THE SPATIALITY OF CARING

Connecting Disability Services Personnel to Care Environments Through Augmented Reality.

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Abstract. In traditional e-learning modules, users are disconnected from a physical learning environment which may lower the retention of desired content and impact learning outcomes. Augmented reality (AR) is a technology that can enhance learning experiences by overlaying the learning content onto the physical environment. AR is beneficial in a range of learning environments, including the training of disability carers. One of the significant barriers to the uptake of AR includes limited resources to develop and manage AR training modules. Specifically, in the disability services context, where effective and engaging learning content needs to be created quickly, there are limited resources to do this. Therefore, this research explores ways to connect disability services personnel to their care environments, specifically for training in safety procedures regarding syringe disposal. An AR learning prototype will be created for disability services personnel, which can be further developed by industry partner 'HowToo' as a template block within their software. These AR modules increase interaction within the learning environment and ensure safety procedures are understood by personnel. Once this base block is incorporated into HowToo's software, users can quickly and easily integrate AR into their learning modules without any coding experience. Additionally, this extends the scholarship on AR applications for learning and training settings. More specifically, contributing valuable knowledge on the development methods for AR training applications in a disability services context. By enhancing the connection between carers and caring environments through AR, this research enriches the disability service training experience and the overall quality of care.

Keywords. Augmented Reality: AR; Disability services; Learning; Training.

1. Introduction: (Research context and motivations)

In traditional e-learning modules, users are disconnected from a physical learning environment which may lower the retention of desired content. Augmented reality is a technology that can enhance learning experiences by overlaying the learning content onto the physical environment. AR is now used in a range of primary, secondary and tertiary educational settings, but it offers particular value in vocational training settings such as in the training of disability carers. However, one of the major barriers to the uptake of AR is the limited resources to develop and manage AR training modules. Developing an AR training module in the disability services sector often requires technical coding or programming skills as well as familiarity with the unique challenges and requirements for learning and training for the sector. Also, without a learning development background, it is difficult for users to create a meaningful experience from scratch. This is a further barrier to the use of AR in learning, as companies need to quickly create learning content that is effective and engaging for the learners. Thus, this research explores ways to connect disability services personnel to their care environments, specifically for training in safety procedures regarding syringe disposal. The research is undertaken with industry partner, 'HowToo', a software company that has developed a tool for companies to create customised learning modules. This research will allow the creation of an AR learning prototype for disability services personnel, which can be further developed by 'HowToo' as a template block within their software. To reach this goal, the research and development process will include analysing existing related case examples, identifying key concepts, developing user flows and creating a prototype as a proof of concept. It was found that AR modules increase interaction within the learning environment and ensure safety procedures are understood by personnel. Once this base block is incorporated into HowToo's software, users can quickly and easily integrate AR into their learning modules. This research contributes to extending the scholarship on AR applications for learning and training settings. More specifically, this research contributes valuable knowledge on the development methods for AR training applications in a disability services context. By enhancing the connection between carers and caring environments through AR, this research aims to enrich disability service training experience and the overall quality of care.

2. Research Aims

This research aims to explore how augmented reality can be used to enhance learning processes within the care environment of a disability services worker. Further, the aim is to create a proof of concept augmented reality module, which can be further developed by industry partner, 'HowToo' as a template within their software.

3. Research Question(s)

Based on the issues outlined in the introduction and the derived aims, the question this project investigates is:

How does Augmented Reality influence disability service personnel's sense of connectedness and awareness of safety procedures in a care environment?

