas. However, since the beginning of this course, I have changed and have always asked Yi and my teammates many questions. They were all excellent teachers to me. As we did our projects mainly after class, Yi always checked on us in VCER during these times...I remember one time I had trouble creating a scripted house in Sandbox. Yi teleported me to other people's worlds, where we visited their buildings and discussed possible solutions. Later, I successfully helped my teammates solve similar problems using these techniques, and I feel like I finally got to the point where I could contribute to our group project as a member of our team...Personally, it was a successful experience because it changed the way I learned.

Despite the unfamiliar relationships, Caleb and Effie's responses reflect that the VW design practices fostered peer learning within a group and student-teacher collaboration in the early design learning stages. Group A participants expressed similar feelings of connectedness within their groups by developing shared understanding and distributed leadership to find and solve problems. Finn explained:

Participating in the VW design practices made us feel happy and relaxed about our collaboration. Although I volunteered to be our group leader, we shared this leadership whenever we needed to make decisions in our areas of responsibility.

Halley also described the positive relationships that developed since the class started, stating:

We discussed and made every key decision together...As we made our design challenge very clear at the beginning and we chose the tasks to work on according to our own interests, we felt motivated to work toward our own designs to contribute to our shared vision. We reflected and discussed possible solutions if something went wrong, or it didn't work. I think we progressed our project fast and came up with many innovative ideas.

Group I members Kaden, Leah, Megan, Nina, and Olivia described that having their avatars unite to explore SL after classes allowed them to develop more trust within their group. This trusting environment encouraged them to share ideas freely and be more open-minded to accept new ideas. Nina explained:

At first, I thought we would just sit in the classroom listening to our teacher's lecture about a new type of design technology, and I felt I would never get the hang of this. However, I became immediately drawn to this environment when our teacher guided us to SL via avatars...Each session was quite short, so our team always visited SL after a whole day's class. When we saw each other as avatars wearing fantasy or silly

clothing, we couldn't help but laugh and make jokes about each other's appearances. We always extended our time in SL.

Megan also expressed a similar sentiment of engagement, curiosity, and novelty that emerged in this design stage. She said:

I felt like my teammates became my good friends after exploring SL several times in our free time...At night, everyone in our team was at the computer in their own dorms and turned on our microphones to explore SL. We drank together in the bar, danced in the ballroom, and visited galleries while commenting on pieces we liked. We also created some simple objects to play pranks on each other in Sandbox. So, when we needed to make decisions to frame our design problem and assign responsibilities to group members, we felt at ease. Everyone was open to listening each other's ideas and adjusting their plans to work with others.

These responses suggest that VW design practices encouraged a strong sense of trust and hence developed team-based learning communities at the beginning of the design stages. Within these communities, students were more willing to participate in extra work activities and exchange information beyond what was specific to their project. With these repeated learning experiences, the communities became a source of motivation and empowerment through which they gradually recognized and valued each member's voice and ideas, leading to more creative output.

Class-based design learning community

Participants' interview responses also indicate that the small team-based design learning communities emerged into a larger class-based community along with the development of their VW design projects. Group P members Anna, Caleb, and Effie expressed that they were inspired by how well Group A took advantage of VCER's pre-built objects and redesigned them into a recontextualized ancient Chinese mythical environment. Effie, Group P's leader, stated:

We were impressed by how well they redesigned these objects to deliver an ancient Chinese mythical story. As you know, the pre-built objects were not Chinese at all. We felt their project was pretty awesome. Finn (Group A member) suggested that we might be moving too fast on our project and not noticing the potential problems. So, we decided to slow down our design process and regather more information to refine our solution concepts... I watched the movie [*Pan's Labyrinth*] several times before sharing vital information with my teammates.

As the teacher-researcher, I regularly organized formal critique sessions among students for design review. However, according to participants' reflections, they often conducted informal cross-group design evaluations in their VWs. Group A participant Gena explained:

I like VWs because they emphasize the user experience through avatar-mediated interaction. In the previous assignments, it was hard to review and evaluate the functionalities of our designs. In VWs, however, our project was presented in a simulated environment and assessed by our team members, the teacher, and classmates. They used their avatars to move, rotate, and point and click the designs for user interaction. They evaluated our project not only by seeing it but also by experiencing and interacting with it in a realistic space.

Ivy, from Group A, also noted:

It was efficient to detect problems with other teams in remote design evaluations. In the classroom, we sat together, and sometimes we were unaware of the potential issues. Luckily, asking other team members to come into our world after the class and review our project remotely helped us obtain constructive feedback and recommendations.

Group I participants considered the formal and informal evaluation to be inspirational and competitive since they had difficulties realizing their initial concept for several weeks and reformulated their design challenge near the end of the course. Kaden reflected, "It was a different learning experience for me. I never thought I would become passionate about competing, even though there was no actual prize." Megan elaborated on her experience as follows:

You know, we fell behind in the design process. I remember one time Group P came to our world for a visit. Because they didn't understand the instructions, it was difficult for us to coordinate our project's functions. We had to teleport each of them so many times in order for them to participate in our designed activities...At that time, we realized the problems of our project, and Group P members offered us immediate feedback, prompting further reflection and solutions generation.

Participants' responses reveal an evolution from team-based learning communities to a class-based learning community that was fostered in the VW-integrated design course. Their reflections also suggest that the avatar-to-world and avatar-to-avatar interactions positively impacted students' engagement with their peers and the teacher in real and virtual worlds. By engaging in positive interactions and relationships within a design learning community, these students were expected to feel a

sense of connectedness that could empower them to critically reflect on their decisions and generate more creative solutions, thus contributing to the reconstruction of their identities.

6.3.4. Theme 4: Developing a sense of empowerment in values and beliefs

According to participants' interview responses, a feeling of empowerment emerged as a theme that permeated many aspects of students' VW design practices. Among these aspects, three were distinct as interrelated sub-themes: Students became self-reflexively aware of their own and others' strengths and achievements, gained more creative confidence in their abilities to manage design uncertainties, and established growth mindsets and intentions for their next stage of design learning and career aspirations. These responses reflect that the VW-based design practices had created a conducive space for TAE, leading to participants' personal and social changes in their values and beliefs.

Self-reflexive awareness

In O'Neill's (2012a) view, the concept of empowerment in art education concerns nurturing learners' reflexive capacity to reflect inwardly on connections between self, art, and sociocultural understanding. Participants in this study expressed feelings of empowerment that resulted from the increasing awareness of their own and others' achievements, weaknesses, critical voices, and self-limiting beliefs. Specifically, Group P members Anna, Ben, Caleb, Daisy, and Effie explained their pride in their VW project. Anna said, "I felt that our virtual labyrinth was the most creative project in the class because our design was coherent." Ben stated, "Our group project was the most creative because we coordinated smoothly throughout the process." Daisy also noted that:

With the help of the VW platform, we redesigned Pan's Labyrinth into an interactive virtual environment that was integrated with gaming functions. We were committed to our goal throughout the process, and we achieved it by the end of the class...the result was beyond our expectations.

Ivy expressed a similar sentiment, stating that "only in VWs could they make their goal achievable." When asked about the least creative thing they did during the design processes, none of Group P participants described their designs as uninventive. They all

expressed that their project was innovative and meaningful, as they invested significant effort as a team.

Additionally, participants spoke honestly about their weakness in integrating knowledge and skills across disciplines to develop more sophisticated VW projects as well as their awareness of the connections between art, design, and other disciplines employed in the increasingly complex designs. Specifically, Group A participants Gena, Ivy, and Jessica expressed that despite the overall satisfactory virtual environment, they felt that they did not achieve detailed construction and simulation due to their limited VW building skills and knowledge. Gena stated:

At first, I didn't take VW seriously because the image rendering was low fidelity, and I thought VWs were just for fun and not complicated. Soon I came to realize that it required cross-disciplinary knowledge and perspectives, such as programming, physics, architecture, furniture designs, and so on to construct a sophisticated virtual project or environment...Due to the limited time and our unrealistic goal, a large part of our project was constructed by redesigning the objects that pre-existed in the system.

Ivy also reflected on their redesigned project as follows:

Although our project was not purely original, we transformed the pre-existing objects into something new...You know, it was challenging, as VWs are essentially transdisciplinary...My participation in the VW design project broadened my horizons. I have tried to apply disciplinary knowledge I had never imagined I could employ in my first digital design assignment...Personally, it was a big achievement.

Jessica spoke about the significance of developing transdisciplinary knowledge and skills before entering the professional design industry. She said, "My major is graphic design, but I have become aware that I can't limit myself to this specific type of design. I need to develop multidisciplinary portfolio assets to attract my future employers."

