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# Enhancing 21st-century competencies via virtual reality digital content creation

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**ABSTRACT**

This study aimed to foster development of the 21st-century five core competencies, including Creativity and innovation, Critical thinking and problem solving, Communication, Collaboration, and Computer-information literacy using Student-Centered Active Learning in an instructional design in which student groups created their own virtual reality content. Fifty humanities students participated. Mixed-methods data collection included a questionnaire, VR artifacts grades, student reflective journals, and focus group interviews. The most important findings were that (1) the instructional design of the study led to improvement in all of the five competencies of .01 significance or better (2) additional cycles of VR artifact production led to increases in empirical quality, and (3) the participants also found the hands-on VR creation projects to be distinctive and motivating. This VR content creation project provides detailed implications and guidance for instructors seeking to replicate a hands-on technology-oriented instructional design in order to strengthen the 21st-century core competencies.

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VR production; critical thinking; problem solving; computer-information literacy; creativity; active learning

## Introduction

There is an urgent call for curriculum reform at the global level resulting from developments in educational technology (Sentwa, 2018) because current curricula are often rooted in the past (Chalkiadaki, 2018; Sanabria & Arámburo-Lizárraga, 2017) and often do not meet the needs of contemporary learners (Bedir, 2019a, 2019b). Instructional designers need to reflect 21st-century skills and competencies to enable students to accomplish not only academic achievements but also subsequent life success (Chalkiadaki, 2018).

The Organization for Economic Co-operation and Development (OECD) explained the concept of the competencies as follows (Hooft Graafland, 2018): "Competency" goes beyond the acquisition of knowledge and skills. It represents the utilization of knowledge, skills, attitudes, and values to meet the dizzying requirements of the complicated school and society in flux. OECD also emphasized the importance of teaching and learning underpinned by combined 21st-century skills and competencies. More specifically, 21st-century competencies, as defined by Hooft Graafland (2018), consist of the following four elements, so-called "the 4Cs": *Creativity and innovation*, *Critical thinking and problem solving*, *Communication*, and *Collaboration*.

Digital literacy, also referred to as Computer and Information Literacy (CIL) or Information and Computer Technology literacy (ICT), has also been identified as an essential competency (Vavik & Salomon, 2015; Voogt et al., 2013) and education programs have been called upon to

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incorporate this form of literacy across the curriculum (Albion et al., 2015; Fu, 2013). These five skills/competencies, therefore, must be taken into account for any realistic consideration of implementing new teaching and learning curricula that fit 21st-century learners and their needs.

Virtual Reality (VR) is also gaining attention among language instructors because it can transform traditional learning materials into a live and self-directed interactive experience, thus increasing both motivation (Lanier, 2017) and language performance (Chen, 2016). Due to the global pandemic of 2020–2021, learners around the world were required to stay home and sit in front of the computer or smartphone screen to attend virtual lectures, meaning that this unprecedented situation forced an unexpected and unavoidable shift in education (Marek et al., 2021). More specifically, existing in-class teaching and learning were transformed on short notice into online teaching and learning. At the university where one of the authors teaches, school guidelines led to 80% of classes being conducted online. During this stay-home period, learners were deprived of active learning opportunities and face-to-face social environments. However, regardless of the situation, innovative instructors still employed a sound curriculum design, making good use of educational technologies to provide learners with authentic learning environments and meaningful learning opportunities.

In response to these challenges, one of the authors developed a plan to encourage learners to engage in a stimulating outdoor learning activity using a hands-on VR tool to capture sites in Taiwan, such as their local neighborhood, famous sightseeing spots, and historical venues. Furthermore, this study was designed to provide learners with abundant opportunities acquire the five core competencies (5Cs) in a contextualized authentic environment via VR artifact production. Accordingly, the purpose of the study was to determine whether offering hands-on, engaging VR creation experiences is related to development of 21st-century competencies. The following research questions (RQs) guided the study:

RQ 1. To what degree did this VR hands-on production experience enhance the learners' 5C competency development?

RQ 2. To what extent did the students improve their VR artifact creation ability?

RQ 3. What were the learner perceptions about their VR production learning experiences?

The significance of this study lies in the VR production experiences of the participants, and the corresponding development of their 21st-century competencies by creating a technology-rich authentic learning context during the COVID-19 pandemic. Many studies have employed pre-produced VR artifacts which participants then experienced. Research about engaging participants "learning by doing" via self-VR creation experiences has remained scarce. The affordances of VR creation to foster 21st-century competencies have been investigated even less. Many studies have used surveys and other data collection based on the perceptions of the participants, whereas this study also included quantitative analysis of outcomes. In addition, most research has put comparatively more focus on experiencing 3D virtual worlds (3DVW) or VR-aided learning, not examining VR creation and not incorporating the 5C competencies necessary in today's teaching and learning (Hsiao et al., 2017; Wang et al., 2020). Thus, this research plays a unique role compared to past research and provides detailed recommendations for instructional designs using VR production as a learning tool in non-technical disciplines.

## Literature review

### *Student-centered active learning*

This study was based on a foundation of educational and instructional design theory known as "Student-Centered Active Learning" which is grounded in the constructivist model of learning (Bruning et al., 2011; Ellis, 2009; Fresen, 2007; Nunan, 1997).

Many studies of how students learn have found that lecture-memorization instructional designs are demotivating and less engaging for the student (Kao, 2011; Wu et al., 2020). The widely-embraced alternative today is learning in which students have worthwhile-feeling "real world" tasks to accomplish, often collaboratively with others, making them active learners.

Student-centered learning means that students are able to make significant decisions with respect to their learning (Huang & Xia, 2010; Myron, 1949). In this learning context, the students likely need more initial assistance, advice, and support from the teacher, but the teacher provides less support in subsequent repetitions to promote student independence and problem-solving. This instructional technique is called Scaffolding (Lee, 2003; Van de Pol et al., 2010). It is based on the work of Lev Vygotsky and socio-cultural theory (Villamizar, 2017) and has been shown to improve student confidence and ability over time.

Such an instructional design has the potential to increase the amount of time students spend engaged in their learning activities and make them active participants in their learning, as opposed to passive receivers of information (Shadiev et al., 2017; Stockwell, 2010). This form of learning has also been called "organic" learning (Marek & Wu, 2011) because the students learn in a way that is natural and almost automatic.

Similarly, the way teachers learn to employ technology in their learning designs is an important question. Koehler and Mishra (2005) proposed a Learning by Design model in which in-service teachers should work collaboratively in small groups to solve what they called authentic pedagogical problems with solutions grounded in learning technology. Their process, in effect, calls on the teacher to use also active learning to identify and solve learning technology problems.

### KSAVE model

Researchers have recently studied the kinds of skills needed to succeed in the ever-changing digital world (Spires, 2008; Voogt & Roblin, 2010). Different research groups have developed different frameworks to describe this skillset (P21.org, 2016).

