INTERNATIONAL CONFERENCE ON ENGINEERING AND PRODUCT DESIGN EDUCATION
3 & 4 SEPTEMBER 2015, LOUGHBOROUGH UNIVERSITY, DESIGN SCHOOL, LOUGHBOROUGH, UK

AUGMENTED REALITY FOR ENHANCED STUDENT INDUSTRIAL DESIGN PRESENTATIONS

Basak TOPAL[1] and Bahar SENER[1, 2]
[1]Middle East Technical University, Turkey
[2]University of Liverpool, UK

ABSTRACT
Augmented reality (AR) has developed rapidly in recent years, causing the technology to move out of the preserve of large budgets and significant infrastructure, into an accessible and affordable visualization tool capable of running on a smart phone. However, the usage of this technology for superimposing digital content such as 3D models and images onto the real world, has not been sufficiently explored in industrial and engineering design for presentation purposes. Even though designers have access to various tools and methods for presenting design projects, some of which are digital, intended user experiences or product specifications are sometimes not conveyed satisfactorily. This paper explores the potential of AR technologies to enable designers to enhance their 2D presentation boards and 3D physical mock-ups with an additional layer of digital information. The study was carried out in an educational context through a design project (bedside alarm clock) with eight postgraduate students. Students were exposed to three project parts: 1) AR presentation and software demonstrations; 2) concept design and creation of AR content; and 3) evaluation of utilized AR software. Digitally-created design content was successfully presented interchangeably and overlapping in real-time with physical media. The experience was variously described as presentation boards and mock-ups 'coming to life' with augmented content including text, images, animations, video and sound. The latter was found especially valuable for properly conveying the audible design intent for the alarm clock projects. The paper concludes on how AR technologies can support industrial design presentations and some suggestions for technological developments.

Keywords: Augmented reality, design presentations, industrial design, visualization.

1 INTRODUCTION

Augmented Reality (AR) is a way of superimposing information generated by a computer into a real environment [1]. In other words, AR is a vessel to incorporate computer-generated data within real space, combining real and virtual objects with each other in real-time [2]. According to Milgram et al. [3], AR is situated in a continuum of mixed reality, between the real environment in which humans exist, and a completely virtual environment comprised only from digital data. For a system to be described as AR, it needs to be combined of real and virtual elements, be interactive in real-time, and be observable in three dimensions [4].

AR is made possible through a combination of hardware (e.g. computers or mobile devices, cameras, projectors, monitors, trackers/markers) and software (e.g. apps or programs, web services, content servers). The technology has uses in a wide array of commercial and research fields. In the commercial field, sectors such as advertising, architecture and construction, museums and tourism, medicine, mechanics and repair, social networking, entertainment, military, and navigation have made use of AR. Recently, research and development examples of AR have also gained public attention, with the AR head-mounted display Google Glass (developed by Google X) being one of the most widely known.

Until recently, AR was the preserve of large budgets and significant infrastructure. In the intervening time, AR has become accessible and affordable, such that AR applications can now run on smart phones, and are able to display digital content such as 3D models and animations onto 'augmentable' surfaces. There has been research on the uses of AR in industrial design activities, including: visualization of products, usage simulations and ergonomic analysis [5]; virtual design environments, augmented prototyping, and industrial design assembly [6]; and collaboration across design disciplines

[7],[8]. One underexplored area where AR has potential benefit is during formal design communications in industrial and engineering design. Throughout their education, industrial design students are expected to present the progress of their design development with a variety of visualization tools. Although designers generate highly convincing photorealistic renderings or simulations of product proposals, it can be argued that in some circumstances intended user experience or product specifications are still unsatisfactorily conveyed. In other words, presentation boards and mock-ups are sometimes not adequate to show interaction details of a proposed product such as audiovisual feedback. At the current state of the technology, there are various ways that AR could supplement the presentation of a product. Accordingly, this paper reports on a study to explore the potential of AR technologies to beneficially provide an additional interactive digital layer of information onto 2D presentation models and 3D physical mock-ups, typical of the deliverables of an industrial designer.

2 THE FIELDWORK

The study was carried out in an educational context through a design project ('bedside alarm clock') with postgraduate students. This provided an ideal setting for experimentation and feedback, whilst being sufficiently close to professional practice to judge commercial applicability.

2.1 Selection of Participants

Eight graduate level industrial design students, taking 'ID 535 Design for Interaction' course at Middle East Technical University, Turkey during 2013-14 Fall semester, participated in the study. All of the participants had design and modelling skills expected from a postgraduate-level student, and all had a mobile digital device (e.g. smartphone or tablet) which was necessary for their participation.

