

An Immersive, Interactive and Augmented Classroom: A Proof-of-Concept

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Abstract

The use of mobile technology has individualized education in certain ways and even when there is a sense of a connected learning community, the classroom itself remains a passive space whose only function is to contain users, faculty and furnishing. This research introduces a prototype that combines movement, projections and an interface that surrounds the user. It presents a study of the interface design and considers different ways to generate interactions by using 3 types of body gestures: made with the fingers, the hand and the arms. It will also explore the hand as an element that defines the proportion of the interface instead of the fingertips like currently happens in touch-enabled devices. Interactions can range from acquiring information from diverse web sources, to sharing a document or an image, to combining classroom supplies like post-its and markers in a common environment. This environment allows the student to integrate their mobile device as a key that will give them access the projected interface, their files and materials on the cloud while interacting with their peers.

Users will be able to manipulate virtual objects with gestures as if they were physical ones; objects can be rotated, resized, shared, mixed and even modified by several participants at the same time. No longer a will student have to print or pin a mockup of a piece. Instead, they can upload it from their device into the projected Workspace and share the work with their peers. Physical objects like paper sketches or physical models and prototypes can be integrated by capturing their images and inserting them into the environment. This method of mobile technology will change the parading of a device as an isolated personal object and will transform the classroom into an active space.

Keywords: Interaction, Design, Natural User Interface, Augmented Reality, Mobile Learning

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1. INTRODUCTION



Figure 1: John Underkoffler explains the human-computer interface he first designed for the film *Minority Report*. Photo by Steve Jurvetson under Creative Commons License

A lot has been speculated about the future of user interfaces and its evolution. In the 2010 TED Talk series, John Underkoffler from Oblong Industries and UI consultant for several movie studios in California presented a several gesture enabled interfaces designed as interactive systems (**Fig. 1**). He proposed leaving behind the idea of the mouse, as a medium of interacting and replacing it instead with the hand as a more accurate way to do it. During his presentation, he presented the iconic scene in *Minority Report* in which the main character of the movie uses natural gestures without keyboard, mouse or command line to interact with a computer. [1]

A team from the Microsoft Research Lab discussed the use of peripheral projected illusions in interactive experiences during the 2013 edition of SIGCHI Conference [2] (**Fig. 2**). IllumiRoom, the name given by them for this system, proposed extending the visual experience of playing video games beyond the TV screen into furniture and other furnishing in a common room.

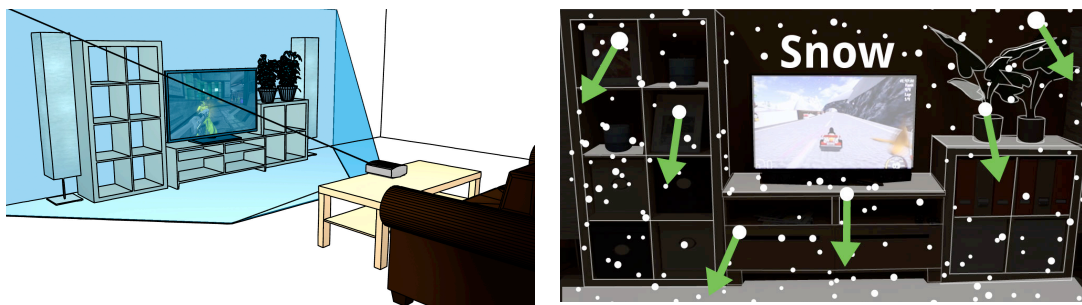


Figure 2: IllumiRoom concept. Room setting and physical environment reaction of particles. Image courtesy of Microsoft Research: <http://research.microsoft.com/en-us/projects/illumiroom/>

By leveraging physical environments to create combined virtual-physical experiences using projections this project enhances and augments objects and spaces in the real world over visible surfaces. For example, if in the video game it is snowing, then the projection outside the TV screen would show snow particles falling and bouncing over the real furniture that exists in that space. In the paper “*IllumiRoom: Peripheral Projected Illusions for Interactive Experiences*” the team discussed the potential of this technology not only in the entertainment industry, but in a professional setting like an office or even a classroom.

