Location and Place: Two Design Dimensions of Augmented Reality in Mobile Technologies

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Abstract

Augmented reality (AR) integrates virtual objects in real environments in real time. It is becoming widely adopted in education, entertainment, and beyond. In this chapter, authors introduce "location" and "place" as two key design dimensions for designing AR-based mobile technologies for learning. "Location" is defined as the user's physical location, and "place" is defined as the user's engagement with the physical location she/he is in. Authors further operationalize "location" and "place" as independent constructs and map out their intersection using a quadrant-based framework. In each quadrant, a mobile application is presented to illustrate how this framework informs and contextualizes designs and developments in mobile technologies. The framework introduced in this work aims to highlight the importance of "location" and "place" when designing AR-based educational technologies.

Introduction

The ubiquity of smartphones and low-budget tools such as Google Cardboard provides an easy access to experience augmented reality (AR) and virtual reality (VR) (see "▶ VR and AR in Future Education"). This proliferation has fundamentally shifted the conversation around learning with technology both in and out of classrooms. The use of AR in mobile technologies has immense potential for educational purposes. AR bridges formal and informal learning by enabling learning in ubiquitous, collaborative, situated, and immersive environments and helping visualize the invisible in 3D perspectives (Squire and Jan 2007; Squire and Klopfer 2011; Wu et al. 2013) (see "▶ Augmented Reality and 3D Technologies: Mapping Case Studies in Education" and "Augmented Reality in Education"). This new type of teaching and learning afforded by AR has shown to improve and/or increase learning performance, learning motivation, student engagement, and positive attitudes (Bacca et al. 2014).

When transitioning toward designing AR learning experiences, it is important to consider the design trade-offs of these experiences to ensure that researchers, designers, and educators effectively and efficiently leverage its affordances to support learning. Past studies show that there are three primary issues, namely, technological, pedagogical, and learning, when implementing AR in education (Wu et al. 2013). Technological issues comprise of cumbersome and expensive design (e.g., head-mounted displays), improper interfacing and/or integration between multiple devices (leading to issues while navigating between reality and fantasy), device failure, and trade-off between location dependency-ones that provide new meanings to familiar locations and location independency-ones that are

Table 1 Location and place – the two design dimensions for AR-based learning technologies

Design dimensions	Definition
Location	User's physical location
Place	User's engagement with his/her physical location

portable, flexible, and could save cost on transportation (see "► Characteristics of Mobile Teaching and Learning"). Pedagogical issues comprise of constraints from schools and resistance among teachers and instructional design (i.e., the distribution and flow of information between two realities and multiple devices). Learning issue includes cognitive overload, when applying and synthesizing multiple complex skills in spatial navigation, collaboration, problem solving, technological manipulation, and mathematical estimation (Wu et al. 2013). Designers of AR should make efforts to minimize these issues and maximize the use of capabilities of mobile technologies (such as GPS capabilities). The aim of this chapter is to present a new set of design dimensions necessary for designing AR experiences for education. Overall goal is to consider the locative and place-based features of AR-based mobile technology in the context of learning theory and present a framework to inform future learning designs and applications of mobile technology.

Lave and Wenger (1991) define "learning" as something, i.e., is situated in learner's everyday experiences and the social settings she/he experiences. Therefore, designers must carefully choose the different types of contextual engagements to support their design. Hence, this chapter introduces "location" and "place" as two design dimensions for designing AR-based learning experiences (see Table 1).

These two design dimensions make up four quadrants, which any educational app can map onto. This framework complements Wu et al.'s (2013) claim that AR could enable more situated learning. The goal of this framework is to aid educational app designers by helping them leverage the fullest potential of AR technologies. This framework helps understand the two dimensions of AR, location and place in detail, and analyze the affordances when considering either of the one or both of them as parameter(s) for learning technologies.

