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# Developing an Embodied Pedagogical Agent With and For Young People with Autism Spectrum Disorder

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**Abstract.** This paper describes how we developed an embodied pedagogical agent (EPA) with and for young people with autism spectrum disorder (ASD). ASD is characterised by impairments in social communication, imagination, and perspective-taking, which can compromise design and collaboration. However, if an ASD preference for visual processing can be supported by providing images of design ideas as they develop, these difficulties may be overcome. We describe a methodology that successfully supports the visualisation and development of EPAs using our prototype visualisation tool (EPA DK), enabling ASD users to function as active design participants.

**Keywords:** Embodied Pedagogical Agent, participatory design, autism spectrum disorder.

## 1 Introduction

Our aim is to include young people with ASD in the design and development process of educational software. To achieve this, particular impairments that are associated with ASD, including social communication, creativity, imagination, and perspective taking, need to be overcome. However, there can be enhanced visual processing abilities. It may be possible to support these preferences for visual material to allow young people with ASD to contribute effectively to design and collaboration processes by visually supporting the externalisation of ideas.

We have developed an intelligent tutoring system for mathematics, which includes an educational pedagogical agent (EPA). The benefits of EPAs have been widely documented. They can enhance motivation, understanding and attitudes in learners (e.g. [3, 5, 7]). However, this research was based upon a typically developing population and may not be generalised to users with ASD, given their social communication deficits. Therefore this paper outlines the process whereby a pedagogical agent was designed and developed with and for young people with ASD. We offer a contribution to methodology in this area: a simple tool which enables us to visualise, develop, and code EPAs dynamically, on-the-fly, in design sessions with the active participation of young people with ASD.

## 2 EPA development kit (EPA DK)

Yamamoto & Nakakoji [10] state that a design process involves the externalisation of partial solutions to a problem (for example, sketching an idea), which will be constantly revised in order to gain a better understanding of the problem, whilst aiming at a solution. Thus, a key issue is how do we develop appropriate means of supporting externalisation for ASD users.

A computer system can be seen as a tool able to define a user's externalisation space and the ways in which the user can interact with it [9]. Different types of software models and tools have been developed that are able to support ideas generation and collaboration. As described in [8] the success of such tools may depend upon their use. The tools encourage the externalisation of ideas as well as the manipulation and / or management of external representations.

For individuals with ASD, an effective tool for idea generation and integration needs to provide an externalisation space that is narrowed down and restricted to what is currently relevant in the design process, but still allows enough space for the integration and refinement of ideas. Current tools are unable to provide such an externalisation space as they are too generic. Thus, our EPA development toolkit (EPA DK) supports the process of both developing and visualising EPAs. The tool specifically supports the process of externalising and refining ideas, by transforming EPA sketches into a functional prototype directly, on-the-fly. It also provides a means of demonstrating different layout and EPA feedback / interaction options; and of changing an EPA's appearance using different media, such as screen printouts, and / or a software drawing package.

In order to investigate how the ASD preference for visual processing can be used to overcome difficulties in imagination and social communication, we applied the EPA DK tool in our system design and development process.

## 3 EPA design and development process

The design process adopted Druin's [4] and Guha's et al. [6] work. It includes a three-stage participatory design process of individual idea generation, mixing of ideas, and integration into a 'big idea'. We complement this with on-the-fly rapid prototyping facilitated by EPA DK in the design and development sessions.

### 3.1 Study aims

In order to involve young people with ASD as active participants, the study investigated whether difficulties in imagination [2], social communication and collaboration [1], could be overcome by supporting the externalisation of ideas to help make things concrete and also by providing a foundation for visually processing ideas of others.

### 3.2 Design teams

For our design sessions, six high-functioning young people with ASD (all male, 11-15 of age) were divided into two groups. Each session included three young people with ASD; a specialist ASD teaching assistant; and three researchers, who took different roles, including facilitator, designer, and note-taking observer. The studies took place at the school to provide an environment that was familiar to participants.

### 3.3 Procedure

**Idea generation and mixing of individual ideas.** Participants in each design group were asked to individually design an EPA for a mathematics tutor using different coloured pens, pencils, and blank A4 paper sheets. Participants were instructed that the role of the character was to encourage the student to perform certain exercises and would give feedback on answers. Further, the character's appearance and interaction could be decided by the participants, including its different emotional responses.

At the end of the individual idea session, participants were asked to explain each idea to other group members. This was followed by combining the individual ideas into one group idea, together with a drawing of this group idea on paper.

**Big idea.** The next part of the EPA design process involved combining the two group ideas into a 'big EPA idea'. Here, all six participants were instructed to generate a 'big and even better' EPA design idea. A group spokesperson explained his group's idea to members of the other group, while a researcher noted the main features of the EPA design on a whiteboard. A mark was placed on features that were particularly liked by participants from the other group. Participants then decided on a 'big EPA idea' that conjoined the 'best' and 'most liked' features of the two group designs. This was followed by building the EPA idea using art materials.