Similarly Paul Marshal from the Open University defined a framework that focuses on tangible interfaces aimed for learning. [3] This framework included considering

the possible benefits to the users as well as the exploratory and expressive activity carried over by the interacting subjects. The integration of representations in this type of interactions allowed the learner to assimilate new information to improve learning transfer, planning and reflection.



Figure 3: "The Office of the Future"
Sketch by Andrei State and Henry Fuch. Use of
the image with permission from the authors.

Henry Fuchs and his team from the University of North Carolina presented something similar to Underkoffler and Jones in Siggraph'98 with the paper "The Office of The Future". [4] (**Fig. 3**) They proposed using projections over different surfaces and furniture in an office setting. The paper discussed the challenges of projecting over un-even and irregular objects to transform them into immersive displays. This paper also outlines the possible optimization of light schemes that can capture depth and reflectance of the surface at different levels during any given interaction. Finally, Chris Dede from Harvard University discussed other benefits of

immersive interfaces. [5] In his paper, he mentioned that enabling digital simulations leverage interaction between learners with different skill levels. Projected interfaces activate existing spaces and transform them without making significant changes to a structure. This activation facilitates new experiences and augments existing physical spaces while complementing the learning context. In some way, this acts as a bridge between the real and the virtual world.

2. CONTEXT

2.1 Components

There are three main components that define this project:

- **Immersion** is defined in this context as a way to generate an image whose main objective is to surround the interacting subject or subjects. Currently, immersion can be achieved by using virtual reality head-mounted displays like the Oculus Rift or through big scale projections that involve several projectors at the same time.
- **Interaction** is the two-way flow of information between a computer and a user while responding to a particular input. For example going to an ATM machine to make a cash withdrawal or simply talking to another person. In the paper "*How Bodies Matter: Five Themes for Interaction Design*" by Klemmer, Hartmann, Takayama, they discuss the way physical bodies are important when interacting with the world shape and how those interactions the way people think, learn and solve problems [6].
- The last component would be **augmentation**; making something greater by adding a layer information to it. For example, the Google Glasses are a recent case of



Figure 4: Projection Mapping to Tokyo Station -Tokyo Michi Terrace 2012.
Photo: t-mizo Creative Commons

augmented technology; by using a wearable device (the glasses) with an optical head-mounted display; it adds an extra layer of information to what is visible in the real world. This works by beaming a projected image directly onto the retina at the back of the users' eye. For example someone can walk to buy groceries and be able to see step-by-step directions on how to get there. Another example of augmentation is 3D Projection Mapping, known also as Spatial Augmented Reality. Used mostly in digital art and advertising; this video technique turns surfaces, often irregularly shaped, into a display surface for video projection (**Fig. 4**).

2.2 Interaction and Augmented Reality: The Challenges

Technology itself is a huge challenge for education through interaction, and sometimes plays the opposite role and ends up being a distracting element in the educational process. Social Media, chatting, downloading other content takes all the attention during class, to the point that some Universities are banning the use of Smartphones and Social Media in the classroom. [7] Mobile Learning, when used correctly is a great interactive tool, but there is no real collaboration as most of the work is done through each students' individual smartphone or tablet. The sense of learning community is present, but it is, in certain situation isolating and individualistic.

The cost itself of some technology also represents a big challenge; currently the average cost of a brand new Smart board is around \$5,000 US dollars. A prohibitive expense to most institutions. Even investing in less expensive and most common technology. A 30 million dollar initiative by the Los Angeles Unified School District in 2013 pretended provided 640.000 iPad tablets to the students, but after the first year the program was cancelled due to students hacking the devices, using them with other ends besides education, as well as issues with the distribution model. [8]

Technological over-saturation can also be a challenge. Institutions are investing heavily in implementing big screen TVs, high definition projectors and surround sound speakers in most classrooms, changing its real nature of a learning environment and making them media centers instead [9].