Motivation

This chapter is built on the work of Litts and colleagues, who identified five dimensions of mobile technologies that connect theory and practice: place, embodiment, narrative, identity, and design (Litts et al. 2013). The goal of this chapter is to explore the "place" dimension of mobile technologies in depth and conceptualize "location" and "place" as two separate and independent entities. This is important as there is a significant difference between being at a location and being engaged with that location. The expansion of the "place" design dimension also informs the design of mobile technologies for situative learning (ones that engages learners with their physical location) contexts using AR.

Context

Affordances offered by mobile technologies, such as portability, context sensitivity, connectivity, and ubiquity, make them as ideal learning tools (Klopfer 2008). To make full use of these affordances, mobile technologies have evolved from basic phones to smartphones to smart kits, such as MS HoloLens, Oculus Rift, HTC Vive, etc. (see "▶ Characteristics of Mobile Teaching and Learning"). In this section, authors first discuss the concept of reality, a continuum that stretches from real environment to a virtual environment. Further, they discuss the use of AR in mobile and the importance of location and place in designing learning technologies.

The Concept of Reality

Virtuality continuum, as shown in Fig. 1, has real environment (completely real) on its one end and virtual environment (completely fictional) at the other end. In the middle of the real and the virtual environment lies augmented reality (AR) and augmented virtuality (AV) (Milgram and Kishino 1994). AR is when the display of real world is augmented by means of virtual objects, whereas AV is when the display of virtual world is augmented by the means of real objects. Mixed reality (MR) is a subclass of virtual reality (VR) that merges the real and the virtual environments (Milgram and Kishino 1994).

The focus of this chapter is on the AR. AR is when the 3D virtual objects are integrated into a real environment in real time (Azuma 1997). Applications of AR include medical, manufacturing and repair, annotation and visualization, robot path planning, entertainment, military aircraft, etc. (Azuma 1997). In this chapter, authors explore the use of "location" and "place" dimensions of AR in learning.

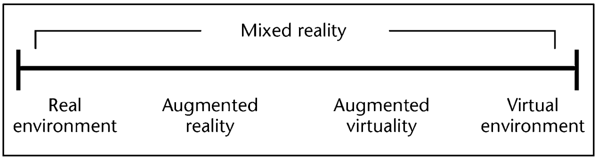
AR in Mobile

Leveraging smartphone affordances, such as GPS, camera, object recognition and tracking, voice and motion detection, etc., is crucial for supporting learning. The best use of mobile affordances will create immersive learning experiences that will enable learners to see the world around them in new ways. Immersion in digital environments enhances learning by allowing multiple perspectives within a specific context (situated learning) (Dunleavy and Dede 2014).

Location

Past studies have often used "location" and "place" interchangeably. However, in this chapter, these parameters are used as two distinct entities, one (location) as the learner's physical location and the other (place) as the learner's engagement with his/her physical location, respectively.

Fig. 1 Virtuality continuum (Milgram and Kishino 1994)



Place

Gruenewald (2003) refers "place" as a "community" with the perceptual, sociological, ideological, political, and ecological dimensions. Smith and Sobel (2010) also describe place as something inseparably intertwined with the community. Definition of "place" for this work is also somewhat congruent with the above definitions, where authors define "place" as the learner's engagement with his/her physical location and not merely his/her physical location.

Two Design Dimensions of Mobile Technologies

"Location" and "place" are two of the many dimensions for designing mobile technologies. Definitions of "location" and "place" on the continuums and their usefulness in learning are discussed in the following subsections.

Location

"Location" is defined as the user's physical location. In reference to this definition, one end of the "location" spectrum consists of "location agnostic" apps, while the other end consists of "location-dependent" apps (see Fig. 2). Location agnostic apps are the apps that do not make use of user's physical location. Examples of location agnostic apps include Google Expeditions (an app that allows users to take virtual trips all over the world), Google Earth VR (an app that allows users to explore world in VR environments), The Climb (an app that allows users to climb in VR environments), and The Blu (an app that allows users to explore oceanic lives in VR environments). Though the location agnostic apps give users the flexibility of using them from anywhere, the downside is that they disconnect or distract the users from their surroundings. Location-dependent apps are the apps that require users to be at a designated location to access the app. Examples of location-dependent apps include Sky Map (an app that shows the names of celestial bodies present over user's head), Field Trip (an app that notifies users about interesting nearby locations), Pokémon Go (a popular mobile AR game in 2016), and Landlord Real Estate Tycoon (an AR app that allows users to buy, sell, and trade real-world properties). All these apps require users' physical location. Though the location-dependent apps take users out to particular locations, they may or may not always connect users with those locations. For example, in Pokémon Go, players go to poke

