Intelligent Environments 2016
P. Novais and S. Konomi (Eds.)

doi:10.3233/978-1-61499-690-3-249

Harnessing the Potential of Augmented and Virtual Reality for Military Education

(LCDR) Andrew T. GREENWOOD[a,1] and (CDR) Michael P. O'NEIL[b, 1]
[a] *U.S. Coast Guard Force Readiness Command (FC-T), Washington DC*
[b] *U.S. Coast Guard Human Systems Integration Division (CG-1B3), Washington DC*

Abstract. Augmented Reality, Virtual reality and technologies have been pointed to as the next wave of technical innovation. As the capability matures, many possibilities exist to integrate into military education. This paper will provide the theoretical foundations and will show how to improve and advance to new frontiers in education and design innovation. Simulations applied for military purposes for many years. Virtual and Augmented Reality can provide application to various industries that again can be modeled after military educational design. This paper explores existing and potential applications in intelligent environmental design in military education.

Keywords. Augmented Reality, Virtual reality, Simulation, Military Education, Product design, 3-D rendering, Vygotsky, Social Development Theory, Connectivism, Environmental Augmentation, Educational Environments, Intelligent Design.

Introduction

Technology continues to change the way we interact with the world. Mobile devices connect and empower us in ways that would have been difficult to imagine a few decades ago. This integration of technology into every facet of our daily activity has happened for good reason: it allows us to extend our human capabilities and develop knowledge in ways not previously possible. This phenomenon has profound implications in the realm of military education and training, and this paper will discuss two emerging technologies: Virtual Reality (VR) and Augmented Reality (AR).

VR and AR both offer unique capabilities for a variety of purposes. VR can be used to simulate an existing, planned or imagined environment, creating contextual and interactive fidelity for the learner. AR affords the ability to overlay images, text, video and audio onto existing structures, space or imagery in real time and in context with learner's environment. The immersive and engaging nature of VR and AR make them especially attractive tools for education.

This paper focuses on andragogical aspects of VR and AR as a way of understanding applications for military education context. While there are many potential applications, we will briefly discuss current research and application of VR and AR in education, and state the case for the inclusion of these technologies as integral approach for military education.

[1] Corresponding Author.

1. Theoretical Foundations

1.1 Distinguishing AR and VR from traditional simulation

Simulations occupy a unique place in military education and training. Fletcher & Chatelier (2000) observed that simulated environments possess a unique ability "to make the invisible visible, compress or expand time, and reproduce events, situations, and decision points, enabling us to train aspects of performance that would otherwise be inaccessible." [1] VR and AR evolved from the larger world of simulation to become essential elements of of the military training. But important differences set VR and AR apart from traditional simulation. As summarized by Winn (1993), VR's distinctive ability to immerse and connect the learner in ways not possible in standard simulation is its hallmark. Specifically, VR's ability to reify subject matter through direct, first-person experience is its primary distinguishing characteristic [2]; we would argue that AR possesses the same characteristic, albeit in a different medium. Both technologies enable the learner to interact and connect with subject matter in ways not possible by other means. As we will examined below, this learning is an active and constructive process, lending itself to well-established theories of learning.

1.2 Social Development Theory

With the wide dispersion of portable computing technology, examples of VR and AR learning are readily observable in informal, voluntary educational activities. Participants in massively multiplayer online (MMO) games, for example, learn almost exclusively in a virtual, immersive, and collaborative context. Smartphones, watches, tablets infuse virtual resources to supplement learner activities in the real world through texting, screenshots, and other readily-available media (imagery, video, screenshots, etc). AR adds the potential to overlay these elements directly onto real world environments; participants are able to interact face-to-face, enabling kinesthetic learning through physical interaction in temporally and spatially accurate contexts [3]. Learning in these socially–created, distributed virtual communities parallels the practices of cutting-edge knowledge-based workplaces. Learning in this context is both active and constructive, with the learner creating subjective representations of reality. While constructivist theory provides a broad context for understanding VR and AR in education, social development theory (SDT) provides a more granular view. As proposed by Vygotsky, SDT contains three major themes pertinent to AR and VR:

- *Social Interaction.* Social Interaction plays a fundamental role in the process of cognitive development. In contrast to Piaget's understanding of development (in which development necessarily precedes learning), Vygotsky proposed that social learning precedes development, occurring first between people (inter-psychological) and then inside the learner (intra-psychological) [4]. The contextually rich environment provided by AR and VR provide uniquely furtive ground for learners to leverage social interaction and augment their understanding of their surroundings. In formal and informal educational settings the social interaction for adults also will assist in cognitive development.

