The Creation of an Immersive Environment to Provide Shop Equipment Training

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Abstract

The purpose of this project was to create an immersive environment to provide an introduction to machine shop equipment on the Penn State Berks campus. Using a 360º video camera, operational videos of a lathe, vertical band saw, horizontal band saw, mill, and arc welder were produced. The videos were edited to incorporate informational narration and processed for viewing on either a desktop computer, or with an immersive virtual reality (VR) headset. Videos were published and distributed such that the instructional videos could easily be incorporated into a curriculum. Results of the project will be assessed for both immersiveness as well as pedagogical value.

Keywords: Virtual Reality, Augmented Reality, 360º Video, Teaching with Innovative Technology

Introduction

Many engineering programs incorporate hands-on experience in manufacturing methods and fabrication. The experience levels of students prior to the training can vary widely, and it's not unusual for some students to have no familiarity with the equipment, let alone its operation. Integrating a virtual, immersive, experience as the first step of the training process may serve to offset some of the cost and time constraints associated with student machine shop training. By using 360º video as a method to introduce the student to the shop and its equipment, the learning curve can be reduced, and the subsequent hands-on training process is made more efficient and effective. This technology allows students to gain experience and exposure without having to step foot in the shop. In this project, a series of operational videos were developed to give students an in-depth look at each piece of equipment. Each video portrays a machine performing a task, while audio provides an introduction to its capabilities. The videos therefore provide information on both the form and function of equipment in the shop by means of a 360º, active, immersive experience. This increases the shop awareness and comfort level of students, who will subsequently be provided hands-on training. In addition to providing the student with an introduction to the campus machine shop, these videos also have the potential to serve as virtual training for engineering programs that may not have a functioning shop.

VR and 360º video are emerging technologies in many areas, including manufacturing, the medical field, and the automotive industry.[1-4] Traditional hands-on training in these sectors is time-consuming, costly, and requires a lot of resources, and the capability to provide virtual training is an attractive alternative. VR is also becoming an effective teaching tool in education.[5-7] There are several attributes which make it particularly appropriate for educational purposes. Its fundamentally interactive nature provides for a more active, immersive, learning experience than traditional lessons. These active experiences involve and engage the students in a way not achieved in the typical learning environment. While wearing a VR Headset, otherwise known as a "head mounted display" (HMD), the user is isolated from the surroundings and therefore

distractions are minimized while immersion is maximized. These characteristics make the use of 360º video in education a very attractive alternative. In addition, the multimedia aspects of VR provide a very effective teaching and learning environment for students of different learning styles (kinesthetic, visual, aural).[21] The differing learning styles are targeted by the video, audio, textual, and movement-inspiring nature of the VR experience, and subsequently enhance the understanding of the concepts being taught.

In addition to using VR or 360º video in education, many industries are embracing the use of VR as a training tool. There have been a number of studies that have focused on the success of using VR for training individuals in areas such as welding, construction, medicine and engineering.[8,-16] One study, in particular, was done which compared the results of the traditional method of welding training with one that integrated VR into the training process. After the study was conducted, the results showed that integrating VR into the training had a large number of advantages, such as increase in weld quality, reduction in time required for training, reduced costs for the simpler welds performed, a higher number of certification rates, and improved kinesthetic skill learning.[10] In the construction industry, VR simulation was the ideal way to reduce common errors. Simulation allowed workers to repeatedly practice tasks and become acquainted with the hazards that were present in the working environment. This training led to a better comprehension of the training material and reduced accidents.[11] Throughout the medical field, VR is becoming a useful resource for a number of reasons.[17,18] With uses ranging from exposure therapy, to treatment for PTSD, to surgical training, VR is disrupting the traditional methods used to train medical professionals, as well as the conventional forms of diagnoses and treatment.

This project involved the creation and delivery of educational 360o videos as a method of providing an introduction to machine shop equipment. Informational narration, as well as text and an immersive environment allow for a delivery method that transforms the learning experience from passive to active. Results of the project will be assessed for both immersiveness as well as pedagogical value.

