Influencing the Learning Experience Through Affective Agent Feedback in a Real-World Treasure Hunt

(Extended Abstract)

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ABSTRACT

We explore the effect of the behaviour of a virtual robot agent in the context of a real-world treasure-hunt activity carried out by children aged 11–12. We compare three conditions: a traditional paper-based treasure hunt, along with a virtual robot on a tablet which provides either neutral or affective feedback during the treasure hunt. The results of the study suggest that the use of the virtual robot increased the perceived difficulty of the instruction-following task, while the affective robot feedback in particular made the questions seem more difficult to answer.

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1. TREASURE HUNT ACTIVITY

The overall goal of the EMOTE project (*www.emote-project.eu*) is to develop artificial tutors with the perceptive and expressive capabilities to engage in empathic interactions with learners in school environments. Previous studies on robotic companions in real-world classroom environments [2] have shown that robotic platforms are promising tools for experimental learning. We hypothesise that a robot tutor that is able to detect the user's affective state and respond appropriately will result in increased motivation and better learning outcomes—and a crucial aspect of this overall goal is the specification of appropriate robot behaviour.

To address this issue, we carried out a user study investigating how the presence and nature of feedback from a virtual robot affects a child's perception, experience and performance in the context of a real-world treasure hunt activity. The real-world treasure hunt activity (Figure 1), which has been carried out at a local school for several years, requires the students to carry out a series of navigation steps in the real world, following a predetermined route on a map. Each navigation step first requires the students to walk a few yards while making use of their map-reading skills, and then to answer a series of questions regarding their new location; for example, they might be asked to identify the colour of a nearby door.

In the traditional version of the treasure hunt, the students are given a map on paper, along with a paper-based questionnaire listing the steps to follow and the multiple-choice questions to answer. For the purpose of the current study, we implemented an Android application for the treasure hunt (Figure 2), keeping the features of the application as close to the paper version as possible. In particular, all images, fonts and layout are comparable between the two versions, and the application displays a map corresponding to its paper counterpart and presents a sequence of the same steps as in the paper version to be carried out by the students. The application also includes a virtual robot head which presents the navigation instructions, poses the questions, and gives feedback on the correctness of the students' answers; depending on the application settings, this feedback could be either **neutral** ("correct", "incorrect") or **affective** (e.g., "well done", "too bad").

Figure 1: Students carrying out the treasure hunt

Figure 2: The Android application for the treasure hunt

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2. USER EVALUATION

We carried out a user study designed to compare the two agent feedback strategies with each other and with the traditional paper-based version of the questionnaire. This study involved 37 students aged 11-12, in pairs, across the following three experimental conditions: one-third of the student groups used the paper-based map and questionnaire, one-third used the Android-based tablet application with neutral feedback from the virtual agent, while one-third used the tablet application with affective agent feedback. We compared the students' task performance and subjective opinions across the three experimental conditions. This paper summarises the main results of the user evaluation; for a full discussion of the complete results, please see [1].

To measure the students' objective success at following the intended route, we used the GPS traces of the groups' progress around the treasure hunt route to compute two measures: the number of the intended waypoints that the group reached, and the total time taken to complete the treasure hunt route. We had also intended to analyse the subjects' responses to the treasure-hunt questions; however, due to a technical failure, that data was not available.

The students' subjective experience of the treasure hunt was measured through a three-part questionnaire:

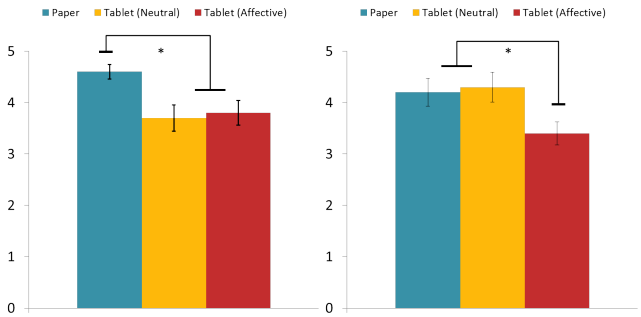
- Three questions regarding the student's opinion of the robot agent before the treasure hunt;
- Four questions regarding the treasure hunt itself; and
- Seven questions addressing the students' opinion of the virtual agent during the treasure hunt. *(Only to students from the two tablet conditions)*

To test the influence of the experimental manipulation on the objective and subjective measures, we used a two-way ANOVA analysis to determine the significant factors, and then used a Mann-Whitney U test to assess the actual significance. The experimental manipulation had no effect on the objective task success measures; however, the feedback strategy did have a significant impact on responses to two of the items on the subjective questionnaire (both $p < 0.05$ on a two-way Mann-Whitney U test):

- How easy the instructions were to follow ($F(2, 30) = 5.49$, $p < 0.01$): as shown in Figure 3a, the participants who used the paper-based questionnaire found the instructions significantly easier to follow than did any of the tablet-using participants.
- How easy the questions were to answer ($F(2, 30) = 3.60$, $p < 0.05$): as shown in Figure 3b, the participants who experienced affective feedback reported finding the questions significantly harder to answer than the other participants.

The results of this study suggest that the choice between tablet and paper-based presentation for the treasure hunt had no overall effect on the students' performance in the treasure hunt. However, as our objective measures (duration and waypoints reached) are unfortunately a proxy for performance on the actual question-answering task, it is difficult to be absolutely certain about this finding.

The choice of feedback strategy did have an effect on the subjective items measuring the perceived difficulty of the instructions and the questions on the treasure hunt. The participants who used the paper-based questionnaire found the instructions significantly easier to follow than did any of the tablet-using participants. This is likely because the paper presentation allowed the students to "look ahead" in the instructions, and therefore to have access to more context during the treasure hunt.



(a) Instruction ease (b) Question ease

Figure 3: The influence of feedback strategy

The other effect—where the participants who experienced affective feedback reported finding the questions harder to answer—is more difficult to explain. One possible explanation is that the affective feedback on incorrect answers (e.g., "Too bad") magnified their impact, while the affective feedback on correct answers ("Fantastic!") somehow made the participants feel like answering correctly was more of an accomplishment. However, since the actual question-answering performance of the different groups is not available, it is difficult to draw any definitive conclusions here.

3. FUTURE WORK

In the short term, we intend to re-run the treasure hunt study in order to obtain more accurate objective task success in terms of questions correctly answered; this should allow the impact of different forms of feedback to be assessed more fully, and should also permit more informative investigation of the relationship between the objective and subjective measures. For the next study, we will also update the app to incorporate more of the context provided by the paper version, which should make it easier to follow the treasure hunt instructions. Finally, we will update the feedback strategies in consultation with teachers and psychologists, in the hopes of making them more effective.

More generally, we will also apply the findings from these studies to the other affective robot tutors being developed in the project: in particular, we will be careful to ensure that any affective feedback from the agents has the intended effect on the overall pedagogical goals of the interaction.

4. ACKNOWLEDGEMENTS

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