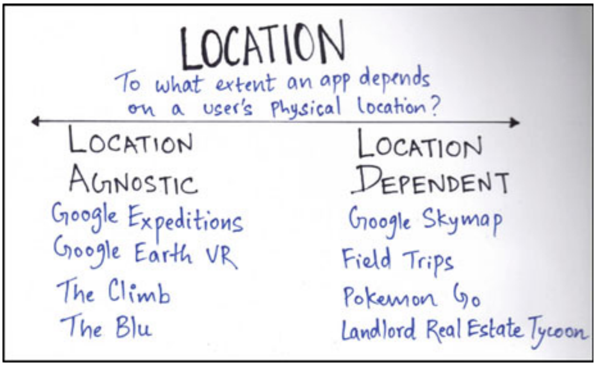


Fig. 2 Location continuum

stops but do not really engage or learn about those locations. Learner's physical location is useful in learning as it provides gateway to real world, such as under the sky, on the busy streets, in the botanical garden, etc.

Place

"Place" is defined as the user's engagement with his/her physical location. Therefore, while one end of the "place" spectrum has "no engagement with place," the other end of the spectrum has "engagement with place" (see Fig. 3). Apps that fall under "no engagement with place" criteria are the apps that do not engage users with their physical location. Examples of such apps include The Climb, The Blu, Pokémon Go, and Landlord Real Estate Tycoon. Apps that fall under "engagement with place" are the ones that engage users with their location. Examples of such apps include Sky Map, Field Trip, Google Expeditions, and Google Earth VR. It should be noted that the apps that cause engagement with place don't really require users to be at specific locations. For example, Google Expeditions teach users about a high rise in Dubai, without requiring them to be physically present in Dubai or in that building. Place is an important factor to consider, when designing AR applications for learning. Based on the extent a learner is engaged with, his/her surroundings affect his/her learning motivation. Place also plays a key role in designing immersive experiences, one where the learner is immersed into the application.

Game Illustrations

To demonstrate the use of mobile technologies in influencing learning, authors present eight apps outlined in Fig. 4. These eight apps fit into one of the four quadrants that depict the intersection of the "location" and "place" dimensions of mobile technologies. Each quadrant has two examples. Quadrant I includes Sky Map and Field Trips, apps that engage users with their physical location. Quadrant II includes Google Expeditions and Google Earth VR, apps that educate users of