Methods

For this project, a series of 360º videos were developed for the purpose of introducing students to shop equipment at Penn State Berks. The 5 pieces of equipment that were featured within the series are the Geared Engine Lathe, Vertical Bandsaw, Horizontal Bandsaw, K2 Vertical Knee Mill, and a Gas Mig Arc Welder. Initially, each machine was filmed in operation using a Nikon KeyMission 360º camera. This camera has two lenses which allow the user to capture a 360º view of whatever is being filmed. After filming each machine in action, the footage was edited so that it was usable for training purposes. Adobe Premiere Pro was used to edit the footage and make it compatible with a VR headset. This program allowed for text, narration, and special effects to be added to the videos to serve as instructional narration for the students. Once completed, each video was finalized and converted into an mp4 file that was compatible with a VR headset. In addition, the videos were injected with metadata and uploaded to YouTube in order to make them viewable online in 360º.

Equipment
Hardware: Nikon KeyMission 360º Camera

One of the most important tools in this project is the Nikon KeyMission 360º camera. This camera provides the capability of capturing a 360º video, which is what gives the videos that immersive sense. The housing for the camera holds two back-to-back, ultra-wide-angle NIKKOR lenses. Each lens has its own dedicated 21-megapixel CMOS image sensor. Together they record 4K video, a resolution that is four times higher than full HD, of the surrounding scene. Although 360º video implies that camera records a full 360º, the camera has a 2º blind spot. Therefore, the camera is unable to capture subjects within about 2 feet from the camera's top, bottom and sides because the subjects are outside of the angle of view. After filming a video, the software automatically stitches together the missed 2º by blending together both sides. It is important to take the blind spot into consideration when positioning the camera, orienting it such that the least important image is located in the blind spot. For success during the filming operation, one essential feature is the dedicated SnapBridge 360 /170 mobile app. The app allows for camera setup and remote operation and playback of the camera, allowing for subjects to be filmed without interference of the videographer.

VR Headset

To give students the most immersive experience possible, viewing the 360º videos through a VR headset is ideal. The reason the VR headset provides such an immersive experience is that viewers must rotate and look around to view the video in its entirety. Compared to passively viewing the videos in 2D, or in 360º on a desktop computer, the headsets isolate the viewer from the surroundings and demand interaction, which creates a totally immersive experience. For this project, it was determined that the Samsung Gear VR Virtual Reality Headset gave a high-quality viewing experience without being overly expensive. The Gear VR is the most popular headset with over 5 million users. It has extremely accurate head tracking, allows for the videos to be viewed in native mp4 file format, and allows for videos to be organized and displayed in a user-friendly arrangement. The disadvantage of the Gear VR is that it requires a Samsung phone for viewing, making it somewhat prohibitive in a classroom environment.

An alternative to the Samsung Gear VR, the ViewMaster Deluxe VR Viewer, was chosen in order to deliver content to a wider variety of users. Because this headset is compatible with over 30 smart phones, it allows for an equally immersive experience while also providing the flexibility to deliver content to a wider audience at a more reasonable cost.

Software

After shooting the raw footage, each video had to be edited and processed. Using the program Adobe Premiere Pro, each video was modified. Premiere Pro is a professional-level, cost effective editing software that provides its users with a variety of capabilities. Within the software, users can add effects and filters, edit and arrange different elements and segments, and export the edited video in a wide range of formats. One specific format within Premiere Pro that is essential to the project is the VR format. When exporting a video, Premiere automatically recognizes footage shot with a 360º camera and provides the option to format the video into a VR video. After the video is exported and finalized, users can view the video within a VR

headset or on a computer which allows for users to click and move around.

To provide students with a more instructive experience, narration was provided within each video to "guide" the student throughout the entire video. To record the audio for this, the software GarageBand was used. GarageBand is software that simulates a music creation studio and was created by Apple for its Mac computers. Users have access to a complete sound library that includes a variety of instruments and provides its users with a line of digital audio workstations that can be used to record music or podcasts. When recording audio segments in a room without sound canceling technology, the audio is sometimes hard to hear or understand, which makes it seem unprofessional for training purposes. To ensure clarity within the audio segments, a sound isolation enclosure WhisperRoom was used when recording. The WhisperRoom's technology significantly reduced acoustic and ambient noise which helped greatly in recording the narration of these videos.

Narration

Each video contains narration which is put in place to guide/direct the students. As each video begins, the narrator welcomes the students to the shop and introduces the machine that they are viewing. Once the machine starts up and begins performing a task, short segments of text start to appear around it. The text is meant to complement the narration, which is a more in-depth description. In addition to information about each machine, safety tips are included within the narration. The narration ends with a summary of what was covered in the video.