Kaden and his teammates reflected on their experience of overcoming the challenge of rebuilding the project near the end of the course, describing it as meaningful, reflective, and empowering. Kaden elaborated:

We were under pressure when we realized we needed to redesign the whole environment and saw other groups' amazing design progress. As our group leader, I definitely had negative thoughts, feeling a little bad about myself. However, this self-critical voice didn't last long because

no one had ever judged our project. In the critique sessions, other team members and our teacher walked through our virtual environment and offered constructive feedback that encouraged our reflection. For example, some of my classmates sent messages directly linked to the problematic areas and objects, which provided more precise frames of reference to improve our project. Even though I still felt my competitive urge, I appreciate that we learned together.

Expressing a similar sentiment, Megan described:

Taking the VW-integrated design fundamental course had a huge impact on my design learning...Or I could say that it had a significant impact on me... We fell so far behind in our class when we realized that we had underestimated the difficulty of our problem and the time needed to arrive at acceptable solutions...We were frustrated and almost gave up when Yi encouraged us that we could do it because she had experienced many difficulties while learning to build in VWs. She suggested we keep working on our initial project because creative solutions always emerge from the process...We took her advice and divided our efforts into recollecting inspirations in SL. In the end, it was all worthwhile because our group coincidentally found a futuristic sci-fi world. We were very excited, and everyone's passion was instantly rekindled...We finally settled on our design theme as a futuristic world, and we haven't changed it since...I think the challenge our group encountered was unique. However, with Yi's help and the rich resources of VWs, we were able to turn the design challenge into an opportunity through reflection and exploration. I felt empowered to learn not only our weaknesses but also our strengths in dealing with the problems until we solved them.

Creative confidence

Many participants expressed that they felt empowered to have the creative confidence to undertake increasingly adventurous design tasks and challenge disciplinary boundaries in their design practices. For example, Group P member Caleb described his increased sense of autonomy, and the experimental nature of virtual environments enabled him to gradually gain confidence. Caleb explained:

It was my first time designing with digital technology, so I was not confident at the beginning of the class that I could produce an animated 3D design with my teammates in a short time...Our problem-finding and solving processes seemed endless, but I never felt bored when designing in VCER because we thought we were playing games. I enjoyed exploring others' virtual environments and experimenting with tentative solutions with my teammates. Through these iterative practices, I have become more aware of my own and others' achievements and strengths, and as a result, I've gradually gained the confidence to take risks to accomplish my tasks.

When asked whether their VW experience involved other types of learning, most participants—13 of 15— responded affirmatively. They stated that they gained skills to solve real-life problems and challenges. For instance, Group A participant Finn reflected on his increased ability to be a leader:

Um, you know, it wasn't my choice to be the leader of our group. Because I was the only boy in my group, my teammates pushed me to take this job, which I did accept. Often, I preferred to focus on my own work rather than spend time managing the team or helping others with their tasks. But, with this one, I felt like I was really into the role. For sure, it was challenging to coordinate all of the tasks while encouraging my teammates to work toward our goal. However, we really had a passion for achieving the best group in our class, and we did everything we could. It was a rewarding experience for me personally.

Many participants related their feelings of empowerment to their enhanced “life skills” (O’Neill, 2015, p. 10) that resulted from their collaborative and individual efforts in self-initiated designs, project management, workflow control, negotiation, and communication. For example, Group I member Leah stated:

At the beginning of our class, I felt it was interesting and fun to play in VWs, but I didn't expect to learn much from it. However, in the last few weeks, we self-initiated a project, managed our own tasks to coordinate our design processes, and communicated to find and solve problems. We needed to apply multiple competencies at the same in our VW design practice.

These reflections suggest that the VW collaborative design practices combined the key characteristics of design thinking and TAE to their ideal advantages, providing safe and experimental spaces for students to take creative risks and develop leadership and life skills. As they learned through repeated processes, students became more aware of their own and others' achievements and strengths, thereby developing further resilience to tolerate and manage uncertainty as well as confidence to conjecture and explore additional creative solutions.

Intrinsic motivation and growth mindset

Eleven out of the 15 participants stated that they felt motivated to leave their comfort zones and expand their knowledge in areas that excited them to prepare for the complex and uncertain design industry. For example, Group P member Caleb reflected on his self-directed learning experience in applying different digital software to achieve his creative idea of building luminous music players:

My my music players' visual appearances were not detailed, but they enriched the mysterious atmosphere of our labyrinth...You know, I haven't yet learned any professional digital design technologies. Nonetheless, I used the music editing software to cut the sound I downloaded into small pieces and combined some of them into a new piece. I also edited the images in Photoshop before uploading them into VCER to design the music players...My English was terrible, but I researched many English resources and found a script that allowed the music players to loop the sound...I also designed the music players in different neon-luminous colours and half-buried them in the ground. For me, our environment looked so much better and felt more dynamic after adding these music players...It was a good way to get started with digital design, and it inspired me to learn more about VW design and other types of technology-based design.

Group A member Jessica mentioned that the VW-facilitated, peer-based learning and assessment motivated her to continuously improve her designs to realize their own and her teammates' collective goals. She stated:

In previous design classes, I chose more manageable tasks over difficult ones. This was because I didn't want to embarrass myself in critique sessions and wanted to maintain my smart image. In the VW class, however, we learned together and supported each other regardless of which team we were in. We praised each step of our design processes instead of performance. Therefore, I felt safe and motivated to challenge myself during the process to produce creative solutions that would improve our group project rather than throwing my hands up quickly.

Group I participants also expressed a similar sentiment when describing their VW group design project. Kaden stated that "they celebrated and learned from mistakes." Nina explained that their design processes were "engaging, challenging, and meaningful," which motivated them to be "more resilient to deal with difficulties." Megan expressed a feeling of empowerment by "learning collaboratively" and "believing in their potential to solve problems."

According to participants' interview responses, students believed that the VW collaborative design practices fostered their "growth mindset" (Dweck, 2008). In other words, they were motivated to change their values and beliefs by viewing challenges and obstacles as opportunities. They shifted their mindsets toward strengthening each other's potential, designs, and creativity, which increased participants' intrinsic motivation to improve upon their mistakes and encouraged intellectual and personal development. Therefore, I conclude that the collaborative affordances of the VW design pedagogy provided TAE-related opportunities for students to develop expanded forms of

creative expressions and growth mindsets to believe in their power to navigate the future of complexity.

6.4. Summary of Post-Pre Assessments and Interviews

On the post-pre assessments, all three groups of students had higher after-course mean scores in all three TAE items than their before-course mean scores. These results yielded credible indicators of the positive impact of VW design pedagogy on students' perceptions of their creative collaboration related to TAE learning capacities. However, Group P and A students' top mean score differences were only found in their ratings on engaged agency and connection items. Especially Group P students, who demonstrated remarkable creativity in codesigning their multimodal virtual *Pan's Labyrinth* (as described in Chapter 5) but reported only a slight increase in valuing VW design practices for enhancing their creative collaboration.

The subsequent open-ended interviews regarding VW collaborative design learning experiences provided additional insights into significant learning instances that were difficult for students to describe in the post-pre surveys, thereby elucidating the affordances of VW design pedagogy for creative collaboration with TAE learning capacities in greater detail. Below is an overview of the three most important findings:

First, all participants, regardless of their differences in their group design processes and experiences, demonstrated positive perceptions of changes in their creativity associated with the three TAE learning capacities (engaged agency, connection, and values and beliefs). This result suggests the VW design pedagogy positively affected all participants' design learning in each TAE outcome.

Second, although the results reveal several trends in the students' responses that are not statistically significant, it cannot assume that there was no impact on students' creative collaborations. The trends are listed as follows: (a) Group I reported the highest overall mean differences in each TAE learning capacity and exhibited a slight edge over Group A in three TAE learning capacities; (b) Group P reported the lowest overall mean differences in every TAE learning capacity; (c) the top three mean scores for Groups P and A were distributed over the engaged agency and connection items;

and (d) the top three means scores for Group I were evenly distributed over the three TAE items.

Finally, the three groups' interview reflections do not significantly differ from their responses to the post-pre assessment items. However, their reflections, particularly those of Group P, provide additional information regarding what they felt could not be properly expressed in the post-pre assessments but was crucial for their collaborative VW design learning. I synthesized the information from the interviews into four main themes: building design thinking skills, developing avatar-mediated multimodal designs, transforming from team-based learning communities to a class-based learning community, and developing a sense of empowerment in values and beliefs, which can be directly linked to students' participation and perspectives of VW-based collaborative design learning on creativity in the TAE learning outcomes.

Together, the two sets of data present a comprehensive view of the VW design pedagogy's affordance for creative collaboration in relation to TAE capacities, revealing its potential for use as a strategy to foster transformative design engagement. As an extension of the TAE framework, this pedagogical approach develops a strong sense of empowerment in students to become creative, collaborative, autonomous, and agentive design learners with the capacity for reflective self-awareness and resilience in complex design challenges and uncertainty.