2.3 Zayed University: A case study

Zayed University (ZU) is one the three government-sponsored higher education institutions in the United Arab Emirates offering undergraduate and graduate programs. Among the six Colleges that are part of Zayed University, the College of Arts and Creative Enterprises offers the programs of Visual Arts, Graphic Design, Interior Design Multimedia and Animation. Design classes tend to differ from lecture classes in the way the material is presented and manipulated by the students; it follows a learn-by-doing approach that allows the student to experiment, interact, build, critique and discuss their project in an open context. The classes at ZU are thought in specially designed studio classrooms with state of the art equipment and

furnishing. The layout of the classrooms follows the same structure as other studios in other design institutions around the world. Classrooms include a common space where the students meet and critique their projects, as well as computing equipment to develop prototypes and mockups. **(Fig. 5)** The classrooms are also equipped with high-speed Internet, HD projectors and in some cases TVs or Smart boards.

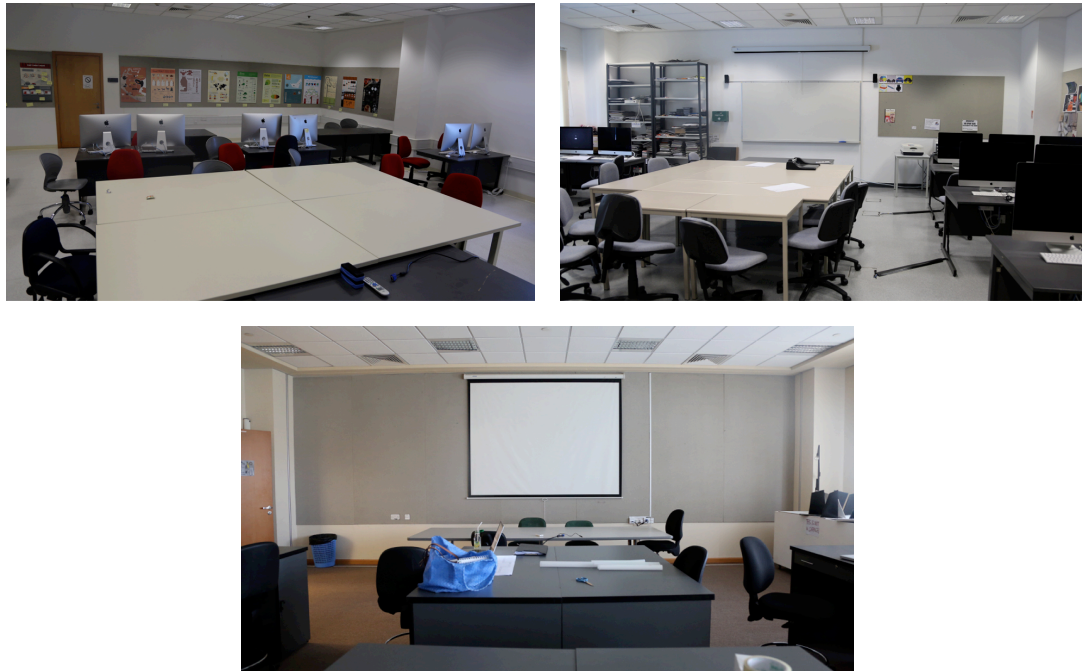


Figure 5: Three of the studio classrooms available to Zayed University design students.

After analyzing the spaces available for Design Students in Zayed University, three common elements that could be considered as a challenge for an Immersive, Augmented and Interactive classroom were found: existing furniture, recent investment in technology and empty surfaces (walls, desks and pin boards). These challenges were also identified at other institutions consulted by the author including the School of Visual Communication Design at Kent State (USA), and the Graphic Design program at Colegiatura Colombiana (Colombia).

