

Converging Digital Literacy through Virtual Reality

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Abstract—Full Paper. Virtual reality has become a new platform for communication and engagement to share knowledge. This paper describes the TalkTech 2020 project, in which students at two universities on different continents partnered to use CoSpaces EDU, a beginner's VR authoring tool, to develop virtual visits to international businesses in their home countries. They researched their assigned companies' innovations, products, and services, and conveyed their findings in an original digital story presented in VR. The project represents a convergence of learning about business and technology with arts and sciences, as students develop skills in digital literacy, creative thinking, problem solving, teamwork, and cultural awareness. These experiences will help students prepare for their future careers in many disciplines. The VR experiences that students created for their partners enabled them to learn about and virtually visit international businesses in each other's home countries. They discussed cultural similarities and differences during a video call with their international partners, managed the challenges of working as international team members arranging online meetings across time zones, and chose the collaboration tools that they thought would serve them best to complete the project.

Keywords—virtual reality, digital literacy, international business, collaboration, cultural awareness

I. INTRODUCTION

STEM education becomes more attractive when learners have the opportunity to experiment with new technologies in projects of their own creation. This paper describes the TalkTech project, a project-based learning scenario where learners take ownership of a project, collaborate through different forms and media, apply critical and creative thinking to their work product. Learners used a series of tools to build virtual reality experiences gaining collaborative digital and IT skills to complete outcomes. This focus on technology to support pedagogy, rather than use technology for its own sake, ensures a more profound learning experience. The innovation in this learning endeavor creating a project-based international collaboration in which students create original VR and multimedia as a way to develop and demonstrate their digital literacy skills.

A goal of this study is to see what digital literacy skills were developed by the students participating in the TalkTech Project, which is also our research question. Section II provides a model of digital literacy skills and projects for developing those skills through one's digital intelligence quotient; Section III describes the TalkTech Project, Section IV provides a brief overview of the CoSpaces tool used to create VR artefacts, and Section V

analyzes the project through the lens of digital intelligence. The discussion focuses on levels of digital intelligence in the TalkTech project as informed by results of student survey and interviews regarding their participation in this project, the tools they used. The paper ends with conclusions and further discussion.

II. ACHIEVING DIGITAL LITERACY

Future-focused, 21st century skills require students to be creative thinkers who are able to research information and apply their knowledge to new settings. They need to know how to work together in teams using technologies and tools that will be found in the workplace. These skills extend beyond the technical skills needed to function in a technology-driven society but also focuses on how to use those technologies responsibly. Digital literacy is a combination of technical, procedural, cognitive and emotional-social skills, for example, using a computer involves procedural skills (file-management), cognitive skills (intuitively reading the visual messages in graphic user interfaces) [1, p. 1]. As technology continuously evolves, educators constantly must adapt their courses to include the latest technological trends so students can achieve digital literacy [2]. Learning to use new technologies is an important skill in achieving both critical thinking and digital literacy [3] and immersive technologies enable students to develop "critical media awareness and adaptability" [4, p. 1] for learning future technologies.

Recent studies have shown the efficacy of creating digital content as a means toward achieving digital literacy skills [5]–[8]. [9], [10] use a project-based learning approach toward having elementary school students create augmented reality artifacts to acquire competences in a curriculum characterized by learning by doing. This paper extends the work of [11], [12] by placing students in the role of content creators [13] developing immersive media-rich experiences using virtual reality [14]. "Digital intelligence" (DQ) is an emerging umbrella term encompassing digital skills, digital competencies, digital readiness, and digital literacy, all of which terms are often used interchangeably [14]. The ability to understand and create digital resources, analyze data, and contribute collaboratively are critical for success in a technology-driven world. Digital intelligence is quickly becoming a measure of one's ability to think differently and succeed in the digital era, as future workers will need to learn and evaluate constantly changing technologies. This agility requires a new way of thinking that needs to be taught so that today's students will be prepared to master tomorrow's new digital technologies [15].