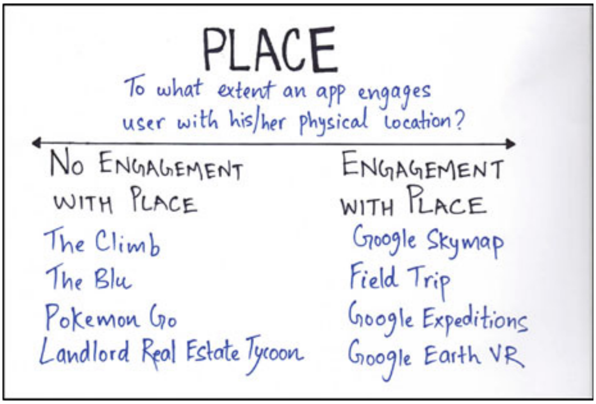


Fig. 3 Place continuum

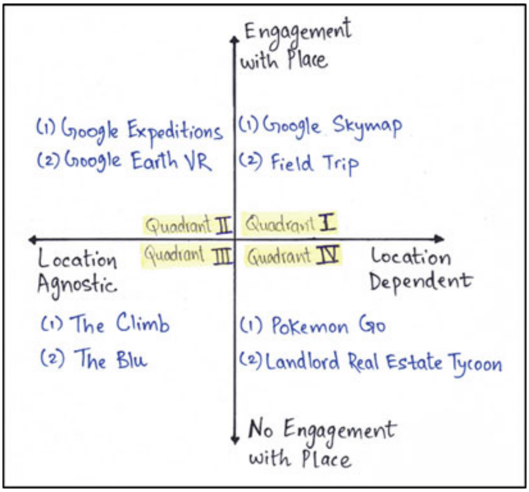


Fig. 4 Two-dimensional framework of location and place

distant places. Quadrant III includes The Climb and The Blu, apps that take users into a virtual environment. Quadrant IV includes Pokémon Go and Landlord Real Estate Tycoon, games that take users to a specific location but don't really engage them with that location. Details of these apps and why they fit into a particular quadrant are given below.

Sky Map

Sky Map (see Fig. 5) is a handheld planetarium for Android devices (https://play.google.com/store/apps/details?id=com.google.android.stardroid&hl=en#details-reviews). On pointing an Android device such as a mobile phone or tablet toward the sky, Sky Map shows the names of the stars, planets, and other celestial bodies present over users' head. The app was developed by Google in 2009 but was open

Fig. 5 Sky Map icon

sourced in 2012. Sky Map doesn't require Internet connection, except when putting one's location. This can be done without Internet, by adding the latitude and longitude of the user's location. Sky Map is free of charge and is available on Google Play. It is a fit for Quadrant I because (1) it is sensitive of user's physical location and (2) it engages the users with the physical location they are in. The app influences learning by educating users about the part of the universe above their head.

Field Trip

Field Trip (see Fig. 6) is available for android and apple devices and glass (https://www.fieldtripper.com/). The app runs in the background of the users' phone and notifies them as they get close to an architecture, historic place and events, lifestyle, offers and deals, food drinks and fun, movie locations, outdoor art, and obscure places of interest. In addition to notifying users about an interesting nearby location, it gives users an option to read more about that location. When the app is used in conjunction with a Bluetooth or headset, it can also read aloud that information for the users. This is ideal even while the user is driving. Users can also share their travel experiences using Field Trip through email and social networks. Field Trip is a fit for Quadrant I because (1) it is sensitive of user's physical location and (2) it engages the users with the physical location they are in. The app influences learning by informing users about the interesting things near them.

Google Expeditions

Google Expeditions (see Fig. 7) allows users to lead or join immersive virtual trips all over the world by putting their phones into a Google Cardboard viewer or using their mobile devices in a 2D magic window mode (https://edu.google.com/expeditions/#about). The app allows users to explore historical landmarks, dive underwater with sharks, or visit outer space. It connects the devices on the same Wi-Fi network, though if an expedition is pre-downloaded, no Internet connection is required to

Fig. 6 Field Trip icon

Fig. 7 Google Cardboard viewer

run it. The app is free of cost and is available in multiple languages. It is a fit for Quadrant II because (1) it works irrespective of user's physical location and (2) it engages users with a remote "real" location. The app influences learning by educating users about different places.

Google Earth VR

Google Earth VR (see Fig. 8) is available for Oculus Rift and HTC Vive (https://vr.google.com/earth/). It is free of cost but requires VR headset. The app puts the whole world in front of users, letting them explore whatever part of earth they are interested in. Google Earth VR is a fit for Quadrant II because (1) it works irrespective of user's physical location and (2) it engages users with a remote "real" location. The app influences learning by allowing users to see 360° views of the places and geographical features all around the world.

