A Pedagogical Virtual Machine for Assembling Mobile Robot using Augmented Reality

Malek Alrashidi Ahmed Alzahrani Michael Gardner Vic Callaghan
School of Computer Science and Electronic Engineering,
The University of Essex, Colchester, UK
+447446102060
{mqaalr, araalz, mgardner, vic}@essex.ac.uk

ABSTRACT
In this paper, we propose a pedagogical virtual machine (PVM) model that aims to link physical-object activities with learning objects to reveal the related educational value of the physical objects in question. To examine the proposed method, we present an experiment based on assembling a modularised mobile-robot task called "Buzz-Boards." A between-group design method was chosen for both the experimental and control groups in this study. Participants in the experimental group used an augmented reality application to help them assemble the robot, while the control group took a paper-based approach. 10 students from University of Essex were randomly assigned to each group, for a total of 20 students' participants. The evaluation factors for this study are time completion, a post-test, cognitive overload, and the learning effectiveness of each method. In overlay, assemblers who used the augmented reality application outperformed the assemblers who use the paper-based approach.

CCS Concepts
• **Human-centered computing →Human computer interaction (HCI)→ Interaction paradigms → Mixed / augmented reality**

Keywords
Mixed Reality, Augmented Reality, Assembling Robot, Buzzboards, Pedagogical Virtual Machine.

1. INTRODUCTION
Augmented reality (AR) has shown great potential for aiding users in assembly and maintenance tasks[1][2][3] . AR provides a magic-lens view that, overlaid on the physical object, assists people while they perform tasks so that they need no prior knowledge, manual instruction, or expert assistance regarding the subject at hand. By integrating a virtual or animated object into people's experience with the real object, assembly and maintenance tasks become less demanding. But, however up to date, assembly tasks using AR are often abstract; AR provides a predefined sequence of actions with the minimum amount of information required to perform the task. From an educational point of view, this does not enrich the assembler's experience of learning how to construct or maintain the physical object. Thus, there is a need to exploit the advances in AR technology to provide a more sophisticated learning experience for assemblers. By turning the physical object into a "smart object" that communicates and interacts with the assembler with the use of AR, we can help the assembler achieve a higher level of knowledge and awareness of the technology. By integrating AR with a smart object, the assembler not only learns to assemble hardware components but also gains a deeper understanding of and insight into the software components within the embedded computing.

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2. PEDAGOGICAL VIRTUAL MACHINE (PVM)
The 'Pedagogical Virtual Machine' is a mechanism that translates student driven computer activity into learning outcomes [4][5]. Like the Java virtual machine, it responds to messages but, rather than returning computational states, returns information relating to pedagogical achievement. Being a virtual entity, it can run on diverse platforms while offering a common interface and language to students and teachers. For example, it can interpret low sequences of sensor-actions to signal the attainment of a higher level pedagogical goal, such as constructing a working control system. By making such abstract information visible it augments reality, thereby providing a means to supplement student learning by making hitherto invisible computer processes, and pedagogical activities visible to the student (and teacher) advancing both educational technology and augmented reality.

3. ASSEMBLING MOBILE ROBOT LEARNING ACTIVITY
An embedded computing learning activity is deigned that allows students to learn embedded computing activity and understand hidden technology. We propose a learning activity that demonstrates the workflow of the pedagogical virtual machine (PVM) model. The learning activity is based around assembling a modularized mobile robot called buzzBot which is illustrated in figure 1. To assemble the robot, students need to connect five main modules; Buzzbot, Buzzberry, two BuzzLink3 units and Raspberry pi. Thus, we structure the learning activity into a sequence of steps to achieve the desired learning outcome. This sequence includes both static and live data. The static data (information representation) is the data that guides learners to achieve each step while the dynamic (live) data gives feedback based on the current state of each physical object. If the dynamic data does not give any feedback, the learner will normally not be able to move to the next step until they plug the modules together correctly.

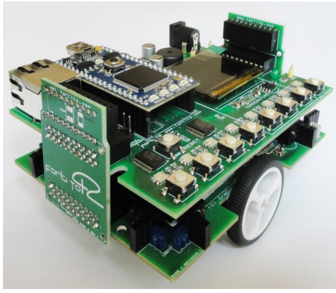

Figure 1 buzzBot (a Modularized Mobile Robot)

4. IMPLEMENTATION

We developed an augmented reality (AR) learning application that uses and supports embedded computing activities. The application uses the principles of the pedagogical virtual machine (PVM) model (i.e., AR with PVM). The learning design contains 3D arrows, overlay images, and text. The AR with PVM application was developed using a Unity3D[1] game engine with Vuforia's[2] AR software development kit. Then the application was built and run on an iOS Apple tablet using Apple's integrated development environment (IDE) called Xcode[3]. The physical object's (buzzBot[4]) main component was implemented using a Raspberry[5]—a small, low-cost computer with a Linux-based operating system. The other components were connected on RPi's general-purpose I/O pins, and communication was achieved using a python[6] library via the integrated circuit bus (I2C). Communication between the physical object and the tablet was accomplished using a web-socket framework.

5. EXPERIMENT

A group of students both undergraduate and postgraduate who study at Essex University, especially targeting the school of computer science and electronic engineering were assigned randomly to both AR with PVM and Paper-based approach figure 2. A between subject design was chosen, and the target number for each group was 10 students, which equal to 20 in the total for all groups. Participants were asked to fill in a basic knowledge and background survey. This was given to indicate of the validity of the samples. Both groups were given a brief instruction corresponding to each application and on its use. After that, participants completed the assembling mobile robot learning activity based on the respective approach. At the end of each activity, the participants were asked to complete a post-test followed by a user questionnaire to examine the learning effectiveness of each approach. Students who participate on AR with PVM will answer an extra section in the questionnaire to get a feedback about its benefit and difficulties and their experience of using the application. Time completion, a knowledge test, cognitive overload, and the learning effectiveness of each method are considered as measurements factors between the both groups.

[1] Unity3D Game Engine http://www.unity3d.com

[2] Vuforia https://developer.vuforia.com/

[3] Xcode https://developer.apple.com/xcode/

[4] Fortito Ltd – http://www.fortito.mx/en

[5] Raspberry Pi Foundation – http://www.raspberrypi.org

[6] Python - http://www.python.org/

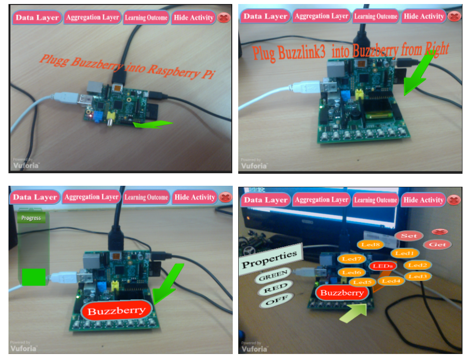

Figure 2 Example of Assembling Mobile Robot using AR

6. INITIAL RESULT

The assemblers who used the AR application outperformed the assemblers who used the paper-based approach in the post-test. Participants who used the paper-based approach were able to assemble the robot more quickly than did the AR participants. Participants who used AR had to spend extra time at each step during assembly of the robot because the AR application provides real-time data for each component and enriches learners with a more sophisticated learning experience with respect to assembly. Moreover, the experiment revealed no differences in the cognitive overload of both groups.

7. FUTURE WORK

We will invite more participants to take part in the experiment in the future. In addition, we will analyze data from both qualitative and quantitative sources. We will have a full explanation of the experiment, and we aim to choose a different learning scenario to confirm the generalizability of the pedagogical virtual machine.

8. REFERENCES

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