Screen shots of selected videos are shown in Figures 1 & 2. These figures demonstrate the essence of how the video and text complement the narration.

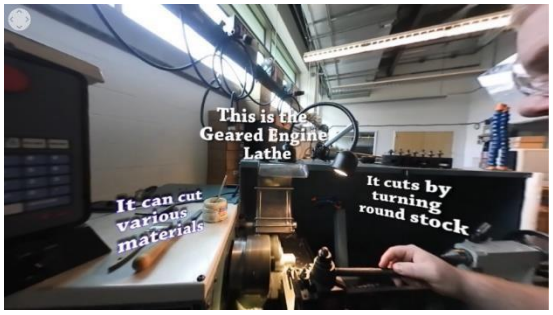

Figure 1: Screenshot of 360º Video of Geared Engine Lathe

Figure 2: Screenshot of 360º Video of Arc Welder

Distribution

Because this technology is in its infancy, optimal methods of distribution have not yet been identified. To make distribution most efficient**, e**ach video was uploaded to YouTube, which still allows for the 360º viewing experience whether the user has an HMD or not. In order to upload a 360º video, the file first had to be modified with an app and script before uploading, as the video file needed to contain certain metadata in order for 360º playback to be enabled. Once this metadata was injected, the uploaded video was automatically recognized as a 360º video. YouTube supports uploading and playback of 360º videos in Chrome, Firefox, and Opera browsers, however, difficulty was encountered when viewing using Internet Explorer. It is

recommended that Firefox is used when viewing using a browser. The YouTube app also allows for efficient distribution. In addition, to organize the distribution and streamline workflow, a website was created to host every video within the series.

Assessment

Although many engineering programs provide students with a hands-on experience in a machine shop at some point in the curriculum, the time of first exposure often depends upon both the university as well as the program of study. For example, some students may not operate equipment until they are required to utilize the various pieces of equipment for their capstone design project, while for others it may occur as part of a second-year manufacturing class. In either case, that first experience is, for many students, the first time they have been exposed to the equipment, let alone trained on it. Instruction on the equipment is typically done in small groups, and it is a repetitive, time-consuming process to train an entire class. Often times, this group training results in different degrees of success for each student, depending on prior knowledge and comfort levels with the equipment.

The production of 360º introductory videos is not intended to serve as a replacement for hands-on training, however, the videos address and mitigate several of the problems with the current methods of instruction. Students who normally are not exposed to the equipment until very late in the curriculum can now become familiar with the equipment at any point, whether as part of an existing class or independently, without the need for an instructor. In addition, by requiring viewing of the videos, the shop instructor is guaranteed that each student enters the training with a working knowledge of each piece of equipment, which will allow for a more meaningful experience from both the student's and the instructor's perspectives. In addition, university programs that don't have a robust machine shop may utilize the videos to provide an immersive, rather than passive introduction to the equipment.

A major goal for the research was to evaluate the effectiveness of the immersive 360º video on the educational experience. To that end, a series of assessments are being developed to evaluate the efficacy of the 360º videos. A study has been designed to introduce the videos as part of an Introductory Materials and Manufacturing course (IET101). Students will view the videos as part of a manufacturing curriculum, and data as to the impact of the videos, the instructional value, and the comparison to student comfort levels and training success will be evaluated. In addition, assessment as to the impact of an immersive 360º video format and its advantages over HD video will also be assessed.

Conclusion

The series of 360º videos for the purposes of introducing students to the shop equipment at Penn State Berks was successfully developed. Within the series, there are 5 operational videos that cover the Geared Engine Lathe, the Vertical Bandsaw, the Horizontal Bandsaw, the K2 Vertical Knee Mill, and the Gas Mig Arc Welder. Each video covers the basics of the machine and provides students with background knowledge and safety tips. The impact of this series will be assessed with respect to both content delivery as well as effectiveness in student training.