The final chapter discusses how this study relates to the previous theories and research, proposing pedagogical implications for art and design educators who are interested in engaging in transformative education, as well as other related sectors to promote students' creative collaboration.

Chapter 7. Discussion and Conclusion

7.1. Discussion of Research Findings

The purpose of this research was to address two central questions: (1) How might the purposeful use of multimodal pedagogy leverage the affordances of VWs to foster creative collaboration among junior art and design students? (2) How might the multimodal pedagogical approach in conjunction with the TAE framework create transformative learning opportunities through VW-based collaborative design processes?

In response to the first question, I framed three units of a fine-grained multimodal analysis for each group using three conceptual characteristics of a sign—the environment, affordances, and the motivated relation of forms and meanings (Bezemer & Kress, 2016). Moreover, the three units of each analysis served a case study that examined each group of student participants who worked through the design thinking process to collaboratively explore the virtual environments, exploit VW affordances, and develop group design projects as motivated signs. Regarding the second question, I employed the constant comparative method to analyze the data collected from students' responses to the post-pre assessments and interviews. This approach facilitated understanding students' perceptions of changes in how they valued VW group design practices that offered TAE-related learning opportunities for fostering their creative collaboration. The following sections discuss and relate the two principal findings to the previously stated literature review and theoretical framework.

7.1.1. Multimodal ways of design thinking

The multimodal analysis of three case studies reveals that, despite the distinct characteristics of the three groups' design collaborations, five recurrent themes emerged from the five design thinking stages of students' semiotic work. These themes characterize specific VW affordances that motivated students to cultivate a habit of design thinking to coconstruct creative meanings in their multimodal designs.

Multimodal resources and embodied interactions for discovery

Regarding the discovery stage, my examination of participants' exploration of virtual environments reveal that VWs provided rich contextual and embodied multimodal resources that captured participants' attention and curiosity for collaborative engagement as interpretation. Their creativity was embedded in their capacity to engage with unfamiliar virtual environments and other avatars in their motivated choices of the embodied semiotic modes.

All avatar-mediated participants embodied exploratory experiences through connected textual, tactile, visual, auditory, and movement modes. For example, without detailed instructions on the SL user interface, Group P participants demonstrated their creativity by utilizing multiple communicative modes to interact synchronously with other avatars; they participated in dancing events and voice- and text-based conversations, which motivated them to create more interactive effects in their virtual labyrinth as a group interest. In addition, despite their initial competing interests in defining the goal, participants in Group A creatively designed different role-playing identities to engage appropriately with avatars outside the classroom and in virtual environments, enabling them to transform their semiotic resources and ultimately reach a consensus. Finally, all participants of Group I expressed that the imaginary historical virtual spaces in which they navigated their avatars to run through, fly by, and jump over the objects or listen to sounds and music motivated them to clarify their goal efficiently. Participants increased their embodied knowledge about this new platform through these practices of seeking inspiration in group activities; this knowledge encouraged them to question, recognize, and challenge their assumptions to develop deep and shared understandings of their design challenges and contexts.

Communication and copresence for approximation in interpretation

For the interpretation stage, my analysis of participants' design drafts as semiotic outcomes of their exploration of virtual environments validates and expands the understanding of VW affordances identified in the first design thinking stage. After defining their goal of recreating the Spanish fantasy horror movie *Pan's Labyrinth*, Group P participants collectively visited virtual environments with the same labyrinth theme, recollecting information by interacting with multimodal ensembles regarding genre, space layout, visual, auditory, movement, and among others. Participants of Group A

also expressed that their trip to simulated ancient European fantasy cities and participation in the cities' events with other avatars inspired them to redefine their goal.

One can observe from the above examples that as groups of participants continued to seek inspiration by synchronously engaging with socially and culturally shaped virtual environments, their increased level of awareness of their own and others' appearances and actions heightened their sense of copresence and communication, which VW technology uniquely afforded. The combination of copresence and communication affordances was a multimodal ensemble with sociocultural meaning potentials that prompted participants to rethink their design challenges from various perspectives, thereby approximating their interpretations to frame their goals.

Personalized avatars and content-creation tools for agentic ideation

Two VW affordances were proven to be essential in encouraging participants to produce a variety of wild and creative ideas throughout the ideation stage. First, with VWs' changeable avatar affordance, participants demonstrated their collaborative creativity through their agentic actions of personalizing their avatars in numerous modes (e.g., colour, shape, style, and action) and utilizing avatar embodiment to envision imaginary concepts with their teammates—previously confined by their real-world identities. During their visit to various virtual environments in SL, Group A participants demonstrated their interests and abilities in changing and designing their avatar appearances. In their subsequent group meetings, they came up with various creative ideas for defining their design goal. Second, VWs' hands-on content-creation tools that were available for design motivated many avatar-mediated participants to autonomously and multimodally prototype their ideas during the ideation process. For example, despite the lack of step-by-step instructions for the content-creation tools, Group P participants initiated their ideas quickly and directly in their virtual environment. Although Group I participants overestimated their ability to realize the initial complicated design draft, the modifiable virtual environments prompted them to collaboratively express their stylistic ideas in negotiation with others. These modal ensembles widened participants' grasp of multiple semiotic modes that they had utilized. Accordingly, it increased their potential for meaning-making, thus encouraging participants to revisit their design challenges and generate novel ideas for refinement.

Changing frames of reference for design engagement and experimentation

During the experimentation stage, changing frames of reference (e.g., avatars, roles, surroundings, and viewpoints) within VWs allowed participants to build prototypes collaboratively and multimodally while sharing them in real time with their group members. For instance, Group I participants spent over six weeks exploring their design problems and solutions by continually designing and redesigning modes available in the environments before making their creative leap in defining their design goal.

Additionally, VWs allowed participants to engage with their prototypes, utilizing modes unique to this platform (e.g., flying the designed object around and observing it from a third-person view via their avatars). For example, Group P participants, such as Caleb and Effie, continually evaluated the functionality and modified the designed objects by interacting with them directly. These distinctive modal ensembles added new potential for meaning-making and engaged participants to experiment innovatively with these modes, resulting in continuous transformative and creative collaborative processes.

Participants became more engaged, inspired, and empowered when they learned about their group members' real-time prototyping actions in virtual environments. For instance, Ivy and Jessica from Group A were motivated by observing their teammate Halley's synchronized design process in the VW. As a result, they created a floating bridge and palace that were stylistically coherent with Halley's design. Although the prototypes were typically rough at this stage, participants in each group displayed exceptional creativity in utilizing VWs' changing frames of reference and communication affordances to share their understanding while simultaneously improving their multimodal designs. Thus, they demonstrated expanded creative possibilities for sign-making.

Integration of multimodal choices for transformation and evolution

Evolution was the stage during which participants improved their understanding of the affordances of specific available VW modes and honed their abilities to make informed decisions about integrating particular modes into new meanings consistent with their motivating interests. I examined each group's design project as motivated signs of completion at this stage to discover how VWs' numerous modal options motivated and

engaged participants to continuously evaluate and evolve their concepts, resulting in transformative changes. These changes to their multimodal designs were most evident after their self-organized and informal cross-group design reviews conducted in VWs near the end of the course.

Each group of participants continually sought other groups' comments and feedback on their prototypes. Although design review meetings occurred without actual clients' or customers' participation and feedback, they were nevertheless collaborative design activities that emphasized the user experience and allowed each group of participants to discover crucial practical issues from the user's standpoint and feedback. Furthermore, by considering the user experience, each group took more time to adjust their designs. They thus made more creative and effective decisions by employing various modal strategies to bring their interests, the semiotic resources, and the audience—the core of human-centred design thinking—into coherence (Bezemer & Kress, 2016).

All five themes identified connected to creative collaboration: an act of sign-making that students, as sign makers, coconstructed throughout their VW design learning and practices. By viewing these junior design students as creative sign makers, I was able to recognize specific VW modal affordances that fostered students' resourcefulness in collaboratively and continuously engaging and expanding the semiotic potential of the modes to coconstruct transformative meaning, thereby bringing the three aspects of design into coherence. Through the iterative and multimodal processes of transformative engagement, these young design students began to develop a habit of mind for design thinking.

7.1.2. Connections with previously discussed research and theories

The first significant finding—multimodal ways of design thinking—that was fostered in the VW-based collaborative design practices corroborates Bezemer and Kress's (2016) assertion: a design-oriented and multimodal pedagogical approach will support and recognizes students' meaning-making processes, the role of agency, and the components of signs of creativity in the increasingly media-blended participatory learning environments. Accordingly, my meticulous examination of each group of students' collective and individual semiotic work produced during the design thinking

stages confirms that employing a multimodal pedagogical approach could reveal VW affordances as ever-growing and expanding rather than being a fixed set of tools.