The IEEE's DQ Framework includes eight areas of an individuals' digital life, ranging "from personal and social identities of individuals to their use of technology including device and media, their online communication and collaboration at work or at leisure, their practical, operational and technical capabilities that are critical for daily digital lives and professional careers, potential safety and security issues related to technology, emotional and relational aspects and human rights in the digital age" [14, p. 14], as shown in Fig. 1.

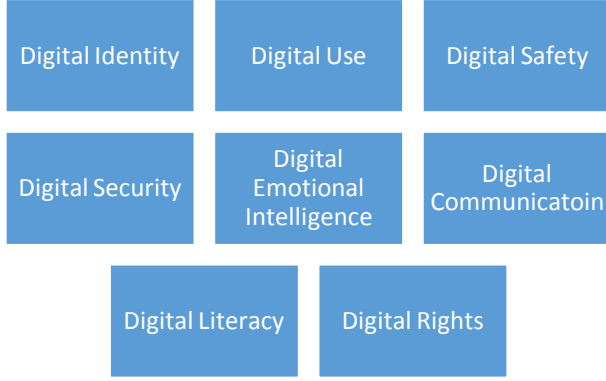


Fig. 1. Framework for Digital Intelligence (DQ).

"These competencies should allow people to not just use a computer or smartphone, but to deal with the modern social and economic challenges and demands resulting from technological advances" [14, p. 8]. The IEEE report summarizes digital literacy as a "finding, reading, evaluating, synthesizing, creating, adapting and sharing information, media and technology" [14, p. 15]. Each of these attributes of digital literacy is divided into three levels as shown in TABLE I.

TABLE I. THREE LEVELS OF DQ (INTELLIGENCE) AND DIGITAL LITERACY COMPETENCIES

Level of DQ	Definition	Digital Literacy Skill
Digital Citizenship	Using digital technology and media in safe, responsible, and ethical ways	Media and Informaiton Literacy
Digital creativity	Becoming a part of the digital ecosystem, and creating new knowledge, technologies, and content to turn ideas into reality.	Content creation and computational literacy
Digital competitiveness	Solving global challenges, innovating, and creating new opportunities in the digital economy by driving entrepreneurship, jobs, growth and impact.	Data and AI Literacy

This paper explores the IEEE definition of digital literacy as it applies to the TalkTech 2020 project, and analyzes it through the lens of the three levels of DQ.

III. TALKTECH 2020 PROJECT DESCRIPTION

A. Overview

Virtual reality enables new forms of engagement and experiencing the world when travel is impossible due to the current pandemic. In this project, students enrolled in IT 101 (Introduction to Information Technology) at Bentley University

in Massachusetts and students enrolled in a TMM (Technology of Multimedia) course at University of Timisoara Politehnica (UPT) in Romania, participate in groups of four, with two students from each school forming international teams, to create a VR scene while learning about an internationally known company. Both classes were conducted remotely by their respective universities due to the COVID-19 pandemic.

Throughout the project, students chose the collaboration and communication tools they thought would best suit their group's needs, based on the type of communication in which they engaged. Students communicated with web-based collaboration and communication tools to meet both synchronously, in real time using voice, video and chat, and asynchronously, using email and messaging services, to discuss the uses of VR in business and to create VR scenes for their partners, as they determined the best use cases for these technologies.

B. Project Description

Working as members of international teams, students at a New England Business University enrolled in IT 101, Introduction to Information Technology, paired with fourth-year students at a Romanian Technical University enrolled in a Technology of Multimedia course to create digital stories using VR that share their research about international businesses. While the potential impact of VR continues to increase across academic disciplines and industries, introducing the topic through an intercultural context in an introductory computing education context is a novel contribution of this work. The TalkTech project represents an exciting opportunity for students to explore emerging technologies such as VR. Visit <http://talktechproject.net> for additional information and examples of student work.

