

Teacher Perspectives on the Potential for Scaffolding with an Open Learner Model and a Robotic Tutor

Aidan Jones, Susan Bull and Ginevra Castellano

Electronic, Electrical and Computer Engineering, University of Birmingham, UK
axj100@bham.ac.uk, s.bull@bham.ac.uk, g.castellano@bham.ac.uk

Abstract. This paper considers the potential for scaffolding learning in open-ended learning environments using a robotic tutor and an open learner model. While we expect this approach to be more broadly applicable, we here illustrate with a map-reading activity in geography and/or environmental sciences. The paper presents issues raised in open-ended teacher interviews, which suggest real possibilities for incorporating a robotic tutor together with an open learner model in the classroom.

Keywords: affect detection, open learner model, scaffolding, social robotics

1 Introduction

Open learner models (OLM) externalise the learner model in a way that is interpretable by the user, e.g.: skill meters [16], concept maps [19], treemaps [14]. One of the aims of opening the learner model to the learner is to help promote reflection on the part of the learner; to facilitate their planning and decision-making; and raise their awareness of their understanding or their developing skills [3]. Thus, the OLM can be seen as a form of scaffolding for cognitive and metacognitive processes, with a particular focus on supporting and developing self-regulation. This focus is very much in line with previous considerations of tools offering scaffolding (see e.g. [1]). This approach to supporting the learner can be very light or can be more closely guided, depending on the level of detail of the modelling and the visualisation of the model, as well as the goals of the interaction and the user's current learning needs.

Most learner models that are inspectable by the learner have focussed on knowledge-related attributes. However, despite it being a difficult task, there is growing interest in detecting and responding to affective states (e.g. [6]; [24]; [25]), and increasingly with a goal of adaptive scaffolding to support individual differences [10]. A taxonomy of "academic emotions, which are directly related to academic learning, classroom instruction or achievement", has been identified [17]: the positive activating emotions of enjoyment, hope, and pride; the positive deactivating emotion of relief; the negative activating emotions of anger, anxiety, shame; and the negative deactivating emotions of hopelessness and boredom.

OLMs can offer an additional mechanism by which learner model data about affective states can be confirmed and/or clarified. In addition to visualisation of the learner

model, the term ‘open learner modelling’ encompasses methods that allow users to contribute to, edit, or negotiate the contents of the learner model [3]. While we do not wish to require or rely on self-report about emotions and affective states, if a learner is frustrated by feedback that has been generated in part based on inaccurate or incomplete affect detection, a simple method to advise a learning environment of this could be of substantial benefit. Thus, while providing an OLM of the more traditional knowledge/skills representations, we recommend also allowing the learner to access the representations regarding their affective state (e.g. inferred through sensors [24], semantic and contextual cues [25], or based on a video corpus of affective expressions [7]). This may bring new issues to the problems of affect modelling (e.g. if the learner model indicates an affective state that the learner disagrees with, might this make them angry, demotivated or frustrated?) Nevertheless, as well as offering an opportunity to modify or influence the representation of affect, it may also help increase learner trust in the learner model, as the user will be able to identify why certain aspects of feedback or scaffolding are tailored in the manner that they are, and have the opportunity to address or challenge any discrepancies. In this paper we take the starting point of benefits previously demonstrated for OLMs (e.g. [12]; [16]), and consider their use in a more open-ended context, and with affect modelling.

2 Scaffolding with an Open Learner Model

As argued above, OLMs can be considered as ways to help scaffold learning and the learning process, and may have particular potential in open-ended tasks and environments. With the increasing focus on professional competency frameworks and the inevitable extension of the competency perspective to educational contexts (e.g. for language [8], for STEM literacy [2], for geography [21]), there comes even greater scope for future use of open-ended learning environments, and corresponding challenges for scaffolding learning in such situations. Competency frameworks have already been applied in a generic OLM context, with examples for language [4] and meeting facilitation [20]. We propose that such approaches be further developed to meet the requirements of the changing educational focus, curricula, and assessment.

We illustrate here with a geography and/or environmental science map-based activity, where tools may be used to discover information from a map, to measure distance and area, to view terrain or entities on the map such as buildings, cities and countries. The learner may identify features, follow directions in a trail, explore the area, or determine the best location for some purpose (e.g. where to situate a new visitor centre). Such activities can range from specific to very open-ended, and a range of competencies may be demonstrable (e.g. map-reading, map sketching, mapping, geographical argumentation, ethical judgement (see [21]).) This relates closely to the England and Wales National Curriculum for Geography [9] key processes, e.g.:

“Pupils should be able to:

- use atlases, globes, maps at a range of scales, photographs, satellite images and other geographical data;
- ask geographical questions, thinking critically, constructively and creatively;

- analyse and evaluate evidence, presenting findings to draw and justify conclusions;
- solve problems and make decisions to develop analytical skills and creative thinking about geographical issues.”