4. Methodology

Action research can be described as "learning by doing" (O'Brien 1998) or "on-the-job research" (McNiff 2013). 'Action' refers to what the researcher is doing and involves considering their circumstances, how and why they got there. 'Research' refers to data collection, reflection and generating evidence. Action research helps to provide the 'how' and 'why' questions which inform the practice; however, this cannot always be found through statistics or quantitative methods (Azhar et al. 2009). It is the cyclical process of becoming aware of one's learning and research methodology and how this informs their practice (McNiff 2013). Azhar et al. (2009), define this cycle as consisting of five successive stages as can be seen in Figure 1. The first stage, "diagnosing," is where the researcher identifies the problem. Next, the "action planning" stage helps to establish the target and approach for change, thus planning the action. "Action taking" is where these planned actions are implemented. The researcher then evaluates the outcomes from the previous phase. The "specifying learning" phase, while the final phase is often an ongoing process where the researcher reflects on their actions (Azhar et al. 2009). This systematic approach supported by "theoretical considerations" is what differentiates Action Research from other forms of study (O'Brien 1998). Thus, a similar cyclic and iterative process will be used to assess and reflect upon the research and learning. This is beneficial because it helps to provide an understanding of the relationship between "learning" and "actions" (McNiff 2013). This method forms a routine which will allow the continuous reflection and insight into the project. O'Brien (1998), further discusses that action research is "participatory" and "collaborative", which provides multiple insights on the research. In this case, the research will be done with industry partner, 'HowToo', and teachers from UNSW. This will be beneficial to the research as each team member has a varying perspective on the technical and theoretical aspects of the project.

As a digital artefact will be developed through iterative processes, aspects of Design Research will also be incorporated into the project. Cole at al. (2009) defines design research as a process which "consists of activities concerned with the construction and evaluation of technology artifacts". Comparatively, action research is more of a "change oriented" process where theoretical concepts and processes are observed by introducing change and observing the results (Cole et al. 2009). Design Research is also cyclic; however, it is mainly concerned with iterations through building and evaluating.

The industry partner, 'HowToo' typically uses the methodology of Design Thinking to develop software tools. Razzouk & Schute (2012) describe this as "an analytic and creative process" which goes through the cycle of "experiment, create, prototype, feedback and redesign". Similar to action research and design research, design thinking is based on the concept of constant cyclical development and feedback. Further, the development and evaluation of a digital artefact or product is similar to design research. However, design thinking focuses less on theoretical concepts and processes than action research and design research. Therefore, this methodology is optimal for the practical development of the digital experience, yet aspects of action and design research will need to be incorporated to fulfil the theoretical aspects.

Thus, through this research, a combination of action and design research will be undertaken to fulfil the theoretical and practical requirements of the project. For the theoretical aspect, a continuous cycle of action research will be followed, which consists of theoretical research and discussion, change and reflection on actions taken. For the practical development of the project, various iterations of the digital artefact will be worked through, reflecting on each change.

Figure 1. Azhar et al. 2009 Action Research Cycle.

5. Background Research/Literature review

This research aims to develop an Augmented Reality (AR) training module for personnel working in disability services. This learning content is continuously being updated and is critical for the safety of those in care and in caring roles. Therefore, the intent is to increase the effectiveness of the training and the attentiveness of the carers. Specifically, personnel need a way to learn safety procedures regarding syringe disposal in various care environments. The research question that is explored is: "How does AR influence disability service personnel's sense of connectedness and awareness of safety procedures in a care environment?". There will be focus on the implementation of AR in learning experiences to understand the benefits and challenges of the technology. Through the research, scholarly articles and journals from 2005-2020 will be examined to ensure accurate and relevant information.

5.1. AUGMENTED REALITY

Wang (2009) defines AR as "an environment where … information generated by a computer is inserted into the user's view of real world scene (sic)." Further, AR adds digital objects to the real environment (Doswell et al. 2006, p.1). AR brings virtual information into the user's real world view rather than pushing the user into a virtual world (Wang 2009, p.311). "AR is an amalgamation of computer graphics, vision and multimedia, which enhance the user's perception of the real world through the addition of virtual information" (Liarokapis & Anderson 2010, p.1). In the context of a learning environment, AR has the potential to enhance awareness and connection between caring procedures and caring environments. Comparatively, in Virtual Reality (VR), the surrounding environment is entirely digital (Doswell et al. 2006, p.1). VR systems constrain the user within a "magic circle" (Montola 2011), while AR systems augment the user's "sensory perception of reality" (Giglioli et al. 2015, p.1). AR is also less expensive and more efficient as it can be utilised on personal devices and does not necessarily require expensive headsets like VR. As Wang 2009 describes, in AR, fewer virtual objects need to be rendered. Further, AR integrates the power of computing environments with the comfort of the traditional workspace (Wang 2009, p.321).