In this six-week project conducted during Fall 2020 semester, students used Open Virtual Mobility Hub, an environment developed by UPT, dedicated for international collaboration and mobilities, as a common open online learning platform, to share their work, blogs, projects results and communicate with their instructors [16], [17].

Each team created one VR experience with their partners that combined scenes created by each team, showcasing the accomplishments of the same international business in their home countries. TABLE II. lists the companies selected for students to research and present in their projects.

TABLE II. TALKTECH 2020 COMPANIES

Adobe	IBM	Nokia
Amazon	Instagram	Samsung
Apple	Intel	SAP
Cisco	LinkedIn	Twitter
Facebook	Microsoft	Uber
Google	Netflix	

Students researched the company to find out about their products, services, innovations, history, and any localized aspects particular to their home countries. They first summarized their findings in a short blog post as shown in Fig. 2, and then used that information to guide the design and development of their shared VR scenes.

After commenting on each other's blog posts, students created video demonstrations of their VR scenes, which included a teleport feature to switch between scenes from each country, and created a video in which they reflected on their group process, challenges and successes while working on the project. The process of reflecting on their progress allows students to claim ownership of the creative approaches that worked or identify things they might have done differently after completing the experience. These insights also inform the instructors, who have been evolving the TalkTech project each year since 2008.

About Tesla Model 3

This car is perfectly for a family is an electric four-door fastback sedan.

The Model 3 Standard Range Plus version delivers an EPA-rated all-electric range of 263 miles and the Long Range versions deliver 353 miles.

The Model 3 carries full self-driving hardware, with periodic software updates adding functionality. Tesla Model 3 is instead more of an all-electric alternative to compact luxury sedans !

Model 3 comes with the option of dual motor all-wheel drive. Performance Brakes and lowered suspension. all allowing Model 3 to accelerate from 0-60 mph in as little as 3.1 seconds.

Safety is the most important part of the overall Model 3 design. The metal structure is a combination of aluminum and steel, for maximum strength in every area. In a roof-crush test, Model 3 resisted four times its own mass, even with an all-glass roof: that's the same weight as two full-grown African elephants.

Source

https://www.tesla.com/en_ca?fbclid=IwAR3gFbwlcOMcTq-JJoIFZ72CAXjm_EvLqHMUmLHto3G6mrcsSemEopiD55s

The exterior and interior of Tesla Factory were found on an Youtube 360 degree video. I downloaded the video and made caption on two scenes the parking spot and the Interior factory. Sadly the quality of the video and of the images were not enough for a good quality in cospaces.



Fig. 2. Content from a blog post summarizing their research of a company. informs their VR scenes.

IV. CONTENT CREATORS WITH CoSPACES

Students used the CoSpaces EDU VR creation tool[18] to create VR scenes combining locations in their home countries associated with their assigned companies, combined into one immersive experience. The authors chose CoSpaces EDU as the VR authoring platform because of its low barrier to entry: students can easily build three dimensional models and add

interactions with block-based coding, and then explore their creations using a laptop, phone, or cardboard headset. Since many of the students had not coded before, CoSpaces is an appropriate choice for a VR tool that enables students to become digital content creators. They created 360-degree images, imported them into the CoSpaces designer, and enhanced and animated them with avatars to tell a digital story.

Figure 3 shows the work completed in CoSpaces by a team researching Tesla. Modeled after a 360-degree VR factory tour they saw online, they created their own virtual visit to the company's facility, using a 360 photo created from Google Maps Street-view as their background.



Fig. 3. Creating a Scene in CoSpaces.

Using the CoBlocks visual programming environment integrated within the CoSpaces tool, students can add avatars and animate them with dialogue, gestures, and motion to produce digital stories, and switch between scenes by clicking on an object in them. In this scene, an observer remarks about the features of the Tesla Model S as he admires the vehicle, represented by a beige avatar on the screen. See Fig. 4.