The KSAVE 21st century Skills framework proposed by Binkley et al. (2012), has four dimensions and 10 categories of skills as outlined in Table 1. Binkley et al. (2012) conceptualized *Ways of Thinking* as including creativity and innovation, critical thinking, problem-solving, learning to learn, and the development of metacognition. *Ways of Working* includes communication, collaboration, and teamwork. *Tools for Working* involves information and ICT literacy. *Living in the World* highlights a changing emphasis on local and global citizenship, aspects of life and career development and personal and social responsibility. Binkley grouped these dimensions under the acronym KSAVE for Knowledge, Skills, Attitudes, Values, and Ethics. In particular, *Ways of Learning* and *Ways of Teaching* must be considered in the development of the assessment strategies that focus on these skills.

### 5C core competencies

Modern ideas of curriculum design begin with outcome requirements. Understanding the marketplace for graduates is an important part of formulating those curricular outcome goals (Marek & Wu, 2020).

The Organization for Economic Co-operation and Development (OECD) has been heavily involved in establishing educational standards and developing learning metrics (Jakobi & Martens, 2010; Meyer & Schiller, 2013; Piro, 2019; Volante, 2018). It also has a strong capacity to mobilize experts and steer consensus building that is central to the production of knowledge in education policy making (Bloem, 2015; Grek, 2013). While there is extensive literature focusing on the OECD's educational activities, these have been primarily associated with the Program for International Student Assessment (PISA) and its management, use and impact on national policies (Xiaomin & Auld, 2020). Knowledge has become vital in the 21st-century and people need

**Table 1.** Binkley et al. (2012) KSAVE framework of 21st century skills with four dimensions and ten categories of skills.

| |
|---|
| *Dimension 1: Ways of thinking* |
| 1. Creativity and innovation |
| 2. Critical thinking, problem solving and decision making |
| 3. Learning to learn, Metacognition |
| *Dimension 2: Ways of working* |
| 4. Communication |
| 5. Collaboration (teamwork) |
| *Dimension 3: Tools for working* |
| 6. Information literacy |
| 7. ICT literacy |
| *Dimension 4: Living in the world* |
| 8. Citizenship - local and global |
| 9. Life and career |
| 10. Personal and social responsibility - including cultural awareness and competence |

to acquire such skills to enter the workforce, called 21st-century skills. The OECD has also emphasized the ability of individuals to be effective in using technology, communicating and working with groups, self-management, self-defense, and the ability to defend their own and others' rights, as needed in the 21st century (Ananiadou & Claro, 2009; Dede, 2010).

The understanding of these 21st-century competencies is necessarily underpinned by newly-released educational benchmarks and learning implementations (Chen et al., 2020). OECD proposed four critical competencies that all learners should be equipped with for keeping up with the world, which is changing at a dizzying speed. The four competencies identified by OECD included *Creativity and innovation*, *Critical thinking and problem solving*, *Communication*, and *Collaboration* (Hooft Graafland, 2018).

These four competencies are fundamental, but may not always be sufficient for more advanced, elaborate, and discipline-specific instructional/teaching design. The researchers drew on the KSAVE model to include one additional competency in the theoretical foundation of this study, *Computer-Information Literacy* (CIL) (Fu, 2013) also referred to as Information and Computer Technology literacy (ICT), or simply as Digital Literacy. Professionals are expected to be competent in using computer and information technology and thus be able to function effectively in electronic/digital contexts, but many learners have insufficient competency (Alavi et al., 2016). Such literacy central to today's use of familiar skills that have been part of school learning for many years, such as inquiry, reasoning, critical thinking, and problem-solving (Binkley et al., 2012).

Even though future-ready learners are expected to employ these competencies during their school years, as well as throughout their lives, most curricula have not been properly designed to equip them with these skills. Integrating cutting-edge and innovative technology, taught via Student-Centered Active Learning, has proven that it has potential to empower learners in various aspects including the five core competencies, which are discussed in more detail below.

## *Creativity and innovation*

Sternberg (2001) defined creativity and innovation as a cluster of skills needed to produce ideas that are both original and valuable. The 21st-century world is characterized by global competition and task automation. In such a world a creative spirit and innovative capability are increasingly required for personal and professional success (Pardede, 2019b). The inventive-thinking cluster, characterized by higher-level cognitive skills, critical to thriving in the Digital Age, includes the concept of creativity, which is defined as "the act of bringing something into existence that is genuinely new and original, whether personally (original only to the individual) or culturally (where the work adds significantly to a domain of culture as recognized by experts)" (NCREL & Metiri Group, 2003).

### *Critical thinking and problem solving*

Critical thinking is now accepted as an essential skill in 21st-century education worldwide (Atkinson, 1997; Rear, 2017). Pardede (2019a, 2019b) highlighted the need of students to develop critical thinking because it increases their ability "to passionately and responsibly take, apply, and control of their thinking skills (question, analyze, criticize, reflect, and synthesize), develop proper principles and standards to evaluate their thinking, and willingly judge, accept, or reject new ideas, concepts, and viewpoints" (p. 169). Critical thinking and reflection allow detection of misconceptions and underlying problems as well as seeing new opportunities in practice (Noonan, 2013). Critical thinking skills enable pre-service teachers "to reflect on their practice in meaningful ways, to consider the effect their teaching has on student learning, and develop habits that will stay with them" (Ward & McCotter, 2004, p. 244).

### *Communication*

Employers greatly value communication as an entry-level skill (Penrod et al., 2017) which is important in business, academic, and professional environments (Okoro et al., 2017). In the teaching and learning process, communication skills can be integrated into the curriculum through the Student-Centered Active Learning approach, particularly via cooperative learning or project-based learning, in which groups of learners work together to complete a task, solve a problem, or create a product (Pardede, 2020).

### *Collaboration*

The collaboration concept is defined as "Cooperative interaction between two or more individuals working together to solve problems, create novel products, or learn and master content" (NCREL & Metiri Group, 2003). Employers often consider collaboration to be an essential competency in the workplace (Martin & Nakayama, 2015). It is the ability to work with others effectively to accomplish some defined goal and is ubiquitous in the professional workplace (Chen et al., 2021). To build solid teamwork, collaboration skills are needed so that the skills, knowledge, and attitudes of the collaborators can be united (Foster-Fishman et al., 2001). Collaboration is widely accepted as a teaching and learning approach, implemented by putting students into groups to complete a task, to solve problems, or to work on a project (Harmer, 2007). This instructional strategy draws on Student-Centered Active Learning by employing collaboration, which helps students learn from each other about the immediate subject matter, but also prepares them to collaborate effective in their post-school jobs. The concept of collaboration is discussed as part of *Teaming and collaboration* in the *Effective-Communication* skills cluster, stressing the importance of managing the use of information technologies with awareness of their impact on society.

