Learning through Situated Simulations: Exploring Mobile Augmented Reality

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Overview

The story in William Gibson’s 1993 novel, *Virtual Light*, revolves around a pair of high-tech “virtual light” glasses that offer a special view of the world:

Friend of mine, he’d bring a pair home from the office where he worked. Landscape architects. Put ‘em on, you go out walking, everything looks normal, but every plant you see, every tree, there’s this little label hanging there, what its name is, Latin under that...¹

Fifteen years ago this was science fiction, in both literature and film; today it is reality, or rather, augmented reality. Computer-generated supplementary information overlaid onto the real world is becoming widespread, not so much in glasses—yet—but with smartphones.

Mobile computing and augmented reality have for many years been identified as promising technologies in the digital domain. More recently we have witnessed a convergence of the two—that is, the emergence of mobile augmented reality. An increasing number of devices are capable of running a variety of mobile augmented reality applications, and higher education stands to benefit from these exciting technologies. What is mobile augmented reality, and how is it useful in the context of teaching and learning?

With mobile augmented reality the computer, or rather, the smartphone, is used to extend or improve the quality and quantity of relevant contextual information available at a certain place and time. Most common, so far, is a combination of information coming from the phone’s camera, overlaid with computer-generated graphics and resources (links). This is so-called mixed reality, as in Gibson’s vision. To achieve this mixed reality, the smartphone combines GPS data (for global position), compass information (for orientation), accelerometer (for vertical movement) or fiduciary markers (objects used as points of reference that appear in the image produced), and calibration of the real video feed with the graphics layer. Other solutions use a non-mixed, full screen for the digital representation. The latter approach provides more screen space and fewer problems with calibration, but there is no ability to annotate and refer to live video representations of objects in the real world.

A situated simulation is an example of a non-mixed “clean screen” solution. When using a situated simulation, the user’s visual perspective in the real physical environment is almost identical to the visual perspective in the 3D graphics environment displayed on the screen. In the same way that your view changes as you walk around a three-dimensional sculpture, as you change position and move the phone in the real world, the perspective (or view) on the screen is updated and changes accordingly. It feels as if you are looking through the phone at a three-dimensional scene, and the scene adjusts as you move. A situated simulation is a type or genre of mobile augmented reality that can be used to present audiovisual information related to a specific place, as well as broader information that would otherwise not be available.
This research bulletin illustrates and reports on a series of experiments with situated simulations that have been tested with students in real environments in Norway, Athens, and Rome over the past couple of years. As researchers, our aim has been to understand the extent to which this technical platform and expressive potential can improve situated learning. When students and learners visit historical sites, for instance, they find a scarcity of information on site. Oftentimes, ruins and ancient remains appear confusing and are difficult to understand. Signs, brochures, or books can shed some light, but it is difficult to experience the site as it once was when one only sees the remains of the site. An educated and enthusiastic lecturer or guide is helpful, as this person can describe how the site once looked, how it was used, how people lived, and so forth. Guides have limitations too, however. They basically provide verbal information; their oral presentation does not substitute for visual displays of what is not there. Situated simulations can use verbal resources in combination with 3D graphics to create a multimodal dynamic representation that augments the real place with relevant information needed for different educational purposes. The big question is how these simulations should be composed and organized in order to improve learning. The experiments reported here are early attempts to build knowledge and experience in this exciting field.