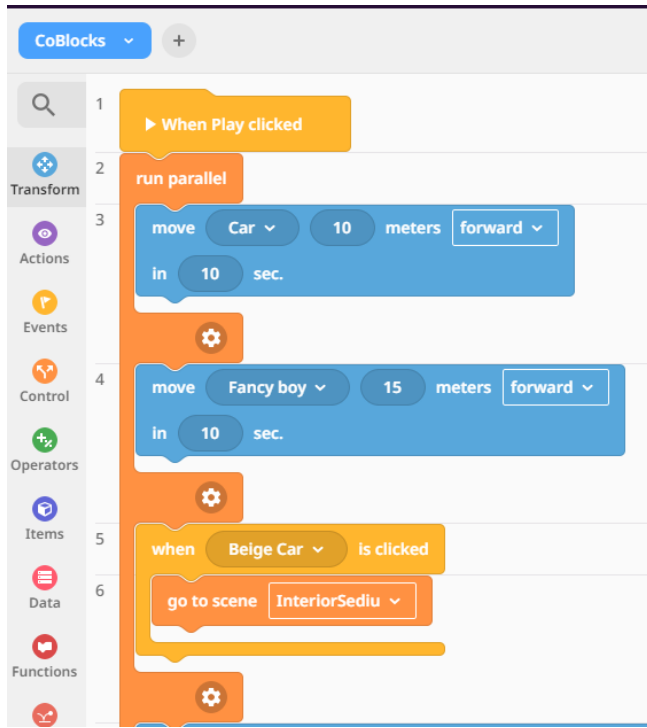


Fig. 4. Designing a scene in CoSpaces, and animating it with CoBlocks.

Clicking on the car switches to the scene created by the Romanian team, displaying the inside of the Tesla showroom. Students enhanced the scene with a large video wall playing a video about Tesla vehicles, as shown in the background of the first screenshot in Fig. 5. The second shows a sales person sharing facts about the vehicles to prospective customers.



Fig. 5. The inside of a Tesla dealership's showroom.

After creating and coding their VR experiences using CoSpaces web app, students share their work with others by providing a link to view them in a browser or on a mobile device using the CoSpaces app. When using the mobile app, users can view these scenes using a Google Cardboard or similar VR headset to create a fully immersive experience. See Fig. 6.



Fig. 6. Viewing a CoSpaces scene in a mobile device with a cardboard headset.

V. TALKTECH 2020 THROUGH THE LENS OF DQ

While 25 American and 32 Romanian students participated in the TalkTech 2020 project, survey responses from 21 Bentley students and 15 UPT students, along with student interviews, blogs, and reflections inform the results shared here. The authors posit that by completing the steps required in the TalkTech 2020 project successfully, students will develop their digital literacy skills and further their own digital intelligence.

The American students are on average two years younger than the Romanian students. Both groups were evenly matched in their self-assessment of familiarity with various technologies prior to starting the TalkTech 2020 project. TABLE III. analyzes response on a 5-point scale (never, rarely, monthly, weekly, daily) representing frequency of use of several tools prior to the start of this project.

TABLE III. PREVIOUS TOOL FAMILIARITY PRIOR TO PROJECT

Field	Min	Max	Mean	Std Dev	Var	Count
American Students						
Search engines	1	5	4.62	0.95	0.9	21
Mobile messaging	4	5	4.67	0.47	0.22	21
Video Conferencing	1	5	4.62	0.9	0.81	21
Team Conversations	1	5	3.24	1.44	2.09	21
YouTube	1	5	4.33	1.28	1.65	21
Collaborative Documents	1	5	3.95	1.4	1.95	21
Augmented Reality	1	4	1.9	1.06	1.13	21
Virtual Reality	1	5	2.05	1.33	1.76	21
Romanian Students						
Search engines	2	5	4.69	0.77	0.59	16
Mobile messaging	1	5	4.56	1	1	16
Video Conferencing	2	5	4.25	0.83	0.69	16
Team Conversations	1	5	3.75	1.15	1.31	16
YouTube	2	5	4.44	0.79	0.62	16
Collaborative Documents	1	5	3.31	1.21	1.46	16
Augmented Reality	1	5	2.56	1.32	1.75	16
Virtual Reality	1	5	2.88	1.58	2.48	16

Search engines, mobile messaging, and video conferencing apps were the top three used most on average by both groups. As this project took place during COVID 10 lockdowns, the use of video conferencing especially is not surprising.