### *Computer-information literacy*

Lewin and McNicol (2015) said that the growing impact of globalization and the knowledge society have led many to argue that new skills, not common in the past century, are essential to be successful in the workplace and that ICT is central to their development. These skills go beyond the mere technical annotation. American The North Central Regional Educational Laboratory (NCREL) (2003) has listed digital literacy as a 21st century skill, in the light of recent historical events, globalization and digital era, creative thinking, effective communication and high productivity. The Asia-Pacific Economic Cooperation (APEC) states that the knowledge, skills, and attitudes necessary to compete in the 21st century workforce have become increasingly diverse, and that individuals must have a participatory understanding and the ability to use new technologies. It is also stated that individuals need to cope with rapid change. In this context, APEC (2008) identified 21st century skills as lifelong learning, problem solving, self-management and cooperative team work. In 2013, the International Computer and Information Literacy Study (ICILS) defined *Computer and Information Literacy* (CIL) as a necessary competence in any learning context incorporating information communication technology (ICT) without limitation of time and space (Cevik & Senturk, 2019; Scherer et al., 2017). CIL is the "individual's ability to use computers to investigate, create, and communicate in order to participate effectively at home, at school, in the workplace, and in society" (Fraillon et al., 2013, p. 17). CIL consists of two major facets with seven phases. The first facet is *Collecting and managing information* including (1) Knowing about and understanding computer use, (2) Accessing and evaluating information, and (3) Managing information. The second facet is *Producing and exchanging information* including (4) Transforming information, (5) Creating information, (6) Sharing information; and (7) Using information safely and securely (Scherer et al., 2017).

### *VR in education*

Thanks to the breakneck advancement of technology suitable for use in education, educators today have ever-growing choices for educational technology that maximizes learner achievement and outcomes. The growing access to VR technology can be a gap-filling solution for learners struggling with a severe shortage of innovative learning contexts and social presence (Chien et al., 2020). Use of VR as learning technology fits the definition of Student-Centered Active Learning because the VR user makes abundant decisions about where to go in the VR artifact, as well as making decisions about seeking additional information via the VR interface.

With the abundant and distinctive capability and scalability of VR, which is capable of making learners feel presence and immersion, researchers now have more opportunities to take advantage of VR in the field of education (Häfner et al., 2018). VR can provide not only an interactive and stimulating learning environment in which learners interact with virtual figures and objects, but also a realistic learning experience that holds tremendous potential for empowering learning achievement as well as learning motivation (Makransky & Lilleholt, 2018; Yang et al., 2010). In particular, through such an environment, learners can integrate new information into their prior knowledge schema and thus have more useful experiences via their VR immersion (Yeh et al., 2020). One of the significant benefits of VR in education is "safety." VR can provide the learners with a safe environment in which they can repeat complicated learning tasks until they feel satisfied or achieve mastery. Cognitive skills can be also developed through experiential learning (e.g. visiting unfamiliar environments and dangerous places) (Çalişkan, 2011). To be more precise, learners can be allowed to visit environments and undergo situations that cannot be reproduced by any other teaching approaches and tools. Furthermore, when it comes to cultural learning, employing VR is considered an appropriate way to let learners cultivate cultural knowledge, which is an indispensable factor of language instruction for language learners trying to master intracultural learning and enhancing foreign language competency (Chen et al., 2021; Fuhrman et al., 2021; Lan, 2015).

In summary, the literature shows that Virtual Reality can be an effective learning tool and one that fosters Student-Centered Active Learning. Little research has been performed, however, about the process of using Student-Centered Active Learning to create VR artifacts that serve as learning resources, and about how such VR projects may bolster the core competencies of those creating the artifacts.

## Methodology

### *Participants*

In this VR project, 50 freshmen enrolled in a Common English class were recruited as participants and asked to produce VR artifacts as part of class requirements by forming teams of four to five members each. In the spirit of student-centered learning, in which students are allowed to make decisions about their learning, the students were allowed to form their own groups, but were instructed to team with fellow-students possessing different levels of English proficiency.

The participants were all from a prominent university in Central Taiwan which promotes the adoption of advanced technology in the teaching and learning process.

Altogether, 12 groups were formed with each required to generate three VR artifacts/projects via collaboration. The VR creation projects took place during the 18 weeks of the regular semester from March to July 2020. Most of the participants lacked training in the 5Cs during their high school years because the Taiwan College Entrance Examination mainly tests rote memorization as well as knowledge acquired through drill and practice.

An English class was chosen for the study because majors in English as a Foreign Language (EFL) are often weak in CIL. Although no prescreening was performed, it was assumed that students lacked training in the techniques of VR production to be used in the class. Although the participants were expected to improve their English skills as the result of Student-Centered Active Learning collaboration on their VR projects, assessment of proficiency changes was not part of this study. Taiwan was experiencing caution, but not strict COVID-19 pandemic "lock-downs" at the time of this study.

## Instructional design

### VR hands-on creation projects

This study used VR production assignments as a "means to an end, not an end in itself." The learning design employed group collaborative work to foster core competencies, as defined above, in the process improving the English proficiency of participants.

The VR artifacts were produced using Google Tour Creator. Google Tour Creator was a web-based application accessed by computer allowing production of immersive VR works, known as artifacts. Users could easily use 360-degree panoramic photos provided by Google Street View, or taken by themselves, to create the VR scene. When the scenes were arranged contextually, the user could create an immersive VR environment. Every scene could have highlighted points of interest to allow viewers to explore the site in more detail. In addition, creators could attach a text description, narrative, or picture to each point of interest to provide a more detailed description.

The researchers used Google Expeditions as the VR viewing platform. Google Expeditions, released 2015, allowed teachers to bring mobile VR content into the classroom (Ebadi & Ebadijalal, 2020). The student was able to use the Google Cardboard Viewer, a head-mounted display (HMD) device, to view the VR content and features via mobile phones. Furthermore, the student could interact with these points of interest by pressing the action button on the HMD. Google Expeditions had the potential to transport learners to multiple locations around the world, generating in learners the sense of being present in the then and there (Dubovi et al., 2017). Through use of Google Expeditions, teachers could take learners to the heart of a given phenomenon, providing them with firsthand experience, and moving them well beyond the limitations of traditional textbooks, images, and videos (Alizadeh, 2019). The authors believe that the VR tasks and related learning activities described in this study can be performed effectively with other VR production systems, as well, such as EduVenture, Nearpod, Uptale, or Veative, which have similar affordances and can therefore play a similar role in research and lesson plans, allowing reasonable replication and extension of this study.