**Highlights of Situated Simulations**

Imagine a student of antiquity visiting the Forum in Rome for the first time. Impressive as the site might be, it is also deeply confusing and difficult to comprehend. Congested archaeological excavations and dubious reconstructions mixed with buildings and ruins from various periods make the experience frustrating, even for an enthusiastic young scholar. With a situated simulation (sitsim) in hand things are different. The student can download a sitsim of the Forum's main square as it looked at the dawn of the republican era. Watching the smartphone screen next to the real environment, the student can walk around and view the buildings as they appeared in the last century BC: the Senate House, Basilica Amelia, and the Capitoline Hill. Users can access information, written or spoken, about architecture, people, and politics. The sitsim displays a full reconstruction of the historical center of the growing Roman Empire, and it also becomes an interface to all types of use and online material, including a meeting place for other students, learners, and scholars, posting and sharing their research and reflections. Users can also activate dynamic sequences and observe/participate in historical events, such as Julius Caesar’s funeral and cremation. This may sound a bit like science fiction, but it is not. The basic element of the described scenario has already been designed and tested/evaluated with students using smartphones (Apple’s 3GS iPhone) in situ. In the following I will discuss and describe some of the sitsims we have developed and evaluated so far, including one from the Roman Forum.²

**Basic Features**

In digital design for learning, rapid changes in technology, such as improved hardware, are both a problem and an opportunity for the developer/designer. It is necessary to move forward step by step and not try to do everything at once. With the first two sitsims
that were implemented, the Oseberg Viking Ship and the Mission Dolores, we needed to establish the basic elements and dynamics of the application. In general, the educational challenge in these early attempts was primarily to create a form of representation that could generate added value to the environment and experience of the learner—in particular, a form that the students found easy and intuitive to use and understand.

Figure 1 illustrates a situated simulation view of the Norwegian burial mound of the Oseberg Viking ship. (To better understand and “see” how situated simulations work, click on the short video demonstrations at http://inventioproject.no/sitsim/.)

Figure 1. Situated Simulation of the Oseberg Viking Ship Burial Mound

Notice how the perspective on the smartphone screen is almost identical to the user’s real perspective.

We selected and put together four basic elements for the sitsims:

- **Static 3D objects in a navigable environment.** This is the basic space and inventory of a situated simulation. The 3D virtual environment is a landscape that simulates the real physical space at a certain place while displaying elements that do not exist in the real space. Imagine, for example, being able to stand in front of your home and use your smartphone to “see” the building as it looked while it was under construction. In the case of Oseberg, the simulation presents something that was once present—the original Viking ship and its contents (3D objects) as they might have looked almost 1,200 years ago, the night before the grave mound was erected above it.

- **Links.** Although the objects and environment in this version of a situated simulation cannot be modified or changed, the user can navigate and access information via links. These links are spatially placed, and the link icon is itself connected (by a visible string) to either an object or a position in the environment. This type of link is called a “balloon link” (see Figure 2).
Figure 2. The Oseberg Viking Ship (AD 834, Tønsberg, South of Oslo)

In the prow of the ship we see a “balloon link” with its string attached to the stem of the ship where the carving (Utskjæring) is located.

- **Link layer.** In a situated simulation, the user can switch between two user modes. In one mode the user can explore the environment as a visible (and audible) world, basically trying to simulate the scene as realistically as possible. In the other mode, the user can make all the links in the environment visible and active, thus enabling access to additional information about both the place and its objects. Using the Mission Dolores sitsim as an example, Figure 3 illustrates the two modes.

Figure 3. Mission Dolores (1791, San Francisco, Twin Peaks in the background)

With the link layer function, all links can be made invisible and inactive so that the user can switch between an experiential mode and an informational mode of exploration. The left image shows the screen when the link layer is turned off; in the right image, the link layer is turned on.

- **Detail view.** The current platform (iPhone 3GS) limits the amount of 3D detail that can be displayed. Thus, in order to view detail of optimal resolution, the general environment is substituted with an abstract environment only showing the detailed object. The transition between the two is achieved by means of a “repositioning” of the object from its original place (low resolution) to a position close up in front of the user (high resolution). This movement creates the impression that the object “comes up to” the user and displays itself in full detail. Figure 4 illustrates how the detail view can be used.
When the user is positioned on top of the mound, the balloon link Vikingportrett 1 (Viking portrait 1, a part of the four wheeled cart) is activated. The scanned 3D model of the carved head can then be brought into view and can be rotated and enlarged by the user, exploiting the touch interface of the iPhone operating system.

