Learning analytics in VR-based chemical training: operator apprentice perspectives

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As several institutions are embracing and coping with the rapid advancement of digital-based technologies such as massive open online courses (MOOCs) and virtual reality (VR) for teaching and training, digital assessment becomes a common practise for gathering and reporting information about user learning and progress [1]. Although research on how to trace and capture learner-generated data in immersive virtual reality (IVR) environment has received considerable attention, little is known about how evaluation should be presented in IVR setting for formative assessment. Thus, this study aims to evaluate the perspective of the participants with regards to the delivery and presentation of their performance evaluation in IVR setting.

For this study, "Operate Your Own Reactor" (OYOR), an IVR-based training system focused on the operational procedures of the commercial production of n-Butyllithium (n-BuLi or n-C4H9Li) was developed [2]. The entire training takes approximately 40 to 45 minutes and consists of four (4) main tasks (*e.g.* preparation, set-up, reaction, and extraction) and twenty-four (24) sub-tasks. Two types of interactions were present in this IVR-based training system: (1) the physical interaction in the IVR environment (*e.g.* chemical equipment and instruments), and (2) the digital control of the reactor through a computer screen inside the IVR chemical plant [3]. The content as well as the design of OYOR was developed in collaboration with experts from the industrial partner to ensure authenticity.

In pursuit of the abovementioned objective, a quasi-experimental approach was implemented. The participants were divided into a control group and an experimental group. The control group performed the IVR-based training and were shown a simple assessment system (*i.e.* only overall grade) while the experimental group performed the same IVR-based training with a detailed assessment system (*i.e.* more information such as the number of mistakes, or hints per sub-task aside from the overall grade).

A two-part questionnaire was used for data collection. The first part, which participant completed at the start of the experiment, consisted of written informed consent and close-ended questions used to determine demographic data such as gender and age. The second part, which was completed at the end of the experiment, contained open-ended questions which asked respondents to identify advantages and/or disadvantages of the assessment system in IVR environment. The questionnaire was originally created in English and was subsequently translated into German by a native speaker. Prior to the distribution of the questionnaire, an ethical authorisation was obtained from the Ethics Committee at the university. The responses were collected from apprentices working in a chemical plant situated in Germany. Since it was impossible to include all apprentices in the sample, convenience sampling, a non-probability sampling method was used. Forty-four (44) participants completed questionnaires were collected. The majority of the participants in the both control and the experimental group were male (73.91% and 76.19%, respectively) and between the ages of 20-30 (82.61% and 71.43%, respectively). All responses were used for data analysis as no incomplete or duplicated data were detected.

Qualitative data collected from the open-ended questions were analysed using inductive thematic analysis [4]. Seven themes (no advantage = 9%, no opinion = 18%, provides immediate results = 57%, helpful = 4%, great = 4% additional motivation = 4%, and simplicity = 4%) emerged from the question 'What do you think are the advantages of using the assessment overview system?' for the control group while four themes (no opinion = 24%, provides immediate results = 66%, great = 5% additional motivation = 5%,) for the experimental group. Given that more than half of the participants from both groups confirmed that the assessment system was advantageous, this simply means that the ability of the assessment system to provide immediate results is more important than the amount of information (simple or detailed assessment system) presented in IVR environment.

On the other hand, four themes (no disadvanatge, no opinion, does not provide better feedback, cause of additional stress) emerged from the question 'What do you think are the disadvantages of using the assessment overview system?' for both the control group and the experimental group. 52% of the participants in both the control group and the experimental group stated that there were no disadvantage of using the simple assessment system or the detailed assessment system, respectively. This observation also supports the idea that the ability of the assessment system to provide immediate results is more important than the amount of information presented in IVR environment. Moreover, 22% and 24% of the participants in the control and the experimental group did not give any comments with respect to the disadvantage(s) of the assessment system. Furthermore, 13% of the participants stated that the simplified assessment system was not good as it does not give detailed feedback while 5% of the participants in the experimental group also stated that they wanted to receive more detailed feedback. Although these numbers were relatively low, this simply indicates that users wanted to know more about their actions to learn from them. Lastly, 13% and 19% of the participants from the control and the experimental group stated that the assessment system was not good as it represented an additional source of stress (*e.g.* showing of grades). These numbers simply indicate that reading and utilising assessment information might be challenging and tiring for some participants.

In conclusion, the present study used inductive thematic analysis to examine the views of 44 chemical operator apprentices toward different presentation of assessment in IVR setting. The qualitative analysis results showed that the ability of the assessment system to provide immediate results is more important than the amount of information (simple or detailed assessment system) presented in IVR environment. Although this research provides some insights for assessment designers, it is important to bear in mind that the evaluation on whether the participants preferred the simple assessment system or detailed assessment system in OYOR prototype is still unknown. Thus, it would be beneficial for the future study to replicate this study with a larger sample, consider conducting follow-up questionnaires/focus groups to ask both groups whether they prefer simple or detailed assessment system and why.

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