2.4 Learning Platforms

Current interaction design paradigms are shifting from interfaces suited for small keyboards and mouse pointers that use small buttons, windows, menus and icons to finger-friendly interfaces that make use of big icons, gestures, contextual menus and clear visual hierarchy. However, the current software used in the classrooms is designed for desktop computers aimed for office use and not class use. This is translated into PowerPoint presentations projected into big screens or PDF documents enlarged in a TV screen, making real interaction almost impossible. Additionally, learning platforms such as Blackboard and Moodle used by institutions does not account for an optimum user experience. These platforms are not responsive to the wide array of mobile devices the students have access to, and end up being overlooked by faculty and students. Recent studies have showed high levels of

dissatisfaction and low usage of these learning platforms especially when posting content, assigning individual tasks, and doing peer reviews on student work. [10]

3. PROOF OF CONCEPT

Taking into consideration the challenges discussed in the previous section and the current state of computing technology, this concept will make use of a projected interface combined with a motion-tracking sensor that will replace the need of mouse pointers and limited screens. At the same time, this will allow to use different surfaces to project on, and adapt them to the needs of the class; a lecture, a studio or a working group session. By following the concepts presented by Underkoffler and others [1-6], this interface will make use of gestures and physical interaction to leverage the learning process of the students and improve the way they think, learn and solve problems.

This Proof of Concept will explore new practices for User Experience, Human Computing Interaction and Interface Design. By using a hand-centered design approach, hand proportions will be the main level of interaction instead of the fingertip or a mouse pointer. The hand-centered design is an adaptable platform that can work with the needs and dynamics of a class while engaging the students, and integrating virtual objects with physical manipulable objects. It will leverage the use of smartphones and other mobile devices as the entry key to a shared space. This leverage expands the interaction in a co-creative environment where real collaboration can happen.

3.1 Technology

In order to develop this concept and later a working prototype, this project will make use of the latest version of Microsoft Kinect V2. Microsoft presented this motion-sensing device in 2009 as Project Natal during the E3 video game conference in Los Angeles. The first version was launched publicly in 2010 bundled with the Xbox 360 console. The V2 version of the Kinect sensor includes an infrared sensor, a 512x424 pixel time-of-flight camera that can measure distance based on the measurement of the speed of light, a wide field of view and a 1080p video camera. It allows tracking of to 6 participants at the same time doing multiple gestures and has a four-microphone array that allows voice control. At the time of writing, the cost of this device is \$200 US dollars including an USB adaptor.

Along with the Kinect Sensor, the project will take advantage of currently installed Video Projectors with HDMI allowing the projection High Definition images and video in the classroom. Both devices will be connected to a laptop computer with USB 3.0 ports for high-speed data transfer and the latest version of Microsoft Windows. The combination of these three elements (Kinect, Projector and Computer) will grant a low budget solution that does not require additional investment other than the motion sensor. This will reduce possible costs of reforming a classroom, as well as full flexibility on where and how the students interact.

3.2 Design

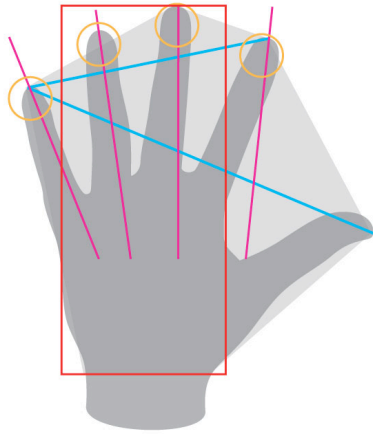


Figure 6: The “Active Grid”, the base of the Design behind the interface and the navigation.

This project explores using the hand as the replacement to the mouse pointer as the main way to navigate an interface. This requires exploring new proportions that go beyond the 30 pixels a pointer has or the 48-pixel size suggested for touch devices. [11]

Figure 6 illustrates several characteristics of the human hand that condition the way the user can interact. Five contact points as the fingertips (orange), the finger’s movement vectors (magenta), the maximum horizontal reach for the fingers (light blue), and maximum vertical reach (red). By overlapping all the physical characteristics of the hand, an “active area” is found in the center of the hand. This active area allows interaction without the need of pointers or

digital pens since it is at the reach of fingers and the palm. At the same time, it adjusts to the proportions of mobile phones and other mobile devices like tablets making the inclusion of this easier. An evolution of this grid takes into consideration left and right hand; by overlapping both of them an “Ambidexter Grid” was created to define the final proportion of every visual element including icons, typography and the layout of the elements in the projected interface (**Fig. 7**).