5.2. AUGMENTED REALITY IN LEARNING

Chen and Wang (2008) argue that AR learning systems provide a "richer form" of learning which previously has not been possible (Chen & Wang 2008, p.351). AR systems improve student retention and participation because it makes learning "more fun" (Liarokapis & Anderson 2010, p.1). In conjunction with this, they provide more interaction with the learning environment, student experimentation and collaboration. AR modules can display information that is too abstract or impractical to present in real world settings (Chen & Wang 2018, p.695). As discussed by Kuo (2009), the learner's knowledge is developed through interaction with the environment. As discussed by Barsalou & Wiemer-Hastings (2005), there are strong links between physical activity and cognition. Thus, "materialising knowledge in physical forms can help learners to further advance" knowledge gained from written media (Chen & Wang 2008, p.353). AR allows learners to "see" and "listen" to digital information (Liarokapis & Anderson 2010, p.2), therefore appealing to a broader range of learning styles (Chen & Wang 2008, p.352). Further, AR environments display objects "with natural affordances for supporting interactions." (Chen & Wang 2008, p.351). These learning systems also allow students to retain content through active experimentation (Chen & Wang 2008, p.351). AR provides a platform that allows users to "play an active role in the learning process" (Terzopoulos et al. 2020, p.308). Along with this, AR provides a space for students to "work in teams, experiment and interact" with their environments in a "natural way" (Liarokapis & Anderson 2010, p.1). Learners also have greater control of the learning environment, allowing them to revisit a specific part of the modules as many times as they want (Liarokapis & Anderson 2010, p.2). Thus, AR has the potential to benefit the user's "long-term memory, problem-solving skills, enthusiasm and collaborative abilities, as well as increase learning performance and learning satisfaction" (Terzopoulos et al. 2020, p.309).

While there are proven benefits of AR in education, as discussed above, it is far from being a common technology in education (Cubillo et al. 2015, p.778). Cubillo et al. (2015) further discuss that this is due to the difficulty of developing AR learning modules, as this usually requires programming skills. They also highlight that there is currently a lack of tools for developing AR modules specifically for education. Another challenge that is faced when using AR learning modules is that most users only remember the special effects and bright colours rather than the learning content (Kuo 2009, p.441). While AR learning systems are beneficial to learning performance, they cannot wholly replace conventional teaching methods because some learners cannot become fully immersed in these augmented realities (Chen & Wang 2018, p.1).

While there are many studies into the effectiveness of AR in learning, there are limited examples of AR and its use in disability services. Most AR research is undertaken in primary and tertiary education, design and architecture, and city spaces and navigation. Thus, it is difficult to determine how AR modules will perform when used by the disability services personnel.

There are many studies which outline the effectiveness of AR learning since it increases collaboration, experimentation and attentiveness. The challenges of AR are also discussed, as they are often challenging to develop for those without coding experience, there is currently a lack of development tools for AR, and often the learning material is forgotten with all the bright colours and interactions. However, there has been limited research into the use of AR for learning in disability services contexts. The project will be focused on AR learning experiences within workplaces, specifically in Disability services, helping to fill this gap of knowledge.

6. Case Study

This case study follows the design and development of the proof of concept learning module for training disability services workers in regards to the safe disposal of sharps in their care environment.

6.1. DESIGNING A PROTOTYPE

Before developing the module, an outline of the user flow and general interface design needs to be completed. To do this, Figma will be used. Figma is a web-based collaborative interface design tool, which can be used to design and test digital prototypes.

First, the user journey is defined to ensure a clear understanding of the learning steps through design and development. To begin the user navigates to the learning modules web page and allows their device to access their camera. Through the live camera footage, location markers are displayed where the yellow sharps containers are kept. When the user moves closer to the containers, they can scan the AR.js marker. A video is displayed outlining how to dispose of the syringes. Then a 3D model is projected above the container, highlighting the maximum level to fill the container to. Written content is then provided, outlining where to drop off the yellow sharps container with a link to a webpage where the user can find these drop off locations.

