MOOC for AR VR Training:

Obstacles, Challenges and Usability

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***Abstract*—This paper provides a case study of massive open online course (MOOC) for augmented reality (AR) and virtual reality (VR). The research studies the obstacles, challenges and usability issues entailed in the management of a novel MOOC for AR and VR training. The electronic learning form of MOOC has been adapted and made available for a number of universities and organizations. It brings learning opportunities for university students and industrial professionals to go through online-based courses on their own pace, and some MOOCs provide certifications for specialized subjects. However, the nature of working on AR and VR requires specialized equipment such as mobile tablets with high computing capability, workstation with fast graphic processing units (GPU) and head-mount-devices (HMD). This case study investigation outlines an overview of the potential obstacles and issues with the intention of how MOOC addresses best practices and the fundamental requirements of AR and VR training.**

Keywords—MOOC; Augmented Reality; Virtual Reality

I. Introduction

The fundamental elements that determine the impact that any education technology tool can make are informed and determined not only by its cost or speed or accessibility, but also by its usability for a diverse and inclusive society. So the question of how we- as diverse users of many levels of physical and cognitive ability- can interact with any tool will be central to its uptake and success.

In this regard, a novel Massive Open Online Course (MOOC) has been developed and tested, and found to be successful with various genres, subjects and contents, online learning approaches that engage socially, et al. However, it remains unclear how well the MOOC works for certain technology-specific contexts such as educational and training applications using augmented reality (AR) and virtual reality (VR) in an on-demand mode, in diverse off-campus environments, with diverse users. MOOC participants can be from all walks of life ranging from active students from academia to professionals who have years of experience in their field of work. This paper describes a case study of managing criteria and practicality of MOOC for AR and VR.

In the context of AR and VR, recent technological advances have allowed augmented and virtual experiences to be possible on handheld mobile devices or low-cost head-mount-displays (HMD). This means it is possible for more people to experience basic AR and VR content using their own devices. However, computing performance and capabilities of users' devices vary subject to several speculated handling factors including complexity of digital content and specialized sensors.

II. Background

Our research referenced to previous work of MOOCs and online e-learning on AR, VR and other digital creation courses [1][2][3][9][10][11]. A MOOC for AR and VR allows participants to learn at self-pace [1] while some other MOOCs require specific timeline for enrollment and require certain form of fees [10][11]. Usually a MOOC allows certain level of communications and interactions with learners and instructors within the social learning platform. Course content may also be experienced in an organic way so that learners could pick up new knowledge, skills and assignments from various perspectives. One of the key elements of MOOC is that learners can choose to follow the provided syllabus, or decide to establish network with other learners to produce an outcome using a different set of new solution with an end-goal mind-set. However, there are some learners who prefer conventional online courses that provide a linear video-based step-by-step learning curve [3][9] which can be easier to learn. In such case, interactions among learners are minimum. On the other hand, a study [12] highlighted that it brings benefits of having conventional MOOC enhanced with AR feature, which speculated to provide a gamification learning experience.

One of the ways that MOOCs can provide AR and VR experiences is through using consumer mobile devices and

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low-cost HMDs. However, more research is needed on how to introduce these devices into an online learning setting, and in particular how to develop digital content for AR and VR. The basic expectation of AR is that users could experience the real-world enhanced with digital context, this shall be operated in a near real-time manner and quicker computer graphics processing time. However, VR demands higher fidelity of computer graphics and realistic visual quality in terms of immersive user experience. The main contribution of our work is to provide an investigation on how some of these basic criteria of AR and VR can be catered in MOOC setting. Fig. 1 illustrates an example of MOOC which promotes peer interactions.

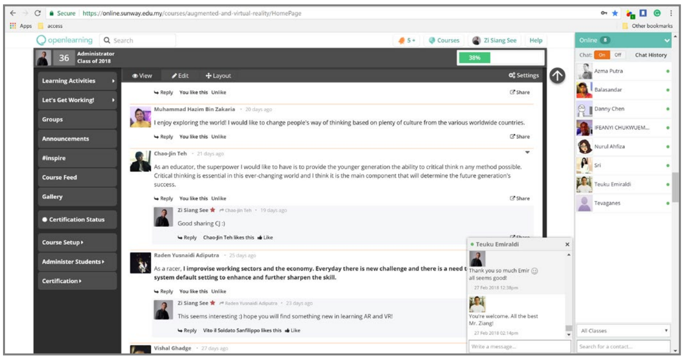

Fig. 1. MOOC with peers interaction.

