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Enhancing multimodal literacy using augmented reality

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Abstract

Augmented reality (AR) technology has been used to successfully improve traditional literacy. However, there has been a paradigm shift in literacy education from traditional literacy to multimodal literacy. Little research has explored how students establish effective multimodal meaning-making using AR technology. This study is an investigation of how EFL college students use different multimodal modes to communicate with others using AR technology. Participants were 52 English as a Foreign Language (EFL) students. The collected data included (a) pre-and post-administrations of a multimodal literacy survey, (b) students' use of different modes to introduce tourist spots within the location-based AR app, and (c) students' reflection essays. The results demonstrated that the modes which students used were categorized into visual and auditory forms. The visual mode was composed of visual effects, images, and animations, whose functions were to focus viewers' attention on what is important, provide concrete ideas, process complex information, and promote engagement. The auditory mode consisted of background music and sound effects, which were used to arouse emotional feelings and enhance immersive experiences. The results also revealed that creating the content in a location-based AR app with the combination of different multimodal media significantly improved students' multimodal literacy.

***Keywords**: Augmented Reality; EFL Students; Multimodal Literacy; Multimodal Media*

***Language(s) Learned in This Study:** English*

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Introduction

The New Media Consortium's 2011 Horizon Report indicated that augmented reality (AR) has become mainstream in higher education (Johnson, Smith, Willis, Levine, & Haywood, 2012). AR refers to technology that blends a real-world context with virtual elements such as texts, pictures, videos, 3D mode and animations (Klopfer & Sheldon, 2010; Saleeb & Dafoulas, 2011; Schiller, Mennecke, Nah, & Luse, 2014). The design of AR technology is categorized into marker-based and location-based. The marker-based AR requires users to use a mobile device's camera to detect an image or a specific object in a camera frame to trigger AR actions, such as showing 3D modes of the object. The location-based AR is developed based on a mobile device's GPS sensor to determine the locations of its users. It asks users to use their phones to find a landmark and a specific location of interest. Once users reach the location, they can interact with virtual elements such as pictures, videos, and 3D animations (Carmigniani et al., 2011). One of the famous location-based AR technologies is the Pokemon Go game, which detects players' locations and allows users to collect Pokemon monsters in different locations based on GPS sensor.

Researchers have explored the potential of these two types of AR technologies for educational use and have summarized several benefits of AR technologies in educational contexts (e.g., Chiang, Yang, & Hwang, 2014; Ferrer-Torregrosa, Torralba, Jimenez, García, & Barcia, 2015). First, AR creates an immersive hybrid

learning environment in which students can interact with virtual objects in a physical world and, at the same time, enhance their perceptions and understanding of targeted learning objects (Chen, Chi, Hung, & Kang, 2011; Dunleavy, Dede, & Mitchell, 2009). For example, Kaufmann, Steinbugl, Dunser, and Gluck (2005) developed a dynamic geometry system allowing students to operate, measure, and manipulate virtual objects in the classroom to better understand spatial relationships. Such an immersive hybrid learning environment, which combines virtual and physical elements, promoted deep learning and high order thinking skills, such as critical thinking, problem solving, and communicating through interdependent collaborative exercises (Dunleavy et al., 2009). The second benefit of AR is to support the 3D visualization of abstract science concepts or phenomena, such as solar systems or phenomena which are not common for students to observe in the real world. Kerawalla, Luckin, Seljeflot, and Woolard (2006), for example, explored the potential of AR for teaching primary school science by dividing students into the AR group and the traditional learning group. The teachers indicated that the AR group, who learned about the Earth and sun, and day and night through watching and rotating a virtual 3D earth demonstrated better learning outcomes. Another application of using AR to augment visualization and comprehension of leaning objects in a 3D mode is AR books. For example, Clark and Dünser (2012) used AR to enhance students' learning experiences with a paper-based coloring book incorporating 3D interactive animations in order for them to visualize more detail information in the book content. These 3D interactive animations supported by AR effectively promote students' conceptual understandings and correct their misconceptions. In addition, a systematic review of AR application in education by Akçayır and Akçayır (2017) concluded that other educational benefits of AR might include enhancing learning motivation, fostering collaboration and interaction among students, and improving learning performance. These educational benefits have made AR a promising and popular technology for education.