Figures 1 and 2 show an example, made by students enrolled in the class and captured from their VR content, introducing the International Bodhisattva Sangha (IBS) in Taiwan, Taichung Dali. In Figure 1, the students added a text description and an attached photograph, both highlighted in red, as well as an audio narration introducing IBS. Via such enrichment of the VR scene, viewers would learn about the site and points of interest, and listen to descriptions at the same time. Furthermore, the picture presented in the center of the figure allowed the viewer to observe the point of interest in detail. The points of interest icon at the top of the figure allowed the viewer to interact with the scene. When viewers used smartphones to view the VR work, they could experience an immersive learning environment via HMD devices, as shown

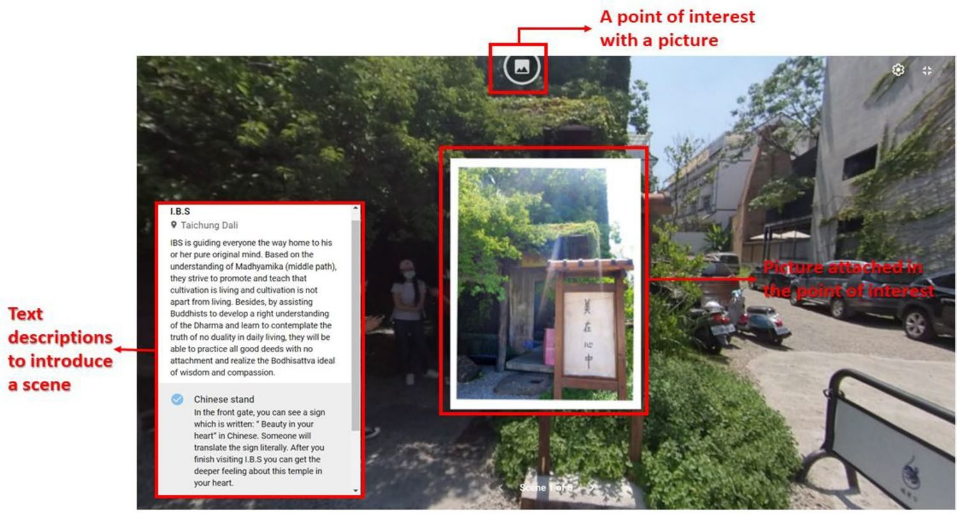


**Figure 1.** VR view from poly website using computer with the immersive scene.

in the Google Expeditions example in Figure 2. The clear interface design and icons guided the viewer to interact with the immersive scene.

### *Instructional philosophy and implementation procedures*

In order to connect the 5C development of the students with their VR creation projects, the researchers employed a series of procedures, based on the Binkley KSAVE framework (Binkley et al., 2012) and theoretically rooted in Student-Centered Active Learning. In order to foster Student-Centered Active Learning, the instructor did not set rigorous rules for the students to follow. This gave the student groups considerable control and flexibility with regard to decisions like the locations chosen for their VR assignments, content creation, picture display, and production steps throughout the entire creation process; however, the instructor met with the groups to provide guidance, comments, and feedback along the way. The instructor used scaffolding to provide higher levels of support in the early phase of the students' work, but less support in

**Figure 2.** VR viewing using mobile.

subsequent rounds of VR production to encourage student independence. On the other hand, the instructor and peers provided feedback after each round of VR production. Therefore, the Instructor's role was not a traditional knowledge provider but rather a VR creation facilitator, thus encouraging core competency development. The competency development is described in Figure 3 and the detailed instructional design is presented in Table 2.

### *Research design*

The researchers used four mixed-methods categories of data to answer the three research questions. They included a core competencies questionnaire, evaluation of the VR artifacts the students produced, reflective essays, and focused interviews to answer the research questions.

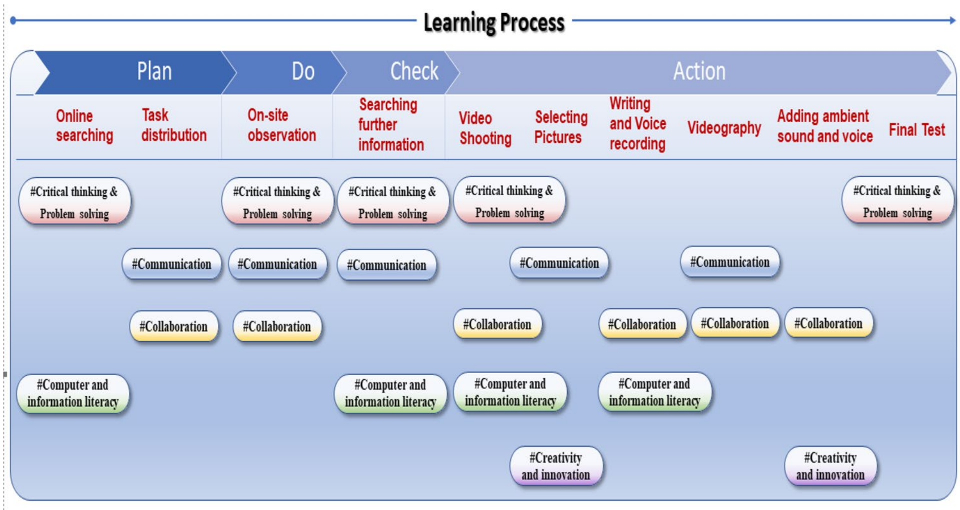


**Figure 3.** Competency development.

**Table 2.** Instructional design.

| |
|---|
| Phase one: Warm-Up Stage |
| Step 1: Group building and training on using VR with HMD |
| Step 2: Orientation workshop on the usage of Google Expedition and technique of video making using 360-degree camera |
| Phase two: VR Creation Stage (Plan, Do, Check, and Action Cycle)<br>Plan:<br>Step A: Online searching general info and understanding about potential places and deciding the spots/sites to visit (critical thinking and problem solving; Computer and information)<br>Step B: Scheduling your time/Timeline and task/job distribution (communication, collaboration)<br>Do:<br>Step C: On-site observation and exploration to gain general idea about the sites (communication, collaboration, critical thinking and problem solving)<br>Check:<br>Step D: Searching further information about the sites/objects online or from other sources (critical thinking and problem solving; communication)<br>Action:<br>Step E: Formal video Shooting activity (collaboration; critical thinking and problem solving; computer and information)<br>Step F: Selecting Pictures to display (creativity and innovation, communication)<br>Step G: Multiple Writing and Voice recording for scenes and points of interests: Each student was responsible of his or her own part of writing and voice recording but scaffolded by more capable peers from their team members (computer and information, collaboration)<br>Step H: Videography: editing pictures and sound (communication; collaboration)<br>Step I: Adding ambient sound and voice (collaboration; creativity and innovation)<br>Step J: Final Test (Critical thinking and problem solving)<br>Phase Three: VR Artifact Viewing and Appreciation Stage |

### RQ 1: Core competencies

RQ 1, about whether the VR production experience enhanced the 5 C competence development of the learners, was answered by a "5 C Competency Questionnaire" developed by the researchers based on instruments in other studies (Chai et al., 2015; Jenson & Droumeva, 2017; Lai & Hwang, 2014; Lin et al., 2019). The questionnaire (Appendix) included five factors or constructs with total of 44 statements to be rated favorably or unfavorably on a five-point Likert-like scale, to explore the perceptions of the students about how their core competencies changed as a result of the VR production learning design. In the post-test, the students were asked to rate their learning experiences during the class. In the pretest, they were asked to rate their experiences in past group or team collaborative learning. To ensure the validity of the survey instrument, a group of five Taiwanese faculty members, proficient in quantitative instrument design, were invited to complete and comment on the wording, organization, and content appropriateness of the questions. Then, a pilot study group of 30 students completed the questionnaire. The survey was then revised based on the comments of both groups. To assess the internal consistency of the survey, Cronbach's Alpha values were computed. Compared to a minimum required value of .70 considered evidence of reliability (Segars,1997), the Cronbach's Alpha value for the pilot study survey, $\alpha$ = .96, indicating the strong reliability of the survey. The Alpha value for each learning factor was also above .70, ranging from .89 to .93. Table 3 shows the results of the reliability of the survey.