However, the nature of this type of open-ended activity may also lead to different affective states across and within individuals. In the next section we consider the opportunities for improving scaffolding using OLMs that include representations of affective states, supported by an empathic robotic tutor.

3 Support from a Robotic Tutor

Opening up a system’s representations of a learner’s affective state could, as indicated above, further influence learner affect. To mitigate a possibly negative reaction that could impact motivation, we recommend taking a social robotics approach. Artificial tutors may incorporate their understanding of the learner’s emotional state in their pedagogical strategies and interventions [5]. The presence of a 2D or 3D character has revealed some positive learning effects, especially in engagement [15]; and recall has been shown to be higher with a robotic teacher when adaptive cues have been given based on EEG measurements of engagement [22]. Studies that compared virtual representations of characters with robots showed a preference for robotic embodiment with reference to social presence [13], enjoyment [18] and performance [11]. Thus, we suggest this to be a useful avenue to explore for scaffolding learning particularly when affective states are also modelled. For example, Figure 1 shows the Nao Robot and its ability to point or gesture towards items on a tabletop, which include visualisations of the learner model. Since many of the activities we envisage are map-based, we will use an interactive map approach on a touch table in this example.



Fig. 1. The Nao Robot and a competency-based open learner model (skill meters and word cloud shown, from the Next-TELL open learner model [20])

Examples of general interactions and scaffolding between the learner and the robot include: offering assistance by guiding the learner through instructions; asking questions (to prompt reflection); gestures (to illustrate or focus attention, or indicate shared focus); offering affective support if learners’ actions are not optimal (telling them not to worry and try again); drawing attention back to task if a learner becomes distracted; mirroring affective state when this is positive, and bringing awareness to affective state if it is negative. This aims to foster a perception of the robot as empathic (see e.g. [7]).

In addition to the learner model visualisations on the tabletop, the robot can itself express the model content by giving a summary of relevant knowledge or competencies, perhaps at the start of a session to show that it remembers the learner, but also during a session to give the learner a sense of achievement and to prompt them to think about their learning and how they might use the learner model information. As with adaptive scaffolding in general, interaction about the learner model will be tailored as appropriate to the individual, as will other scaffolding behaviours from the robot.

When using the OLM to investigate its representations of their affective state, the learner will already be accustomed to the robot's shared understanding of their competencies. Therefore, when it then comes to reviewing affective states in the model, the robot's ability to invite or allow discussion or adjustment to the affective model contents can build on the relationship that the learner has with the robot, with reference to their understanding or competencies. This approach will build on previous findings using a chatbot, that child-system negotiation of the knowledge-focussed data in an OLM resulted in significant improvements in children's learning without additional tutoring [12]. In that case negotiation involved student or system challenges and discussion about the child's beliefs (representations in the learner model) with the aim of prompting reflection and increasing the accuracy of the learner model by taking students' opinions about their learning into consideration. In our current work we propose also encouraging the learner to think about their affective state, how this may influence their learning, and how they might regulate their affect. In effect, this is an approach to help learners self-scaffold during the transition from more tightly to less tightly guided interaction. The first step towards this goal involves obtaining teacher viewpoints on the potential of this approach in the classroom. This is considered in the next section.

4 Teacher Interviews

Following from the arguments above that suggest possibilities for scaffolding in open-ended tasks using an OLM together with an empathic robot, teacher interviews were undertaken to determine the likelihood of uptake of this approach in contexts where the required technologies are already in place.

4.1 Participants, Materials and Methods

Seven participants took part in open interviews (4 teachers, 2 teaching assistants, 1 trainee). The aims of the study were described, highlighting emphatic tutoring and interaction, and personalising robotic tutoring to the learner's needs. In a semi-formal interview, specific questions relevant to scaffolding and OLMs included:

- What role would a system like this play? (To ascertain teachers' views on how the robot could effectively 'fit' into the classroom and classroom practice.)
- If you had a robot that could monitor how a child is progressing, how would you like that robot to interact with the child? (To provide information for the design of the learning scenarios and robot interactions.)
- Would it be beneficial to set the level of difficulty and how do you do this at the moment? (To gauge the extent of teachers' likely acceptance of a coarse-grained personalisation approach with a robotic tutor.)

- How do you detect when a student is having difficulties and how do you help the learner overcome the difficulties? (To ascertain how teachers detect when a learner is facing difficulties in this kind of open-ended activity, and whether they may be receptive to more fine-grained adaptation with the robotic tutor.)

Written notes were made by the researcher. Comments were then categorised to help design subsequent formal interviews before building the prototype environment.