- *The More Knowledgeable Other* (MKO). The MKO refers to anyone who has a better understanding or higher ability level than the learner with respect to a given task, process, or concept. The MKO role is traditionally associated with teachers, coaches or accomplished performers, the VR and AR invite new possibilities. The MKO could also be a avatar, collective, or the simulation itself [5]. The rich contextual information available through VR or AR offer the capacity to supply information or insight necessary for comprehension or knowledge direct to the learner, in context, at the moment of choice, with AR/VR technology acting as the intermediary.

- *The Zone of Proximal Development (ZPD)*. The ZPD has been described as the distance between a student's ability to perform a task under expert guidance and/or with peer collaboration and the student's ability to solve the problem independently. According to Vygotsky, learning occurs in this zone [5]. Considering VR/AR technology's basis in simulation as described by Fletcher & Chatelier, these technologies uniquely support the ZPD by providing the learner with a low-risk, low-consequence, yet highly interactive and realistic environment in which to develop the skill to solve problems independently.

1.3 *Connectivism*

In keeping with Constructivist Theory, Connectivism explains how the Internet and other technologies have created new opportunities for people to learn and share information with collectives. Connectivism acknowledges that learning is a process that can occurs within nebulous environments of shifting core elements – not entirely under the control of the individual [3]. The technologies this paper addresses reflect connectivism. Learning is no longer an internal, individualistic activity.

In VR and AR learning occurs with new tools. By integrating external sources, virtual or augmented developed, the learner is assisted and has help mastering learning outcomes. Informal learning is a significant part of how we learn. Integrating technology into formal educational environments helps to integrate how learning occurs in a variety of ways in and outside of the classroom [4]. VR creates collaboration opportunities, reducing the time needed to facilitate learning and creating in business and product development. VR can be emphasized in human-product interaction and the function in product design and analysis. Utilizing VR in development and design applications affords opportunities to collaborate with 3D renderings of future workspaces, and educating the future workforce in the space.

2. Utilizing VR and AR in Military Education

Augmented Reality (AR) interfaces enable "ubiquitous computing" models. Students carrying mobile devices through real world contexts engage with virtual information superimposed on physical landscapes (such as a tree describing its botanical characteristics or a historic photograph offering a contrast with the present scene). This curated immersion can infuse digital resources throughout the real world, augmenting student's experiences and interactions [5]. AR allows educators a level of flexibility which is useful in providing content. It can be utilized through a variety of mediums, mobile/wearable devices, tablets, laptops, and computers. AR is portable and adaptable to a variety of scenarios and can be used to enhance content within a formal setting and provide context to content found in informal settings. Content can be extended into the world and combined with other technologies to enrich their individual applications [6].

2.1 *Virtual reality in and out of the classroom*

Aviation was one of the first industries to adapt fully immersive simulators, having long been certified by the FAA as sufficient for used in check rides and other important flight training [7]. With the cost of entry ever decreasing, virtual reality based simulators and instruction are now used in a wide variety of industries including medicine, computing, nuclear, automotive, defense, aerospace, education and entertainment (to name a few). The essence of VR is perhaps best captured by Sherman and Craig, who describe it as "...a medium composed of interactive computer simulations that sense the participant's position and actions and replace or augment the feedback to one or more senses, giving the feeling of being mentally immersed or present in the simulation" [8]. A wide variety of visualizations, renderings, 3D models and virtual environments may all be considered as VR given this definition. However, Burdea and Coiffett emphasize three critical properties of VR that distinguish it from other means, the "3 I's": immersion, interaction and imagination [7].