Moreover, my examination allowed me to recognize that—with available VW modes for multimodal design—each group of students exerted their creative agency by constantly shaping and expanding the modes' semiotic potential to produce new meanings aligned with their shared interests and target audience. Specifically, Group P transformed and transduced the modes and media from *Pan's Labyrinth* to a recontextualized virtual environment. Group A redesigned various technological and social resources available in VWs into a coherent style representing ancient Chinese mythology. Group I utilized their resourcefulness to overcome the constraints they encountered and created sophisticated modal ensembles of a futuristic virtual city that prompted a variety of engagement forms from the intended audience.

At the centre of these codesign processes is transformative engagement, through which each group of students continually explored and assessed the potential of the available VW modes for their social needs. They collaborated on ideas, transformed their existing understanding through their multimodal designs, and conducted user-centred evaluations of their designs for continuous refinement. The steps involved in this transformative engagement process evoked several stages of IDEO's (2012) design thinking model discussed in Chapter 2, including discovery, interpretation, ideation, experimentation, and evolution. These stages provide user-centred, accessible structures and collaborative approaches that are widely used to creatively address complex, uncertain design challenges (Cross, 2006; Lawson, 2006).

This research was conducted without the participation of actual clients. However, the multimodal analysis reveals that the avatar-mediated exploration and evaluation of design works allowed students to develop a relatively superficial level of understanding of the potential audience's needs, which continually challenged students' assumptions and motivated them to engage with and transform their semiotic resources to redesign the multimodal meaning systems to meet their audience's needs. This potential for a user-centred design has been proven to be a unique affordance of VW design pedagogy, as it supported students in achieving the three components of what Bezemer and Kress (2016) defined as *coherent design*: "the designer's interest, the semiotic resources and the characteristic of the audience" (p. 64).

Furthermore, this study's findings expand existing relevant literature regarding students' meaning-making processes in VWs and the creative affordances of this technology by employing this multimodal viewpoint of collaborative design, learning, and creativity. In other words, by encouraging students to iteratively engage with and transform such complex digital and semiotic modes in their multimodal group design practices they may develop a habit of human-centred design thinking, culminating in the creative production of meaning that shapes audience engagement.

7.1.3. Transformative design engagement

Examining student participants' responses to the post-pre assessments and open-ended interviews revealed that the VW-integrated collaborative design practices have the potential to foster students' creative collaborations and transformative design engagement. These can empower students to develop the TAE-related learning capacities necessary for progressing toward advanced design learning and confronting more complex design challenges. The main findings include four dimensions that connect to TAE's three critical learning capacities.

Engaging with design thinking as a habit of mind

Junior design students with little or no prior experience in digital design encountered numerous social and technical challenges and constraints when collaborating on an unfamiliar VW platform. However, according to the findings from the post-pre assessments and interviews, students developed the capacity to honestly question the ever-emerging assumptions about these difficulties. This development was due to the cultivation of design thinking as a habit of mind during VW collaborative design learning and practices, which emphasized trial and error, playful inquiry, and experimentation. For instance, the post-pre-assessment results revealed that all three group participants considerably raised their rating on the "after" items of communication, collaboration, and motivation. Additionally, all three groups described their collaborative management of design challenges as enjoyable, motivating, and rewarding. Through iteration and repeated experience in engaging with design challenges with increasing awareness of personal and others' accomplishments, these students developed their design thinking as a habit of mind. Consequently, they produced diverse, creative ideas to address problems and propose solutions.

Engaging with multimodal design as autonomous agents

Students often expressed a sense of autonomy, agency, and ownership over their designed avatars, virtual environments, and collaborative design processes. For example, all participants highlighted how the VW design course provided them with freedom and ample choices to create and control their imaginative multimodal designs that would be impossible to develop in other digital programs. They also stated they felt safe and creative while expressing their reflective views and visionary ideas throughout their avatar-mediated communication and collaboration. More crucially, the avatar-mediated embodiment and navigation enabled these junior design participants to interact directly with their designed objects and environments; this allowed participants to continuously identify and reflect on the practical issues within their concepts and prototypes and generate new insights.

Engaging in connected and collaborative learning

Another notable finding is that students collaborated more and felt connected to others throughout their VW-based design learning, perhaps because all three groups of participants felt that integrating VWs into the design course enabled a safer, more open classroom. Additionally, the sense of copresence mediated by avatars in virtual environments increased their feeling of connectedness with their peers and their teacher. For instance, Group A participants changed their avatars' appearances to traditional Chinese characters to reflect their design theme (an ancient Chinese fantasy environment). In interviews, Group A participants expressed that this setting highlighted their sense of belonging and collective identity; they felt more attached to their project when seeing their teammates appear in their VW as avatars with similar looks. Participants in Group I described how their informal cross-group reviews after class helped the entire class build stronger relationships and trust. This trusting environment motivated and empowered students to openly share ideas and continually manage complex design challenges as individual and collective agents, thereby gradually turning their learning from team-based communities into a wider classed-based community.

Developing a positive and empowered mindset

After analyzing post-pre-assessment results and interview responses, I discovered that after taking this VW-integrated design course, participants transformed from junior design students who lacked creative confidence to those prepared for

advanced design learning, typically involving the use of complex graphic design technologies. Furthermore, according to their interviews, many participants expressed a greater critical awareness of their creative skills and capacities, a sense of empowerment, and a positive mindset that would enable them to take on more complicated and uncertain design challenges in collaboration with peers and diverse teams.

The four major discoveries interconnect with the three critical TAE learning capacities for creative collaboration. Moreover, they validate my presumptions about VW design pedagogy. Specifically, the purposeful use of design thinking, multimodal pedagogy, and the TAE framework based on the affordances of VWs in a foundational design course offer junior design students substantial opportunities for creative collaboration and transformative design engagement.

7.1.4. Connections to the previously discussed research and theories

The second major finding—transformative design engagement—that occurred during students' VW codesign processes and learning outcomes confirms O'Neill's (2012a, 2014) theoretical TAE framework, indicating that VW design pedagogy's potential to foster student creative collaborations in relation to the TAE learning capacities. Specifically, this finding reveals that the VW design pedagogy is capable of promoting Jenkins' (2009) participatory form of learning and Gee's (2005) affinity spaces, in which engaged groups of students share their knowledge and connect with others to pursue their common goals through collective efforts to effect change in a frame of reference (Mezirow, 1997). This course did not provide step-by-step instructions for building in VWs. However, students from Group I expressed in their interviews that they were deeply engaged in the playful experimentation with VW content-creation tools and felt motivated to share their knowledge to support their teammates throughout their self-initiated collaborative project. Group P students stated they felt comfortable questioning others' ideas and prototypes because they believed everyone was equal and felt connected with their peers and the teacher in the VW design course. Group A students remarked that their project became more meaningful and creative because of each member's contributions. These fundamental characteristics of participatory learning and affinity spaces, as captured in the research findings, support Han's (2019b) claim that VWs can increase students' intrinsic

motivation, creative play, and teamwork, all of which are critical components of developing the TAE capacity of engaged and autonomous agency (O'Neill, 2012a, 2014). With the capacity for autonomous thinking, students' approaches to various challenges and constraints during their VW codesign processes paralleled the design thinking process as a habit of mind (Cropley, 2016; IDEO, 2012) rather than simply following the iterative process.

In addition to VW design pedagogy's affordance to foster students' engaged agency and autonomy, their shifted perceptions that their VW-based collaborative design learning was connected indicate that their attainment of the TAE learning capacity of connectedness (O'Neill, 2012a). This finding implies that the VW design pedagogy has the potential to transform these young design learners, most of whom had little acquaintance with each other before the course, into a connected learning community dedicated to sharing and producing knowledge. Students expressed that they often worked in collaborative groups to design their virtual projects during their free time. Furthermore, they claimed that when they collaborated in VWs, they generated more innovative ideas. This team-level creativity supports the findings of Koutsabasis et al. (2012), who posit that the copresence of the avatar-mediated team members promotes the exposure of diverse ideas and engagement with their design tasks, resulting in creative and reflective collaboration. Moreover, students in all three groups stated that they enjoyed designing in VWs because they felt happy interacting with their peers and the teacher via avatars. Kaden and Megan, members of Group I, stated that they frequently returned to SL in groups to gather more information. During their visits, they participated in social events, such as attending art exhibitions and having a drink in a bar. Additionally, they occasionally interacted with avatars outside of their group and classmates. These examples reinforce Ward and Sonneborn's (2011) findings, which identify the connection between the development of trust among virtual team members and the extent to which these members participate in extra VW work activities. Consequently, trust within these design groups facilitated caring and supportive relationships that fostered students' sense of belonging and prompted them to engage more deeply and critically in the multimodal projects, resulting in a genuine sense of connectedness that facilitated creative collaboration (O'Neill, 2017).

