Advancing Machine Operating instruction through Augmented Reality

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After contacting Roy Damgrave in January and discussing the possibilities of performing a bachelor assignment with the focus on Augmented Reality, an investigation into the potential application of AR for machine operating instructions was pursued as a bachelor thesis assignment. Following extensive deliberations at the University of Twente (UT), the decision was made to explore the utilization of AR for imparting machine operating instructions, with a specific focus on conducting a case study at the UT workshop.

Within industrial settings, the provision of proper machine operating instructions is critical. Currently, these instructions are mostly communicated verbally by experts, resulting in potential limitations and inconsistencies. Moreover, the shortage of experienced personnel necessitates a departure from traditional methods of knowledge transfer. Employing AR instructions presents an opportunity to deliver standardized instructions to new employees without the requirement of an expert's presence.

The primary aim of this assignment was to examine the feasibility and potential of using AR instructions for machine operateng instructions. The case study conducted at the UT workshop sought to investigate the applicability of AR instructions for the PICOMAX 20 machine.

To assess the added value of AR instructions, two qualitative pilot studies were conducted. For these studies, prototypes were developed to administer safety instructions using AR technology for the PICOMAX 20 machine. The prototypes were subjected to testing by students and workshop employees, and their feedback was used for refining the prototypes. Additionally, interviews were conducted with Workshop and Health Safety Environment (HSE) employees to ascertain their perspectives on the use of AR instructions, comprehend the existing regulatory framework, and gain insights into conventional training methods. Cost estimation models were also employed to gauge the financial viability of the project.

For the prototype, the HoloLens 2 was used for development. The developed prototype employed a combination of instructions, questions, and tasks to foster user engagement with machine operations.

Fig. 1. Different examples of using numbers to indicate operation steps of the PICOMAX. The operation steps shown are Changing machine chug (Left), Referencing the Axis with the manual wheels (Middle) and Changing the size of the Clamp (Right). The numbers are also displayed on the instruction screen, indicating what needs to be done at the place of the number.

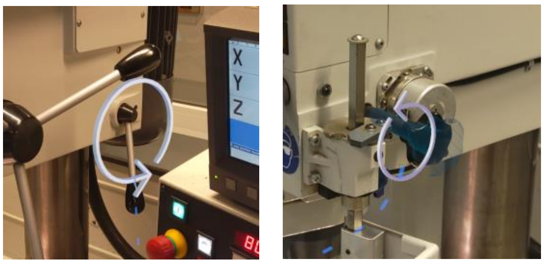

Fig. 2. Difference between the part-specific hologram (right) and the part without a part-specific hologram (left). The part with the specific hologram has a light blue hologram of the designated part which is clearly visible while wearing the HoloLens.

Holograms were strategically positioned around the machine to indicate relevant components. Part-specific and non-part-specific holograms were used to test a potential difference in clarity between these parts (Figure 2). The prototype encompassed both safety instructions and questions, followed by a step-by-step walkthrough of machine operations, incorporating embedded questions to evaluate user knowledge, assess the machine's mode, and ensure the completion of requisite steps. The flowchart (Figure 3) shows several different questions, and the effect of the answer on the continuation of the instruction.

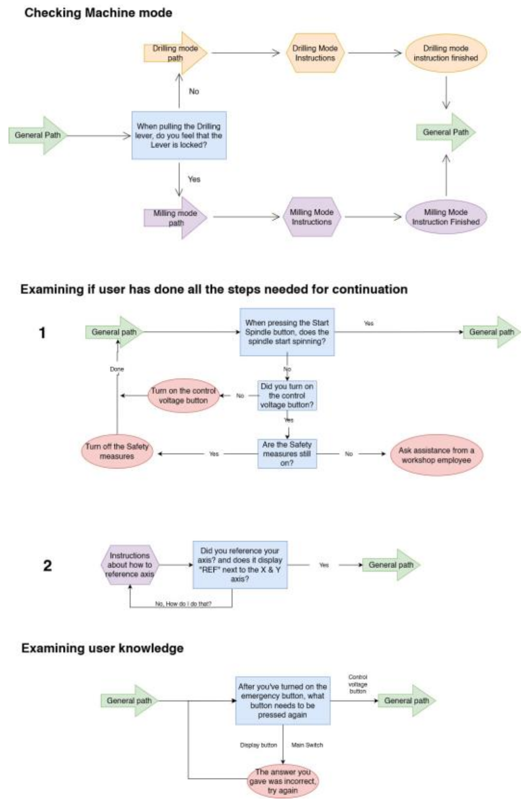

Fig. 3. Flowchart of the examples of different questions, and the paths following that question. Checking machine mode (Top), Examining if user has done all steps needed for continuation (Middle), and Examining user knowledge (Bottom).

The pilot studies yielded positive outcomes among students, with heightened satisfaction, engagement, and comprehension reported compared to traditional methods. Furthermore, no differences between the clarity of part-specific and non-part-specific holograms were found. However, certain challenges were encountered by students in locating the holograms, and feedback suggested the inclusion of narration as an additional feature. This feedback was used for the development of the prototype used in the second pilot test.

The second pilot study was conducted with a UT workshop employee. This also resulted in positive feedback regarding the possible substitution of using AR instructions for giving the safety training. However, the employee indicated that more testing is needed to assess the overall safety improvement and implications.

Furthermore, the result of the cost estimation shows that deploying AR instructions at the UT is financially feasible, since the costs are not disproportionally high. And the result of interviews shows that using AR instructions are possible within the regulations.

Future steps, potential, and implications were presented, a method for future testing as well as an ethical evaluation were given. Advice was given for the further development of using AR instructions at the University workshop. Next to that potential purposes are proposed for using AR in for example Education, The upcoming learning factory as well as in industry wide factories.

This assignment successfully validated the feasibility and potential of AR technology for machine operating instructions. However, further research is needed to assess the efficacy of implementation, the actual value added by the AR instructions, and address associated considerations. Recommendations for future investigations include comprehensive testing, ethical evaluation, risk assessment as well as possible changes in the safety training logistics, to refine the deployment of AR instructions within the university workshop. Furthermore, the potential application of AR instructions in educational contexts, such as the upcoming learning factory as well as the Industrial Design Engineering Curriculum, as well as broader industrial settings, were also presented.