Burdea was one of the first to discuss the issues of virtual reality in education. Integration of tasks into the immersive environment created the link to helping learners obtain learning outcomes. These outcomes are supported through traditional formal and informal learning materials that the learner can reference outside of the VR space. Current technology for VR requires support and infrastructure that is not needed for AR. While VR exist virtually the equipment and space to run the simulations is needed and normally is in a lab style setting. This will allow the instructor to facilitate the virtual experience and guide the learner through the learning objectives. Fully immersed the learner will have the needed interaction through the tasks and virtual environment. The design for educational needs should ensure the learner has the necessary tools to complete the assigned task. As capabilities increase, a higher level of fidelity will be possible across applications. However, the potential currently exists for virtual environments to be used in education.

In aviation applications, flight simulators are more cost effective than using an aircraft. In addition, many emergency procedures would be unsafe to practice in flight. In general, development of flight simulators also led to a better understanding of the technical requirements underlying VR. Like VR, simulators are only effective if from the participants view, the experience is an accurate one [9]. This example of existing of VR used in training can be applied to other industries. With Haptic feedback medical simulations could be used to trained professionals in the field. As in aviation other transportation industries could use simulators to train their employees.

2.2 *AR in and out of the classroom*

In formal training environments, classrooms are constrained to the resources available in the room. The learner's reach can be expanded through individual devices and internet connectivity to include readily accessible information, but discovering new data can be problematic as learners may easily lose focus without curated content to view. In VR and AR, in contrast, material can be attached directly any object in the learning environment (simulated or real). If a lesson is configured to allow mobile device access, the learner can retrieve stored content to augment the lesson from a variety of triggers. Aurasma, for example, is a free mobile application that can scan images to trigger content (e.g. videos, animations or 3D data) [10]. This capability allows educators to embed content virtually anywhere. 3D simulations displayed virtually over real objects can be interacted with and change based on the learner inputs. Depending on the device and capabilities of the software, learners can select to view the content again, providing learning materials that can be referred to after the instruction has ended. Content can further be shared among peers and instructors. Classrooms that are more lab and student oriented can provide a more collaborative environment when sharing and participation is extended beyond the physical limitations of the classroom.

As AR technology is more widely employed in education, a growing body of work offers evidence of its utility. In the European Union, Webel & colleagues (2011) undertook study of VR and AR instruction for assembly and maintenance tasks included the use of expert teleconsultation, 3D model overlays, haptic feedback, virtual notation and AR-based instruction [11]. Results have been favorable when comparing VR and AR based methods with classic instruction methods, including roughly equivalent transfer of training as compared with and a reduction of error when delivering AR instruction [12]. In the defense sector, the US Navy (NAWCTSD/SPAWAR) is currently exploring the use of VR and AR for training and manufacturing under a Collaborative Research and Development Agreement (CRADA) with the Newport News Shipbuilding (NNS) for the CVN 78 Program. Scale models of crew compartments aboard CVN 78 with embedded AR functionality and user-triggered content have been successfully developed and demonstrated. The automotive industry has recognized similar utility for VR and AR, with Volkswagen and BMW employing the technology in their assembly lines [8].

3. Limitations of VR and AR

Although VR and AR offer numerous possibilities for military education, the both technologies have their limitations. As a case in point, a recent meta-analysis of VR and AR training in the automotive service industry concluded that although VR and AR education reduced error rates and was generally preferred over traditional training methods, research has focused almost exclusively on simple, skill-based tasks [12]. Additional research is needed to establish effectiveness of VR and AR, and in particular, methodologies for determining the proper application of VR and AR for training complex, knowledge-based tasks. Further, research indicates that VR and AR training methods must be tailored to match the learner's expertise for maximum effect. VR and AR can be misapplied, applied in excess, or under-utilized if without careful consideration of its target audience and the task [11, 12].

4. Conclusion

Virtual Reality and Augmented Reality technology are already in use by learners in a wide variety of industries and settings, and are helping them to learn more efficiently and effectively [13]. With the wide dispersion of affordable and capable portable computing, VR and AR become increasingly practical avenues for learning, and should be considered as integral approach for education in the military context. Although evidence suggests that care must be taken to tailor virtual and augmented content to the learners experiences, VR and AR remain a uniquely engaging way to deliver content in formal and informal learning environments, allowing the learner to collaborate, and providing a unique setting for deeper understanding of subject matter. As results from the studies cited have shown, VR and AR systems can provide motivating, entertaining and engaging environments conducive for learning. In addition, AR applications in educational settings are attractive, stimulating and exciting for students and provide cost-effective support for learners [14].

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