Can Young People with Autism Spectrum Disorder Benefit From an Open Learner Model?

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Abstract. This paper describes the evaluation of Maths Island Tutor - an intelligent tutoring system for children with autism spectrum disorder (ASD). The tutor includes an open learner model (OLM). In order to benefit from this feature, the learner needs to be able to process metacognitive attributes, which can be impaired in ASD. In order to address the needs of this specific population, young people with ASD were involved in the design of the software for their use, including the OLM. A preliminary study evaluating the system demonstrated that young people with ASD did initiate access to their OLM, could correctly reproduce details from their OLM, and could also highlight the location of (study-intended) errors within their OLMs giving rise to suggestions about their abilities to remember and potentially meta-cognitively reflect on their learning.

1 Introduction

The research aim was to develop and assess the utility of educational tutoring software for mathematics, especially designed for the needs of young people with ASD. The mathematics tutor includes an open learner model (OLM) that could encourage self-reflection to enhance learning outcomes. The research sought to extend the benefits of OLMs to young people with ASD by involving them in the design of the OLM through a process of participatory design. OLMs are an external representation of a learner model. They can demonstrate to students their own learning trajectories in order that they are made aware of which learning strategies they had adopted and which were or were not successful. The aim of OLMs is to support metacognitive processes, for instance in reflecting on the use of different learning strategies with the intention of enhancing performance [1]. Different types of external representation have been applied in OLMs. They range from simple textual descriptions [2], to complex representations, such as conceptual graphs [3], and tree structures [4, 5].

All of the research outlined above has been based on the general population. ASD is associated with a weakness in metacognition including self-reflection [6]. Consequently, the research sought to assess if this was the case with the OLM, given the young people's involvement in the OLM design.

2 Maths Island Tutor

Maths Island Tutor is a system for teaching multiplication, which is part of the 'number' subject from the UK National Curriculum for Mathematics. It includes an OLM. For the development of the OLM young people with ASD were involved in the design process.

A map was chosen by the participants as a basic idea for the representation of the OLM. Maps were preferred above other representations by young people with and without ASD [7]. Figure 1 shows an example of the OLM which was developed with the young people with ASD in the participatory sessions. Each mathematical concept is represented as an island. The flags on each island 'fill up' with colour as the student answers questions correctly and include a symbol which appears when the topic has been concluded. The position of the user on their learning route is represented by a car that moves along from topic to topic.

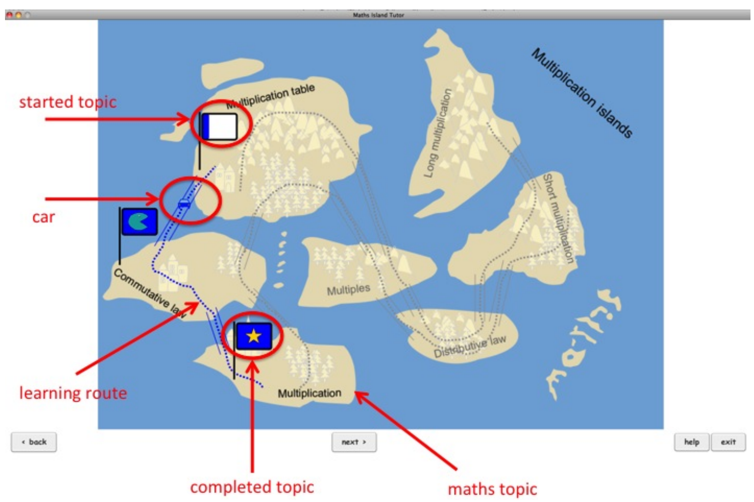

Fig. 1. Example of the OLM

The OLM can be accessed by the student at any time by clicking on a button. Additionally, the OLM will be displayed automatically at the beginning of a new mathematical concept, and also after completing the mathematical concept.

3 Evaluation

We were specifically interested in identifying whether young people with ASD are able to benefit from an OLM and whether it encourages self-reflection. Participants were 24 school children with a clinical diagnosis of ASD (19 male and 5 females), with a mean age of 13.6 years (s.d.=1.3). Although these schoolchildren had an IQ within the normal range, they were underperforming in mathematics. The control group chosen therefore were typically developing (TD) children who were studying the same course material in class. There were 28 TD school children, 10 males and 18 females, with a mean age of 10.5 years (s.d.=0.5).

To investigate the young peoples awareness and understanding of the information provided by the OLM, a decision was made to include both accurate but crucially also inaccurate information (i.e. errors) in the OLM. We therefore conducted three 20-minute sessions, where in two sessions the OLM was altered in a way that would give insight into its effectiveness as a tool for self-reflection: **session 1** - OLM with no error; **session 2** - OLM with an error - participants were not informed that the OLM included an error; **session 3** - OLM with an error - participants were informed that the OLM included an error. After sessions 2 and 3 participants were provided with a screen printout of an empty OLM representation for the purpose of self-reporting. They were requested to indicate which mathematical concept they had learned by ticking the flags on the relevant mathematics islands and circling the flag that included any error.

3.1 Results

The TD group completed roughly double the number of mathematical concepts as the ASD group in all 3 sessions. This also means that the TD group was provided with the OLM automatically more often after a mathematical concept was completed. However, there was no differences between the groups in how often they self-initiated the OLM (through the button).

There were no significant differences in the proportion of flags (mathematical concept learned) correctly identified as being present in sessions 2 or 3 by the TD and ASD groups (0.71 vs 0.59 ($t(50)=1.06$, ns; 0.77 vs. 0.73 ($t(50)=0.33$, ns). A pairwise t-test also showed no significant difference in the proportion of correctly identified flags *between* Session 2 and 3 for both TD and ASD groups ($t(27)=1.16$, ns; $t(23)=1.61$, ns; respectively).

More of the TD group than the ASD group identified the presence of an error in both Sessions 2 and 3 (0.93 vs 0.71: $t(35.07)=2.06$, $p<.05$; 0.89 vs 0.46: $t(44.48)=3.33$, $p<.01$) suggesting either they were good at noticing errors or were guessing an error had occurred. However, of those who had identified the presence of an error, those with ASD were significantly more likely to accurately locate the error than the TD group, significantly so in Session 3 (.38 vs .53 ($t(41)=.92$, ns ; .33 vs .73 ($t(33)=2.27$, $p<.05$).

4 Discussion and Conclusion

There were no differences between the groups in correctly identifying flags after sessions 2 and 3. This implies either that young people with ASD can benefit from an OLM despite the ASD weakness in metacognition, or that they were very accurate in remembering the state of their OLM. This needs to be investigated further along with the potential implications for self-reflection of accurately remembering details of their OLM as this may relate to growing awareness as part of the processes necessary for successful self-reflection.

At some level, it is not surprising that more of the TD group identified an error than the ASD group, as ASD is associated with a weakness in metacognition. There are several possible explanations for this result: i) asking the TD group if there was an error might prime them to say Yes; ii) guessing might be more likely in the TD population; and iii) children with ASD might be less likely to believe the computer could be inaccurate and to literally believe all computer outputs. Interestingly, of those who had accurately identified the presence of an error, those with ASD were significantly more likely to accurately locate the error than the TD group, particularly in the last session (session 3) where participants were advised at the beginning to watch out for an error. This corresponds with the ASD trait of attention to detail [8].

The results crucially indicate where further research is necessary to eliminate any other interpretations of the results relating to guessing, enhanced memory and so on. Further studies and analyses specifically investigating whether benefits to learning occur as a result of accessing the OLM are being undertaken.

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