**EPA DK.** All six participants were involved in a day-long prototyping session, where the EPA design was further refined using the EPA DK. The session was divided into three phases. The externalisation space given to participants was specifically tailored to particular design tasks, which changed and built up across the three phases.

The **first phase** demonstrated an idea using EPA DK, looking at the effect of transferring an idea into a concrete prototype, including different interaction options. Participants' feedback was used to change the prototype on-the-fly, with the resultant EPA prototype including only preferred EPA responses. The externalisation space was narrowed down to the specific idea, which placed the idea into its relevant context (an EPA prototype) and allowed its visual exploration.

The **second phase** investigated how the process of refining an existing idea could be visually supported. An electronic version of an EPA idea was given to participants that showed an external representation of an idea that could be refined. Participants were asked to change the EPA as they preferred, and the resulting image was then uploaded into EPA DK.

In the **third phase**, screen printouts of the EPA prototype were given to participants, as a medium where new ideas could be integrated. Participants were asked to externalise ideas for the verbal feedback a character could give for a positive and negative response to maths questions. The screen printouts showed the existing EPA idea with empty speech bubbles, in order to encourage participants to externalise ideas about the EPA's feedback.

# 4 Results

## 4.1 Idea generation and mixing of individual ideas

Participants in both groups were able to generate individual ideas that were then combined and mixed into a group idea. Figure 1 shows the evolution of the EPA ideas from the individual to the group ideas (shown in bold frames). One participant in the second group was unable to attend this session, hence only 2 individual ideas are shown in the second group.


**Fig. 1.** Examples of participants' EPA ideas and combined group ideas (bold frame).

The first group decided on a car, where you could see two characters from the back. Instead of showing emotions through facial expressions, the characters (shown from the back) would have a conversation about the student's progress on learning performance.

The idea of the second group included a 'pac man' character, which would dance, smile and jump when getting answers right. Emotions were expressed through the character changing colour: for example, yellow to express happiness, blue for sadness, or orange for pride.

## 4.2 Big idea

The groups met to discuss the 'big EPA idea'. It was decided amongst participants that the EPA design should include characters that were sitting in a car. The characters would change colour to express emotions. Using art materials, participants then undertook different roles in building certain parts of the big idea. However, participants focussed on their original individual ideas from the previous sessions without actually integrating them: instead of building an EPA design based on a combination of their group ideas, participants referred back to their own individual ideas.

### 4.3 EPA DK

In this session the EPA DK tool was used to both visualise and develop the EPA idea. As a basis, we used the central idea from the 'big EPA ideas' session - the car design - with two characters sitting in the front seats, from a back-seat passenger's perspective. The EPA prototype was shown to participants and different feedback options and interaction styles were demonstrated. Participants expressed preferred and non-preferred feedback / interaction options. Non-preferred options were removed directly on-the-fly during design session.

Participants were then asked to refine the EPA design according to their wishes, providing an electronic version of the external representation of the EPA shown in the prototype. The refined design was then included within the EPA prototype and demonstrated to participants.

Participants were finally asked to develop ideas for the character's verbal interaction using screen printouts showing an EPA design. Figure 2 shows examples of participants' ideas for the character's responses. Interestingly, in contrast to the study described above (Section 4.2), participants were not only able to externalise and integrate new ideas, but to integrate their individual EPA idea from previous sessions.


**Fig. 2.** Examples of participants' ideas for verbal agent interaction.

## 5 Discussion

Contrary to impairments in autism in imagination [2], participants were able to express and externalise their individual ideas for an EPA and to mix their individual ideas within a small group. We need to investigate further whether participants were able to mix their individual ideas within the smaller groups based on the ability to look at the other participant's drawings. Transforming an EPA idea into a concrete prototype enabled participants to visually explore different designs. By narrowing down the externalisation space, participants were able to visualise an idea (which might be someone else's idea).

The 'big ideas' session showed that when participants were asked to externalise and build an idea that was based on a combination of both group ideas, they reverted back to their individual ideas. This result supports the theories of autism outlining difficulties in social communication and collaboration [1]. However, these problems may be overcome if the externalisation space restricts participants to a specific collaborative issue or provides opportunities for adding further detail collaboratively.

## 6 Conclusion and Future Work

It is important to include users in the design of software, especially if the software is targeted at a special needs user group.

ASD is associated with social communication difficulties and imagination deficits, which may relate to problems in imagining the ideas of other participants. Those difficulties can be overcome by using our computerized tool (EPA DK), which allows participants to view and experience different design ideas.

The next stage in the research agenda is to evaluate our intelligent tutoring system. This will include an assessment of the effectiveness, for engagement, motivation and learning, of the EPA design, created with and for young people with ASD.

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