Design and Production of 360º Instructional Video for Mining Engineering Education

Leping Liu, liu@unr.edu
Li-Ting Chen, litingc@unr.edu
Sergiu Dascalu, dascalus@cse.unr.edu
Ying Yang, yingy@unr.edu
Pengbo Chu, pengboc@unr.edu

Abstract: In mining engineering education, students learn from textbooks, lectures, demonstrations or illustrations, lab experiments, hands on projects and field work. It is advocated that first-hand experience such as mine site-visit can benefit students' learning. On one hand, if a site-visit takes place before the learning on a content topic, it will help students to understand more contextual knowledge before their classroom learning. On the other hand, if it takes place during or after the learning, it will enhance students' understanding of what they have learned. A site-visit video may serve for the purpose of pre-learning introduction. This article (poster) presents the design and production of a site-visit 360º instructional video on "Froth Flotation" for a mineral processing course in mining engineering education, and the procedures of collecting the first-hand media-materials for the video from a real-world site-visit to a gold mine in a western state.

Keywords: mining engineering, froth flotation, instructional video, instructional design, STEM teacher education

Introduction and Background Information

Digital technology (such as automation, cameras, sensors, touchscreens, virtual reality, artificial intelligence, etc.) has been adapted to mining industries (Young & Rogers, 2019), as well as in mining engineering education to improve teaching and learning over years (Chen et al., 2016; Özyurt, et al., 2021; Suppes et al., 2019). In mining engineering education courses, mostly students learn from textbooks, lectures, demonstrations or illustrations, lab experiments, hands on projects and field work. It is advocated that first-hand experience shows considerable promise to improve the effectiveness and efficiency of mining teaching and learning, which can be (a) digital first-hand experience through virtual reality or 3D video simulation, or (b) real-world experience from lab or mine site-visit (Chen et al., 2016). Mine site-visit can benefit students' learning in two ways. On one hand, if a site-visit takes place before the learning on a content topic, it will help students to understand in more depth what they will learn when they come back to the classroom. On the other hand, if it takes place during or after the learning, it will enhance students' understanding of what they have learned. A site-visit video may serve for the purpose of pre-learning experience (Kalkofen et al., 2020). Then students can have one trip to the site during or after their learning.

This article (poster) will present the design and production of a mine site-visit 360º instructional video on the topic of "Froth Flotation" for a mineral processing course in mining engineering education, and procedures of collecting the first-hand media-materials from a real-world site-visit to a gold mine in a western state.

Another purpose of this article is to provide an example to STEM teacher education faculty, preservice and in-service STEM teachers on the design and production of digital experience for their teaching and learning. The article (poster) will include the following main sections:

1. The mining engineering course and the topic
2. Design of the mine site-visit 360º instructional video
3. Site-visit to a gold mine and media-materials collection:
4. The 360º Instructional Video Production
5. Implications to STEM teachers and teacher education faculty.

The Mining Engineering Course and Topic

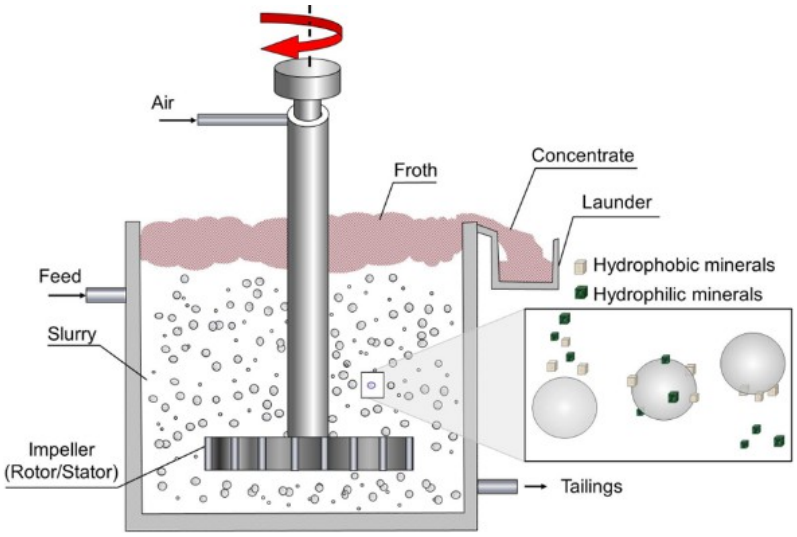
The course titled *Advanced Mineral Processing* is offered by the Mining and Metallurgical Engineering Department in a western state university. It teaches scientific and engineering principles involved in froth flotation,

including concepts of the liquid state, thermodynamics of surfaces and adsorption, chemistry of flotation, and flotation separations. Originally, lectures, laboratory work, and technical projects/papers are required for the class. From the studies of this course, students are expected to

1. understand the fundamental principles of flotation technology, including the chemical aspects of different reagents, the physical aspects of the machines, and the interaction between the two,
2. understand key flotation process parameters, and use them to conduct performance analysis,
3. independently design, conduct, and analyze flotation tests, and
4. learn the latest advances in mineral processing technologies.