The extent to which learning experiences utilizing AR and VR can be delivered online greatly depends not only the scalability and reliability of the MOOC platform but also the educational affordances of the MOOC platform used to deliver the course. The design of the example of MOOC on AR VR training and the educational affordances of the OpenLearning platform [1] appeared to lead to a high level of peer interaction although further research is needed to determine the actual cause of that increase. In an ideal situation, with the appropriate design of a MOOC learning workflow, teachers and instructors are there to support the learning process rather than take control of it.

III. Case Study and Approach

Case study methodology was popularly used by the University of Chicago, Department of Socialogy since early 1900 [4]. A case study is a research strategy used when attempting to understand complex organization problems; in essence allowing one to focus on something which is sufficiently manageable and can be understood in all its complexity [6]. Case study can be done by giving in-depth attention to completeness in observation, reconstruction and analysis of the cases under study [5]. Triangulation for this case study is achieved via methodological triangulation where multiple sources of data are used, being inspected and discussed. Yin [7] highlighted that the reasons of conducting case studies includes explaining the linkages between causes and effects, to describe a phenomenon in its own context, to explore an issue or a question, etc. This is done via the usage of several common types of case study sources of evidence as recognized by Stake [8] and Yin [7]. These includes archival records, interviews, analytics, direct observation and participant observation.

As AR and VR continues to evolve becoming part of our daily lives as shown in Gartner's Hype Cycle [16], the demand for new generation workforce with AR and VR readiness may be supported via formal education and social way of learning, such as MOOCs. Learning through MOOC usually are more flexible in terms of time and place when compared to a formal education environment. Other unique characteristics of MOOC includes the option of paid or free certification, on-demand customized content dissimilar to conventional university syllabus.

A. *Augmented Reality*

Augmented Reality (AR) mixes a live real-world view with digital interactive content on a mobile or wearable device. One of the key enablers for this is tracking technology, such as computer vision techniques for tracking off pre-defined markers or markerless images. In such case, the mechanism of having these digital elements and experience must be provided instantly. For instance, a way-finding AR experience may require the mobile user interface to provide accurate guidance of directions so that a user would follow it correctly. Therefore, graphical elements have to be fast, intuitive and simple to understand for users. The performance of mobile devices and tablet may vary depending on the hardware capability. In the context of learner's device used for MOOC in AR training, it may be difficult to assume everyone has an AR-ready device. Unlike a university laboratory environment, students can be provided with standard equipment and facilities to learn. MOOC learners may range from resourceful person to a student with tight budgets to spend. Therefore, it may be reasonable to imply two sets of goals in designing the learning outcome of MOOC for AR training, a basic low-end goal and another high-end goal which requires specialized equipment.

Azuma [13] highlighted that displays, tracers, and AR systems in general need to become more accurate, lighter, cheaper, and less power consuming. In such context for AR, we categorized basic or high-end goals based on subjective observations:

- Image-based tracking (basic goal) has been one of the most-used AR tracking method to date. It is commonly being used on flat surfaces, such as AR on books, magazines and printed advertisement. This can be operated using the auxiliary camera of user's mobile devices or computers. This is a vital technique that ought to be covered in the basic training of AR in any form.

- Way-finding AR experience (basic goal) is crucial and practical for wide range of purposes. However, it has not been easily adapted in many AR authoring platforms. One of the main reasons that it is not as common as image-based AR is that such mechanism relies on both capabilities of a device's camera and GPS, which can widely vary among users.

- Authoring of conventional multimedia (basic goal) is essential to develop usable content for AR. These

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include working with basic multimedia elements of text, image, video, animation and sound. However, it may be difficult to cover these areas within the scope of AR training, therefore it may be reasonable to set this as a knowledge-based requirement prior joining the training.

