

Virtual laboratories in chemical and laboratory safety education

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Abstract: We present a next-generation web-based 360° virtual laboratory safety training which a mandatory training for all the students and staff members in Aalto chemical engineering department. We collected feedback from the students and staff members in Aalto University School of Chemical Engineering and University of Eastern Finland. The feedback of training was highly positive. In the open feedback, students reported significant decrease of anxiety and stress as well as better understanding different aspects of chemical and laboratory safety. Overall, results indicate that the virtual laboratory is effective and efficient tool for laboratory and chemical safety training.

Keywords: virtual laboratories, laboratory safety, chemical safety

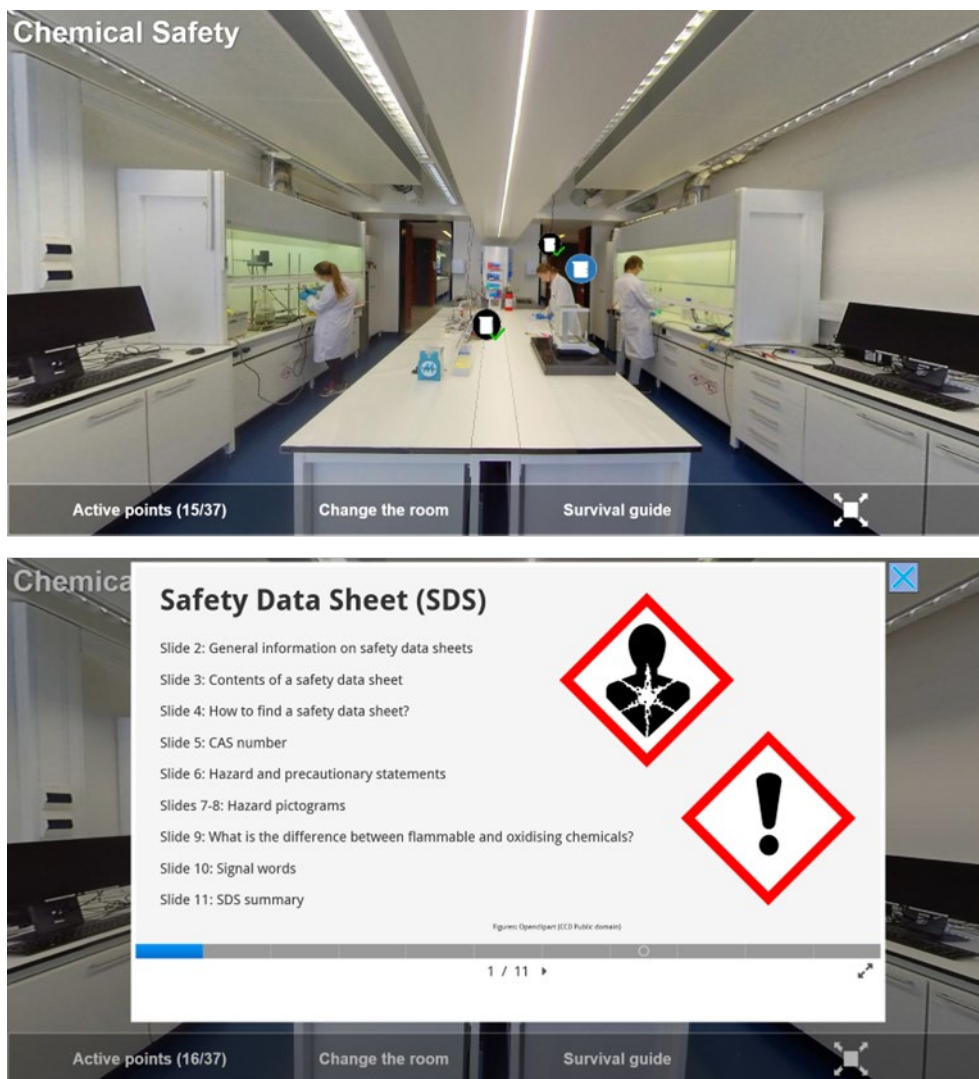
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Introduction

Safety training is crucial in laboratory settings to prevent accidents and promote a culture of safety (Srinivasan et al., 2022). Traditional training methods often lack practical experience opportunities, hindering the development of necessary skills and knowledge (Srinivasan et al., 2022). In recent years, virtual laboratories have gained popularity as an alternative training method for laboratory and chemical safety, especially with the rise of remote teaching (Potkonjak et al., 2016; De Jong et al., 2013; Glassey and Magalhães, 2020). These virtual environments are composed of 360° panorama images, creating a sense of immersion without requiring specialized VR equipment and interactive elements such as text, videos, and quizzes. (Figure 1.). Virtual laboratories offer a risk-free space for students to learn and practice laboratory safety, providing feedback and self-assessment features (Viitaharju et al., 2021; Derichs et al., 2022).