Most of the AR studies reviewed were conducted to address issues in natural science education (Chiang, Yang, & Hwang, 2014), only a few studies have examined the effect of AR technology on English teaching. Among these attempts, for instance, Barreira et al. (2012) devised an AR learning system to investigate Portuguese children's English vocabulary learning and found that children who used it outperformed those who received traditional instruction. Similarly, Vate-U-Lan (2012) used a storytelling technique to teach Thai students in a grade three English class by using an AR 3D pop-up book and found significant increases in students' post-test scores for comprehension and engagement, as compared to their pre-test scores. Most students also reported that the AR 3D pop-up book motivated them to learn. Likewise, Mahadzir and Phung (2013) developed an AR pop-up book to investigate whether it could motivate grade one students in Malaysia to learn English. They found that the students who experienced AR tended to remain focused throughout the class and showed more interest and curiosity in learning English than those who received traditional instruction.

The studies above demonstrate that AR technology has been used to successfully improve traditional literacy, such as vocabulary acquisition (Barreira et al, 2012), reading comprehension (Vate-U-Lan, 2012), and reading motivation (Mahadzir & Phung, 2013). However, there has been a paradigm shift in literacy education from traditional literacy to multimodal literacy (Dzekoe, 2017). Multimodal literacy refers to the skills of integrating and manipulating the relationships among different modes of multimedia such as images, texts, animations, and audio to establish meaningful communication. Multimodal literacy has become the 21st-century literacy competency for current students who are also referred to as digital natives (Mills, 2010). Lotherington and Jenson (2011) note that "In the convergence culture of the 21st century, the individual has become simultaneously creator and consumer of mediated communication" (p. 232). Correspondingly, O'Halloran, Tan, and E (2017) stress that educators should move beyond traditional literacy practices to prepare students with the skills to communicate multimodally in this new digital age. However, little research has explored how students establish effective multimodal meaning-making using AR technology. This study, therefore, is an investigation of how EFL college students use different

multimodal modes to communicate with others using AR technology. Based on the research purpose, the research questions included:

- How do students apply different modes to establish effective multimodal communication using AR technology?
- Do students improve their multimodal literacy after creating the content in an AR app with the combination of different multimodal media?

Research Method

Participants

Participants were 52 EFL students who took a required course, Multimedia English, at a university in Taiwan. In this course, the students were required to produce content in an AR app to introduce the culture of their local communities. The English proficiency of the students was at intermediate level based on school entrance examinations, and none had experienced using AR before the course. They were all informed that their data would be used for research purposes.

Research Design

Project-based learning (PBL) was adopted as an instructional framework to facilitate students' enhancement of their multimodal literacy. The goal of the PBL approach is to ask students to develop artifacts through collaborating with peers. The resulting artifact was a location-based tourist AR app allowing users to use their phones to find a specific location of interest and interact with the locations once they arrived. The students would be the content designers of the location-based AR app and, as such, would apply different modes of multimedia to create virtual elements of the tourist spots in the districts of their home towns across Taiwan (see Figure 1). Therefore, the user of the tourist AR app can have better understanding of the tourist attractions in Taiwan.

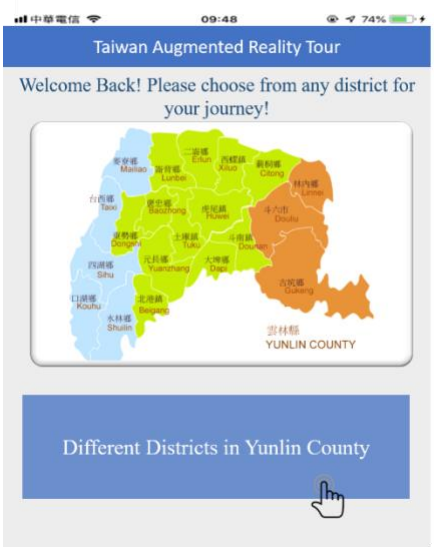


Figure 1. The Taiwan AR tourist APP: Yunlin city as an example

The research project lasted for 18 weeks. During weeks 1 to 2, the students filled out a survey by which to identify their multimodal literacy levels before engaging in the AR project, and were divided into 11 groups. Each group was assigned a teaching assistant for technical support and to monitor the progress of the AR

project. In week 3, the students selected a tourist spot regarding local culture, people, buildings, cuisines or places of entertainment to introduce Taiwan. During weeks 4 to 17, the students created virtual elements of their selected tourist spot. The virtual elements consisted of photos, writing descriptions, graphics, audio or video for the AR app users to interact with at the different tourist spots. In other words, the tourist AR app not only included the textual information, but also contained digital information connecting to the real-world realm. Therefore, the students would have the opportunity to discuss how to integrate and manipulate different modes of multimedia (e.g., text, images, audios, and videos) to create informative and interesting messages promoting the tourist spots. These processes of discussing, designing, and creating a product with the AR app enabled the students to practice multimodal literacy in written, oral, and visual forms. In week 18, the students published their content in the AR app and took a post-survey to evaluate changes in their multimodal literacy levels after engaging in the AR project. They also wrote reflection essays at the end of the AR app project.