In a survey following the completion of the project, students were asked to identify skills that they developed during their involvement in the project, and skills which were important to completing the project. Skills they identified are directly related to the levels of digital intelligence presented in TABLE I. The figures below, showing skills developed and their perceived importance to completing the project, represent responses from students at each university, normalized by percentage:

A. Digital Citizenship

An aspect of digital citizenship is being well-informed and proficient in the use of technology. Students rated their developed skills in this area, and their perceptions of its importance in completing this project. (See Fig. 7).

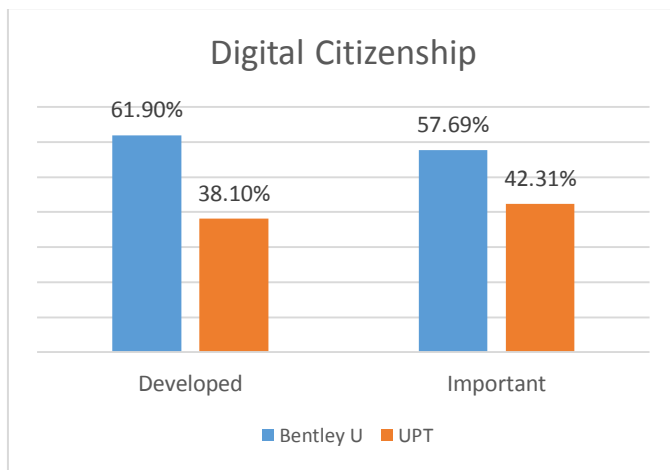


Fig. 7. Well-informed and proficient use of technology (Developed and Importance).

Students commented the impact of technology on global citizenship: "The project showed us how important technology was to them", "It was cool to see the street view from Romania and the US and see how similar they are. I learned that we are a lot more similar than I thought." "This was most certainly different than any other academic project I ever had to take on previously. I have never had the opportunity to [use technology to] work with students from another country, in a different time zone. It was an interesting learning experience to have to adjust and accommodate this factor and completely the project in an organized, timely manner."

Of interest to note is that few students commented on the technologies they used to interact with their international partners; rather, they took it as a given that it is possible (and completely normal) to arrange online meetings with their student partners in another country. Many chose to use tools such as Discord, WhatsApp and Instagram rather than the OpenVM platform provided by their instructors. This behavior suggests that these students are digital citizens, savvy in their use of technology, and able to use their devices and the Internet as part of their daily routine effectively.

B. Digital Creativity

Students recognized creativity as a skill that was important to have, and that a skill that they developed as a result of participating in the TalkTech 2020 project, as shown in Fig. 8

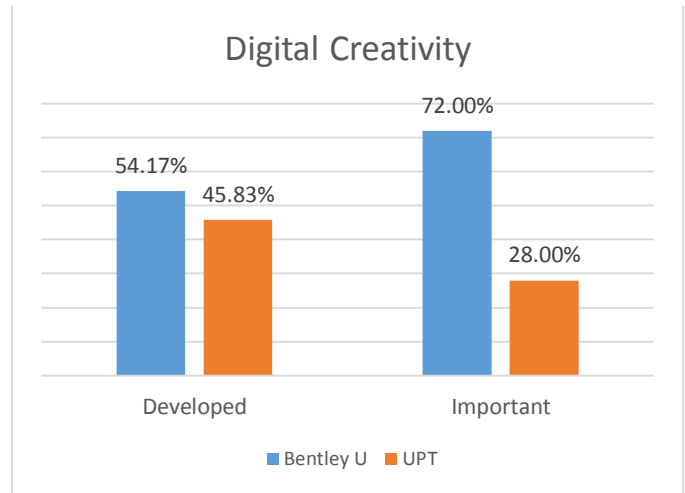


Fig. 8. Creativity (Developed and Importance).

