Enhancing and Transforming Global Learning Communities with Augmented Reality

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ABSTRACT

Augmented and virtual reality applications bring new insights to real world objects and scenarios. This paper shares research results of the TalkTech project, an ongoing study investigating the impact of learning about new technologies as members of global communities. This study shares results of a collaborative learning project about augmented and virtual reality and their applications in a variety of businesses and industries. In the TalkTech project, students from universities in the United States and Romania collaboratively work together to research the use of augmented and virtual reality in an assigned industry, create original augmented reality artifacts, and communicate and share their findings with their international partners. The authors evaluate the TalkTech project through the lens of the SAMR (Substitution, Augmentation, Modification, Redefinition) framework as a pedagogy to enhance student learning about augmented reality and improve students' digital skills. The paper also discusses the SAMR framework as implemented in the TalkTech project and its application to creating learning projects to transform Information Systems education.

Keywords: Augmented reality, SAMR framework, Mobile computing, Global communities, Collaborative learning

1. INTRODUCTION

Augmented and virtual reality are emerging technologies that allow students to use their mobile devices in new ways to enhance their learning experience. Mobile augmented reality (AR) apps use the built-in camera in a mobile device to scan an image, which then causes related multimedia content (often images, maps, hyperlinks, video, or text) to appear overlaid on the image, to create a new digital experience. Some AR apps make use of a mobile device's GPS capabilities to provide location-relevant results.

In contrast, virtual reality (VR) often requires participants to wear a specialized headset for viewing three-dimensional, immersive content. Some VR headsets such as Google Cardboard enable users to view VR content on their smartphones. While AR generally requires no additional hardware beyond a mobile device, VR often provides a much more captivating experience. The ubiquity of smartphones has resulted in increased implementation of both AR and VR educational settings with favorable results (Bartholomew, 2017; Radu, 2014; Teichner, 2014).

Radu has found high levels of enthusiasm regarding AR-based learning: "users report feeling higher satisfaction, having more fun, and being more willing to repeat the AR experience" (Radu, 2014, p. 1536). AR learning requires students to "interpret data and make an argument based on evidence … as they design, test, and build their final creation" (Bartholomew, 2017, p. 27).

This paper describes the research results of global learning communities formed during the TalkTech project, an on-going study, since 2008, teaming students enrolled in a first-year introductory technology course at Bentley University in the United States with fourth-year multimedia students from Politehnica University of Timisoara in Romania. Students work together, in groups of 4-5, during a semester to study and investigate emerging technology trends and apply their technology skills. They become part of a global learning community and simulate a real-world working environment found at companies engaged in new technologies. The website

www.talktechproject.net has more information about this and prior iterations of the TalkTech project.

Matching students with international partners to work on projects together is possible because of the popularity and availability of online and mobile communication technologies. The ability to communicate and collaborate across the globe has transformed education and resulted in the development of collaborative, global learning communities (Cochrane et al., 2013). In a similar learning project, Cochrane et al. (2013) matched students from several countries to work in teams to produce reports with their partners and share them on social media sites. Students "experience authentic international collaboration within student-negotiated teams … enabled by mobile social media tools" (Cochrane et al., 2013, p. 4). They used a variety of synchronous streaming services, social media platforms, and online collaboration tools to create their reports as part of the icollab project, which researched the influence of new technologies over international communities of practice. Their research created a four-staged framework for "building global collaborative learning communities reified in student-generated mobile social media projects" (Cochrane et al., 2013, p. 10).

The TalkTech 2016 project requires students to research applications of AR and VR in several industries. Working independently on subjects of their own choice, students collaborated to create an interactive image using ThingLink, a platform to "enhance images with notes, photos, audio, video, and other multimedia content" (ThingLink, 2017). This interactive image contains, in a single artifact, the entire group's work, as students post results of their research, videos of their original AR experiences created for their international partners, and joint videos or demos of their conversations.

The TalkTech 2016 project provided a learning environment where students relied on mobile technology and the web for conducting research, communication, collaboration, and creating new knowledge. The authors investigated the SAMR (Substitution, Augmentation, Modification, Redefinition) framework (Puentedura, 2006) for introducing technology in teaching and learning, as a framework to present AR and VR in the context of a collaborative global community.

These research questions guided this study:

- What educational enhancements can the process of creating original AR artifacts bring to students?
- How will creating original artifacts about AR applications develop their digital skills?
- How does the TalkTech project implement the principles of the SAMR framework?
- Can learning projects based on the SAMR framework enhance and transform Information Systems education?