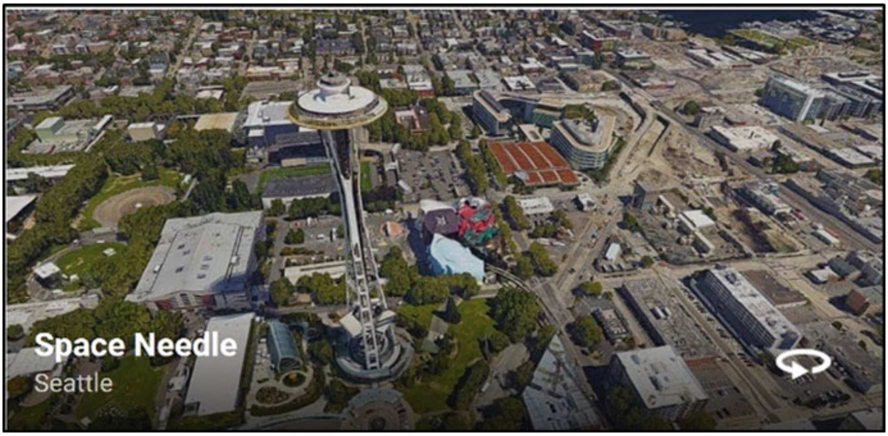


Fig. 8 360° views of Space Needle, Seattle, USA

The Climb

The Climb (see Fig. 9) lets users do rock climbing in VR environments. The app is developed by Crytek and is built on the CRYENGINE (http://www.theclimbgame.com/). It is built for Oculus Rift and costs $49.99. The app features include solo climbing, racing with other players, and bouldering. The Climb has four immersive environments by day and night. It has a tourist mode, a simplified version which is ideal for introducing to beginners. The app does not require Internet connection but requires the Oculus head gear to enjoy the experience. The Climb is a fit for Quadrant III because (1) it works irrespective of user's physical location and (2) it engages users with an "unreal" location they are virtually in. The app influences learning by exposing users to the simulations of rock climbing, where they can learn and/or practice climbing skills without the fear of falling.

The Blu

The Blu (see Fig. 10) is an immersive VR series that allows users to experience the ocean through different habitats (https://www.oculus.com/experiences/rift/984294025016007/). The app is available on Oculus Rift and costs $9.99. The app doesn't require Internet connection but does require Oculus Rift to get the under-ocean experience. The Blu is a fit for Quadrant III because (1) it works irrespective of user's physical location and (2) it engages users with an "unreal" location they are virtually in. The app influences learning by exposing users to the ocean life without a risk of getting harmed.

Fig. 9 The Climb

Fig. 10 The Blu

Pokémon Go

Pokémon Go (see Fig. 11) is an app designed for android and apple platforms (http://www.pokemongo.com/). It is free of cost but requires Internet connection. Pokémon Go requires users to visit poke stops to find Pokémons. The app is built in such a way that your device would notify you as you get closer to a Pokémon. Users can catch, hatch, evolve, and fight Pokémons. Pokémon Go is a fit for Quadrant IV because (1) it is sensitive to user's physical location and (2) it engages users with the "unreal" objects located at the location they are in. The app influences learning by teaching users the skills of navigation.

Landlord Real Estate Tycoon

Landlord Real Estate Tycoon (see Fig. 12) is an AR property game that lets users buy venues as they visit there and then earn rent as people check in at those properties in real time (https://landlordgame.com/#Home). The app allows users to buy, sell, and

Fig. 11 Pokémon Go icon

Fig. 12 Landlord Real Estate Tycoon icon

trade famous properties, such as San Francisco's Golden Gate Bridge. It is free of cost but requires Internet connection. Landlord is a fit for Quadrant IV because (1) it is sensitive to user's physical location and (2) it engages users with the "unreal" aspects of the location they are in. The app teaches users the skills of navigation, decision making, negotiation, money, and real estate.

Intersection of Location and Place

"Location" and "place" are two separate entities that may or may not simultaneously exist. Based on this understanding, we depict the relationship of "location" and "place" using a quadrant-based framework.