Data Collection and Analysis

The collected data included (a) students' use of different modes in video content to introduce tourist spots within the location-based AR app, (b) students' reflection essays, and (c) pre-and post-administrations of a multimodal literacy survey. Students' use of different multimedia modes and their reflection essays were collected to explore how students employed different multimedia modes to establish effective multimodal communication (RQ1). The students' use of multimedia modes was collected from a location-based tourist AR app, which the students created videos for, to enable users to interact with the locations through the textual and multimedia modes (e.g., images, audio, and videos). The reflection essays were collected at the end of the AR app project by asking each student in the group how they have employed different multimedia modes to establish effective multimodal communication. Examples of the questions included "What multimodal modes did you use in your location-based tourist AR app?"; "Why did you decide to use the multimodal modes?"; and "How did you use each of the multimodal modes to create informative messages?"

The students' use of different multimedia modes and reflection essays were analyzed using the four stages of content analysis: coding, categorization, description and interpretation (Patton, 2002). In the coding stage, the researchers read through different multimedia modes within the app to generate the main units (Patton, 2002). In the categorization stage, the students' use of different multimedia modes was divided into different categories based on the systemic functional approach (Lim & Tan, 2017). In the description stage, the two researchers identified supporting statements from students' reflection essays for the categories. In the interpretation stage, the researchers concentrated on furnishing explanations, framing conclusions, making inferences and building connections for interpretations. The inter-rater reliability reached .89. Discrepancies were resolved through discussion to reach a consensus.

To examine the effect of creating the AR content in an app on students' multimodal literacy (RQ2), a multimodal literacy survey was administrated to the students before and after they engaged in making their tourist attraction promotion using the AR tool. The multimodal literacy survey was adapted from Bulut, Ulu, and Kan's (2015) multimodal literacy scale, which is comprised of 17 items. This survey is composed of three multimodal literacy scales: (a) using multimodal structures to express oneself, (b) interpreting the content presented in multimodal structures, and (c) preferred multimodal structure to represent multimodal literacy. The Cronbach-Alpha internal consistency coefficients for the three multimodal literacy scales were identified as .837, .746, and .762. Responses to the pre-and post-multimodal literacy surveys were analyzed using a paired-sampled *t* test.

Results

RQ1: Students' use of different modes to establish effective multimodal communication via AR

The modes which students employed within the location-based AR app were analyzed based on Lim and Tan's (2017) systemic function approach to identify the essential forms and functions of those modes to demonstrate how the students made multimodal representations effectively. The results showed that the modes which students used were categorized into visual and auditory modes. The functions of the visual and auditory modes are shown in Table 1, and students' use of the visual and auditory modes are further illustrated and discussed in the next paragraphs.

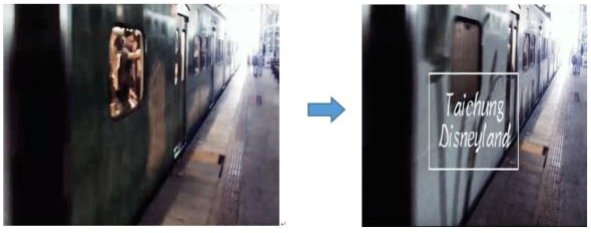
Table 1. *Features and Functions of Visual Forms to Represent Visual Literacy*

Forms	Descriptions	Typical functions
Visual effects	Integration of live-action footage and still imagery	Focus viewers' attentions on what is important and pique interest
Images	The most prominent static pictures in the footage	Provide concrete ideas Process complex information using infographics
Animations	Footage comprising a series of pictures or frames simulating movement	Promote engagement

Visual Modes

The visual mode was the predominant mode that the students used to introduce the tourist attractions using AR technology. The visual forms were composed of the sub-elements, including visual effects, images, and animations. Visual effects were utilized by the students as the integration of live-action footage and generated images to focus viewers' attentions on what is important and pique their interest. Examples of the visual effects included Popping-up and Spilling ink. As Table 2 shows, when Group E introduced the tourist attraction Rainbow Village in Taichung City, the words "Taichung Disney" popped up in the center of the footage, which the students intended as a way to help viewers focus on the main theme of the content. Another example shown in Table 2 was spilling ink, referring to the ink-like spilling of colors. Group C applied the visual effect of spilling ink to intertwine scenes in the Taichung Market to capture viewers' interest.