2. TALKTECH AND THE SAMR FRAMEWORK

SAMR (Substitution, Augmentation, Modification, Redefinition) is a framework that evaluates the adoption of technology in an educational context and provides guidelines for creating projects to assess students' learning through their evolving use of technology (Puentedura, 2006).

The SAMR framework offers a structure by which to evaluate how mobile devices have transformed learning to achieve new experiences (Cochrane et al., 2014; Jacobs-Israel

and Moorefeld-Lang, 2013; Morris and Graña, 2014; Romrell, Kidder, and Wood, 2014; Webb and Gibson, 2015). The SAMR framework presents four levels by which to examine the use of new technology in an educational context, as shown in Figure 1.
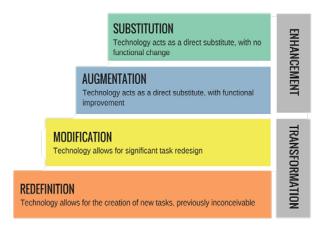

Figure 1. The SAMR Model (Lefflerd, 2016)

Transformational learning activities that are truly personalized, situated, and connected will go beyond merely using a mobile device as a substitute for more traditional tools. "The SAMR framework argues that technology adoption in education can move beyond the substitution of existing activities and assessment practices to create new experiences previously impossible or difficult with prior technology." (Cochrane et al., 2014, p. 5)

QR codes (Morris and Graña, 2014) and augmented reality tools (Cochrane et al., 2014) are two examples of technologies that enable learning with mobile devices.

> Effective use of QR codes or similar, if not more sophisticated, augmented reality applications (like Aurasma) implies that the technology is being used not as a snazzy substitute for something we can already do, but that the technology enables something different. (Morris and Graña, 2014, p. 12)

3. TALKTECH 2016: EXPLORING AUGMENTED AND VIRTUAL REALITY APPLICATIONS

The TalkTech 2016 project introduces AR concepts into the information technology classroom. Students research AR and VR applications to build digital experiences that share their knowledge of how specified industries might make use of these technologies.

Students worked in teams consisting of two or three Americans and two Romanians to research and present applications of AR and VR in one of several industries: advertising/ promotion, architecture/ interior design, education/ training, fashion, gaming, health care, mapping, museums, sports, and travel/ tourism. They used ThingLink to share their findings. Appendix 1, Figure 1 shows an example of one group's ThingLink report for uses of AR and VR in the Travel and Tourism industry. It contains an original background image annotated with reports and videos from the students. Each

group had to create an appropriate background image suitable to their topic and enhance it with content including research showing how their industry uses augmented and virtual reality, videos of their AR experiences, and translations of their notes to English or Romanian. All students were experienced in using new online and mobile technologies for communication and collaborative working (Andone and Frydenberg, 2017).

In addition to researching an application of VR to their group's assigned industry individually, each team created an original AR artifact for their international partners, which they demonstrated via a video call. The process of creating an AR artifact requires students to integrate several technology tools and skills:

1. Research and select an AR development tool, and become proficient in its use. Students were responsible for investigating and selecting an appropriate authoring tool to create their AR artifacts.
2. Research how an assigned industry might use AR; determine an appropriate background image and its augmented multimedia content.
3. Create the background target image(s) for scanning.
4. Create or locate multimedia artifacts (images, text annotations, hyperlinks, or videos) to augment the target image and position appropriately.
5. Test on a mobile device.
6. Save and prepare the completed AR artifact for sharing so others can view it. (AR development apps have different ways to share artifacts. Some require joining a channel or entering an access code, for example.)

Many students used the Vine camera mobile app (Vine, 2017) to create looping, six-second videos that show the process of scanning a target image with a mobile device using an AR app and the augmented content that appears on the mobile device's screen when doing so. Students shared their work as annotations on their ThingLink interactive images.

The artifacts that students created demonstrated their understanding of applications of AR in their assigned industries. For example, students investigating the use of AR/VR in the travel and tourism industry created a demonstration. Figure 2 shows how using an AR app on a mobile device to scan a brochure or photo about the Tower Bridge in London provides additional information about the landmark.
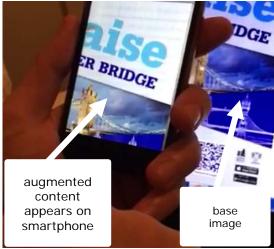

Figure 2. AR Example for Travel and Tourism

4. TALKTECH THROUGH THE LENS OF SAMR

The TalkTech project requires students to utilize several technologies as part of their learning. "The technology cannot guide the instruction; the lesson has to be planned with the technologies blended within the lesson. The SAMR model works well with this idea" (Jacobs-Israel and Moorefeld-Lang, 2013, p. 17).