### RQ 2: VR production improvement

RQ 2, about the extent to which the students improved their VR artifacts creation in subsequent production cycles, was answered by the comprehensive scoring of 36 VR artifacts produced during the study, with each group producing three VR artifacts. Two external English experts performed content analysis to provide an objective score. The grading rubrics adopted to evaluate the quality of the overall VR artifacts consist of six factors, including (1) Overall Content, (2) Storyline/Description, (3) Scene Sequencing, (4) Relevance and Amount of Information, (5) Computer/Techno Literacy, (6) Viewer's Experience, with each factor worth 20 points. The 120-point rubric was converted to percentages for calculation of means, standard deviations, and One-way ANOVA. The evaluations, therefore, considered not only the technical expertise of the student groups, but the overall content creation quality.

### RQ 3: Student experiences

RQ 3, about the learner perceptions about their VR production learning experiences was answered by analyzing both individual student reflective essays and focus interviews. In order to reduce anxiety and gather as much information as possible, the students were allowed to write their reflective journals and answer interview questions in Chinese, their native language. Then, a content analysis was applied to analyze the qualitative data. The data was reviewed several times, coded and categorized according to the research question, with a process of open, axial, and selective coding (Chwo et al., 2018; Chien et al., 2020; Creswell, 2011; Strauss & Corbin, 1998). Qualitative themes were extracted from the analysis and selected quotes from the journals and interviews were translated faithfully into English for presentation in this paper.

**Table 3.** Internal reliability for the various competency factors.

| Competency factors | Cronbach's alpha value |
|---|---|
| Collaboration | .92 |
| Communication | .89 |
| Critical thinking and problem solving | .89 |
| Creativity and innovation | .93 |
| Computer and information literacy | .91 |
| All items | .96 |

## Findings

### *RQ 1: to what degree did this VR hands-on production experience enhance the learners' 5 C competency development?*

At the outset of the semester, the Five Core Competencies (5 C) questionnaire developed by the researchers was administered to the participants as a pretest. The same questionnaire was administered as a post-test after the conclusion of VR artifact production. Table 4 shows the mean scores of the student perceptions of their 5 C competencies on the pre- and post-tests. On the pretest, *Computer and Information Literacy* was the highest (3.69), indicating that 21st-century students had been exposed to computers and technology since they were young and most of them believed they had basic computer literacy skills. The factors on the pretests all had means above 3, placing them in the "agree" side the Likert scale. The post-test scores all exceeded 4.0. Among them, the mean score for the perception of *Creativity and Innovation* (4.04) was the lowest, while the mean scores of 4.32 for the perception of *Collaboration* and 4.41 for the perception of *Communication* were the highest.

Table 5 shows that the Paired-samples *t*-Test of the Five Core Competencies all reached a significance of .01 or better. Among them, the perceived improvement of *Collaboration* and *Communication* capabilities was the highest, presumably because students were offered abundant opportunities for cooperation and communication in their 4-5 person teams. The improvements of *Creativity and Innovation* and *Computer and Information Literacy* perceptions were the lowest.

Among all the 5Cs, the cultivation of *Collaboration* and *Communication* abilities may be relatively easy, whereas *Creativity and Innovation* may be the most difficult to enhance because it takes time to develop and nurture such competency. The production of three VR artifacts in this project allowed the students to experience the creation and development of VR works. In addition, *Computer and Information Literacy* was not much improved, in the opinions of the students, compared to the other three competencies, because most EFL learners in Taiwan, outside technology fields, are only equipped with basic computer skills and are unfamiliar with the operation of products, software applications, and video shooting and editing. Once they

**Table 4.** Descriptive statistics of the five competence factors.

| Five competences | | Mean | Number | SD |
|---|---|---|---|---|
| Collaboration | Pretest | 3.49 | 50 | .452 |
| | Post-test | 4.32 | 50 | .510 |
| Communication | Pretest | 3.68 | 50 | .765 |
| | Post-test | 4.41 | 50 | .382 |
| Critical thinking and problem solving | Pretest | 3.52 | 50 | .406 |
| | Post-test | 4.14 | 50 | .399 |
| Creativity and innovation | Pretest | 3.64 | 50 | .834 |
| | Post-test | 4.04 | 50 | .583 |
| Computer and information literacy | Pretest | 3.69 | 50 | .861 |
| | Post-test | 4.11 | 50 | .543 |

**Table 5.** Paired-samples t-test of the pretest and post-test of the five competence factors.

| | Paired differences | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 95% confidence interval of the difference | | | | |
| Post-test – Pretest | Mean | SD | Std. error mean | Lower | Upper | *t* | df | Sig. (2-tailed) |
| Collaboration | .83 | .698 | .099 | 1.028 | .631 | 8.410*** | 49 | .000 |
| Communication | .72 | .833 | .118 | .961 | .487 | 6.143*** | 49 | .000 |
| Critical thinking and problem solving | .62 | .531 | .075 | .771 | .469 | 8.253*** | 49 | .000 |
| Creativity and innovation | .41 | .999 | .141 | .691 | .124 | 2.886** | 49 | .006 |
| Computer and information literacy | .42 | 1.004 | .142 | .706 | .135 | 2.959** | 49 | .005 |

$^{**}p < .01$, $^{***}p < .001$.

engaged themselves into hands-on VR creation, they may have become aware of their inadequacy on this regard. Some EFL learners even fear and resist of employing technology in the course of their learning.

## RQ 2: to what extent did the students improve in their VR artifact creation?

The researchers answered Research Question 2, about the extent to which the students improved their VR artifacts creation, by the comprehensive scoring of 36 VR artifacts produced during the study, with each group producing three VR artifacts. The mean and standard deviation of the comprehensive scores of the three artifacts are shown in Table 6.

To determine the overall presentation effect of VR, the researchers compared performance differences of the three works in the three experiments and used One-way ANOVA to analyze whether the increase in the number of experiments effectively improved the overall production capacity of the students' VR works. Table 7 shows that the increase in the number of experiments did improve the overall presentation effect of VR.