Quadrant I: Both Location and Place (True AR)

The first quadrant utilizes both the "location" and "place" aspects of mobile technologies. Apps in this quadrant include "Sky Map" and "Field Trip." Both these apps engage the users with their physical locations. For example, "Sky Map" takes users outside under-sky and engages them with the sky above their head. Similarly, in

"Field Trip" users need to be at a location to learn about it. Quadrant I is an example of AR, where the virtual objects supplement the real environment. Apps in this quadrant make users aware of their surroundings.

Quadrant II: Only Place

The second quadrant educates users about their virtual location. Examples of the second quadrant include "Google Expeditions" and "Google Earth VR." Both these apps facilitate remote learning. For example, using "Google Expeditions" users can learn about different landmarks without visiting to those locations physically. Similarly, in "Google Earth VR," users can learn about all the continents and geographical features remotely.

Quadrant III: Neither Location nor Place (True VR)

Apps in the third quadrant neither require users to be at specific physical locations nor educate users about their physical location. This quadrant is a perfect example of VR, where users are taken away from their real surroundings to an imaginary world. Example apps in this quadrant include The Climb and The Blu. The Climb lets users climb the imaginary mountains, the ones inspired from real mountains. Similarly, The Blu takes users to a journey in the ocean, where they virtually dive deep to explore whales and other ocean life. The experiences users have from these apps are designed and not real. Therefore, the learning they have here is about fictional (which mimics or is inspired by real, but not real) objects and not real things.

Quadrant IV: Only Location

The fourth quadrant requires users to be at a particular physical location, but doesn't really engage them to that location. Apps in this quadrant include Pokémon Go and Landlord Real Estate Tycoon. Both these apps require users to be at specific locations, but instead of letting them engage with those locations, these apps force users to interact with the virtual objects present there.

Significance

"Location" and "place" can play a very important role in the future of educational AR applications, but these two dimensions must work together to create better learning experiences, "location" being the requirement that a learner must be in a specific area to experience the app and "place" being the engagement the learner has with the location she/he is in. Designing experiences with both "location" and "place" in mind can result in designs that build mobile interactions that include more situated learning, or learning in learner's specific context, in the activities she/he is already in. The first quadrant of our framework outlines games of this nature. Moreover, the full use of the first quadrant, which uses both the "location" and "place" design dimensions, can produce AR games that are more situated. This situatedness comes when AR supplements the real world by overlaying digital objects on it, thus providing users just-in-time information about their surroundings, also enabling them to experience their surrounding in a way they have never done before. While the other quadrants may provide opportunities for learning, this learning is not in the learners' real, daily contexts. This framework aims to help designers see the AR possibilities outside-the-classroom.

Conclusion

To aid designers in creating AR experiences that better support situated learning, authors here presented a framework made up of two design dimensions: location and place, location being the learner's physical location and place being the learner's engagement with that location. These two design dimensions make up four quadrants of a plane. Location is the x-axis that goes from location-agnostic to location-dependent, and place is the y-axis that goes from engagement with location to no engagement with location. Every AR mobile experience can be mapped onto this framework to determine how the design employs these design dimensions. It can be easy to fall into the idea that learning occurs only in formal learning environments like the classroom, but this framework presents two design dimensions to show designers the possibilities of AR outside of the classroom. AR can facilitate situated learning wherever the learner is like it has never been done before.

Authors, in this chapter, argue that the AR and mobile experiences that are location-dependent and engage learners with their location provide the best experiences for this situated learning or learning that can take place in the social context it applies to. This is because, only when a mobile experience requires learners to be in a specific location, and engage with that location through AR, they are truly taking part in a situated experience that results in being in that place, not just in that location.

As AR technology grows in education, future researchers must not forget about situated opportunities simply because the technology now makes it easier to access virtual locations in the classroom. On the flipside, designers must also not forget the importance of place just because technology can now overlay new worlds on top of our real world. Future research should continue to explore the intersection of location and place in AR as a way to make situated learning a learner's reality.

Cross-References

► Augmented Reality and 3D Technologies: Mapping Case Studies in Education
► Augmented Reality in Education

► Characteristics of Mobile Teaching and Learning
► VR and AR in Future Education

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