One of the main challenges faced when developing a prototype design was making the module seem realistic in an AR context. As can be seen from Figure 2, this prototype does not give an idea of how the prototype might work in a real-life context. Through research, it was found that there used to be a fair few AR plugins for Figma and similar prototyping tools. The leading plugin, TorchAR, has been discontinued due to the inability to receive funding. What does this say about the future of AR? Is AR simply a novelty and not deemed profitable?

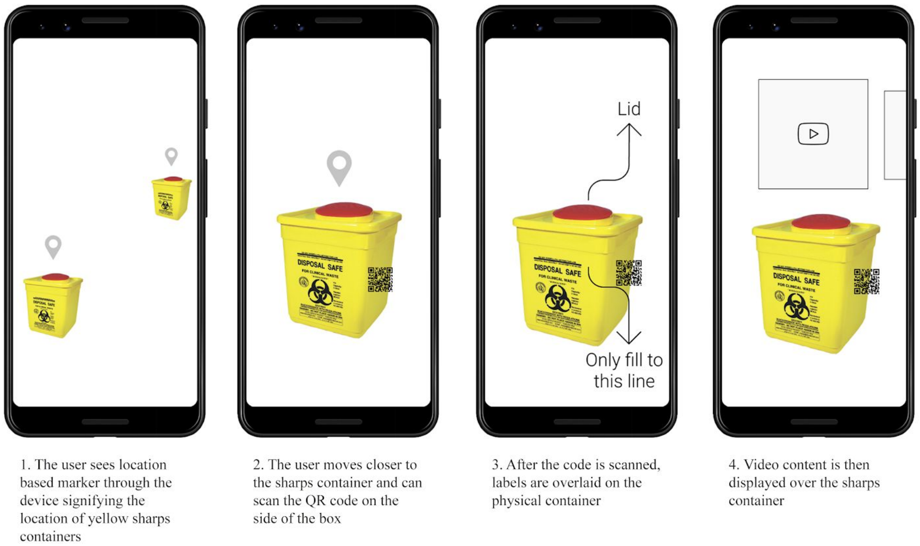

Figure 2. Initial Figma prototype.

Since it was difficult to fabricate an AR experience using Figma, Photoshop was then used to continue the design of the prototype. As can be seen from Figure 3, this prototype is much more realistic and provides an understanding of how the module will work in a real-life context.

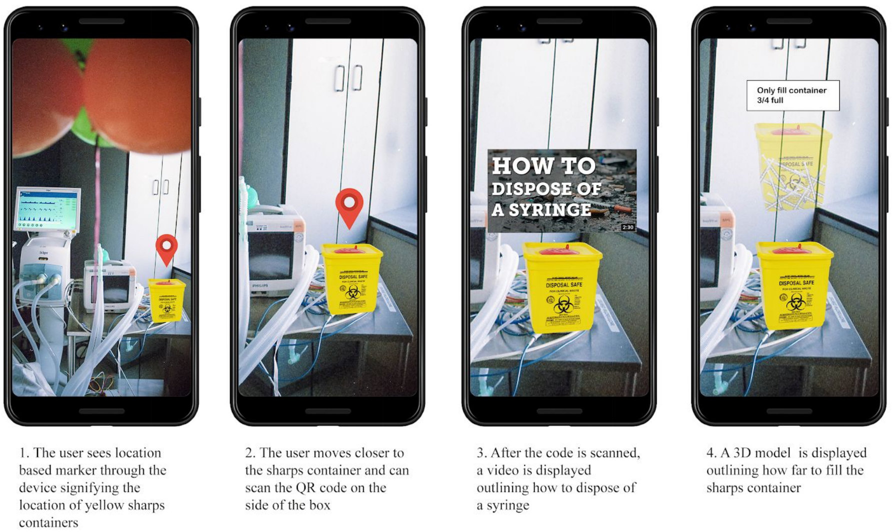

Figure 3. Photoshop prototype.

Members of the HowToo team tested the prototype, and they provided valuable feedback which can be taken into account when developing the prototype. The first point of feedback was that mobile devices are generally not used and are discouraged in a hospital setting. Health workers are generally deterred from using mobile devices at work, due to safety and hygienic purposes. Therefore, a better example would be in a home context where the user or a health worker needs to learn how to use and dispose of sharps for the first time. The User Interface (UI) of the prototype also needs to be developed to allow for more comfortable usage. Labels and titles need to be added to each step of the learning journey to enable straightforward navigation through the module. Further, "back" and "next" icons need to be added to allow the user to move through the module.