The discussion in this section analyzes the TalkTech 2016 project process through the lens of the SAMR framework. The end goal is to investigate if, in this case, the use of technology enables a better understanding of new concepts, in this case the AR/VR concepts.

4.1 Substitution
The most basic level of the SAMR model involves using technology to accomplish the same tasks that might have been performed without it. In the TalkTech 2016 project, students use ThingLink as to create a learning environment for sharing their research results. ThingLink replaces a traditional static "report" which students might have used previously to share their results with an interactive image enhanced with digital content.

4.2 Augmentation
Augmentation occurs when the use of technology provides an improvement or more effective tool for completing the same task without using technology. In the TalkTech 2016 project, adding ThingLink improves the process by enabling students to edit and share their work collaboratively online with their partners and the world. Students' ThingLink interactive images contain multimedia captures of their augmented reality artifacts and summaries of their research on AR/VR in an assigned industry.

Another example of augmentation in the TalkTech project is the use of Facebook Messenger, Skype, and other synchronous tools for audio or video communication. Using these tools show how technology provides a more efficient result over the non-technical (and more expensive!) approach of using a telephone for making international calls.

In the substitution and augmentation levels, students interact with existing applications to share their understanding.

4.3 Modification

In this stage, the use of technology changes the way learning might have taken place previously. The widespread availability of smartphones, with their built-in recording features and Internet connectivity, allows students to create and upload images and videos that capture their understanding and demonstrate learning. Examples of modification in the TalkTech project include creating videos for use in AR artifacts and participating in and recording Skype and conference calls with international partners. "Here technology has been integrated at a level of transformation that allows for innovation and creation" (Jacobs-Israel and Moorefeld-Lang, 2013, p. 17).

4.4 Redefinition

Redefinition occurs when "learners … participate in learning activities that would not have been possible without a mobile device" (Romrell, Kidder, and Wood, 2014, p. 8). In the TalkTech 2016 project, student use their mobile devices to create and consume original augmented reality artifacts. The process of creating an AR artifact requires students to identify or create their own content with which to enhance a base image. By scanning a base image with a mobile device running an AR app, the base image comes to life with overlaid multimedia content in the form of related graphics, videos, text, and multimedia that enhance the story or provide additional relevant information.

Augmented reality relies on the use of mobile devices because of their portable form factor, available camera, and connectivity to the Internet. In this highest level of the SAMR model, students use an AR authoring tool to create artifacts which combine their multimedia objects to create a user experience that was not previously possible. Creating an effective AR experience for their international partners requires students to have a thorough understanding of their topic in order to identify, create, or incorporate the most relevant and appealing content.

At the modification and redefinition levels, students interact with technology and with each other in new, transformative ways (Cochrane et al., 2013; Morris and Graña, 2014). The role of technology changes from a vehicle to present information to a tool to capture and create new digital knowledge in the form of an augmented reality artifact.

"Augmented reality has … been [implemented in educational contexts] predominantly in the form of content delivery to student devices, rather than in the facilitation of student-generated content" (Cochrane et al., 2014, p. 3). The TalkTech 2016 project engages students in creating original AR content in a collaborative environment as members of international teams.

5. IMPLEMENTATION AND ANALYSIS

Thirty seven honors students in a first-year introductory Information Technology course (IT 101) at Bentley University in the United States and 70 students enrolled in a Technologies of Multimedia (TMM) course in their fourth year at Politehnica University of Timisoara in Romania participated in the TalkTech 2016 project during the Fall 2016 semester. All students had some prior experience with the web, collaboration tools, and mobile devices. The Romanian students were about two to three years older on average than their American

partners, a consequence of their instructors' teaching assignments at their universities. The project's common language is English.

Students used Internet-based communication tools such as email, Skype, social media, and messaging apps to communicate, and Facebook groups, Google Drive, and ThingLink to collaborate and share files. Students were responsible for selecting and learning to use the tools necessary to complete the project on their own or with help from their group members.
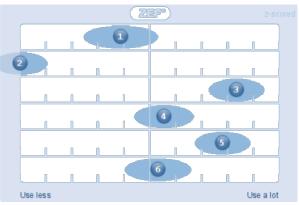
Students completed an anonymous questionnaire at the end of the semester sharing their experiences about how the technologies they used to complete the project enhanced and transformed their learning. The questionnaire relied on experience gathered from previous work (Andone and Frydenberg, 2014, 2017) and the ZEF online tool (ZEF, n.d.) for assessment management (Selkala, Ronkainen, and Alasaareala, 2011).