With an increasing sense of engaged agency, autonomy, and connectedness, students changed their perceptions of their own growth in their self-awareness regarding

their own strengths and weaknesses as well as creative confidence. This finding indicates the development of another crucial TAE capacity: empowered self-beliefs and values (O'Neill, 2012a, 2014). Numerous students from all three groups expressed their increased motivation and confidence in collaborating with others and utilizing their knowledge and abilities to address future design complexity. Kaden and other members of Group I felt empowered when they overcame the obstacles of reconstructing their project near the end of the course, and consequently, they were more driven to confront more complicated design challenges. Group P students stated that the repeated VW design practices, trial and error, skill development, collaboration, reflection, and persistence enable them to gain greater awareness of their own and others' achievements and creative confidence. This compelling evidence demonstrates that the VW design pedagogy is capable of cultivating students' growth mindsets, as proposed by Dweck (2008), which is essential for achieving instinct motivation, positive valuing of one's own and others' efforts, resiliency, and a sense of empowerment (O'Neill, 2006). With these mindsets, students developed a habit of design thinking with the intention of remaining open and collaborative, pursuing challenges actively, refraining from judgements, and transforming numerous ambiguities into creative opportunities (IDEO, 2012).

Overall, the two major findings reaffirm a number of VW creative affordances for creative collaboration and learning that were identified in the literature review. More importantly, they address gaps in the existing literature by demonstrating how VW affordances can be reshaped and expanded to foster design creativity in a collaborative context when utilized tactfully with appropriate pedagogies that align with the platform's affordances.

7.2. Research Limitations

One of the major drawbacks of this study is that all participants shared a common cultural background. As previously stated, this study was undertaken in the Art and Design Department at Zhengzhou University in Henan Province, China. I assumed that the art learning and digital design experiences of these participants would be comparable to those of junior university or college design students throughout the province. However, until cross-province and cross-cultural research is conducted, it is impossible to guarantee that these similar experiences and pedagogical outcomes are

shared by similarly aged design learners throughout China and other countries. Thus, future research should investigate VW design pedagogy with participants from a variety of cultural backgrounds and learning environments to obtain a full grasp of how this pedagogy is manifested in various, common, and interconnected contexts.

Furthermore, because the study was conducted with this particular sample of participants from China, the VW design course and the entire data collection process were completed in Chinese. This required me to translate all narrative materials into English, including students' design journals, interviews, and presentations. However, due to time and resource constraints, I was unable to verify my translation, transcription, and analysis of these narratives with each participant. Consequently, I believe that if I had conducted additional member checks on translations, then I would have uncovered more nuanced interpretations and findings.

Another limitation of this study is that the relatively small sample size of 15 participants may make it difficult to accurately interpret students' statistical responses to the post-pre assessment. A large sample size, however, does not allow for a deep, case-oriented analysis in constructivist qualitative research (Sandelowski, 1995). To justify the sample size chosen, I purposefully extended the amount of time spent with each research participant (Marshall et al., 2013) through after-class contact via VWs, WeChat, and email. Additionally, I frequently referred to the data collection process, which established the scope and nature of the study (Morse, 2000). Consequently, I believe these approaches add a degree of creditability and trustworthiness to the findings.

One of the primary criticisms regarding action research is the possibility that the teacher-researcher would allow personal bias to enter the analysis of the findings (Mills, 2007). Therefore, I was fully aware that that my prior teaching experience may affect my perspectives when conducting this research. I was also mindful that my role as the course teacher would pressure my students to alter their perspectives in their design processes or narratives, thus complicating the research processes. Consequently, I attempted to build a habit of self-reflection throughout my research process by articulating my evolving perspectives in my field notes, journaling, and this thesis. Additionally, I frequently consulted with my supervisor, committee members, and my colleagues to obtain their valuable insights and suggestions. I hoped that by undertaking

these critical examinations, my bias and subjectivity in designing and conducting this action research would not distort the findings.

Finally, more than three years have elapsed since winter 2018 when I completed this study. Due to the dynamic nature of technology, VWs may have improved in functionality since that time. Consequently, my VW explorations three years ago may have constrained the breadth of the study and findings. However, my exploratory study provides a detailed description of VW-supported multimodal collaborative design learning that could foster creative collaboration through engagement and transformation, which offers illustrative resources for educators and researchers interested in the interactions between transformative learning, multimodality, creative collaboration in design education, and VW technology.

7.3. Research Significance and Implications

The findings of this research offer valuable contributions to the discourse on art and design education, as well as art-related educational domains, due to their potential to illuminate noteworthy implications across three distinct areas. First, this study distinguishes itself from earlier research on VW-supported art and design education, which has predominantly focused on the fixed and perceived properties of VWs. Instead, my study integrates the concepts of social semiotic multimodality, TAE, and design thinking to form a holistic pedagogical model that recognizes VW affordances not as static features but as semiotic resources with meaning-making potentials shaped by social and cultural factors. These resources can be strategically designed to foster students' creative collaboration and transformative learning opportunities aligned with their interests and educational objectives. Second, the novel combination of a multimodal approach and the TAE framework not only provides a pedagogical framework but also outlines assessment methods for recognizing and valuing the interests, creative agency, collaborative skills, and evolving perspectives of students about themselves within increasingly multimodal design learning environments. Finally, the study identifies implications for educators, researchers, and curriculum developers concerning the need for transformative, multimodal practice-based approaches to art and design teaching. It points to the fact that art and design education, to empower

students for becoming multimodal designers in today's digitally facilitated complex learning and working contexts, must provide a challenging yet multimodal exploratory space for iterative and repeat experiences with increasing awareness of personal and others' achievements to gain autonomy, creative confidence, and resilience.

The following section discusses in depth how these three fields present a pedagogical framework and assessment methods for optimal integration, with potential implications for design and art-related education.

7.3.1. Designing for multimodal learning

Digital technologies have changed the “communicative patterns” (Kress & Selander, 2012) of educational fields, including art and design education. This change necessitates design educators, who aspire to use emerging technologies to promote students' creative collaboration in design learning, to critically evaluate established pedagogical approaches. Concurrently, it underscores the need for developing a broader understanding of design learning, characterized by increasing virtual, mixed media, and new communicative patterns.

My incorporation of VW technology into the design studio classroom through a combination of multimodal, TAE-oriented, and design-thinking-framed methodologies encapsulates a refined perspective of design pedagogy. This perspective is grounded in the concept of education as a “transformational and interactive process” (Kress & Selander, 2012, p. 265), wherein everyone engaged in learning is a designer or a redesigner of the material resources. It also underpins significant aspects of TAE for creating reflection, experiential, and action-oriented learning opportunities (O'Neill, 2012a, 2014).

Consequently, the purposeful design of a collaborative learning experience that leverages the diverse VW modal affordances to motivate students' various interests and foster their meaningful engagement emerges as an appropriate pedagogical strategy for understanding and shaping the new communicative patterns and social interactions instead of relying solely on the technology. These distinctive communicative patterns cultivated from this approach are signs of creative learning, ranging from acquiring and disseminating information to sharing of experiences and learning of innovative design

forms, which evolved within the VW multimodal collaborative learning environment, indicating significant implications for 21st-century design education. Contemporary design challenges are increasingly multimodal and collaborative, necessitating a reconceptualization of educational environments that expand students' design awareness and engagement with complex codesign processes that transcend the confines of school-taught knowledge.

The research approaches developed in this study contribute to the existing art and design education pedagogical framework by providing a multimodal understanding of digitalized design learning. By incorporating VW technology within multimodal, TAE-oriented, and design-thinking-framed methodologies, it is possible to leverage the potential of the novel communicative patterns afforded by the distinctive VW modes for students' creative engagement and collaboration. Ultimately, the engagement and collaboration indicate an ongoing process of students' (re-)designed transformation/interpretation, whereby an enhanced awareness of multimodal designs leads to reconstituting how one sees their learning and working contexts through changes in perspective.

7.3.2. Recognizing multimodal designers

Moreover, pedagogical methods encompassing multimodality and TAE adopted in current study provide an analytical framework. This framework enables the recognition of students' creative actions in their collaborative VW design learning, suggesting implications for alternative forms of assessment in art and design education. As discussed in Chapter 2, the long-established information accumulation evaluation in design education falls short in appropriately recognizing students' creative efforts and capacities to tackle inherently uncertain and complicated design challenges and processes.

This research diverges from earlier studies on design education, which predominantly focused on the analyses of identifiable information and quantifiable skills manifested in students' final design projects or portfolios. Instead, it recognizes students' learning as a process of sign-making encompassing all modes (Kress, 2013). This process is ongoing and entails a continuous engagement with aspects of the sociocultural world as transformation/interpretation and signs of creativity (Bezemer &

Kress, 2016). This generosity of recognition expands the research scope to emphasize students' diverse ways of learning, which are inherently intertwined with their interests in engaging with specific VW modes as multimodal ensembles, including their 3D modeling, meeting conversations, journal entries, avatar designs, and virtual environmental designs.