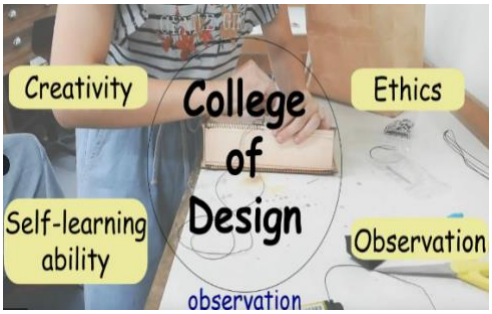
Table 2. *Examples of Student use of Visual Effects*

Visual effects	Examples of groups' statements in the reflection essay	Snapshot
Pop-up	We applied the textual effect of pop-up to enlarge the texts "Taichung Disney" in the middle of the footage; therefore, the pop-up texts helped viewers focus on the main theme of the video. (Group E)	

Spilling ink	At the beginning of the footage, we applied spilling ink to intertwine with the pictures of Taichung market, so viewers were informed about the video content. (Group C)	

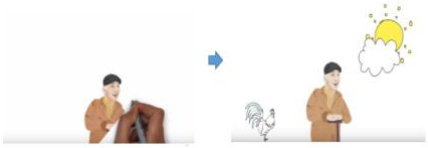
In addition to visual effects, images were largely used by the students. The first function of the image was to present abstract concepts. For example, Group D employed the images to introduce the baking procedures of a famous snack in Taichung. They indicated that the images were the most appropriate multimodal media to present the sequence of making sun cakes, which might be too abstract to explain in verbal form (Table 3). In addition, images were used as infographics by the students as the visual representation of complex information. As Table 3 demonstrates, Group C, in their introduction to the College of Design of Yunlin University of Science and Technology, presented an infographic to systematically provide audiences an easy-to-understand overview of the core values of the College of Design.

Table 3. *Examples of Student use of Images*

Functions of images	**Examples of groups' statements in the reflection essay**	**Snapshot**
Abstract concepts	In order to clearly explain the process of making sun cakes, we inserted images to illustrate each procedure of making sun cake, enabling viewers to have concrete ideas of how they were made. (Group D)	
Massive information	We inserted an infographic of the core values of the College of Design of Yuntech while introducing College of Design, so viewers were able to effectively understand the massive information in an orderly manner. (Group G)	

Apart from visual effects and images, animations were the third multimedia modes which the students incorporated into the AR technology to communicate multimodally. The students intended to use animations to promote viewers' engagement in using the AR technology. As Table 4 shows, Group E was worried that viewers might get distracted while listening to the narrations of the Rainbow Village in a verbal form. Group E thus used hand-drawn pictures to create animations to make the narrations visualized and attractive for the viewers. Similarly, Group B was concerned that simply presenting the content with textual information might not hold viewers' attention. Therefore, they made an animation by forming eye-catching cartoonlike digital graphics to introduce the core values.

Table 4. *Examples of Student Use of Animations*

Types of animations	Examples of groups' statements in the reflection essay	Snapshot
Hand-drawn pictures	We made an animation of a person by drawing a series pf pictures to introduce the history of Rainbow Village to help viewers visualize the narrative in the video. (Group E)	
Digital graphics	We made an animation by using cartoonlike footages to introduce the core values of the Future College in Yuntech to give the material a sense of entertainment to lighten the serious content and hold the viewers' interest. (Group B)	

Auditory Mode

The auditory mode was the other mode used by the students to introduce the tourist attractions using the AR technology. The auditory mode was composed of background music and sound effects. The students used these two auditory forms to arouse emotional feelings and enhance immersive experiences (Table 5). Various background music was used to maintain different moods to match the scenes of the tourist attractions, such as brisk music to evoke feelings of inclusion, classical music to convey calmness and peace, and rock music to stimulate active responses (Table 6). Brisk music was the most frequently used by the students because the main purpose of the AR app was to introduce tourist attractions. Brisk music could create a casual atmosphere and made viewers feel involved.