One major topic of this course is Froth Floatation. It is a separation process "that exploits natural and induced differences in surface properties of minerals, whether the surface is readily wetted by water, that is, is *hydrophilic*, or repels water, that is, is *hydrophobic"* (Wills, 2015, p.265). Figure 1 illustrates the principle of forth flotation.

Figure 1.
Principle of froth flotation (Wills, 2015, p.266)



The hydrophilic materials are separated in this procedure, attached to the air bubbles, and floated with the froth for further process as in Figure 1. This article does not focus on the details of the physics, chemistry, and machine features and functions in the procedure. Rather, the focuses are on the pre-contextual knowledge that students need to know about the procedures, for example, what the real mine or the processing system look like. Such knowledge can be achieved through digital first-hand experience via virtual reality (Ghosh, 2020) or 3D video simulation (Kalkofen et al., 2020). It was decided to first create a mine site-visit 360° instructional video.

The Design of the Mine Site-Visit 360° Instructional Video

In the design of the mine site-visit 360° instructional video, the five-phase ADDIE instructional design model (Analysis, Design, Development, Implementation, and Evaluation) was applied (Gagne et al., 2005). In the phase of ***Analysis***, the following tasks were conducted.

Needs Assessment was conducted to determine the necessity and needs to create this mine site-visit 360° instructional video. A survey was sent out to 31 mining companies, and the respondents were junior mining engineers (14.3%), intermediate mining engineers (3.6%), senior mining engineers (32.1%), engineering manager/supervisors (14.3%), executive senior managers (21.4%), environment specialists (3.6%), geologists (7.1%), and consulting engineers (3.6%). The results indicated the skills and knowledge scopes that were required in the workforce, in which lack of first-hand experience is one that our graduates "are all book smart but cannot implement in the field"(Chen et al., 2023).

Learner Assessment was performed in the *Advanced Mineral Processing* class. Of course, at the beginning of the course, none of the students had any experience of the mine field.

Content Analysis was to determine what contents should be included in this instructional video. Besides the course materials to achieve the learning objectives, we made a trip to a gold mine in a western state. In this trip, we went through the mine site and the mills that contain all the machines to process the froth flotation, lining-up the procedures in textbook content on Froth Flotation with the procedures that we can see in the gold mine. A list of initial media-material productions (such as photos, videos, mine site engineers' introductions, etc), were identified.

Initial Objectives of the Video were then formulated. The objectives were initial ones as some adjustment may need during the production of the videos. For example, adding more or reducing some of the media-materials. The initial objectives include:

1. to provide an overall introduction about the gold mine
2. to exhibits the outside areas and operations of digging the ores from the mountain,
3. to illustrate the process of transporting the ores into the machines in the mills,
4. to show the machines in which the ores were smashed for further processes,
5. to display the mechanic system where the froth flotation takes place (invisible process)
6. to demonstrate some visible process including the stirring process, the tanks, etc.,
7. to record the talk and introduction by the engineer who guided the entire process, especially the explanations to those invisible process that was inside the machines.

Next, in the phase of ***Design***, an operation plan, a to-do list, with specific tasks to conduct this site-visit instructional video was formulated. Table 1 shows an example of the items in the to-do list.

Table 1. Example of to-do list from the Design

Objectives	Operations	Site/Location	Objects	Note
1	Video recording the intro	Entrance	• overall view of the mine area	
2	Taking 360º site photos and videos Video recording the engineers talk	Site 1. Outside areas/mountains	• The mountain area • The mineral seam (stratum) • The tractor	See Task Analysis Table 2.
3	Same	Site 2. The transporting belt & the s	• Transporting belt • The rocks/ores on the belt • The machine	
4	Same	Site 3. The machines in the mill	• machines • system • overall view of the mill	
5	Same	Site 4. Flotation system	• stirring tanks • flotation tanks	
6	Same	Site 5. Flotation system (visible process)	• stirring tanks • flotation tanks	
7	Photo/videos	Site 6. All the way from the start to the exit meeting	• presentations • talks	

To complete the photo/video taking tasks, ***task analysis*** was done, which is an important procedure in the ***Design*** phase. That is, for each operation task, taking photo or video, specific assignments and requirements are identified. Table 2 shows an example of task analysis.

Table 2. Example of task analysis from the Design

Task	Assigned to	Photo/Video Requirements on:	Note
e.g., tasks on site 2.	Photographer A & B	• primary objects: • background : • light: • distance: • angle: • close-up (zoom in) • wide angle (zoom out) • length of video: • ……	

This is mostly the screen design of the photo/video. After the initial task analysis was completed for most of the tasks, to take actions and complete the tasks in the to-do list is the operation in the phase of ***Development*** in the ADDIE model. A second trip was made to the gold mine to take photos/videos for the production of the 360° site-visit instructional video.

Site-Visit to a Gold Mine and Media-Materials Collection

In the second trip to the gold mine in a western state, first the permission and oral consent to take the photos and videos was granted from the key leadership group who worked with the mining engineering faculty in this project. Over years, this gold mine established a cooperative connection with the Mining and Metallurgical Engineering Department in our university.