The Oseberg sitsim was tested with elementary school children in third grade and high school students in tenth grade. In both cases the classes were divided into two groups—one received an introduction to the use of the system and the other did not. There was no detectable difference between the two groups in terms of how they used and experienced the application. All responded that it was intuitive to understand and use. During this experiment, we discovered that at times the screen had low visibility. This was particularly a problem in bright sunlight. Most likely this was caused by our choice of a night scene to display the ship and its content. Lesson learned.

### Transparency and Overlay

With the basic elements in place, it was time to move on to more complex features. The object of choice was the Parthenon temple on the Acropolis Hill in Athens. When students visit this site, the remains of the temple they see today are only a shadow of the temple’s former glory. On site at the temple there is very limited information available, and access to the temple is restricted. Most of the rich detail from the original building is on display in the New Acropolis Museum located in the center of Athens, so students must move between the two sites in order to conceive the Parthenon as a whole. The challenge here was then to make the original building and its impressive detail more available to learners standing at the original location. To do this, we extended the application with two new features: transparency and overlay.

**Transparency.** Since GPS signals are not accessible indoors—and in the case of the Parthenon, the visitor is restricted to only move around outside the building, not inside its remains—there is a need to look inside, through visible obstacles, like walls and columns. In the print world, a solution to this problem is called a cut-away illustration and is frequently used in books on architecture and in travel guides. In our case we used partial and full transparency. It was partial in order to retain a view of the outer limits of the construction (the architectural context), and it was full when the display of objects inside was the primary focus (see Figures 5 and 6).
When the temple is observed from the east, the “Transparency 1” balloon link is activated. This gives us a better view of the cella and the position of the frieze. The columns and upper parts of the Parthenon are still visible in semi-transparent mode, thus providing the context of the whole.

The detailed object can be enlarged and moved using touch conventions. After the balloon link “Transparency 2” has been activated, the cella becomes semi-transparent and the central object of the temple, the statue of the Goddess Athena in the inner chamber, can be observed.

Overlay. Another solution borrowed from the print tradition of architecture is overlay marking. To explain the elements of architecture and their corresponding names, balloon links were stringed to the objects. When these are activated, partly transparent color overlays mark the extension and limitation of each element; in addition the object/marking is described by a voice-over commentary (see Figure 7).
Under the “Building elements” link, the user has chosen the “Architrave” link, and the relevant element has been marked with a transparent red banner while a voice-over narration provides additional information.

The Parthenon sitsim was tested and evaluated by bachelor of arts students in classical studies at the Norwegian Institute in Athens. The reconstructed buildings were designed to imitate freshly cut white marble displayed in a scene of bright daylight. This improved the visibility considerably—so much, in fact, that many of the students who wore dark sunglasses during the testing had no complaints about the visibility.

Overall, the students gave positive feedback about the Parthenon sitsim, and they stressed the usefulness of this sort of application in their educational context. They particularly highlighted the use of detail view and transparency, in addition to the value of the reconstruction itself. Some students, however, were concerned that the simulation could take attention away from the real Parthenon and thus diminish the value of a visit to the actual site. Some also made it very clear that the simulated environment should include other buildings on the Acropolis hill as well and that the environment should be richer in overall content.

**User-Generated Links and Sequences of Events**

Archaeology attempts to reconstruct history by means of physical remains. It thus tends to focus on physical objects, small or large. It is more difficult to conclude and understand how people interacted in these environments so many years ago. Fortunately, we have supplementary sources, both written and pictorial. Our next topic for a situated simulation was the Roman Forum in the final years of the Republic. This is a period in history where the written sources are extremely rich and detailed, particularly when it comes human action. Would it be possible to simulate some of the actions and events described by the classical authors? To answer this question we decided to reconstruct the Temple of Divus Iulius (The Temple of Deified Julius Caesar) as it might have looked when it was completed in the year 29 BC. In addition, we wanted to show the important events that preceded and motivated the building of the temple. We also
saw a need for students and professors to add their own material into the environment to better support their situated learning process.