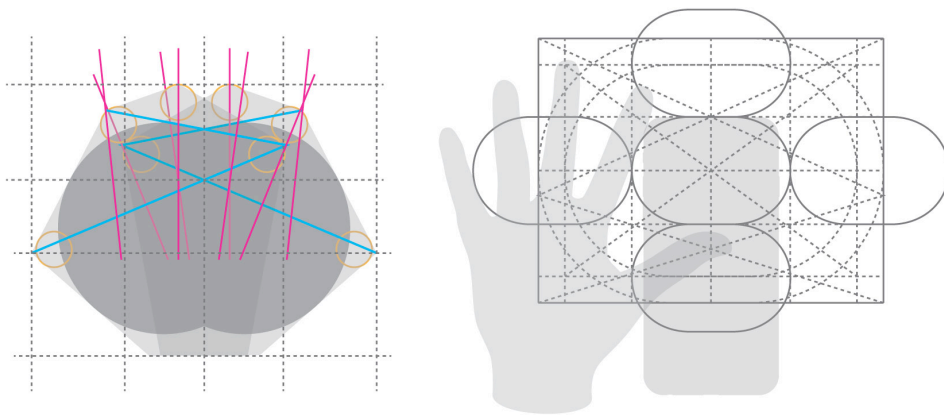


Figure 7: *Left:* Active Grid Overlapping. *Right:* Ambidexter Grid, the proportion of the hand and the average size of a 6” smartphone. Ovals represent the radial placement of the icons.

The use of the grid extends into the entire visual communication of the interface. Icons share the same proportions as the grid and are laid out in a radial way around the smartphone, which becomes the center of the interaction. From that point, buttons and options will be expanded to the reach of the user and other participating users. This way, all the individual options are tied to the mobile while the shared Workspace outside their smartphone extends as much as the projected surface allows.

3.3 Use in the Classroom

The first step for a participant would be placing his or her smartphone over the table where the interface is going to be projected. This can be a table or a small desk where students can be surrounding it. On the screen of the smartphone a QR code will be displayed. The code would have encoded the student name, the student ID and an email address. The camera of the Kinect will identify the code and validate the identity using the institution student database. Once validated, a set of buttons will surround the phone and identify the student with a unique color (**Fig. 8**).



Figure 8: The interface lay out. In the middle a smartphone with the embedded QR that activates the access to the Workspace

Since the Kinect can track up to six participants, six color schemes will be available in the interface; these way participants will identify themselves in the Workspace, making a color the user's avatar. If the student wants to interact the only thing that he or she will need to do is place the hand over the button to activate a function or drag an object into the Workspace. Buttons could also be dragged and changed position as if they were also objects. Objects in the Workspace are manipulated as if they were physical objects; for example to resize an image the gesture would be dragging two opposite corners with the hands, or in order to rotate it one hand would act as axis while the other rotates around that axis.

Files and objects could be shared between users by dragging the objects thumbnail into the other persons' active area, eliminating the need to physically share a USB drive or emailing a file. For this to happen, a cloud storage service will be available to the interface and each student will have access to their own cloud folder; documents, images, video, bookmarks and sound clips can be shared into the Workspace. Any user could upload to their own cloud folder from their smartphone or personal computer and create a "queue" which resembles a playlist in terms of the order certain files would be used. This can be relevant to present a project or during a lecture about a specific topic where the faculty would prepare the queue and then send it to the Workspace from their folders. The Kinect sensor will be tracking each one of the users smartphones and in case there is a need to reposition the device, the entire user environment will move along with the device.