5.1 Improving Group Process with Communication Tools

A survey showed that mobile devices, search engines, mobile chat, and online videos (YouTube) were the technologies students found the most important, and augmented reality, Twitter, and online photo sharing were the least important.

Students used several communication tools to complete the project. Google Hangouts (2) was the least popular tool, while Facebook Messenger (3) and Facebook (5) were the most popular for communication.

Figure 3 shows several communication tools used to complete the project.

(1) Skype   (2) Google Hangouts
(3) Facebook Messenger   (4) Email
(5) Facebook   (6) Online Doc Sharing

Figure 3. Communication Tools in TalkTech 2016

5.2 Creating New Experiences with Augmented Reality

Students applied the technology skills developed in their respective classes to research and master the use of tools for creating multimedia that would become part of their AR artifacts. As creators of AR artifacts, students made use of a variety of tools available, as shown in Figure 4. Aurasma was the most popular tool for creating AR artifacts because of its ease-of-use, followed by Layar. One group used Blippar.
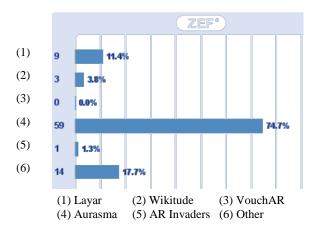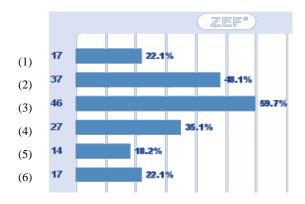
(1) Layar   (2) Wikitude   (3) VouchAR
(4) Aurasma   (5) AR Invaders (6) Other

Figure 4. AR Creation Tools Used in TalkTech 2016

As creators of AR artifacts, students were pleased with their work and with the variety of tools available to help them accomplish it, as shown in Figure 5.

(1) Creating an AR/VR experience is more difficult than I thought
(2) There are many different tools to facilitate the creation of AR/VR experiences
(3) I was successful in creating an AR/VR experience
(4) I thought the AR/VR experience I created was cool
(5) I showed my AR/VR experience to friends not involved in this project
(6) AR/VR experiences provide useful information to viewers

Figure 5. Attitudes toward AR / VR

They considered their own possible uses of AR/VR, and found that gaming and educational applications would be most likely, as shown in Figure 6.
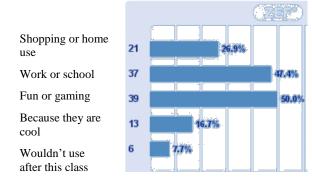

Figure 6. Possible Future Uses of AR / VR

5.3 Word Cloud / Desirability

In order to measure the extent to which students found this experience desirable, the authors created an exercise in which students selected and sorted a set of 40 positive and negative words that may have reflected their experiences during this project. To account for any bias only to give positive feedback, at least 40% of the words in the set were negative.

At the end of the project, students selected words that best describe their "experience participating in this project" and ranked their chosen words on a scale from 1 to 5, where 1 is the most precise. This method presents results visually in the word cloud in Appendix 1, Figure 2, where words in a larger font size were more popular.

"Collaborative" was the most popularly chosen word, which 37 students selected. This describes their experiences working together across continents to create augmented reality and multimedia artifacts that reflect their understanding and research.

"Accessible" was the next-most popularly chosen word, selected by 32 students. This describes their experiences using many of the augmented reality creation tools.

"Attractive" was next at 27, inspired by the visual nature of the project's deliverables: creating an attractive background for ThingLink and an attractive AR artifact for scanning based on their assigned industry.

"New" and "Fun" were each selected by 26 students. Based on earlier survey results, augmented reality was new to many students, and they found it fun to create VR artifacts and use their mobile devices to share and experience them.

The word cloud also shows, in gray, the most popular words that describe the students' experience in a negative context: stressful (27), confusing (19), frustrating (17), time-consuming (13), and inconsistent (10). As in the past (Andone and Frydenberg, 2014, 2017), students chose "time-consuming" and "frustrating" because of their experiences dealing with differences in time zones, slow or unreliable Internet connections, and, in some cases, difficulty making contact with their international partners. That students chose the top five positive words (collaborative, accessible, attractive, new, and fun) 148 times and the top five negative words 69 times suggests that the project was overall positive, and that students' learning about these topics and technologies was engaging and the appropriate academic level.

6. DISCUSSION AND CONCLUSIONS

The TalkTech 2016 project demonstrates that creating original AR artifacts helps students learn about potential and current applications of AR and VR in industry and the technologies used to create such experiences. In addition, students used collaboration and communication tools to interact with their international partners. Students were impressed with the artifacts they produced as well as with their own abilities to make them.