2.2 Selection of AR Software

Several software/apps developed for AR content creation and management including Layar, Daqri and Metaio were reviewed by the authors. Among these, Metaio [9] – available on Android and iOS platforms – was selected, because it enabled users to create their own content and display content through channels that they publish. It was also available as a well-specified freely downloadable version (as well as more advanced paid subscriptions), providing relatively wide opportunities for creating and publishing content compared with the other reviewed apps. Metaio software consists of two interconnected parts serving different purposes. 'Metaio Creator' is used to upload digitally created content and link that content to markers, which eventually become published into channels. 'Junaio Browser' is an application used to scan markers and thus to connect to the channels published with Metaio Creator and view AR content. The types of data that Metaio Creator can augment onto the real world ranges from 3D models to 2D images, sound files, etc.

2.3 Stages of the Fieldwork

Students were exposed to three project parts: 1) AR presentation and software demonstration; 2) concept design and creation of AR content; and 3) evaluation of utilized AR software. The design project ran for five weeks, during which time the authors made themselves available to each participant through a feedback session, essentially acting as a 'drop in' to answer questions and offer advice about how to exploit the capabilities of the apps.

2.3.1 Part 1: AR presentation and software demonstration

In part 1, the participants were familiarized with the mobile AR app (*Metaio Creator*). The basic structure and a short tutorial of the app were shown, along with example uses showcasing the capabilities of the app through design projects that the authors have implemented.

2.3.2 Part 2: Concept design project and adding interactive AR content

In part 2, the participants were asked to make use of Metaio Creator to add an interactive content layer to their final (2D) presentation boards and/or their final physical (3D) mock-up of the concept bedside alarm clocks they had been working on. At the final presentation, the participants presented their interactive content on their presentation boards and 3D mock-ups. The AR layer of each presentation was documented with photographs and screenshots.

2.3.3 Part 3: Evaluation of Metaio AR app

In part 3, immediately after their presentation, the participants were asked to complete a survey evaluating their ‘likes and dislikes’ of the app, alongside an appraisal of how the use of the app had brought about enhancements in design communication. Participants were also asked about extra features that they would like to see added in such an app (not necessarily as enhancements to Metaio Creator), and whether they would be enthusiastic to use AR technology in subsequent projects.

3 RESULTS AND ANALYSIS OF THE FIELDWORK

As can be seen in Table 1, during the final presentation of the bedside alarm clock project, all of the participants had *sound* augmented in their presentation boards. The sound of the alarm was either embedded in a video that showed detailed interaction steps during usage, or activated separately to demonstrate the sound choice for the alarm. The videos were augmented both on the presentation boards and mock-ups. For the presentation boards, most (six) of the participants showed the alarm lights and movements of the product in their videos (Figure 1), whereas a few (three) of the participants showed the interaction steps, be it the screens in the digital interface (Figure 2), or the tangible interaction details. One of the participants chose to show the alarm light glowing, and another participant decided to present the interaction steps of the digital interface in the form of a video on top of the surfaces of the physical mock-up. One participant took it a step further by augmenting a very simple mock-up of the project with a more detailed 3D model, showing qualities of form, material, texture and graphics chosen for the product (Figure 3).

Table 1. Additional AR content in the ‘bedside alarm clock’ project presentations

AR content	**Purpose**	**Number of participants integrated** (out of 8)	**Medium of presentation**
Sound	alarm	8	2D presentation board
Video	alarm lights and the alarm-clock’s movement	6	
	interaction steps	3	
	alarm lights	1	3D mock-up
	interaction steps	1	
3D Model	product form, material texture, graphics	1	