Using the sensors' ability to measure depth, the Workspace will adapt to the geometry of the surface that is projected on. This is useful in cases where the space is limited or the furnishing available is irregular. Thanks to the high resolution camera embedded in the sensor, the interface could also adapt itself based on the surface color or the reflection level optimizing the contrast and colors of the interface and reduce the impact a surface could have in the projection. For example if this interface is projected over a dark wood table, then the interface will intensify the projection output by using bright intense colors and high contrast level. The opposite would happen if its projected over a light wood or white surface. Considering that a projection over a low flat surface such as a table is not always optimum or

comfortable during long periods of time, the interface can adapt itself into a vertical mode more suited for a lecture class or to a presentation. (**Fig. 9**)

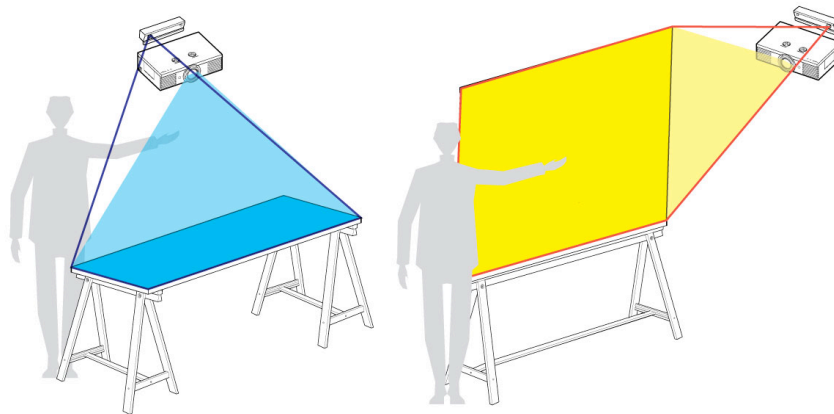


Figure 9: *Left:* Horizontal Mode. Projection over a low surface like a table.
Right: Vertical Mode. Projection over a white board or a wall.

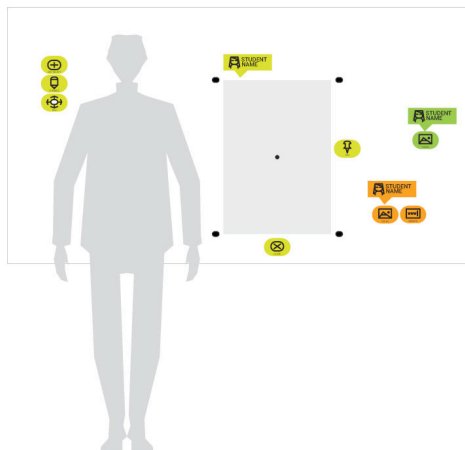


Figure 10: Vertical Mode. “Chasing Toolbox” over the left shoulder. Other students participating in class are displayed in green on the right side of the Workspace

In the vertical model, key actions represented in buttons like drawing, deleting or adding an object a “Chasing Toolbox” will follow the user the same way as when tracking the smartphone in the horizontal mode. This facilitates reaching the tools and reducing the time to switch between them. (**Fig. 10**)

To avoid cluttering in the Workspace, the interface uses a depth-of-field function that will blur out inactive objects emulating the human eye and reducing the attention to distracting elements. Objects will activate themselves when a hand is close to them or in case of the vertical mode, when someone is close. Most objects can use the “pin” feature to avoid getting blur out; for example that is useful if someone is presenting a project and several participants

want to draw over or add extra information to the object. Once the smartphone is removed from the Workspace the user would be logged out from the interface and a new user can enter in case the maximum participant number is reached.

Virtualization of physical objects is possible by combining the HD camera and the Time-of-Light camera in the sensor. By combining both image streams, the interface would be able to differentiate from flat and a volume. A capture button will show next to the object and an image capture of it will be inserted as a new object. Once the object is virtualized, it can be manipulated like any other object in the Workspace and the physical object removed.

4. CONCLUSIONS

This paper is the beginning of an idea that can have a significant impact on the way a student learns and engages with information. Marshal mentioned in his paper that “Physical interaction with interfaces are suitable for collaborative learning; it allows the learner to explore existing representations while improving concreteness and sensory directness of the participant”. [4] On the other hand, Dede [5] argues in favor of projected interfaces as a way to activate existing spaces and transform them without making significant changes to a structure and as a way to facilitate new experiences and augment existing physical spaces. At the end, the concept proposed here acts as a bridge between the real and the virtual world innate to young learners and important initiatives to use technology as a real learning tool.