Table 5. *Features and Functions of Forms of Auditory Forms*

Forms	Descriptions	Functions
Background music	A piece of music that runs through most or all of a video	Arouse emotional feelings
Sound effects	Musical and non-musical sound segments used to express or emphasize actions, moods, and feelings	Enhance immersive experiences

Table 6. *Examples of Utilizing Multiple Types of Background Music in Videos*

Types of background music	Examples of groups' statements in the reflection essay
Brisk music	We inserted brisk music in the footages of strolling around the rainbow village in Taichung to create a free and easy atmosphere making viewers feel relaxed and engaged. (Group E)
Classical music	In order to create an atmosphere that matched the content of the history of saxophones, we inserted classical music as background music, which enabled viewers to become immersed in the video content. (Group F)
Rock music	We think rock music is always a good match for a scene of heading out on a trip, so we used rock music as background

	music in the footages of taking a train to Taichung city. (Group G)

The second audio form was comprised of non-musical sound effects corresponding to the content, such as chirping, doors opening and closing, and various town and city sounds to enhance immersive experiences. As Table 7 shows, Group H added chirping sounds to their video scene of walking in Hebao Mountain in Yunlin County to enhance the users' vicarious experience of observing the scenery of the Mountain. Similarly, Group B matched the sound effect of a door being pulled with the scene of the Japanese door sliding open in their introduction to the history of Yunlin Story House. The pulling sound matched with the scene of pulling sliding doors enabled viewers to establish the illusion of walking into the building in the past.

Table 7. *Examples of Utilizing Different Sound Effects in Videos*

Types of sound effects	**Examples of groups' statements in the reflection essay**
Chirping	In order to immerse viewers in the scenery of Hebao Mountain, we inserted the sound effects of chirping to match with the footage of walking in the mountain. It enabled viewers to vicariously experience the walk. (Group H)
Pulling of doors	We applied the sound of doors being pulled to the scene of the Japanese door sliding open to establish an illusion of walking into Yunlin story house in the past, to help viewers absorb the history of Yunlin story house. (Group B)

RQ2: The effect of creating AR content on students' multimodal literacy

A paired-samples *t*-test was performed to examine students' multimodal literacy before and after experiencing the AR project. The means and standard deviations for the students' multimodal literacy scales are shown in Table 8. The results indicate that there were significant differences between pre- and post-scores for the three multimodal literacy scales, showing that creating an AR app with the combination of different multimodal media significantly improved students' multimodal literacy.

Table 8. *Paired-samples T-test for the Differences Between Pre- and Post- Multimodal Literacy Scale*

Multimodal literacy scales	***Pre***		***Post***				
	M	***SD***	***M***	***SD***	***t***	***df***	**Sig.**
Using multimodal structures to express oneself	3.86	.49	4.01	.53	-2.05	51	.045
Interpreting the content presented in multimodal structure	3.87	.37	4.05	.52	-2.55	51	.014
Preferred multimodal structure to represent the multimodal communication skills	3.27	.82	3.54	.57	-2.28	51	.027

Discussion and Conclusions

The primary objective of this study was to explore how EFL college students used various modes to create the multimodal content in a tourist AR app. The results showed that the students applied visual and auditory modes to establish meaningful multimodal communications. The visual mode was composed of visual

effects, images, and animations, whose functions were to attract viewers' attention to what is important, provide concrete ideas, process complex information, and promote engagement. The auditory mode consisted of background music and sound effects, which were used to arouse emotional feelings and enhance immersive experiences. These results demonstrate the students' ability to construct meaningful information with different semiotic resources and modalities to express their ideas and engage their viewers in the content. The results are similar to Lim and Tan's (2017) study demonstrating that integrating chosen linguistic, multimodal, and semiotic resources to organize and develop information and ideas allows creators to fulfill the purposes of the texts and establish interactions with audiences. In addition, the results revealed that creating a location-based AR app with the combination of different multimodal media significantly improved students' multimodal literacy. These results are consistent with Nelson and Hull's (2009) study showing that engaging students in AR content making supported their multimodal literacy development. These findings may encourage EFL teachers to engage their students in AR content making to develop their multimodal literacy.

The AR app used in this study was self-contrived for EFL students to create an immersive language learning environment to introduce local culture and famous attractions in English. The self-contrived AR app allowed students to contextualize and introduce tourist spots through textual, visual, and auditory elements such as images, animations, videos, and texts. The reason this study adopted a self-developed AR app is the flexibility it affords to students to create and use modes according to their own preferences, while current AR tools such as ARKit, Makar, or CoSpace have rules and limitations about uploading and using multimedia resources. It is suggested that future studies may compare different AR development tools for educators in terms of their affordances.

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