*User-generated links.* In the sitsims described above, the producers of the application provide all links. Users can navigate and access the information that is presented to them, but they cannot explore resources outside what is offered in the sitsim. In the most recent version of the sitsim application, users can create, name, and position their own links. These user-generated links are of two kinds. They either link to and display a node of written text when activated, or they link to a web page. In both cases, the user-generated information is stored on a server independent of the local application (on the actual phone in use). In the case of the web page, the application applies a built-in simple web browser that is displayed inside the virtual environment on parts of the screen. This also makes it possible to update material for use in the simulation independent of the application itself. Users can also comment on other users’ links, thus turning the situated simulation into a spatial constructive hypertext. Figures 8 and 9 illustrate user-generated links.

**Figure 8. Placing a Link in Front of the Temple of Divus Iulius in the Roman Forum**

Here the user has just added and placed a balloon link (the vertical white line) in front of the temple’s rostra and is about to give it a name and turn it into a hypertext node of written text.

**Figure 9. Accessing Classical Books on the Forum**

In this case the user has activated the balloon link “Classical resources” just in front of the Temple of Divus Iulius. Of several sources, all describing relevant contemporary events, the text “Life of Augustus,” written by Nicholas of Damascus, has been chosen and is thus displayed and being scrolled in the internal browser. The browser does not take up all the screen space; the simulation and its 3D objects and environment are still visible and active around and behind the displayed web page.
Sequence of actions and events. While the previous sitsims all display static objects, the simulation containing the Temple of Deified Julius Caesar also includes a dynamic environment—that is, an environment that changes over time. This opens the door for inclusion of sequences containing events and actions. When studying the temple, and after activating the link named Altar, users are asked if they want to experience the events that led up to the building of the altar and the temple. If confirmed, the whole simulation scene changes and moves 15 years back in time to an evening following the murder of Julius Caesar on the Ides of March, 44 BC. This sequence and its structure are described in the following series of illustrations and captions (Figures 10 and 11).

Figure 10. Moving Further Back in Time

When the user accepts the invitation to experience the sequence of events, the temple dissolves and the whole scene changes to a dark evening 15 years earlier, a few days after the murder of the Julius Caesar. The noise of a distant crowd is audible from behind on the other side of the Forum. When the user turns around and points the phone to the Rostra, the speaker’s platform at the foot of the Capitoline Hill, two figures are clearly visible on the platform, surrounded by a large crowd.

Figure 11. Mark Antony’s Speech to the Crowd

One figure is attached to a rotating pole high above the crowd. It is a wax effigy of the beaten body of Julius Caesar. The other figure is Mark Antony giving the eulogy for the murdered dictator. (After some time the audience and the figures dissolve, a few hours passes (in simulation time), and the roar of the crowd can again be heard from the opposing side of the Forum, at the site of the later altar and temple. There a pyre has been lit and the body of Caesar is cremated.)

With this sequence we have introduced a radical new element and turned the sitsim into a potential device for storytelling, not limited to an environment for the experience of static objects and environments. As the sitsim is now designed and described, it serves as a narrative space the user navigates from within—a walk-in-documentary, or perhaps more accurately, a situated documentary.⁴
The Temple of Julius Caesar sitsim was also tested and evaluated by bachelor of arts students in classical studies at the Norwegian Institute in Rome. The students’ feedback was very positive. They enjoyed the access to relevant online material, and they especially liked the fact that they could create and position their own links and comment on other students’ posted links and content. The students who chose to view/experience the sequence of events containing the eulogy and the cremation (on different positions in both the real and the reconstructed virtual Forum) enjoyed it very much, and they saw great learning potential with such extensions to the application. Interestingly, most of the students, despite their explicit enthusiasm for the application, clearly stated that the simulation could not substitute for onsite guiding by a competent professor. Rather, they felt that the sitsim should be seen as a supplement to this more traditional way of teaching and learning on location.

