Assessing the Benefits of Virtual Reality Training for Manual Assembly

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SUMMARY

The aim of this study is to assess, through experimentation, the effectiveness of Virtual Reality training when compared to a traditional written instructions in a manufacturing assembly process. The effectiveness was evaluated in terms of perceived workload and task performance, with participants asked to self-report on the experience during both the written and VR training. Findings indicate that VR training reduced the user's workload perception and errors made during the task, however there was no significant impact on time taken to complete the task.

KEYWORDS

Virtual Reality, Assembly, Workload

Introduction

Virtual Reality (VR) technology has seen rapid advancement in recent years, where applications for training can be found across many industries. However, literature in this area gives conflicting views on whether VR training promotes greater knowledge uptake and retention (Makransky, 2021), with effects of VR on physical and mental workload remaining unevaluated (Werk, 2021). This study (part of an undergraduate student project) investigates the effectiveness of VR training when compared to a traditional written method. Assessment was conducted through experimentation, using the example of the assembly process of a Wankel engine.

Method

The VR program involves an interactive virtual environment that allows the user to manipulate the assembly and parts through 360 degrees of rotation, developed through Unity and Steam VR giving instructions and tips to the user at every stage. The number of errors and time taken to assemble the engine were collected and participants in both groups self-reported their perceived workload after performing the tasks using the NASA Task Load indeX (TLX) (NASA, 2020). The participants were recruited to represent equal sample sizes between gender and those with and without an engineering background to reflect different experience level with assembly tasks. Following ethics and risk assessment, participants with motion sickness or pregnancy were excluded.

Results

The data was evaluated and analysed to establish whether there is statistical significance as to whether Virtual Reality Training improved performance (decrease in assembly time and errors) and reduced the perceived workload of the participants during the task. 22 samples were collected as part of the experiment and fixed ANOVA t-test were performed. Group 1 (control group) performed the assembly with written instructions first, then the VR training. Group 2 (experiment group)

performed the VR training first then the assembly with written instructions. Participants completed the NASA-TLX questionnaire after completing each task as shown in Figure 1.

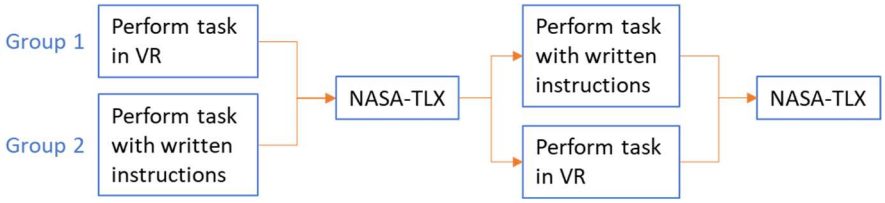

Figure 1: Experimental design (Group 1, n=11; Group 2, n=11)

a) Performance

There was no decline in assembly time between the groups (i.e. learning effects). The mean completion time did not significantly improve with VR training, however the variance is reduced, p=0.019 (Figure 2a). The number of errors was reduced with VR training, p=0.137 (Figure 2b), with participants making fewer errors locating parts.

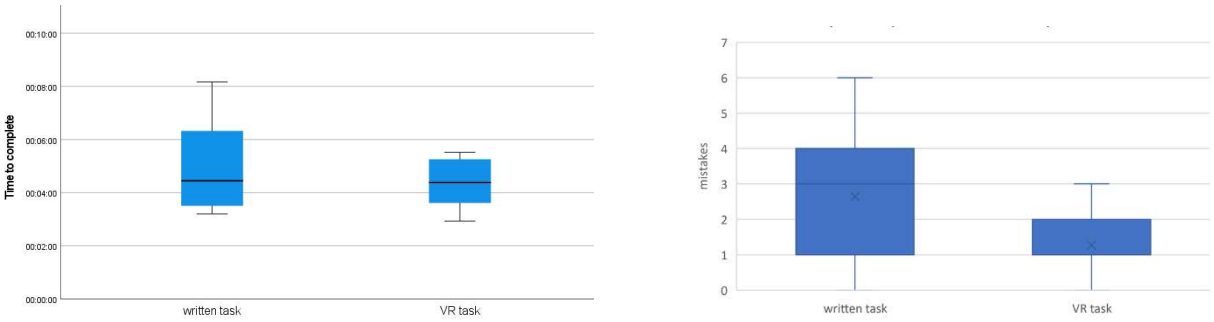

Figure 2: Boxplot of a) time to complete assembly; b) mistakes made during assembly.

b) Workload perception

The average workload for both groups was lower when assessing the VR task compared to the written task (Figure 3). For Group 1, the biggest change in workload was seen in the *temporal demand*, and the smallest change in workload was observed in *frustration*. For Group 2, the biggest change in workload was seen in *time demand*, but the smallest was seen in *performance*.

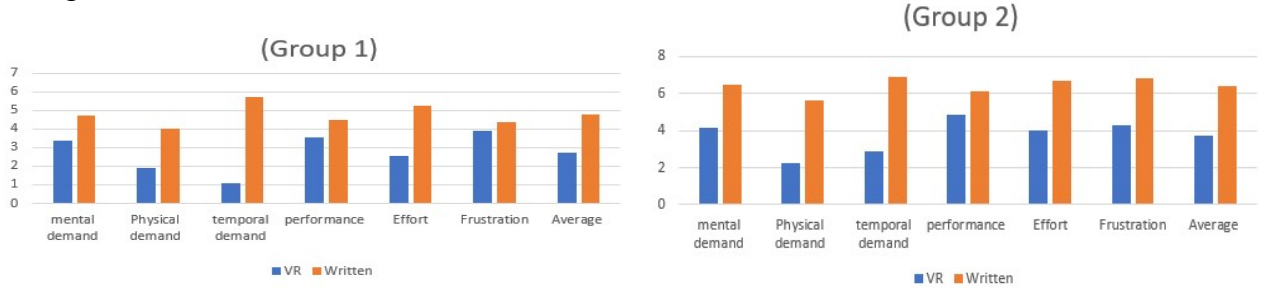

Figure 3: Perceived workload a) Group 1; b) Group 2.

Conclusions

The results of the experiment indicate that VR training did improve the user's perception of workload and reduce the number of errors made in the assembly task. However, there was no significant impact on time taken to complete the assembly task. Perceived workload was reduced in almost all NASA-TLX categories and weighted average workload was significantly lower in VR compared to the traditional written method. Whilst there was an overall improvement in

performance observed in the participants who were given the VR training prior to the assembly task, there were some areas where there was little improvement over the control group. These errors include the incorrect fit of the drive shaft or rotor and could be due to the lack of haptic feedback.

References

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