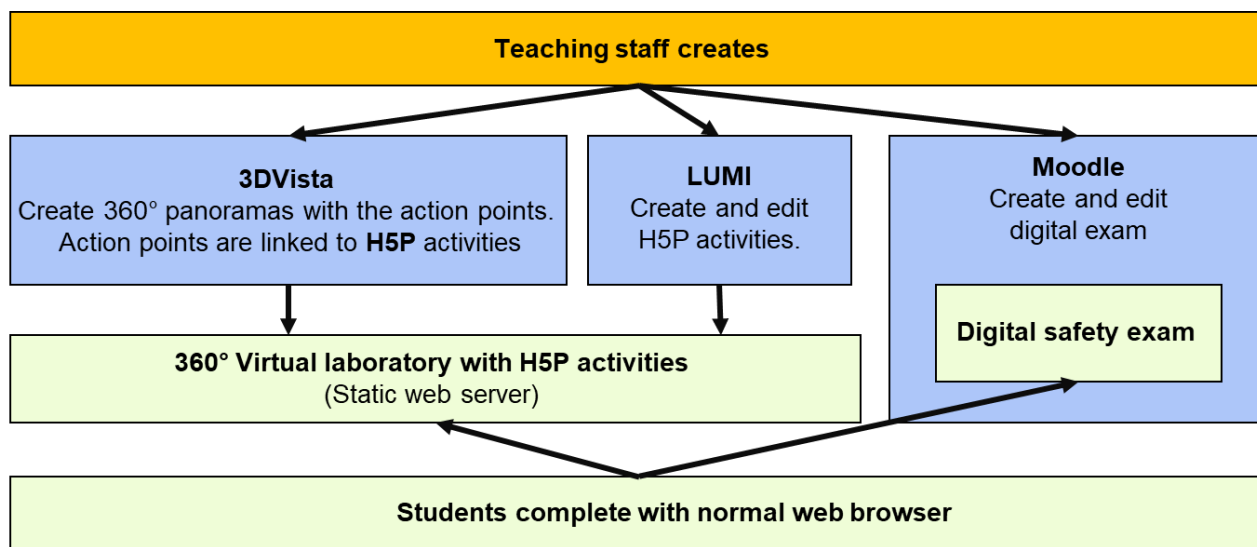


Figure 1. Example view of the virtual laboratory safety tour. Tour is composed of 360° panorama images of actual student laboratories. Inside of panorama images are activity points, which can be seen in the picture either as a blue (not completed) or black (completed) beaker icons. By clicking the icon, H5P presentation will appear which consist of text, pictures, videos, and quizzes. Once activity is completed, window can be closed by clicking blue cross on the upper right corner. Once window is close, new activity point will appear. Previous activities can be revised from the “Activity points” in the bottom panel.



Virtual laboratory safety training: Training consists of two parts: Virtual laboratory and digital exam. Student first goes through the virtual laboratory. Once they have completed the tour, they can do digital exam. They can use virtual laboratory tour open while completing the exam. Exam questions test their understanding, and they would apply their knowledge rather than testing some of the small details. As part of the exam, students were able to give feedback about the virtual laboratory and digital exam. Technical architecture can be seen in the Figure 2.

Figure 2. Overall technical architecture of the virtual laboratory safety training environment. Teacher can create and edit virtual laboratory environment using H5P framework (<https://h5p.org>) and LUMI program (<https://app.lumi.education>). Virtual laboratory is hosted on a static webpage and embedded in the virtual environment created with 3DVista (<http://www.3dvista.com>), giving us more control over the environment and allowing other schools to use the virtual safety lab without access to our Moodle system. After the students has completed a virtual safety laboratory training, the learning is assets with automatically assessed Moodle Quiz. Step-on step instructions to create and edit virtual laboratory environment are found at the Aalto Wiki (Girmay, 2023).



Feedback from students and staff members

According to questionnaire responses (N=942) about virtual laboratory learning experience and the digital exam, over 95% of respondents considered virtual laboratories to be a beneficial learning platform for laboratory safety and over 90% considered digital exams as a suitable assessment method of the topics. These results suggest that students were highly satisfied with virtual laboratory and digital exam, and they considered both as good learning methods regarding to laboratory safety.

Conclusion

Overall, the positive feedback from students highlights the effectiveness of the virtual laboratory in promoting motivation, engagement, and understanding of laboratory safety. Almost no issues were reported to the responsible teacher. Future studies and improvements include enhancing the design of the virtual laboratory. Students also wanted more interactivity into the tour. By continuing to improve design, we are able provide students more effective, inclusive, and engaging learning experiences possible and improve students understanding of the chemical safety.

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