The multimodal analysis thereby facilitates recognition of students as "resourceful" (Bezemer & Kress, 2016) multimodal designers who use their creativity to (re-)design various VW modal resources into new multimodal ensembles that align with their interests, purposes, and intentions. Furthermore, given the inherent technical and social constraints when integrating complex, unfamiliar technology into a foundational design classroom, the multimodal analysis illuminates the diverse potential and capacities of the students in utilizing various means resourcefully and collaboratively to navigate the difficulties imposed by VW design practices.

Notably, TAE also provides a framework for evaluating students' sense of agency, connection, and values and beliefs (O'Neill, 2012a, 2014). When this theoretical lens is utilized in the interpretation of multimodal analysis, it yields enriched understanding of the significant affordances of VW design pedagogy for creative collaboration. Moreover, the research methodology integrates this analysis with TAE-framed post-pre assessments and semi-structured interviews. These methodological tools focus on evaluating changes in students' appreciation of the VW-integrated design fundamental course, in relation to the vital learning capacities identified within the TAE framework.

Collectively, these methods construct a holistic evaluative framework that assesses the effectiveness of the VW design pedagogy from students' perspectives and recognizes their creative agency and capacities. Such recognition is crucial for augmenting students' individual and collective intrinsic motivation, as well as their self-perceptions, eventually encouraging them to persevere in their collaborative creative endeavours.

7.3.3. Transformative, multimodal practice-based approach to student empowerment

This research explores and develops a pedagogical approach that integrates VW technology to foster creative collaboration among junior art and design students, through an exploratory process based on the principles derived from TAE, multimodality, and the design thinking model. The research findings demonstrate that this innovative approach created expansive opportunities for students to develop a sense of empowerment, ultimately catalyzing perspective transformation in their design learning experiences and outcomes.

Art and design educators aspiring to incorporate VWs or other emerging digital technologies into their curriculum can benefit from the practical implications of this approach for fostering positive shifts in student engagement during the design learning processes. This necessitates the development of collaborative, transformative forms of design engagement within a multimodal learning environment that is deeply embedded in studio culture while leveraging the modal affordances inherent in the technology. The pedagogical approach emphasizes the importance of aligning pedagogy with the potential of technological modes in order to motivate students to actively and collaboratively develop their design abilities and capacities through an iterative design process. Through such an iteration and repeated experience that builds on and expands their strengths, the students are empowered to realize their own and others' potential and become more aware of their individual achievements as well as those of peers. This reflective and participatory process not only strengthens their personal design capacities, but also fosters shared learning and mutual empowerment that leads to enduring design learning challenges.

Furthermore, the approach also suggests a shift in the focus of art and design education from simply instructing students to imitate what professional designers do to fostering the empowerment and resiliency necessary for students to become creative multimodal designers capable of addressing complexities present in our technologically evolving world. However, this transformation cannot simply be "allowed" (O'Neill, 2015, p. 4). It requires the development of multimodal challenges in design practices, iterative experience for capability development, safe spaces for "diverse voices" (O'Neill, 2015, p. 6), and creative, collaborative experimentation within a caring, reciprocal, engaging,

dialogical, and empowering learning community. Such a community becomes a source of motivation, inspiration, resilience, and individual and collective empowerment for students to take an active role in deeply engaging with multimodal learning challenges and persistently undergoing recurrent cycles of learning obstacles and difficulties. Consequently, students' repeated learning experience evolves as a process of becoming multimodal designers with design thinking as a habit of mind, thereby enhancing their empowered capacities and reformulating their creative identities through shifts in perspectives.

7.4. Directions for Future Research

The study of the VW design pedagogy offers a theoretical framework, methods, and findings that can serve as a foundation for several future research opportunities. First, a longitudinal study of participants in a VW-supported foundational design course would map the post-pre assessment over a longer period of time, yielding more insights into how the junior design students evolved into those prepared to engage in more complex design challenges, thereby expanding understanding of the transformative nature of the VW-based collaborative design learning.

Future studies could also investigate how multidisciplinary student teams collaborate on complicated and authentic design projects that involve real client participation. Implementing specific methods for participatory and empathetic design research should also be explored, provided the methods are accompanied by tools that student designers may utilize to document and explain their work to their teams and clients. This would allow a greater emphasis on the transdisciplinary nature of VWs and the practice of design thinking by engaging the intersections of human-centred design, collaboration, and VWs.

Additionally, participants from different demographic groups and cultural backgrounds are anticipated to be included in the VW design study to gain further insights into both general and diverse learning experiences in VWs. For instance, it would be interesting to study how participants from different racial and cultural backgrounds develop their collaborative VW design projects by utilizing their unique social, cultural, and semiotic resources, thereby recognizing their interests and agency for developing more culturally appropriate VW design pedagogies.

Future research may also include a case study of problem-based learning (PBL) activities in VWs, which would further illuminate VWs' potential as constructivist learning environments. In PBL, students learn by collaboratively addressing ill-defined and open-ended problems (Bowden & Marton, 2003). An investigation into PBL activities in emerging design areas, such as user interface design and interaction design, may fulfill the affordances of the VW platform, engaging students in codesigning interactive scenarios as their PBL goals for external audiences. This may also suggest that if educators lack the funds to develop a course incorporating new technologies, then VWs could be platforms for exploration and implementation.

7.5. Ongoing Reflection: Becoming a Reflective Practitioner

Pine (2009) clarifies that teacher-researchers' ongoing cycles of critical reflection on their assumptions and actions are crucial to improving them in action research. Throughout my action research, I continually sought and identified my assumptions regarding VW-integrated collaborative design learning and how these assumptions shaped my actions and pedagogical identities as a VW design teacher and researcher. This process of "hunting assumptions" (Brookfield, 1995) proved challenging because my assumptions were my underlying biases that defined my understanding of the classroom and the research issues. These were constantly changing, and although sometimes seemed evident to me, precisely stating them was formidable.

To critically engage in this reflective practice at the research's conclusion, I utilize the four reflective lenses proposed by Brookfield (1995) to discover the hidden assumptions within my practice to understand how they provide meaning and purpose to my role and actions as a VW design teacher and researcher, including the autobiographical lens, the student's lens, the colleagues' lens, and the theoretical lens. This reflective investigation of my assumptions is not merely a recounting of what I have experienced in my research. Instead, it functions as an inquiry into my beliefs that guided my decisions in those experiences, which in turn empowered me to become more autonomous in professional judgment for developing more engaging, participatory, multimodal, and empowering environments for creative and transformative learning and teaching of design.

7.5.1. My autobiographical experiences as a learner and a teacher

The first type of reflection uses the critical lens of autobiography to uncover how one's own previous experiences as a learner or teacher influence personal assumptions about teaching (Brookfield, 1995). My autobiography as a VW learner began in the VW course I took at UBC 5 years ago. During this time, I developed my Ph.D. research focus, which involved utilizing VW technology to improve junior design students' creative collaboration. Upon reflection, I realized that my choice of research topic was informed by my educational struggle as a creative learner and teacher. Before becoming an art and design educator in 2010, my memory of systematically learning visual art began in high school in 1999. During my three years of high school life, I was trained rigorously, utilizing observational drawing skills to prepare for university entrance exams. As a well-trained candidate, I passed the exams and obtained university admission to study art and design in 2003. The first-year university courses emphasized students' perspective drawing skills and foundational design knowledge. Although I was recognized as talented in these drawing skills, I encountered substantial challenges utilizing different artistic approaches and collaborating with classmates when I was asked to explore my creative expressions in individual and group projects the advanced design courses. These courses typically involved professional digital design technologies, such as Photoshop, Illustrator, and 3ds Max. However, I did not question my creative struggles at that time; this examination came after I had taught for a few years at Zhengzhou University.

My career as an art and design teacher began in the 21st century. Nevertheless, China's predominant first-year art and design curriculum still emphasized developing students' basic design knowledge and skills in painting, drawing, and craft making. Similar to my colleagues, I believed that the ideal way to foster students' art and design abilities was to develop their drawing skills—until I gradually identified that many of my junior design students were troubled and anxious about expressing themselves creatively in group design assignments and projects. This teacher experience allowed me to realize that my previous learning experience influenced my assumptions of what art and design is and how it should be taught.

In the fall of 2015, I was offered the opportunity to pursue my Ph.D. at Simon Fraser University in Canada, where I worked as a research assistant in the MODAL

(Multimodal/Music Opportunities, Diversity and Learning) research group, which was established by Dr. O'Neill. While there, I engaged with data that described young people's artistic expressions through the lens of multimodal learning. This learner experience advanced my understanding of art and design learning and motivated me to explore possible ways to foster students' creativity through multimodal collaborative learning. In 2017, after learning and creating in virtual environments in the VW course at UBC, I was impressed by the exciting affordances of this digital technology, which offered transformative potential to enhance students' learning engagement and creative collaboration. Later that year, through a careful investigation of relevant literature, I discovered the gap in research between VW-integrated multimodal design learning and transformative practice to enhance creative collaboration, which became my Ph.D. research project.