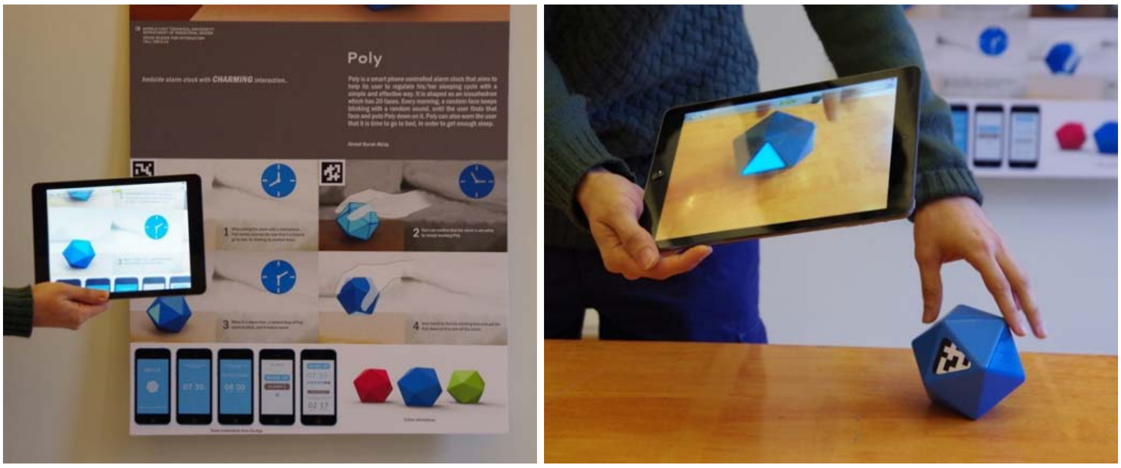

Figure 1. A participant scans the markers on the presentation board (left) then the mock-up (right) to demonstrate the augmented animation of the glowing lights on the alarm clock

Figure 2. A participant shows interaction details through a video located on the mock-up

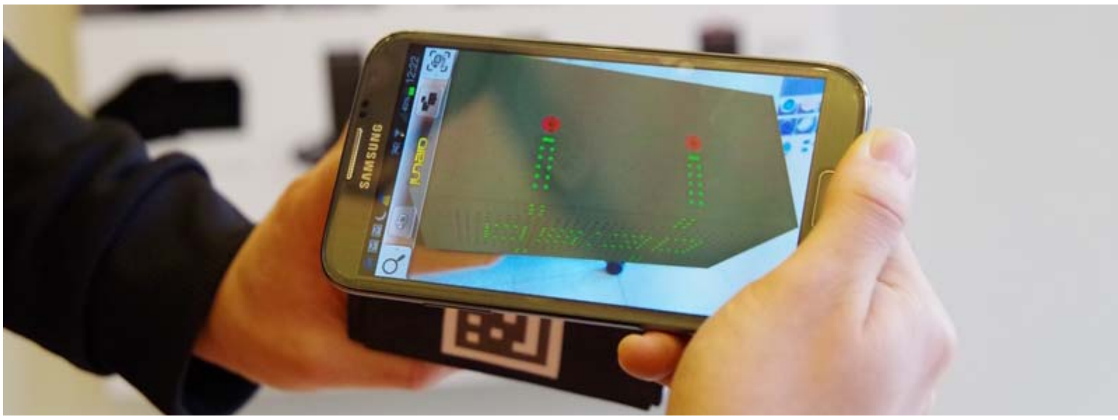

Figure 3. A participant scans the marker on a primitive mock-up to reveal a more detailed 3D model of their intended design

3.1 Using Metaio in a student design project

The participants showed great success in using the AR software package Metaio to enhance their design project presentations. They were able to show the usage scenario and digital interface details from start to finish with audio-visual feedback. Having easy access to an AR app to show digitally created content that explained user-product interaction steps in real-time was an impressive advantage over using static 2D presentation boards. If they had not used AR, the only other way that participants could have shown product operation and sound feedback would have been by using a laptop or computer screen next to their presentation boards, and manually showing the relevant data during the presentation. However, this would not have been possible in a setting where the designer was not present next to his/her presentation board, such as an exhibition. By placing markers on presentation boards, designers allow every viewer with a mobile device to see extra content that can help explain the interaction details of their product proposals.

One particularly inspiring and effective use of AR for student design presentations was demonstrated by enhancements to physical mock-ups. Participants were able to augment videos showing digital interfaces, dynamic details and texture properties that would be either impossible or very time-consuming to create and physically model within the scope of an educational project. The most significant and perhaps revolutionary advantage of this was the way that augmented data was correctly located onto the mock-up, and furthermore able to be rotated within 3D space yet still remain correctly located.

3.2 Feedback on the use of Metaio

Very positive reactions were received from the AR-enhanced presentations, both from the audience (design tutors) and the student participants themselves. The participants found the Metaio software package easy to use, and that the abundance of useful attributes and its free-of-charge availability justified its learning curve. Participants thought that with AR, their presentation boards were much more fun and interesting, while they were able to present information about their product proposals to a greater depth. The adjectives that the participants used to describe using AR in their presentations were: surprising, informing, fun, interesting, attractive, and even magical. They were able to present everything that they would have liked to present about the interactive elements of their designs through the functionality offered by Metaio. It was considered an 'eye-opening experience', which would encourage participants to use AR apps in communicating their future design projects.

The participants also had some negative comments about the AR implementation process. Some technical problems related to the software seemed to be a setback, albeit a minor one. For example, the size of the marker and the lighting conditions were found to affect the smoothness of tracking. Glitches in the interface of the content creation software made it difficult at times for the participants to edit digital content within the app. Perhaps the most noteworthy disadvantage of the software was that it was not specifically tailored to suit to the designer's workflow. However, these disadvantages did not diminish the potential that participants regarded for the implementation of AR within their project presentations, but nevertheless could provide a basis for improvement criteria for AR software or apps targeted specifically for use by industrial designers. These criteria are listed below.