Table 8 shows that the effect presented by the VR project increased with the number of cycles of production, at a significant level. Comparing the scores of the three implementations, the performance in the second and third cycles of production was better than the first cycle at the .001 level of significance. The performance on the third cycle improved over the second at the .05 level of significance. In other words, the implementation of this instructional design in which student groups created multiple VR artifacts resulted in improved quality of production in each cycle or iteration, indicating that more experience and longer implementation times lead to better results.

## RQ3: What were the learner perceptions about their VR production learning experiences?

The learners' overall perceptions were collected from both individual student reflective essays and focused interviews at the end of the semester and analyzed to identify common themes. Analysis identified the following five themes: (1) Learning by doing through outdoor exposure, (2) Physical social interaction and rapport with other learners, (3) Interplay of language learning and the use of technology, (4) Sense of accomplishment, and (5) Self-directed learning. The following sections explore each theme.

**Table 6.** Mean and standard deviation of the overall VR production evaluation results of three projects.

| Item | Order of VR artifacts | Number of groups | Mean % | SD |
|---|---|---|---|---|
| The overall VR artifacts effect | 1 | 12 | 41.08 | 13.47 |
| | 2 | 12 | 60.52 | 10.02 |
| | 3 | 12 | 70.37 | 10.47 |

**Table 7.** The overall effect of VR presentation of VR works, one-way ANOVA analysis of the number of three experiments.

| Source | | Sum of squares | *df* | Mean square | *F* | *p* |
|---|---|---|---|---|---|---|
| The overall VR presentation effect | Between groups | 5332.399 | 2 | 2666.200 | 20.430 | .000** |
| | Within groups | 4306.669 | 33 | 130.505 | | |
| | Total | 9639.069 | 35 | | | |

**$p < .001$.

**Table 8.** Summary of LSD's test for mean % differences between experimental order.

| The overall VR presentation effect | First | Second | Third |
|---|---|---|---|
| First | – | −19.44** | −29.29** |
| Second | | – | −9.85* |
| Third | | | – |

* $p < .05$, ** $p < .001$.

### Theme 1: Learning by doing through outdoor exposure

The students appreciated that they had opportunities to use their VR cameras in popular locations and learn in multiple different ways (language, culture, CIL, and teamwork).

> *We have had relatively fewer outdoor activities due to the impact of the epidemic. It was good to go visit Taiwan's scenic spots and to learn about their culture and history through this class* (Learner 6).

> *Online courses have made most other classes very boring. Instead of staying at home and watching some boring videos, we can go outside [in this class] and also learn more practical knowledge about these visited spots. We really like Teacher Vivian's class because of its hands-on learning and we are more motivated to learn this way.* (Learner 19).

The students appreciated that their VR production assignments took them outdoors. Although Taiwan did not experience the extensive "lockdowns" during the COVID-19 pandemic that much of the world did, the students we still accustomed to doing their school work indoors during this semester. As a result, allowing them to go outside and do activities meant a lot to them and they felt motivated to do hands-on VR projects away from their home and school. The researchers concluded that doing novel activities that move students away from their familiar routine and environment can build motivation.

### Theme 2: Physical social interaction among, and rapport within, the team

Learners formed groups of 4-5 members for this project. Their work required social interaction to succeed, i.e., they needed physical and direct interaction and cooperative relationships with each other. The reflective essays indicated that the students appreciated this dynamic.

> *I am very happy that team members were willing to communicate and discuss with each other and had the ability to realize and come up with new ideas. Everyone actively put forward many opinions on the overall work* (Learner 29).

> *Previous English classes had fewer interactions with classmates, but this VR activity brought everyone together, mutual encouragement was a good opportunity to learn from each other* (Learner 15).

> *Part of our team's cooperation was very good, but not everyone shared similar and certain aspects, so we divided our labor and rotation, so everyone was responsible for different tasks in these activities* (Learner 30).

Peer help (communication and discussion) within the group and contribution to the team (giving ideas and sharing tasks) are necessary facets to lead any team-based project to success. In consequence, physical social interaction among learners/groupmates in this study played an important role in their success and learning achievement. To be more specific, interaction allowed them to share ideas, give opinions, and make decisions to complete their projects successfully.

### Theme 3: Interplay of language learning and the use of technology

Although language learning was not included within the analysis of this study, the class in which the VR production occurred was a university-level English as a Foreign Language class for English majors. Most of the students were Humanities students (e.g., language or literature) and were not familiar with the actual use of VR tools to complete the assigned activities. They appreciated that the requirement to interact in English while producing their VR artifacts improved both their English and technology skills.

> *After the three assignments, we could improve all production skills and English skills. Our overall ability to use technology has also been greatly improved* (Learner 7).

> *This course was challenging but much different from other English courses in terms of application of VR technology, video shooting and editing, and 5C competencies. This course let us learn how to present VR works in Tour Creator* (Learner 33).

In this class, learners were expected to improve their English and learn technology competencies simultaneously. However, the course design contributed to their learning by cultivating all of their 21st-century competencies through their VR content creation.

### *Theme 4: Sense of accomplishment*

As a result of their VR assignments, the students came to feel a sense of accomplishment by completing all of the VR production tasks. For most of them, doing creative media activities outside the classroom was an unfamiliar experience. They felt that accomplishing their VR projects on their own, using Student-Centered Active Learning, was a fresh and unique experience, compared to other classes.

> *I felt a sense of accomplishment when I finished the whole task with my team members who were very cooperative and worked hard to do their best jobs* (Learner 33).

> *Because we went to scenic sites to shoot videos by ourselves, found materials, wrote descriptions of the sites, and made VR recordings, this unfamiliar experience made me feel a sense of accomplishment and really proud of our VR projects after we finished making the products* (Learner 48).

The reflective essays and interviews made clear that learners experienced a sense of accomplishment by completing their VR projects with the help of groupmates. This was true even though most had little or no experience creating and using VR.

### *Theme 5: Self-directed learning*

Students each had their own accountability and responsibility within their group to complete tasks. These individual tasks required self-directed, autonomous learning. In addition to learning the technology itself, group members found themselves researching the locations portrayed in their VR productions. They had to search for resources, gain new information via diverse channels, and construct meaningful new knowledge through their learning experiences. The reflective essays and interviews revealed that the students found that self-directed learning is not easy; however, because they realized and were sensitive to what they were learning and how they are maturing in the process of learning, it broadened their views.

> *I finally could experience something different about learning in my university life. We, of course, have to challenge ourselves to build some knowledge and try some new things that we have not been exposed to in the past, which could help us grow faster* (Learner 29).

> *For each of the three VR projects, Teacher Vivian just gave us deadlines. So, I myself and our team had to plan our own schedule and decide our visited spots as well to get everything done. In a word, it's very flexible but also, we needed to be independent in many ways, including trouble shooting and problem solving* (Learner 15).

The students in the study realized they were learning in a new way. In other words, they perceived themselves becoming more mature because of the experiential learning process. The students found that the need to learn new things, using an interesting new technology, was motivating and promoted their personal growth.