The hands-on, realistic aspect of this assignment added to their learning. This evaluation shows that producing their own AR artifacts enhances students' ability to understand, apply, and synthesize a new technology (augmented reality).

Student surveys and academic results indicate that students acquired several digital skills:

- Information and data literacy. By researching, filtering, and evaluating digital content, students gained a thorough understanding of their AR topic as they incorporated the most relevant content in their final artifacts.
- Communication and collaboration. By interacting, sharing, and collaborating, students managed and made decisions on the most appropriate tools to facilitate communication. The authors noted that groups with the most efficient communication processes produced the best academic results.
- Digital content creation. By developing, integrating, rewriting, understanding copyright, and programming, students combined AR, videos, interactive graphics, text, and social media to produce their multimedia artifacts.
- Problem solving. By identifying needs and technological responses to solve a problem, students creatively used a variety of tools and processes and proposed new ideas and solutions. Students creatively solved complex problems given significant restrictions imposed on their use of free and available AR technologies, video duration, digital storage, documentation requirements, and reporting of group activity.

The TalkTech 2016 project embodies the SAMR framework for using technology to enhance existing practices, create new digital experiences, and transform a global community of learners.

Guided by the SAMR model, the TalkTech 2016 project provides an opportunity for students to incorporate and embrace new technologies as they collaboratively create and share new knowledge. They enhance their learning by sharing their work on ThingLink instead of preparing a traditional written report (substitution) and use Internet communication tools to accomplish international online and mobile collaboration (augmentation). They transform their learning by creating original multimedia content (modification) and incorporating it into new AR experiences (redefinition).

The SAMR framework and its implementation in the TalkTech project generalize when creating Information Systems learning projects.

Enhancement of Learning:

- Substitution. Allow students to decide by themselves which technologies are applicable to complete Information Systems processes and tasks in a creative project.
- Augmentation. Students recognize the benefit that using an enhanced technology solution provides to improve a process or make it more efficient or cost effective.

Transformation of Learning:

- Modification. Students redesign Information Systems processes and tasks to utilize and demonstrate their newly acquired technology skills.
- Redefinition. Students innovate and develop original student-generated content and solutions to Information Systems problems.

Through their TalkTech project experience since its inception in 2008, the authors conclude that students develop critical and computational thinking skills and the ability to learn new technologies quickly when they actively engage in their learning activities. Information Systems projects can implement these aspects of the TalkTech project and its use of the SAMR framework for enhancing and transforming learning.

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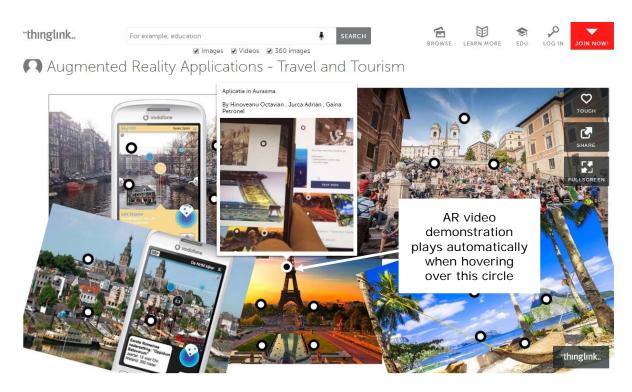

Diana Andone is the Director of the eLearning Center of Politehnica University of Timisoara, responsible for planning and implementing eLearning and the university's award-winning Virtual Campus, CVUPT. She is also a senior lecturer at the same university in the area of multimedia, interactive, and web technologies. She is passionate about the ubiquitous access to technologies and how they can be used to improve people's life. She constantly teaches course modules in universities from U.K., France, Finland, Italy, and Greece. Among her extensive publication list, she counts also seven best paper awards at different conferences and chairing and reviewing conference and journal papers in the areas of learning technologies, open education, open knowledge, Massive Open Online Courses (MOOCs), as well as human-computer interaction. She is also involved extensively in several professional organizations and associations (IEEE, EDEN, IADIS, AACE, W3C, IAFES), actively supports the local start-up movement (StartUp Weekend, HacktTM, CoderDojo) and Women in Tech, as well as acting in the Board of local Romanian NGOs.

Appendix 1. Additional Figures

Appendix 1, Figure 1. ThingLink for Travel and Tourism. Hovering over a circle on displays additional multimedia content, as shown. (https://www.thinglink.com/scene/862343367973928960)

Appendix 1, Figure 2. TalkTech Desirability Word Cloud.

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