Through the autobiographical lens, I was better able to understand my role as the facilitator and colearner of the VW-integrated research course, which enabled me to take "informed actions" (Brookfield, 1995, p. 20) to achieve the intended outcomes. Throughout the research process, I continually interrogated my teaching field notes, reflected on students' weekly design journals, and engaged them in discussions to gather their feedback and comments. As a result, I was able to continuously collect authentic data from students for interpretation, which in turn became my method for identifying aspects of the VW pedagogy for adjustment or refinement to better meet students' learning needs, ultimately leading to a culture of collaboration as the primary goal of my research.

7.5.2. Students' perspectives as a reflective lens

The second reflective lens for educators is to view themselves through students' eyes to uncover critical opinions that they might otherwise overlook. As Brookfield (1995) states,

Seeing ourselves as students see us makes us aware of those actions and assumptions that either confirm or challenge existing power relationships in the classroom. They also help us check whether students take from our practice the meaning that we intend (p. 30).

As the VW teacher-researcher reading students' weekly design journals, I learned how my students utilized my guiding questions to reflect on their design

practices and celebrate their own and others' achievements each week, which confirmed many of my assumptions about the creative affordances of the VW design pedagogy. Additionally, by examining their weekly design journals, I identified areas in which students experienced confusion and challenges that were typically difficult to express explicitly. Their feedback and comments indicated the necessity to further assess my own assumptions and those of my students, which often arose during their collaborative design processes and were the key to transforming assumed frames of reference and adapting to change (Mezirow, 1997).

Furthermore, I incorporated my students' perspectives in the group critique sessions that were regularly practiced in VWs. Part of the requirement for a group critique was to review and analyze the other groups' design projects from the user perspective. As students felt safe and comfortable in VWs, they were motivated to provide their honest feedback to the group that was being reviewed and reflected on their values to address what they would do differently if creating the same project. Concurrently, the reviewed group was often open-minded to receive feedback and willing to engage in reflective conversation with their peers for further exploration.

During these group reflections, I was constantly surprised and inspired by the diversity of meaning my students integrated into their VW design practices. By seeking common themes in students' reflections, I identified my own assumptions that needed to be further clarified. For example, as an art teacher who is originally from China, I was proud that I understood my Chinese students' difficulties in learning English and knew how these students with no prior digital design experience may feel about designing on a completely new digital platform, let alone in English. However, I was overwhelmed when hearing their difficulties in learning in the English virtual environments during the first two weeks of reflective sessions. Several students privately expressed that they felt frustrated and worried whether they would design something interesting and creative by the end of the course. Despite the safe space created, I was initially discouraged by their feedback, feeling that I had overestimated my students' English ability. I even felt anxious at times, as I was afraid that students may leave this course. The onus of open-mindedness fell upon me alone, which demanded that I preempt my fear of analyzing the assumptions that guided my decision to support my students with their difficulties. I reminded myself that reflecting on my teaching would not lead to a final judgement but to a greater awareness of why I previously overlooked this situation. As Brookfield (1995)

argues, “no action a teacher takes can even be experienced as universally and uniformly positive” (p. 51).

Since then, I found the motivation and strength to assist my students in overcoming their challenges. In addition to sharing Chinese VW tutorials and handouts, I spent time with each design group after each class, teaching them to navigate VWs’ English user interface according to their specific needs and problems. After the class, I also regularly entered students’ virtual environments to check on them. Moreover, I established a VW learning group on WeChat (China’s most popular social media messaging application) so that my students could post questions whenever they needed. After a short period of specifically learning the English user interface, many of my students could navigate VWs via their avatars more quickly and design simple objects more efficiently. Consequently, everyone became more engaged in their design process and more willing to share their ideas and difficulties with me. Some students reflected in their interviews that they had become more confident in designing on other digital design platforms with interfaces that were typically in English.

Finally, I utilized the post-pre assessments and interviews at the end of the course to discover how my students felt about their VW design learning and creative collaborations. By asking students to rate the before-and-after items that presented individual changes, I learned that my students valued the implementation of VWs in the classroom to improve their creative design collaborations, so I employed this lens in assessing my own practices. During the reflective interviews, I asked my students to identify specific and concrete instances from their collaborative VW learning experiences that were significant to them. By engaging in continual reflection in the company of others, I exposed the assumptions hidden in my practice through a more complete process of reflective investigation (Dewey, 1933/1985) and learned to “teach more responsively” (Brookfield, 1995).

7.5.3. Reflecting on my colleagues’ views

The third lens involves obtaining feedback from peers and reflecting upon it, which may provide new insight into what happened in practice and improve future work (Brookfield, 1995). During my research, I had opportunities to present and share my work at three international conferences regarding VW education; art education; and

STEM education. While attending these conferences, I dialogued with colleagues from around the world about problems we had in common and gained constructive feedback and advice that assisted me in addressing these problems. Furthermore, I published a part of my research in a peer-reviewed journal. Through the reviewing process, I gained colleagues' critical feedback that revealed the assumptions in my teaching and illuminated aspects that I had not considered before. Finally, I occasionally invited my Zhengzhou University colleagues to observe my teaching and then requested their views based on their observations. These critical conversations not only revealed the hidden assumptions in my practice as a VW design teacher and researcher but also heightened my enjoyment and confidence as we cooperated to determine innovative solutions to teaching problems.

7.5.4. Re-engaging with literature and theories

The final lens, the theoretical lens, requires educators to survey the theoretical literature to describe our practice by illuminating the general elements of what they think are idiosyncratic experiences (Brookfield, 1995). Although there was a lack of published research on the use of VWs within art and design education, I continually reengaged with related theoretical literature that displays "an advanced vocabulary for teaching practices" (Miller, 2010, p. 1) and peers' diverse interpretations of their experiences. Consequently, I connected the other three lenses to an array of theoretical perspectives so that I could gain new insights into my hidden assumptions. These insights ultimately informed the decisions I made regarding my subsequent teaching and researching steps within the study.

However, the most critical aspect of exposing assumptions required me to utilize the four lenses as a holistic perspective for my actions as a VW teacher-researcher. In reflecting on my autobiographical experiences, I recognized my struggles to be creative as an art learner and to foster students' creative collaboration as an art teacher. These pedagogical struggles revealed that my past assumptions framed my previous learning and teaching, which later motivated me to become a VW learner and educator. As I became more aware of my previous struggles, students' views became more important to my teaching and reflective journey. By obtaining students' perceptions of their learning experiences, I confirmed many of my assumptions about VW design pedagogy and accepted my errors by adjusting my teaching methods and goals to meet students'

needs. Furthermore, communicating with and depending on peers and colleagues offered different perspectives that guided me to seek my assumptions accurately and maintained my motivation to continue this reflective practice. Reengaging with theoretical literature supported my desire to clarify my teaching practice and guided me to continue modifying my teaching approaches and documenting those changes as I progressed toward my goal.

7.6. Conclusion

Art and design educators at the post-secondary level face challenges in fostering autonomous and self-directed individuals who can collaborate with diverse teams and manage unpredictable work and life situations that necessitate innovative responses to an increasingly complex work environment and globalized world. This research demonstrates that VW-integrated collaborative design learning supports individual and team creativity to address complex challenges in multidisciplinary areas. As the COVID-19 pandemic continues to disrupt lives and schooling, contactless work and educational environments are more important than ever before. However, little research has been conducted to explore the theoretical framework and pedagogical approaches for integrating VW technology in art and design education with the aim of fostering creative, autonomous, resilient, and collaborative designers. Therefore, I hope this research provides a theoretical foundation for an in-depth understanding of the future direction of creative art and design education, particularly the implementation of collaborative design practices utilizing VW technology.

This action research focuses on a redesigned Design Fundamentals course that incorporated VW technology and utilized design thinking, the multimodal pedagogy, as well as the TAE theoretical framework in art and design education. By tactfully employing the three interrelated approaches, the researcher's junior design student participants creatively and collaboratively engaged with complex and unpredictable VW design problems and solutions through iterative practices and experiential learning. The findings reveal that the affordances of various modalities in this VW-integrated learning environment combined to enrich these pedagogical approaches, providing, most significantly, a safe space for creative collaboration, risk-taking, and imaginative

experimentation without fear of failure. Furthermore, the “participatory culture” (Jenkins, 2009) encouraged students to frequently alternate between being designers, collaborators, audiences, critics, and interpreters, experiencing complex phenomena and reflecting on insights through cycles of “inquiry-based dialogues” (O’Neill, 2011). These aspects of the VW collaborative design practices and learning contexts, in addition to my role as a designer (Bezemer & Kress, 2016; Kalantzis & Cope, 2010b), created supportive relationships and learning opportunities that allowed groups of students to freely and creatively choose and codesign their VW presentational modes that matched their interests.