- Ability to track more than one object; being able to interact with multiple objects at the same time; having object-to-object interaction as well. This would mean that product concepts with more than one component that are linked together in some way could be prototyped.
- Ability to edit digital content on the viewing mobile device, rather than a separate PC, would improve the workflow with regard to content creation and evaluation, prior to finalization.
- Use of video projection to display AR content directly on top of a presentation board or 3D mock-up, as an alternative to viewing through the display of a mobile device. This could provide a more intuitive and convenient way of experiencing the AR content.
- Integration with a head mounted display (such as Google Glass) could provide even more convenient ways of experiencing the AR content on augmented presentation boards and 3D mock-ups.

4 CONCLUSIONS

The work presented in this paper focused on using the mobile AR app 'Metaio' in a bedside alarm clock industrial design project, to enhance students' presentations of interactive and multimedia product details such as sound, visual elements and feedback, and digital interfaces. The study resulted in some remarkable AR content, found to be novel, inspirational and captivating to all involved: students, tutors and guests. Digitally-created design content was successfully presented interchangeably and overlapping in real-time with physical media. Student designers had success with Metaio in presenting such details on their presentation boards and mock-ups. They were able to show videos of alarm lights and movements, the interaction steps, the texture and form of intended designs as a 3D model overlay, and the audible sound of the alarm clock. By creating this additional layer of information on their presentation boards and mock-ups, participants were able to show details of their projects that would not have been possible to show with traditional presentation methods. It was promising that the quality of their presentation was heightened considerably and none of the participants had crucial difficulties during the process. Their ideas about improving the whole experience of using AR to enrich presentation will be useful for further studies on the subject.

Industrial design students were able to present their product and interaction ideas in a much more attention-grabbing way than traditional methods. Because AR was a fun and interesting way of enhancing their presentations, student participants exhibited much confidence during their final presentations. Creating additional digital content to overlay on their presentation boards and mock-ups made them think about the details of their projects in more detail. Additionally, a major achievement from enhancing mock-ups was that even a simple model with very little detail could be turned into an elaborate prototype with lights, sound and digital interfaces. A prototype that shows these details would be very time consuming and difficult to realize in an educational context. However, with AR it was possible to achieve in a short time span with minimal effort.

The principal conclusion, shown through the work of the students, is that in (industrial) design education the utilization of AR for presentation purposes can undoubtedly help students portray their ideas in a more detailed and interesting way. To utilize AR in long-term (e.g. semester length) educational design projects, the view of the authors is that it is essential to (i) introduce students to the technology during the briefing stage of the project through a thorough and effective presentation of possibilities and examples, and (ii) provide students with close (product-specific) guidance to support their implementation of AR throughout their project progression.

REFERENCES

[1] D. Van Krevelen and R. Poelman. A survey of augmented reality technologies, applications and limitations. *International Journal of Virtual Reality* 2010, 9(2), 1.

[2] R. Azuma, Y. Baillot, R. Behringer, S. Feiner, S. Julier, and B. MacIntyre. Recent advances in augmented reality. *Computer Graphics and Applications IEEE* 2001, 21(6), 34-47.

[3] P. Milgram, H. Takemura, A. Utsumi, and F. Kishino. Augmented reality: A class of displays on the reality-virtuality continuum. In *Photonics for Industrial Applications* 1995, pp. 282-292. International Society for Optics and Photonics.

[4] R. T. Azuma et al. A survey of augmented reality. *Presence* 1997, 6(4), 355-385.

[5] S.-Y. Lu, M. Shpitalni, and R. Gadh. Virtual and augmented reality technologies for product realization. *CIRP Annals-Manufacturing Technology* 1999, 48(2), 471-495.

[6] Y. Ran and Z.Wang. Virtual and augmented reality applications in industrial design. In *International Conference on Machine Learning and Computing* 2011, pp. 252-253.

[7] Y. Shen, S. Ong, and A. Nee. Augmented reality for collaborative product design and development. *Design Studies* 2010, 31(2), 118-145.

[8] K. H. Ahlers, A. Kramer, D. E. Breen, P.-Y. Chevalier, C. Crampton, E. Rose, M. Tuceryan, R. T. Whitaker, and D. Greer. Distributed augmented reality for collaborative design applications. In Computer Graphics Forum, 1995, Vol.14, pp. 3-14. Wiley Online Library.

[9] *Metaio Augmented Reality Products Solutions.* Available: http://www.metaio.com/ [Accessed on 2015, February] 2015.