- Interaction (basic goal) brings user control over the context of AR. Graphic user interface (GUI) such as buttons and instructions may have to be simplified that fits to the screen size of mobile devices. Interaction such as pinch, rotation, resize AR content are key features can be introduced for training, this is especially practical in visual programming where learners could explore how these interactions can be customized. Fig. 2 shows an AR example of image-based tracking used for providing a 3D layout of emergency evacuation in a building, with basic interactions for extended details.

Fig. 2. Image-based AR tracking with basic interactions.

- Authoring of AR-optimized multimedia (high-end goal) requires special set of skills and knowledge. AR on mobile usually operates on cloud-based or local-based. Local-based AR content is hosted in the device. However, cloud-based AR usually rely on the bandwidth of internet speed for delivering adequate content to be shown in mobile, crafting small and visual-appealing multimedia content such as CAD/3D file which can be transmitted via internet quickly works with careful considerations.

- 3D object tracking or markerless tracking (high-end goal) allows users to gain AR experience by tracking real-life objects and environment. However, some of these features requires to work with extensive technical preparation and visual programming. For now, AR Kit and AR Core are some of the software development kit (SDK) which introduce markerless AR but they only work with specific mobile devices with higher grade and/or powerful processing power.

B. *Virtual Reality*

Virtual Reality (VR) which can be referred to as immersive multimedia or computer-simulated life, replicates an environment that simulates physical presence in places in the real world or imagined worlds and lets the user interact in that world. It is essential that VR requires high fidelity computer graphics processors and workstations that meets operatable computational requirement of some room-scale VR headsets. For instance, Windows Mixed Reality (WMR) headsets or Vive Pro which offers viewing resolution of 2880 by 1600 pixels, need high-grade and costly GPU for recommended requirement. In such scenario, this does not fit into a common financial situation of most learners. Therefore, it would be ideal to introduce the basics of VR using low-cost HMD such as google cardboard or OEM stereo viewer for fundamental courses. In addition to this, stretch goal that uses high-end equipment may still be introduced by setting up the assignment in low-end requirement, and suggest learners to experiment the outcome by accessing to any rented facility or equipment.

As defined by Ivan Sutherland [14] in 1965, “The ultimate display would, of course, be a room within which the computer can control the existence of matter. A chair displayed in such a room would be good enough to sit in. Handcuffs displayed in such a room would be confining, and a bullet displayed in such a room would be fatal”. For MOOC, we provide a subjective basic and high-end goals which may be relevant to the fundamental of VR:

- Environment simulation (basic goal) is a fundamental aspect of VR. In the basic training, it is ideal to provide necessary knowledge and assistance to learners for creating a basic “virtual environment”. This includes managing lights, physics, shapes, textures or the environment. This may be an area that requires longer period of practical training. Crucially, spherical panorama is another practical option for reproducing VR360 photo of a real-world environment.

- Locomotion and interactions (basic goal) is crucial for VR experience. This refers to how users are allowed to move around in VR environment. However, some features such as room-scale tracking is only available in specialized devices. Therefore, these can still be introduced to learners and it can be tested when they possess such equipment. Manufacturers are making some of these devices lower cost and accessible with greater range of users.

- Presence (high-end goal) is vital for VR, virtual hands, avatar or virtual-body are some of the examples that promote self-realization in VR. Fig. 3 shows a user with controllers, seeing a pair of hands in VR.

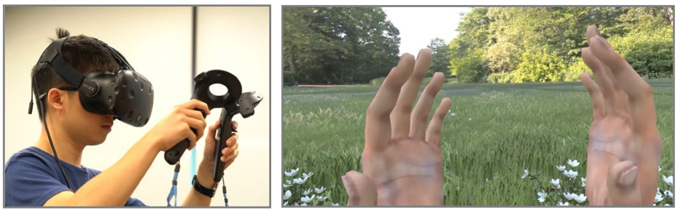

Fig. 3. User experience in VR which can be hightlight in MOOC training.