4.2 Results

Table 1 summarises the number of teachers expressing each of the points addressed below, following the comment categorisations, with representative viewpoints then discussed further. Several teachers were very interested in the fact that they could use the system to encourage independent learning, as this is becoming a key objective for teachers. To address the varied needs of students, at the moment the teachers might give out different question sheets to different students. Typically the teachers change the difficulty of an activity by changing the language style, the number of prompts, breaking down the activity into smaller steps, and the amount of scaffolding provided. The most difficult questions or problems may be very open-ended, and require the learner to argue a point in their own words, or the teacher may apply extra constraints such as working within a budget. All teachers were keen that the system to be trialled should be able to respond to the individual, stretching the most able while also ensuring suitable personalisation for the less advanced students.

Table 1. Teacher comments categorised

Comment	No. teachers
Encourage independent learning	3
Personalisation / adaptivity	7
More open-ended activities	7
Prompt metacognitive behaviours	7
Affect detection	7
Use of progress bars	2
Incorporation of robot into classroom	7

In addition, all teachers stated that they would like the learning activities they undertake to easily move beyond basic map reading skills to activities where the learner needs to make comparisons, decisions and arguments. Comparisons in this space could be to compare high and low CO₂ production, population density, and similar. Decisions and arguments could be made on tasks which involve, for example, deciding on the most appropriate location for a visitor centre or flood defence: the learner must make an argument in favour or against an action. Thus, the teachers are looking for ways to incorporate more open-ended activities into the classroom interaction. All also wanted to encourage reflection and metacognitive behaviours, for example, by saying “Have a think”, “Did you consider...?”. They also thought that the robot could usefully point out that there is no really wrong answer in some of the activities.

All teachers already detect whether a learner is having difficulties, from their behaviour. For example: the teacher can tell if the learner is not listening, not paying attention or not understanding. This information can come from their facial expression, where they are looking, whether they are fidgeting, how they respond to instructions, whether they are actively asking for help verbally or by raising their hand, or if they are chatting or disrupting other children. The teachers can also identify whether a learner is attempting a task in a sub-optimal way.

Two teachers suggested that progress bars may be beneficial. They stressed that real time assessment would be desirable, and if a learner faced difficulties, these need to be caught promptly and acted upon as appropriate by the system or the teacher.

There were no concerns from any of the teachers about fitting the robot into the classroom activities, particularly if the lesson plan actively included the robot (e.g. as a station in a station rotation lesson where a number of learners in a class would have a turn with the robot). The teachers were interested in monitoring the learner's progress from a console, enabling the teacher to intervene if the learner stopped making progress, particularly useful if there were multiple learners interacting with multiple artificial tutors. They also thought that the simple fact that there was a robot would make any task seem novel and more engaging.

4.3 Discussion

Because the interviews were open, not all points were discussed in each interview. The lower level of comments in some areas therefore may not indicate disagreement, but rather that these issues were not raised during the interview.

The possibility for the robot to adapt to individuals, as requested by all participants, is exactly the kind of approach enabled by a learner model. For this reason the learner model is anticipated to be acceptable to teachers in this robot-tabletop context. All teachers also wished to use open-ended tasks such as described above, to match the requirements of the England and Wales National Curriculum for Geography [9]. This is, therefore, another indication of likely acceptance. Furthermore, because teachers are already identifying student engagement and other affective states, the modelling of affect and use of a physical robot is an approach that they will understand: while they may not be able to discuss knowledge and competencies individually to the extent they wish, a robotic tutor can help in this task while maintaining an approximation of the empathic approach a teacher would use. The fact that two teachers suggested progress bars indicates that these participants wish to have a view of learning visible on the tabletop, in line with OLM. In addition, the OLM should facilitate the kind of metacognitive behaviours considered important by all teachers. The request for being able to monitor learners is also in line with OLM also being a tool to support teachers [20]. This goes beyond many learning analytics visualisations (e.g. dashboards [23]), to focus on understanding, competencies, and now also affect.

An important immediate concern is practical deployment in the existing learning context and curriculum. All teachers could see how the robot and touch table could be integrated into the classroom, and could identify benefits for doing so. Thus we argue that there is a role for empathic robots and OLMs in scaffolding open-ended learning.

5 Summary and Conclusions

This paper has argued the benefits of using an OLM as a means to lightly scaffold learners in open-ended learning contexts where the development of self-regulation skills and metacognitive behaviours are considered important. This is becoming increasingly central with the competency focus adopted in many subjects and countries. Affective modelling is considered beneficial in such contexts, given the potential frustrations of the open-ended nature of activities, and the provision of a means to discuss and possibly correct the system representations of affect is suggested. Because of the advantages of robotic tutors, an empathic robot approach is proposed. The teacher interviews confirmed the feasibility of introducing this solution to real classrooms that have the appropriate technologies.

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