6.2. EXPLORING AR DEVELOPMENT POSSIBILITIES

For the development of the learning module, the various AR software needs to be evaluated. An inexpensive and easy to run platform is ideal, and it needs to be compatible with 'HowToo's pre-existing tool. The module also needs to be accessed by a mobile phone and compatible with both Android and iOS operating systems.

Terzopoulos et al. (2020) outline the various AR platforms available currently and provide information on the usefulness of each one. From this, it was decided that AR.js would be the most appropriate framework to create the module. AR.js is one of the leading frameworks for creating web-based Augmented Reality. The platform is "portable, lightweight, free-to-run and not resource-demanding" (Le & Nguyen 2020, p.74). This results in an inexpensive and relatively easy to run framework, thus making it ideal for this project. Further, It is compatible with the pre-existing tool, 'HowToo' and can be used on both iOS and Android devices. The program is still under development, however, meaning that there is a lack of documentation and resources (Le & Nguyen 2020, p.74). However, members of the 'HowToo' team are familiar with this program and can assist when needed. There are three main categories of functionality within the framework of AR.js. The first is marker-based AR, which detects a set barcode or pattern-based marker and displays content accordingly. Second is Image tracking, where the camera recognises an image, drawing or object and overlays visual elements on or around the object. These two functionalities enable learners to scan specific objects to view desired content, which would extend the capabilities of the physical space to provide additional learning content. Last, is location-based AR, which eliminates the need for a marker of image. In this method, the developer can allocate real-world coordinates to specify places of interest where the user can view content. This functionality could be used in the manner of a scavenger hunt where the learner needs to search their environment to find specific points of interest. In 2019, Google introduced a “Live View” on Google Maps, where there are directions overlaid on the camera view of the footpath. This is a great innovation as it allows users to connect directions on a map to their physical environment. Location-based AR would further immerse the learner in their physical environment and coupled with a marker and image-based interactions, and the learning experience would be engaging.

6.3. DEVELOPING A PROTOTYPE

Once the AR framework has been decided, it is time to begin the development workflow. The workflow diagram can be seen below in Figure 4.