- Authoring hyper-realistic VR content (high-end goal) is a challenging process in research-creation. This needs a workflow with higher computational capability for visual graphics. Techniques such as 3D scanning using photogrammetry and working with building information modeling (BIM) requires additional training which is part of the long-term effort in VR research-creation.

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IV. Discussion

Communications among peers is significant to keep the learning community active. Similarly, this resembles the behaviors of learners similar to casual interaction within social media platforms. Post reaction of "comments" and "likes" are essential for involvement of learners. This helps learners to ask or answer questions, share new solutions and demonstrate their achievement of coursework. Fig. 4 shows an example of interactions of a MOOC in AR VR [1] within a timeframe of 3 months. Fig. 5 shows MOOC related to virtual design and construction (VDC) across the timeline for more than 3 years, with over 4,903 learners [2]. In demonstrates the livelihood of supporting learning community that is sustainable and scalable in MOOC platform. To illustrate, fig. 6 demonstrates graphically a MOOC's global diversity of learner profiles from 152 countries.

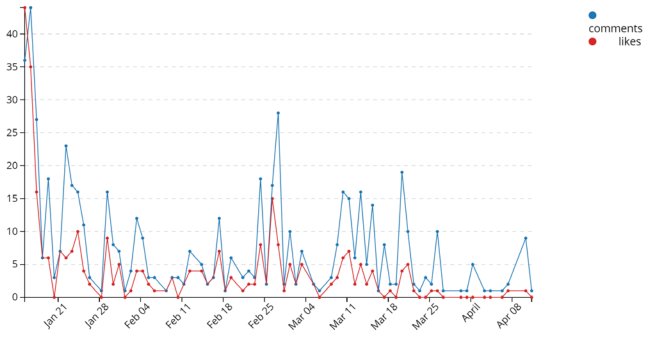

Fig. 4. Interaction of learners in 3 months, AR VR subject.

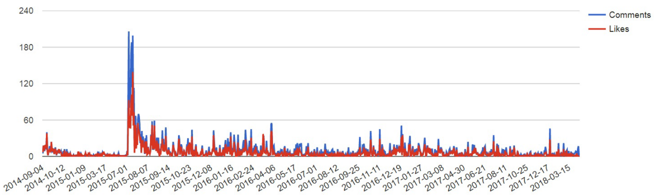

Fig. 5. Interaction of learners in 3 years, VDC subject.

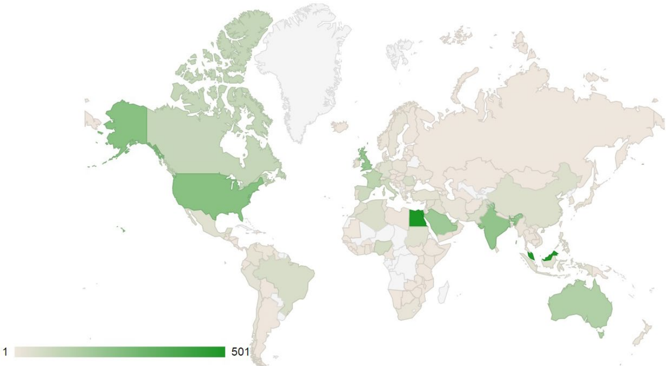

Fig. 6. Diversity of learners profile, benefited from MOOC platform.

While every MOOC platform is designed differently, provider from some MOOCs [1][2][15] have focused on developing a flexible and extensible platform that supports a variety of input devices. This is an example of student-centred approach effort which makes off-campus and on-demand learning practical. As AR/VR technology develops, it is possible that MOOC platforms will adapt to automatically capture learning experiences conducted through AR/VR headsets, tablets and other tools. Meanwhile, learners may want to complete the entire learning experience through a mobile or a tablet device, making it difficult to require students to use a desktop computer.

V. Implications and Conclusions

This is an on-going investigation and research into best practices of training in AR and VR, particularly in MOOC platforms. We hope this case study can benefit to any training design that involves AR and VR, and other emerging technologies. In the future, the case study will also experiment with hybrid facilities such as 3D scanning and VR avatar.

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