What It Means to Higher Education

Learning is contextual. It is a function of the activity and culture in which it occurs. Lave and Wenger call this pedagogical approach “situated learning.” In situated learning the contextual space and place are central. With mobile augmented reality and situated simulations it is possible to support and extend the “situatedness” of learning and education in new ways by means of information technologies (IT). This is not limited to historical topics as described above. It extends to any discipline or subject matter that may benefit from making present what is absent, be it past, current, or future topics. The combination of the real and the virtual (what is simulated) also provides added experience and value. It gives the learner information from multiple sources—what Gregory Bateson in his epistemology has deemed “double description.” In his view, the combination of two sources of information generates a new type of knowledge and experience, as is the case with binocular vision (of depth). The notion of double description has been an important perspective in combining the virtual and the real when designing the sitsims presented here, and we believe it has a great potential for future solutions.

While mobile augmented reality is a promising platform for learning, it is at the same time an immature technology. It is also a mode of communication and meaning-making that is still in its infancy. This represents a challenge for higher education, but it is also an opportunity! The technology is there, in all its innovative splendor, and it is still improving and changing. How learners might benefit from this is up to higher education leaders and how they manage teaching and learning. The threshold for entering this technology is not insurmountable—it is actually relatively easy. Any university IT center can be innovative here and develop and adjust the technological means to sound pedagogical ends. The question is whether an institution wishes to do so. In ICT and education there is a tendency to buy into the educational solutions offered by software companies. ICT and learning are much more than software; they also include genres of communication. And these have (almost) always been shaped by the users themselves—teachers and students—in their everyday communication and exchange, be it the seminar, lecture, textbook, workshop, thesis, paper, discussion, project presentation, and so forth. We must not forget that this is also the case with digital
technology, and mobile augmented reality is no exception. This is the challenge of the INVENTIO project: to explore and shape the pedagogical and expressive forms of emerging digital technology.

Key Questions to Ask

- In what academic disciplines might mobile augmented reality and situated simulations be applied in our institution? To what extent are they currently in use?
- How might we further the local creativity among students, staff, and faculty in order to be innovative in the exploitation of these technologies?
- How ubiquitous is the use of mobile technology on our campus?
- Who are the academic and administrative stakeholders for emerging mobile technologies in our institution?
- What technological milestones must be achieved for simulation technologies to noticeably contribute to teaching and learning at our institution?

Where to Learn More

- INVENTIO Project, Department of Media and Communication, University of Oslo, http://inventioproject.no/. See also INVENTIO Project Situated Simulations, http://www.inventioproject.no/sitsim.
- KHARMA—KML/HTML Augmented Reality Mobile Architecture. Augmented Environments Laboratory, Georgia Institute of Technology School of Interactive Computing, https://research.cc.gatech.edu/polaris/.
Liestøl, Gunnar. Sitsim Demo II. 
http://www.youtube.com/watch?v=NliEGCnlSwM (video demonstration of situated simulations)

Liestøl, Gunnar. Situated Simulation Demo. 
http://www.youtube.com/watch?v=Gxb19WyB3i0 (video demonstration of situated simulations)


Endnotes


2. A few words on method: Exploring the communicative potential of an emerging digital platform, such as mobile augmented reality, is a fascinating process of design. In this research and development work (conducted by the INVENTIO Project at the University of Oslo, Norway) our starting point is not the technology per se but a humanistic perspective on the communicative and textual potential of IT. We aim to explore and experiment with how the converging and emerging technologies make possible different expressive forms or genres. Conducting this design process is often, as we shall see, a question of selecting, combining, and repurposing elements (conventions) from other existing media.


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