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References

1. Marlett, D. (2015). The Virtual Reality of John Carmack. D CEO, September 2015.
2. Carson, E. (2015). Virtual Reality in 2016: The 10 Biggest Trends to Watch. TechRepublic, December 2015.
3. Sinclair, B. (2016). The Promise of Virtual Reality in Higher Education. Educause Review, March 2016.
4, Ai-Lim Lee, E., Wong, K.W., Fung, C.C. How Does Desktop Virtual Reality Enhance Learning Outcomes? A Structural Equation Modeling Approach, Computers & Education (2010), doi: 10.1016/j.compedu.2010.06.006
5. Antonietti, A., Rasi, C., Imperio, E., & Sacco, M. (2000). The representation of virtual reality in education. Education and Information Technologies, 5(4), 317-327.
6. Chen, C. J., Toh, S. C., & Wan, M. F. (2005). Are learning styles relevant to virtual reality? Journal of Research on Technology in Education, 38(2), 123-141.
7. Reynard, R. (2017). The Impact of Virtual Reality on Learning. [online] campustechnology.com. Available at: https://campustechnology.com/Articles/2017/04/26/The-Impact-of-Virtual-Reality-on-Learning.aspx?, April, 2017.
8. Fast, K., Gifford, T., and Yancey, R. 2004. Virtual training for welding. 3rd IEEE and ACM International Symposium on Mixed and Augmented Reality, pp. 298, 299.
9. Mavrikios, F., Karabatsou, V., Fragos, D., and Chryssolouris, G. 2006. A prototype virtual reality-based demonstration for immersive and interactive simulation of welding processes. International Journal of Computer Integrated Manufacturing 19(3): 294–300.
10. Stone, R. T., E. McLaurin, and K. Watts. "Full Virtual Reality vs. Integrated Virtual Reality Training in Welding." Supplement to the Welding Journal (2013): 1-8. American Welding Society and the Welding Research Council, June 2013. Web. 16 May 2017.
11. Dong Zhao & Jason Lucas (2015) Virtual reality simulation for construction safety promotion, International Journal of Injury Control and Safety Promotion, 22:1, 57-67, DOI: 10.1080/17457300.2013.861853.

12. Ahn, S., Fox, J., & Hahm, J. (2014). Using Virtual Doppelgängers to Increase Personal Relevance of Health Risk Communication. Lecture Notes in Computer Science, 1-12. doi:10.1007/978-3-319-09767-1_1.

13. Keshner, E. A. (2004). Virtual reality and physical rehabilitation: a new toy or a new research and rehabilitation tool? Journal of NeuroEngineering and Rehabilitation. doi:10.1186/1743-0003-1-8.

14. García-Betances, Rebeca I. et al. "A Succinct Overview of Virtual Reality Technology Use in Alzheimer's Disease." Frontiers in Aging Neuroscience 7 (2015): 80. PMC. Web. 6 June 2017.

15. Repetto C, Serino S, Macedonia M and Riva G (2016) Virtual Reality as an Embodied Tool to Enhance Episodic Memory in Elderly. Front. Psychol. 7:1839. doi: 10.3389/fpsyg.2016.01839

16. Sveistrup, Heidi. "Motor Rehabilitation Using Virtual Reality." Journal of NeuroEngineering and Rehabilitation 1.1 (2004): 10. BioMed Central, 10 Dec. 2004. Web. 10 May 2017.

17. Wolfgang K. Müller, Rolf Ziegler, Andre Bauer & Edgar H. Soldner (1995) Virtual Reality in Surgical Arthroscopic Training, Journal of Image Guided Surgery, 1:5, 288-294.

18. Fluet, Gerard G. et al. "Robots Integrated with Virtual Reality Simulations for Customized Motor Training in a Person with Upper Extremity Hemiparesis: A Case Report." Journal of neurologic physical therapy : JNPT 36.2 (2012): 79–86. PMC. Web. 6 June 2017.

19. Al-Ahmari, Abdulrahman M., Mustufa H. Abidi, Ali Ahmad, and Saber Darmoul. "Development of a Virtual Manufacturing Assembly Simulation System." Advances in Mechanical Engineering 8.3 (2016): 168781401663982. SAGE Journals. Web. 17 May 2017.

20. Raths, David. "Augmented and Virtual Reality: Where Is the Educational Value?" The Journal. The Journal, 15 June 2016. Web. 16 June 2017.

21. Nooriafshar, Mehryar and Williams, Ron and Maraseni, Tek (2004) The use of virtual reality in education. In: American Society of Business and Behavioral Sciences (ASBBS) 2004 Seventh Annual International Conference, 6-8 Aug 2004, Cairns, Australia.