Students noted the aspects of this project which enabled them to be the most creative as shown in Fig. 8:

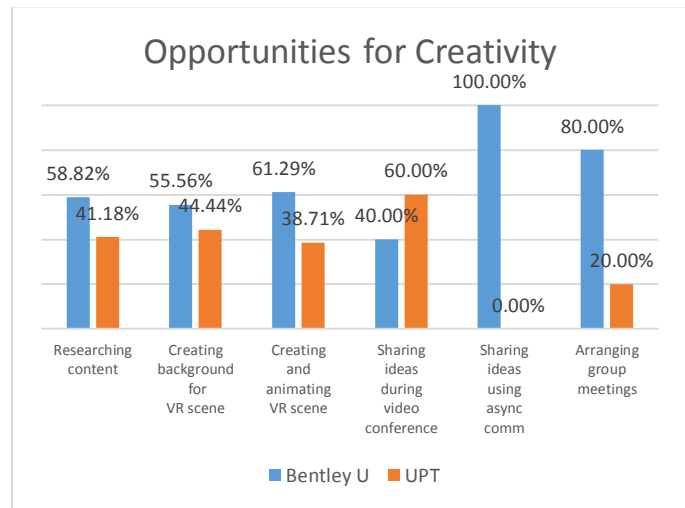


Fig. 9. TalkTech 2020 Opportunities for Creativity.

Clearly, creating and animating their scenes in CoSpaces was the aspect of this project which enabled them to be the most creative, but also the most challenging. One student commented, "Throughout this project, I learned how to use CoSpaces more efficiently and how VR can contribute to learning, specifically virtual learning. At first, the most challenging part of the whole project was probably getting a 360 image for the background of the scene. Eventually, with help from our Romanian partners, we figured it out. Also, it was challenging to create all the animations to happen simultaneously and to look as realistic as possible. Virtual Reality can definitely contribute to online learning through an interactive experience if the scene incorporates useful and insightful information and animations that catch the attention of the person using the VR."

C. Digital Competitiveness

Digital competitiveness includes solving global challenges, innovating, and creating new opportunities in the digital economy. In this project, Students navigate the challenges of working together as members of international teams, including time zones and technology hurdles necessary to operate their team efficiently.

Fig. 10 suggests that approximately half of the students participating from each university identified "developing a competitive edge" as a skill that was important to have. For many of these students, it was one whose development was fostered by completing this project:

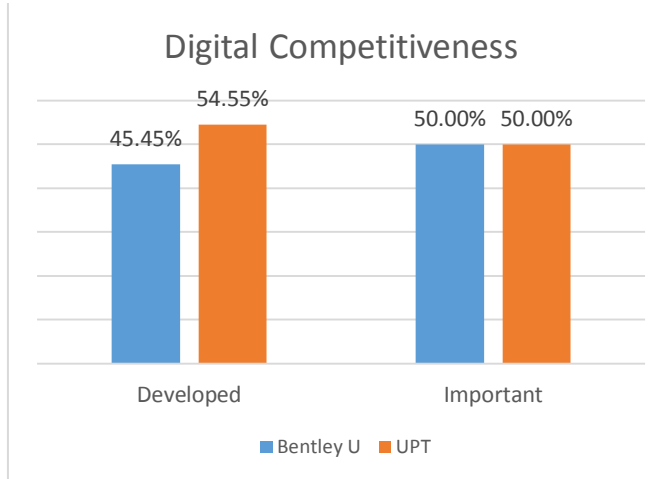


Fig. 10. Competitive Edge (Developed and Importance).