One of the most interesting challenges is breaking common conceptions on how we interact with machines; we are used to clicking on buttons, closing windows, and using metaphors to represent actions, all inside the limits of a screen. Interaction should be limitless as ubiquitous computing becomes common and accepted in the day-to-day life. Having a hand-centric approach to interactions allows users to have a natural flow of information with the machine, and requires less use of fine motor skills and integrates better in diverse learning environments. Mobile learning is an relevant tool, but should not be seen as only using a phone to take pictures or solve a quiz using a learning platform. Mobile learning needs to extend beyond the smartphone and integrate as a seamless tool inside any curriculum.

This interface can be applied to fields other than learning design or classroom use. Its simple language, high contrast color scheme and large scale interface could suit people with limited mobility, limited vision and other learning disabilities such as problem solving or spatial reasoning. It could be used in the corporate world in presentations and brainstorming sessions. Inside the operation room, where there is a limited space, projections could aid doctors and nurses without the need to depend on a screen next to the patient.

As any other concept, this project is still a work in progress that will present interesting challenges from a design and a computing perspective. Currently this research is focused on completing the interface design and doing basic paper testing with a small sample of students. Funding is being sought through the Office of Research and via the Research Incentive Grants from Zayed University. Funding will be used to develop a working prototype and will move into identifying what the impact Augmented Reality could have in a shared environment. It will explore not only the way students respond to an interface like this, but how it affects their design work, their engagement from other students, the ways it can enhance discussions and influence the student's strategy within their projects.

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References

1. Underkoffler, J. (2010). "Pointing to the Future of UI." TED Talk presented at TED2010, Oxford, UK, June 6, 2010.
2. Jones, B., Hrvoje B., Eyal O., and Wilson, A. (2013). "IllumiRoom: Peripheral Projected Illusions for Interactive Experiences." In Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 869–78. ACM.
3. Fuchs, H., Raskar, R., Welch, G., Cutts, M., Lake, A., Stesin, L., and (1998). "The Office of the Future: A Unified Approach to Image-Based Modeling and Spatially Immersive Displays." In Proceedings of the 25th Annual Conference on ComputerGraphics and Interactive Techniques, 179–88. ACM. <http://dl.acm.org/citation.cfm?id=28>
4. Marshall, P. (2007). "Do Tangible Interfaces Enhance Learning?," 163. ACM Press. doi:10.1145/1226969.1227004.
5. Dede, C. (2009). "Immersive Interfaces for Engagement and Learning." Science 323, no. 5910 (January 2, 2009): 66–69. doi:10.1126/science.1167311.
6. Klemmer, S., Hartmann, B., and Takayama, L. (2006). "How Bodies Matter: Five Themes for Interaction Design," 140. ACM Press, 2006. doi:10.1145/1142405.1142429.
7. Strauss, V. (2014). "Why a Leading Professor of New Media Just Banned Technology Use in Class." *The Washington Post*, September 25, 2014. <http://www.washingtonpost.com/blogs/answer-sheet/wp/2014/09/25/why-a-leading-professor-of-new-media-just-banned-technology-use-in-class/>.
8. Blume, H., (2015). "LAUSD's \$1-Billion iPad Effort Beset by Problems, Report Finds." *Los Angeles Times*. Accessed June 1, 2015. <http://www.latimes.com/local/lanow/la-me-ln-ipad-bidding-20140821-story.html>.
9. Richtel, M. (2011), "Technology in Schools Faces Questions on Value." *The New York Times*, September 3, 2011. <http://www.nytimes.com/2011/09/04/technology/technology-in-schools-faces-questions-on-value.html>.
10. Piontek, M., and Morrone, A. (2013). "Evaluation of the Pilot of the Blackboard Learning Management System Implemented in Fall 2013." Indiana University, December 18, 2013.
11. Anonymous (2015). "Metrics & Keylines - Layout." *Google Design Guidelines*. Accessed June 1, 2015. <http://www.google.com/design/spec/layout/metrics-keylines.html#metrics-keylines-ratio-keylines>.