Furthermore, the analysis of data indicates that positioning students as creative multimodal designers enables the recognition of their resourcefulness in constantly expanding and transforming VW modes and their semiotic resources for collaborative meaning-making. Concurrently with the ever-expanding virtual and physical sites of meaning-making, students became more autonomous, self-reflective, and resilient, and they felt connected to their learning and others. All of these characteristics are considered necessary for students’ positive learning transformation to occur.

Finally, the findings emphasize the benefits of adopting TAE as a transformative pedagogical approach to VW-supported multimodal collaborative design learning. This approach enabled students to iteratively enhance their design skills and capacities through reflection and dialogue-centred creative praxis, effectively integrating design thinking to their greatest advantage. Students repeatedly engaged with multimodal designs that stimulated their engagement and challenged them to broaden their perspectives, and the data illustrate that students adopted a habit of design thinking for creatively and reflectively addressing complex and uncertain learning challenges and constraints in their VW codesign processes. Consequently, students experienced increased motivation, confidence, and awareness of their personal and others’ strengths and achievements.

To conclude, the scope of this study is limited to the classroom-level description of developing a VW design pedagogy to nurture junior design students’ creative collaboration rather than changing the overall educational area of art and design. However, this research is a starting point for future studies that entail substantial team-based design stages and activities utilizing VW technology. The findings capture the

possibilities of VW collaborative design practices for creativity and transformative engagement as a result of the purposeful implementation of design thinking, multimodal pedagogy, and the TAE framework, thereby empowering individuals to increase their capacity to advance to the next stage of design learning and navigate the continuous, complex process of change.

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Appendix A.

Post-Pre Assessments

In answering these questions, we would like you to compare yourself now with before **the elective course 3D Virtual Worlds (3DVWs) Exploration: Design Fundamentals** began. **Knowing what you know now**, how would you rate yourself before **this elective course**, and how would you rate yourself now? Please use a two-step process:

- a. Decide whether the statement is “not true for me” or “true for me”
- b. Check the rating that most applies

- (0) **not at all** true for me
- (1) **not very** true for me
- (2) **sort of** true for me
- (3) **mostly** true for me
- (4) **very** true for me

Thinking about the elective course, and knowing what you know now, how would you rate yourself before the elective course and how would you rate yourself now?

Table 33. Post-pre assessments

		Before VW-Integrated Design Course			Now						
		Not true For me		True for me	Not true For me		True for me				
		0	1	2	3	4	0	1	2	3	4
1.	I think it is interesting to explore design principles and elements through VW design practices.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2.	Learning design principles and elements helps me think about how I can communicate effectively and appropriately through VW design practices.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		Before VW-Integrated Design Course					Now				
		Not true For me		True for me			Not true For me		True for me		
		0	1	2	3	4	0	1	2	3	4
3.	Having opportunities to participate in design practices is critical to learn design principles and elements.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4.	I have developed a working knowledge of concepts and technical skills needed to facilitate my understanding and creation of effective and artistic visual compositions.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5	I can find out connections with other learning and design experiences when I am designing my VW project.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6	Learning design principles and elements through VW design practices will be useful for my future study.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7	VW design practices give me a sense of accomplishment.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8	I often feel absorbed in activities when I am designing in VWs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9	I always feel motivated to design in VWs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10	I think about my VW design project/work even when I am not designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11	I like to challenge myself and take risks when I am designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12	I am able to experiment my own ideas when I am designing in VWs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13	I can make my own choices and decisions when I am designing in VWs.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		Before VW-Integrated Design Course					Now				
		Not true For me		True for me			Not true For me		True for me		
		0	1	2	3	4	0	1	2	3	4
14	I constantly reflect on my design processes to find out what I need to improve when I am designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
15	I like to communicate with my peers and teachers when I am designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
16	Communication with peers and teachers is an important part of designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
17	I feel comfortable and safe to give others feedback and comments on their design projects /works.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
18	I feel comfortable and willing to accept feedback and comments from my peers and teachers.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
19	My peers value my feedback and comments when working in a group	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
20	I feel inspirational and willing to explore ideas when working in a group.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
21	Designing in a group makes me feel connected with others.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
22	When designing in a group, being able to collaborate with others is important	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
23	I like designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
24	I think I am good at designing.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
25	I feel confident about learning new technology to design in the future.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
26	I feel my VW design project/work is creative.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

		Before VW-Integrated Design Course			Now			
		Not true For me	True for me		Not true For me	True for me		
		0 1	2 3 4		0 1	2 3 4		
27	I think I am a creative person when it comes to design.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Appendix B.

Semi-Structured Interviews

1. How would you describe your collaborative design learning experience in VWs?
2. How would you describe your collaborative design experience in VWs?
3. Do you think VW learning and design experiences involved exploring and implementing design principles and elements?
4. Do you think VW collaborative learning and design experiences are different from your previous design learning experience or artistic experience? (Probe: why you think this?)
5. How do you feel about VWs as collaborative design learning environments?
6. What have you seen in VWs?
7. What ideas have you come across when you were in VWs?
8. What was the specific goal you wanted to achieve in your design project(s)/work(s) in VWs? How did you come up with the goal? Have you changed your goal? How well do you think you have achieved the goal in your project(s)/work(s)?
9. Do you think the VW technology helped you to express your creative ideas?
10. Compared with your previous collaborative design experience or design learning, do you think VWs allow you to be more creative? (Probe: Why do you think this?)
11. Do you think you created and represented meaning in your design project(s)/work(s)? (Probe: can you describe why you think this?)
12. Do you think VWs provided you with opportunities to make choices and creative decisions during your design processes? (Probe: Can you describe a particular choice or decision you made that you are proud of?)

- 13.** What was the most challenging or difficult moment you have experienced during your group design processes in VWs? (Probe: Did you conquer the challenge or solve the problem? If yes, probe: Can you describe how you conquered the challenge or solved the problem?)
- 14.** During the course, how well were you able to communicate with your classmates and the instructor (me) through avatars in VWs? Is it different from the communication in the real classroom setting? (Probe: Can you describe how different you think the VW communication is?)
- 15.** What role does the communication with your classmates and instructor play in your VW design learning and design processes?
- 16.** Have you had any previous experience with digital graphic software? (Probe, if yes: Can you describe your previous experience? How helpful do you think your previous digital experience assisted you with the VW manipulation? If no: How helpful do you think the VW experience is to your digital graphic software learning in the future?)
- 17.** What is the most creative thing you did in this class? (Probe, if needed: Why do you think this was the most creative?)
- 18.** What is the least creative thing you did in this class? (Probe, if needed: Why do you think this was the least creative?)
- 19.** What aspects of the VW collaborative design project(s)/work(s) creation were you good at? (Probe: Can you describe why you felt this?)
- 20.** What do you like about this elective course—3DVWs Exploration: Design fundamentals?
- 21.** What do you dislike about this elective course—3DVWs Exploration: Design fundamentals?
- 22.** What do you think you have learned the most from participating in the design fundamental course incorporating VW technology?
- 23.** Do you think your VW collaborative learning experience involved other learning? (Probe, if needed: Can you describe what they are?)

- 24.** Have you learned anything from this elective course that you can use in your life outside of class? (Probe, if needed: Can you describe what it is and how you would use it?)
- 25.** Is there anything else you would like to comment on the elective course and/or your participation in this elective course?

Appendix C.

In-Class Second Life Group Trips (Weblinks)

Week 1

Session 1:

<http://maps.secondlife.com/secondlife/Immersiva/17/111/24>

<http://maps.secondlife.com/secondlife/Paris%202000/151/248/24>

Session 2:

<http://maps.secondlife.com/secondlife//154/36/1930>

Week 2

Session 3:

<http://maps.secondlife.com/secondlife/Dreams/152/46/2554>

Session 4:

<http://maps.secondlife.com/secondlife/Retrospect/111/48/21>

Week 3

Session 5:

<http://maps.secondlife.com/secondlife/Freyr/100/147/1216>

Session 6:

<http://maps.secondlife.com/secondlife/China/128/128/19>

<http://maps.secondlife.com/secondlife/Nautilus%20-%20Kothar/107/76/1506>

Week 4:

Session 7:

<http://maps.secondlife.com/secondlife/Lost%20Unicorn/229/221/30>

<http://maps.secondlife.com/secondlife/Monash%20University%202/201/176/26>

Appendix D.

Student Weekly Design Journal Guiding Questions

1. What have you designed during this week?
2. What was the most difficult part of the design work you completed this week?
3. What was the easiest part of the design work you completed this week?
4. What was the most creative part of the design work you completed this week?
5. What was the least creative part of the design work you completed this week?
6. Have you done any virtual world design after school?