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Augmented reality training for improved learnability

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ABSTRACT

In the current era of Industry 4.0, many new technologies offer manufacturing industries to achieve high productivity. Augmented Reality (AR) is one of the emerging technologies that has been adopted in industries to aid users in acquiring complex skills and carrying out many complicated tasks such product assembly and maintenance. Nevertheless, most AR applications have been developed without clear understanding of how such technology can facilitate improved learnability in terms of knowledge reusability. This paper proposed an enhanced AR-based training system that provides multimodal information with a contextualized information to improve task comprehension and knowledge reusability compared with traditional AR that presents unimodal and decontextualized information. An empirical test was carried out to assess the task performance and the task learnability aspects of this enhanced AR compared to the traditional AR and the paper-based document. The experiment consisted of a training phase where participants carried out an electrical connection task of a sensor followed by a knowledge reuse phase where participants had to wire a second sensor using their previous training. A pre-test quiz was given before the experiment followed by the post-tests phase after the training. Post-tests consist of one post-test given directly after the experiment (short-term retention test) and a second post-test quiz given one week later (long-term retention test) to measure information retention. The results indicated that AR-based approaches could enhance knowledge acquisition by around 18 % for traditional AR and almost 25 % for enhanced AR as compared to paper-based approach. While all training systems achieved relatively equivalent well for short-term retention test, trainees who used the enhanced AR training systems statistically outperformed those in the paper-based group for long term retention test. Furthermore, there was a positive correlation between the score of short-term retention test and the score in the knowledge reusability which was also shown by the higher scores in knowledge reusability for the enhanced AR training system compared to the other two approaches. These findings are discussed in relation to the Industry 5.0's human centric core value.

1. Introduction

The adoption of Industry 4.0 technologies enables new capabilities to produce and to deliver product faster with a better quality, and more cost efficient. However, this industrial revolution is leading to an increased complexity of manufacturing systems and an increasingly rapid renewal of these systems. Consequently, upskilling employees' competencies to handle and maintain the complex engineering assets (CEAs) is indispensable. In recent years, finding a skilled worker has become a difficult task. The reason is that there is a talent shortage nowadays. Indeed, in 2018, 45 % of employers said that they could not find the necessary skills among candidates [17]. Furthermore, a new issue will arise from adapting to the changing job dynamics brought about by digitalization [27]. Despite the increased interconnectedness and availability of information globally, the progress of digitalization has not been uniformed across countries or even within industries within the same country [14]. To face this challenge and meet with the adoption of Industry 4.0, employers need to find a new way to ensure their workforces are sufficiently equipped to work with CEAs. In the aviation sector, research examined that traditional training such as in-class training and paper-based manual are not reliable means for teaching job tasks and the skills for visual inspection for the future trend in aviation [11,29]. Visual inspection requires Aircraft Maintenance Technician (AMT) to identify certain characteristics of all types of faults and make decision to troubleshoot various systems from one airplane to another. Due to highly complexity and interrelated components in the

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