Then three photographers (three team members of this project) went through the six sites in the gold mine, taking 360° photos and videos with all detailed requirements as designed during task analysis. Over one hundred photos and over 20 video clips were taken as the first-hand media-materials for the site-visit instructional video. Figure 2 shows some examples of the pictures.

Figure 2.
Sample pictures from the gold mine.

The decision to take 360º photos and videos, instead of 2D still or moving films, was based upon two considerations. Firstly, it would provide the site information from more dimensions, which will provide students the experiences close to the reality. Secondly, the next step of this project is to create a virtual reality (VR) application to demonstrate the procedures of froth flotation. The 360º photos and videos would be useful for the VR production.

The 360º Instructional Video Production

After the first-hand media materials were collected, next was the video production, which is one of the major tasks in the phase of ***Implementation*** in the ADDIE model. In the video production, technique work and the mineral processing contents were carefully reviewed and integrated the video production include the following steps:

1. edit the photos
2. edit the video clips
3. assemble the photos and video clips into the videos on each site (a total of seven sites)
4. edit each site-video frame by frame
5. add sound, including sound effect (or music), and the introduction talks
6. test each site-video, including effects and time-limitation
7. finalize each site-video as a single video file, so it can be played separately according to the purpose of instructions.
8. each site-video reviewed or commented by mine engineer(s) for possible revisions
9. create divider frames at the beginning of each site-video as the introduction to a different site.
10. assemble all seven site-videos into one as the final production.

The site-visit video is now in its final production. Examples of photos, video clips, site-video sections will be presented at the conference.

Another main step in the ***Implementation*** phase is to put the product in use or on the market. While in this case, it should be to deliver it to students in the *Advanced Mineral Processing* class. After the class has used it, the ***Evaluation*** of it will be conducted, which is the last phase of ADDIE model.

The Implications to STEM Teacher Education and Instructional Design

This article describes the authors' first-hand experience designing and producing a 360º instructional video of a gold mine site-visit for mining engineering education. Video production for simulation or demonstration is used very often in STEM education and STEM teacher education. In the field of science, technology, and engineering education, sometimes it is hard to have existing videos for the particular purpose of teaching, instructor-developed video would be better targeting to the topics. The procedures to apply the ADDIE instructional design model described in this project could be of reference to educators who are interested in producing their own instructional videos. Also, the same design procedures could be applied to VR design. Currently AI applications have appeared to have a critical impact on the design. However, careful considerations are necessary to focus on the real objectives of teaching and learning. We will discuss more with the audience at the conference.

References

Chen, L. Liu, L., Urade, S., & Chu, P. (2023). An industry perspective on the current US metal mining engineering education. *Mining, Metallurgy & Exploration (2023)*, 1-18. https://doi.org/10.1007/s42461-023-00782-6 IF: 2.13

Chen, Z., Liu, L., Qi, X., & Geng J. (2016). Digital mining technology-based teaching mode for mining engineering. *International Journal of Engineering and Technology, 11*(10), 47-52. https://doi.org/10.3991/ijet.v11i10.6271

Gagne, R. M., Wager, W. W., Golas K. C., & Keller, J. M. (2005). Principles of instructional design. Thomson.

Ghosh, S. K., Bhuyian, T., Chowdhury, R., & Jabiullah, I. (2020). On the use of virtual reality based engineering education. *Journal of Business and Economics, 11*(8), 959-964.

Herbert, J. H. (2019). Development of innovative labs for education in mining engineering programs. Presented at the *15th International CDIO Conference*, Aarhus University, Aarhus, Denmark, June 25 – 27, 2019.

Kalkofen, D., Mori, S., Ladinig, T., Daling, L., Abdelrazeq, A., Ebner, M., Ortega, M., Feiel, S., Gabl, S., Shepel, T., Tibbett, J., Laine, T. H., Hitch, M., Drebenstedt, C., & Moser, P. (2020). Tools for teaching mining students in virtual reality based on 360º video experiences. *2020 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW).* https://doi.org/10.1109/VRW50115.2020.00096

Özyurt, O., Cagiltay, N. E., Özyurt, H., & Akgun, A. (2021). A systematic review and mapping of the literature of virtual reality studies in earth science engineering education. *Journal of Pedagogical Research, 5*(2), 237-256. http://dx.doi.org/10.33902/JPR.2021067651

Suppes, R., Feldmann, Y., Abdelrazeq, A., & Daling, L. (2019). Virtual reality mine: A vision for digitalized mining engineering education. In Mueller et al. (Eds), *Mining Goes Digital* (pp. 17-24). Taylor & Francis Group, London.

Wills, B. A., & Finch, J. (2015). Wills' mineral processing technology: an introduction to the practical aspects of ore treatment and mineral recovery. Butterworth-Heinemann.

Young, A., & Rogers, P. (2019). A review of digital transformation in mining. *Mining, Metallurgy & Exploration (2019)36*:683–699. https://doi.org/10.1007/s42461-019-00103-w