## Discussion

This study employed VR artifact creation in a Student-Centered Active Learning framework to stimulate development of the five core competencies (5Cs) of *Creativity and innovation*, *Critical thinking and problem solving*, *Communication*, *Collaboration,* and *Computer and information literacy* (CIL). The most important findings were that (1) the instructional design of the study led to self-reported improvement in all of the 5Cs at the significance level of .01 or better, (2) the participants found the hands-on VR creation projects to be distinctive and motivating, and (3) additional cycles of VR artifact production led to increases in empirical quality.

### *Five core competency improvement*

Educational technology, itself, is just one of the elements of the context that determine successful learning. The instructional context in which the technology is used is vital (Marek & Wu, 2014, 2016, 2017). Because the instructional design of this study was theory-based, the researchers were not surprised that the students felt that their Five Core Competencies all improved at a high level of significance. This outcome aligns with other studies that have shown that the KSAVE model (Binkley et al., 2012), when used in the context of language learning, focuses particularly on communication and collaboration skills (Lima et al., 2018).

Use of Virtual and Artificial Reality has been shown to align well with the KASVE framework, although less research attention has been given to the *creativity and innovation*, *critical thinking*, and *problem-solving* moderators examined in this study (Parmaxi & Demetriou, 2020). It is therefore also not surprising that the mean perceived improvement of *Collaboration* and *Communication* capabilities was the highest, while the improvement of *Creativity and Innovation* and *Computer and Information Literacy* (CIL) capabilities showed the least improvement, albeit significant. *Collaboration* and *Communication* can be conceived of as relatively easy to improve in a group project setting, whereas creativity and CIL may take much longer. Indeed, other studies have shown that today's "digital natives" who have grown to maturity as technology users, are not as digitally competent as they are assumed to be (Engen et al., 2014) because they may not have a deep understanding of how the technology they use works. Their starting level of both creativity and CIL were moderators that could take considerably longer than the other 5Cs to elevate to an equally high level.

Evaluating the actual change in competencies of the students was beyond the practical scope of the project, but the fact that the students believed subjectively that they had improved is enlightening. Past research (Wu et al., 2011) has shown that perceived success in using newly-acquired skills produces higher confidence, which in turn leads to higher motivation. Higher learner motivation means the students will apply themselves harder, resulting in higher ability over time. The perception of the students of improvement in the five core competencies addressed in this study equated to the success component of this documented sequence, suggesting that the perceived improvements would positively affect the motivation of the students, leading to greater improvement over time.

### *VR production is distinctive and motivating*

The motivation resulting from the perceived improvements in core competencies dovetailed with motivation resulting from the VR production assignments, which were unlike any other course the EFL students had taken. Similar to other studies, the students in this study found their VR production assignments to be unlike anything they had previously experienced in classroom requirements and were motivated by the differences (Yeh et al., 2020). This well-known phenomenon is called the "Novelty Effect" (Chwo et al., 2018). Over the long term, such as longer than eight weeks, the Novelty Effect fades (Clark & Sugrue, 1991) but the initial novelty and resulting motivation led to improved outcomes in each progressive round of VR production. The Novelty Effect has often been seen as a negative factor, possibly skewing quantitative analysis showing positive results in short-duration educational technology studies (Stockwell & Hubbard, 2013) but it also offers an affordance that instructional technology designers can make thoughtful use of, promoting the motivational benefit that students gain from their novel experiences in the early phases of a study.

The VR production assignments in this study made strong use of Student-Centered Active Learning, based in the Constructivist model of learning in which students create or "construct" knowledge through hands-on learning, as opposed to passive modes (Bruning et al., 2011). Student-Centered Active Learning, itself, has been found to be motivating for students. Its combination with the Novelty Effect provided a double-dose of motivating influences in this study.

### *Need for multiple cycles of VR production*

Computer and Information Literacy is linked to self-efficacy (Hatlevik et al., 2018). That is, as noted above, better CIL knowledge leads to more confidence, producing higher motivation, and in the long term, a higher level of ability (Wu et al., 2011). In addition, mastery of subject matter has been linked to fluency. The term fluency is often used in connection with language learning, but can be applied to proficiency in any set of skills and knowledge. Fluency is not simply a matter of accuracy; it also includes the speed of accurate performance (Binder et al., 2002). The key to achieving fluency is practice, i.e., focused repetition of the important skills leading to mastery.

Humanities language learning students were deliberately selected for this study because they were known to be generally less sophisticated technologically than students in fields such as math, science, or computer science. Indeed, several participating students needed assistance to simply learn how to retrieve pictures from their cameras for post-production use. It is not surprising, therefore, that the students in this study improved through repetition. The results of this study suggest that for a new or unusual skill set, such as the VR production requirements in this study, at least 2-3 iterations are necessary to build ability. Early success, under the guidance/scaffolding of the teacher, can build confidence, thus leading to improved outcomes over time (Wu et al., 2011).

### *Practical implications for teaching and learning*

There are multiple implications in this study for students and teachers. Based on the findings of this study and their experience, the researchers offer these recommendations:

1. Students need to complete a minimum of two VR artifacts: If time allows, creating three or more artifacts is beneficial in order to yield optimal learning outcomes. Constructive feedback and comments from both instructor and peers, as well as personal self-reflection, should happen immediately upon completion of each artifact to stimulate improvement in the next round of artifact production.
2. Teachers need to scaffold their students with respect to the required advanced skills and not "abandon" them to unfamiliar technology (Marek & Wu, 2019). Most students today have experienced taking smartphone video, but VR creation can be much more complex, including the need for good control of the 360-degree VR cameras, identifying good locations, and determining the best angles to be included in each of the VR scenes. Teacher scaffolding of this active learning can help facilitate the transition from novice to experienced VR creator. Students outside of technology fields are likely to consider VR production assignments with trepidation, because it forces them outside of their comfort zones, meaning that students who generally perform well academically may not feel prepared for the VR assignments. After successful completion of the three VR artifact production assignments, however, their "affective filter" to apply technology will decrease and they will feel more comfortable with the technology. A wise teacher will initially provide higher levels of scaffolding support, to ease the concerns of the students, but expect them to work more independently over time.
3. The instructor needs to purposefully and carefully design the instruction and team formation to promote collaboration and communication among the team members, because learning quality VR creation is a challenging and demanding process and involves many steps. The instructor also requires strong classroom management such as time control, scaffolding the student's active learning of the core competencies, student team work, student collaboration, monitoring student progress continually, and timely feedback provision. The ways in which this 5C scaffolding is performed may need to be different from the scaffolding of technology skills mentioned in implication #2.
4. The instructional framework needs individual accountability during teamwork activities, because individual students completing their fair share of jobs as assigned facilitates the development of student autonomous learning.
5. The teacher may need to provide induction training about critical thinking, in addition to about technology use. Critical thinking is essential to the success of VR production assignments. Students in this study had to decide the right spots to visit and craft their own precise and brief scripts. Although critical thinking is often called an ability, it is better

understood as a process employing recognition of questions and reflection on answers, which can be learned (Wu et al., 2013). Because many students are novices at the critical thinking process, the instructor may need to teach and model critical thinking.