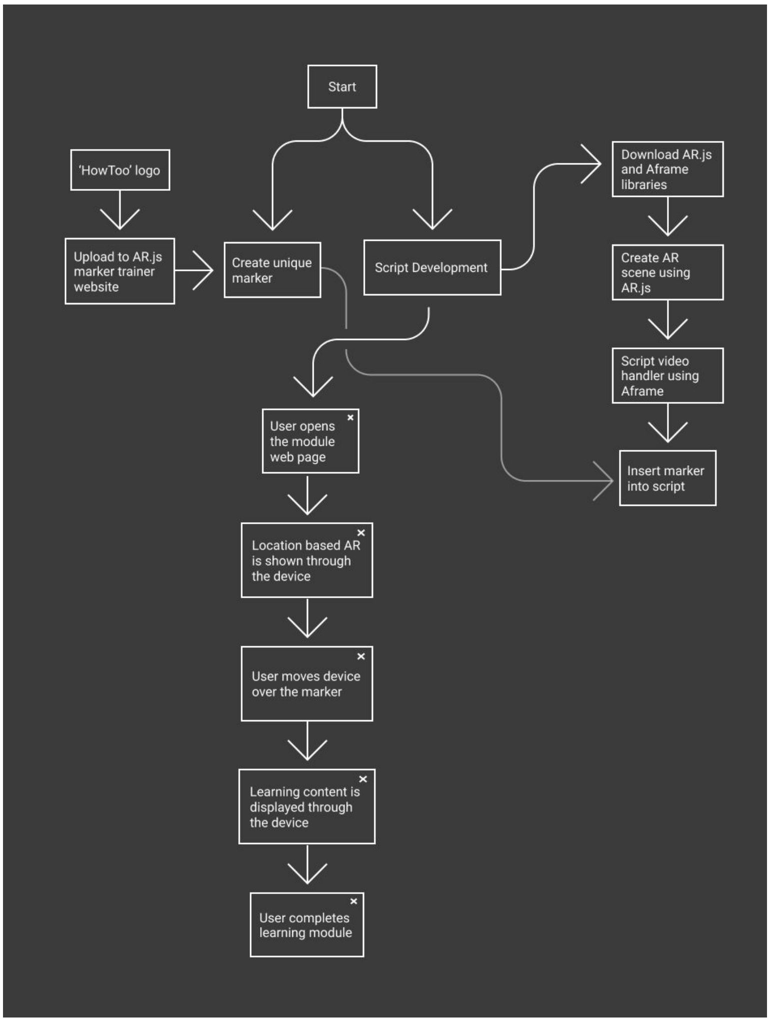

Figure 4. Workflow Diagram.

6.3.1. Creating a Unique Marker

For the development of the proof of concept, marker-based AR will be used with AR.js. The generic 'hiro' marker works well to produce AR, but when using multiple markers with various interactions, it is essential to make them more unique. To create this marker, an image needs to be uploaded to the AR.js marker generator website (https://jeromeetienne.github.io/AR.js/three.js/examples/marker-training/examples/generator.html). Then the website automatically creates a marker which can be downloaded and integrated within the script. Once added to the file, when the user scans this new marker with their device it displays the learning content. The main challenge faced when creating this marker is that it would not work at all. A variety of images were tested with a variety of content types with no results. The project was continued just using the generic 'hiro' marker.

6.3.2. Script Development

To develop the script, first, the AR.js and Aframe libraries are imported. This ensures that the Augmented Reality can be created and other forms of content can be displayed. Then AR.js is used to create an AR scene where the webcam input and unique marker are defined. The desired content is then integrated within the scene, which in this case is a video. With A-Frame, a video handler is scripted so that the video can be used on a variety of devices including ones with iOS operating systems.

One of the main challenges faced developing the script was the lack of resources and tutorials, especially in regards to displaying content other than 3D models. It is also challenging to add any graphic user interface elements, as most of the documentation is focused on displaying very simple content. The framework worked inconsistently and the script was difficult to analyse and recognise what was not working within the script.

In the first couple of weeks of development, an AR experience was created, but only displaying a simple 3D cube on top of the marker. From here, a more complex 3D model was tested, and a button was added to the module. The button when pressed brought up a modal screen; however, it was unrelated to the AR experience and was just scripted onto the webpage itself. From here, image content was displayed onto the marker. This was quite difficult to script due to the limited resources available. However, when it did work, it was inconsistent. Then the script was developed to display video content. This was even more difficult because it would not work on iOS operating systems due to the security settings on these devices. However, with some help from the team at HowToo, it was fixed and now compatible on all devices.

7. Discussion (evaluation and significance)

This research successfully explores the applications of AR in the training of users more specifically, how it can be used to influence a disability service worker's sense of connectedness and awareness of safety procedures in a care environment.

The AR platform, AR.js, is explored and used to create a working proof of concept prototype. Through this, the limitations of this platform and of AR as a whole are realised. AR.js is lacking in documentation and resources, which is the main challenge when developing the module. Therefore, there are graphical user interface elements which are lacking in the proof of concept. Through research, it was clear that AR is difficult to develop and manage for those with little experience in programming javascript. This problem can be overcome by incorporating the concept into HowToo's existing software which allows users to build custom learning modules quickly. This future development would allow users to easily integrate AR interactions within learning modules without programming knowledge required. Thus, expanding the usage of this technology and increasing the effectiveness of learning content to make more meaningful experiences.

Through research and development of an AR prototype, this research results in the expansion of knowledge related to the applications of Augmented Reality within a learning environment. This research will be contributing to the existing works relating to the use of AR in educational contexts. However, it focuses more on how AR connects the user to their learning environment. Further, there are currently limited resources regarding the use of AR in disability services, specifically regarding the training of safety procedures. With more time and resources, the research could explore in greater detail the development of a user-friendly interface. Further, user testing would provide great insight into how this research functions in a real-world setting. 'HowToo' can further develop my prototype into a template block within their custom learning software. This would allow users to easily incorporate AR technology into a wide range of different industries and learning contexts. This research expands the knowledge of AR usage and how this can enhance the learning experience of disability services personnel by connecting the user to their environment.