Students recognized "the importance of communication and how we can use create a platform for others to learn from. Now with COVID, we can use CoSpaces technology to promote business and present new ideas." Student comments also included: "We developed our time management and communication skills because we had to work efficiently as a team, even if we've never met before this project."

VI. DISCUSSION

In this paper, the authors investigated how digital intelligence is influenced by an international project where students co-create multimedia artifacts as members of international teams. In this study we asked what digital literacy skills are developed by the TalkTech project students. The investigation presented here is based on the final survey, analysis of project results as multimedia artifacts, and students' comments. During the TalkTech project students have used more than 16 different tools for communicating and managing their groups, researching their topics, and creating their multimedia artifacts. The process of researching an international business, and creatively sharing that process resulting in a unified digital story through VR, demonstrates student learning and acquisition of IEEE digital skills including digital communication and digital use.

The project had its challenges: students needed to navigate new tools and technologies and manage appointments with international partners living in a time zone seven hours apart.

They needed to maneuver spotty internet connections at home, limited access on their devices to communicate. Students needed to learn to work as members of teams, set reasonable expectations for themselves and their team members.

While conducted in the context of a technology concepts course and multimedia course, the TalkTech 2020 project extends itself to other disciplines. Students who have the digital literacy skills necessary to work through this project's requirements can complete similar projects by creating immersive media to use as a backdrop to tell their digital stories. For example, students studying international languages or history might create VR scenes showing a dialog between avatars placed at culturally or historically significant locations. Like the students in the TalkTech 2020 project, they could use Google Earth or Street View to creating 360-degree images of these locations and use them as the backgrounds of their virtual scenes developed in CoSpaces.

Students demonstrated digital citizenship through their use of technologies and research online to obtain valid and relevant information. By working, researching and learning in a digital international project, students not only gained new skills and professional competencies, but they improved their level of digital citizenship.

They demonstrated digital creativity through their work in developing and sharing an immersive VR scene. The ability to make use of several communication media and technologies in a skillful way and to create a new digital artifact in VR as a result of combining business research with digital stories, validates the students' content creation and computational literacy skills, and fulfills the requirements for digital creativity. The authors conclude that in this international collaboration, students' skills in information, technology, and digital literacy converge to create a tangible work product that demonstrates their understanding of a complex project, as well as the collaboration tools, communication methods, and digital skills required to complete it.

One aspect of digital literacy that does not appear in the Digital Intelligence Framework shown in Figure 1, is creativity. This project gave students the opportunity to explore, and many were willing to do so as evidenced by the variety of approaches in the students' projects. Their digital artefacts, blog posts, and project reflection essays work clearly showed that students needed to become creative thinkers and problem solvers when completing this project. Creativity could be considered an attribute necessary for enhanced digital literacy skills, as students learned to find workarounds to technical issues, and translated the research about their subject - companies into three-dimensional digital scenes with digital storytelling and characters.

The TalkTech 2020 project focused on technological and entrepreneurial innovation topics in international companies, as students researched, analyzed and synthesized their companies' accomplishments in the digital economy.

As an experiment, information technology students in the United States integrated work from another course assignment when completing their work in this project. They used Bloomberg Terminal, a tool which brings together real time

market and financial data, to research their companies, and incorporate their results as part of the digital stories they created in VR. This opportunity provided experience in using web-based databases as a research tool and provided an innovative platform for synthesizing and presenting their findings. Future iterations of the TalkTech project may refine and enhance this endeavor and require multimedia students to perform similar research using web-based tools.

Students also managed the challenges of working on multiple devices and platforms and recognizing the value of VR in the digital economy. These numerous opportunities for further professional development validates their digital competitiveness. All of these components to the project have improved their digital literacy skills, as identified by the three levels of DQ (Intelligence) and digital literacy competencies.

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