6. Teachers should assist students to appreciate and value the real-world outcomes of their VR projects. The students in this study were creating VR content that would subsequently be available to the general public, meaning that they were assisting people around the world to appreciate the beauty of Taiwan and get to know the culture of Taiwan. This real-world outcome of their work rewarded them and gave them a feeling of accomplishment. It had never occurred to them learning can be fun, interesting, and engaging.

## Conclusion

This study has demonstrated a novel way of using Student-Centered Active Learning via VR artifact production to stimulate five core competencies required for success in the 21st-century, addressing both the technology used and the instructional design used to guide the students through the process.

Limitations of the study include that evaluation of the changes in core competencies was based on the perceptions of the students. Further study could attempt to measure actual changes in the competencies. In addition, one specific set of VR production systems was used. Alternative systems with similar affordances should be considered. Students with more technical background could be exposed to the same VR production requirements to see to what extent their competencies changed. Given that this study was performed using language students, their change in English proficiency while using VR production for hands-on active learning could also be evaluated quantitatively. In addition to the summative result-oriented evaluation, formative analysis could be used to explore the ways in which the student groups functioned to accomplish their outcomes, such as adopting behavioral sequence analysis, focusing on qualitative interviews, and analysis of learning and production process to explore in mor depth the learning behaviors and learning benefits associated with VR integration into education.

Finally, the current study was performed in the context of a university where the teachers, often busy with research, administration, and lecturing, were nevertheless willing to use emerging technologies for teaching innovation. Future research could also explore the factors that affect the willingness and ability of the teachers to adopt emerging-technology-based teaching, to gain understanding of factors influencing the technology-oriented professional development of teachers.

In the pandemic year of 2020, many students in this study were taking online classes, which mainly required the students to watch prerecorded videos or employed online synchronous lecture. They found the VR production requirements of this class, rooted in Student-Centered Active Learning, to be more demanding, yet more meaningful and motivating. Considering that the participants were freshmen, accustomed only to conventional teacher-centered instruction, the researchers hope that this experience with Student-Centered Active Learning and hands-on "learning by doing" approach will pave the way for their future successful college learning, in which they will apply these core competencies.

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# Appendix

## *Five competences questionnaire*

**General Instructions**: The purpose of this questionnaire is to **examine your tendency to perform the Five Competences, namely: Collaboration, Communication, Critical Thinking and Problem Solving, Creativity and Innovation, and Computer and Information Literacy** during the completion of Virtual Reality (VR) projects.

Choose the option (number) that best corresponds to your level of agreement with each statement below. Make sure to respond to every statement.

Choose number 1 if you "Strongly Disagree" with the statement.

Choose number 2 if you "Disagree" with the statement.

Choose number 3 if you are "Neutral" about the statement.

Choose number 4 if you "Agree" with the statement.

Choose number 5 if you "Strongly Agree" with the statement.

| No. | | Question Statements | | | | | |
|---|---|---|---|---|---|---|---|
| | | Collaboration Competence | 1 | 2 | 3 | 4 | 5 |
| **1** | **1** | I believe that all of the team members tried their best to complete the task. | | | | | |
| **2** | **2** | I had a high level of trust in my team members' contribution to collaborative work. | | | | | |
| **3** | **3** | I believe our team successfully collaborated to complete the VR task. | | | | | |
| **4** | **4** | When my team peers proposed ideas, I did not question their motives. | | | | | |
| **5** | **5** | I attempted to communicate with my team members to ensure good collaboration efforts. | | | | | |
| **6** | **6** | I was able to easily build relationships with other team members in my group. | | | | | |
| **7** | **7** | When collaborating with peers, we generally had the tasks properly assigned to each of the team members. | | | | | |
| **8** | **8** | Overall, I enjoyed working in collaborative work. | | | | | |
| | | **Communication Competence** | | | | | |
| **9** | **1** | I tried to communicate with other members in a warm tone. | | | | | |
| **10** | **2** | When talking to other members, I considered their feelings. | | | | | |
| **11** | **3** | I supported other members with words (such as compliments or encouragement) and actions. | | | | | |
| **12** | **4** | I showed respect when I communicated with other members. | | | | | |
| **13** | **5** | During discussion, I was able to express my opinions freely. | | | | | |
| **14** | **6** | When there was a disagreement, we tried hard to communicate with each other until consensus was reached. | | | | | |
| **15** | **7** | Overall, the communication in my group was smooth and successful. | | | | | |
| | | **Critical Thinking and Problem-Solving Competence** | | | | | |
| **16** | **1** | I know how to search information and evaluate the information better. | | | | | |
| **17** | **2** | I considered different opinions to see which one made more sense to me. | | | | | |
| **18** | **3** | I provided reasons and evidence when I proposed my ideas and made a decision. | | | | | |
| **19** | **4** | I learned how to select relevant information from various sources and organize them into logical sequence. | | | | | |
| **20** | **5** | I was able to critique VR the artifacts produced by my peers. | | | | | |
| **21** | **6** | VR production process helped me to think more critically when it came to learning. | | | | | |
| **22** | **7** | When creating the VR, I considered the expectations of the viewers. | | | | | |

| | | |
|---|---|---|
| **23** | **8** | My critical thinking skills has improved this semester. |
| **24** | **9** | I believe that I am better at solving the problems I encounter. |
| **25** | **10** | I believe that I can solve problems on my own. |
| **26** | **11** | I have had the experience of solving the problems I encountered. |
| **27** | **12** | When encountering problems, I am willing to face and deal with them. |
| **28** | **13** | I believe I have always tried my best to solve the problems I encountered. |
| | | **Creativity and Innovation Competence** |
| **29** | **1** | I was able to execute my creativity in this VR project. |
| **30** | **2** | I made an effort to create a different and unique way of presenting the VR project. |
| **31** | **3** | I like to imagine the things I would like to do or know. |
| **32** | **4** | I would like to do something that other people might not have done. |
| **33** | **5** | I was able to produce something original in this VR. |
| **34** | **6** | I was able to create something new in this VR. |
| **35** | **7** | I was able to generate new ideas in this VR. |
| **36** | **8** | I think that this VR project has enhanced my creativity. |
| | | **Computer and Information Literacy Level (CIL) Competence After completing the VR projects** |
| **37** | **1** | My ability in using CIL has improved. |
| **38** | **2** | My ability in videography has improved. |
| **39** | **3** | My knowledge and understanding about new technology that is useful in my learning has improved. |
| **40** | **4** | My skill with new technologies that are useful in my learning has improved. |
| **41** | **5** | I was able to utilize computer applications to solve my problem. |
| **42** | **6** | I was able to use the internet to access different types of information. |
| **43** | **7** | I was able to locate the information sources and then identify the information I need properly. |
| **44** | **8** | I enjoyed using computer/technology to improve my language learning. |