8. Conclusion

The use of AR learning modules can be used to connect users to their physical environments and thus create more meaningful learning experiences. This is explicitly seen in the context of ensuring disability service personnel understand safety procedures within their care environment. It was found that AR.js is one of the best platforms for creating web-based AR experiences because it is inexpensive, easy to run and compatible with a range of devices. However, the lack of resources and documentation made the platform challenging to use, especially for displaying complex media, especially graphical UI elements. Despite this, a successful proof of concept prototype was created. This prototype can now be further developed by HowToo and integrated into their custom learning module tool. This will allow AR to become more accessible to a wide range of users, regardless of whether they have any programming skills. This development will enable users to quickly and easily incorporate AR interactions into their learning modules and thus create more meaningful experiences because the user will be more connected to their environment. This can be applied to a variety of industries, especially for those working in disability services. Therefore, the use of AR in learning modules has the potential to connect users to their learning environments and thus result in a richer learning experience.

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References

Barsalou, L., & Wiemer-Hastings, K. (2005). 'Situating Abstract Concepts'.Grounding Cognition: The Role of Perception and Action in Memory, Language, and Thinking (pp. 129-163). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511499968.007

Chen, R. & Wang, X. (2008), 'Tangible Augmented Reality for Design Learning: An Implementation Framework', Proceedings of the 13th International Conference on Computer Aided Architectural Design Research in Asia, pp. 350-356.

Chen, Y. & Wang, C. (2018) 'Learner presence, perception, and learning achievements in augmented–reality–mediated learning environments', Interactive Learning Environments, pp.695-708, doi: 10.1080/10494820.2017.1399148

Cubillo, J., Martin, S., Castro, M. and Boticki, I. (2015), 'Preparing augmented reality learning content should be easy: UNED ARLE—an authoring tool for augmented reality learning environments', Computer Applications in Engineering Education, Vol 23, pp. 778-789. doi:10.1002/cae.21650

Doswell, JT., Blake, MB., & Butcher-Green, J., (2006), 'Mobile Augmented Reality System Architecture for Ubiquitous e-Learning,' Fourth IEEE International Workshop on Wireless, Mobile and Ubiquitous Technology in Education (WMTE'06), pp. 121-123, doi:10.1109/WMTE.2006.261358.

Giglioli, I., Pallavicini, F., Pedroli, E., Serino, S., Riva, G., (2015), 'Augmented Reality: A Brand New Challenge for the Assessment and Treatment of Psychological Disorders', Computational and Mathematical Methods in Medicine, vol. 2015, pp.1512–1524, doi: 10.1155/2015/862942

Kuo, M. (2009), 'An AR-Based Navigation Interface', Proceedings of the 14th International Conference on Computer Aided Architectural Design Research in Asia, pp. 441-449.

Le, H. Nguyen, M. (2020) 'An Online Platform for Enhancing Learning Experiences with Web-Based Augmented Reality and Pictorial Bar Code.' In: Geroimenko V. (eds) Augmented Reality in Education. Springer Series on Cultural Computing. Springer, Cham. https://doi.org/10.1007/978-3-030-42156-4_3

Liarokapis, F. & Anderson, E., (2010) 'Using augmented reality as a medium to assist teaching in higher education', Proceedings of the 31st Annual Conference of the European Association for Computer Graphics (Eurographics 2010), pp 9-16.

Montola, M. (2011) 'A ludological view on the pervasive mixed-reality game research paradigm.' Personal and Ubiquitous Computing, pp.3–12, doi: 10.1007/s00779-010-0307-7

Terzopoulos, George, Kazanidis, Ioannis, Satratzemi, Maya & Tsinakos, Avgoustos 2020, 'A Comparative Study of Augmented Reality Platforms for Building Educational Mobile Applications', in Internet of Things, Infrastructures and Mobile Applications, Springer International Publishing, Cham, pp. 307–316.

Wang, X. (2009) 'Augmented Reality in Architecture and Design: Potentials and Challenges for Application', International Journal of Architectural Computing, 7(2), pp. 309–326. doi: 10.1260/147807709788921985.