Affective Engagement in Teachable Agents

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Abstract. Students’ use of two different versions of a digital math game, one extended with a teachable agent, is compared. The purpose is to compare the affective engagement of students using the two different versions. An overall aim is to extend our knowledge of the paradigm Learning by Teaching.

Keywords. Learning by teaching, teachable agent, affective engagement

1. Introduction

There is much in favor of the pedagogical idea that a good way to learn something is to teach it. As an everyday psychology phenomenon it is experienced by numerous people involved in education and from a theoretical perspective there are several proposals as to why this pedagogical approach is so powerful. A seminal article by Bargh & Schul [1] discusses three phases of teaching and the possible cognitive benefits involved in them: (i) the preparation to teach, (ii) the actual teaching, and (iii) the responding to the student’s questions. This third phase may give feedback pointing to weak areas of the teachers’ own knowledge, prompt novel explanations, and bring up unthought-of perspectives.

Okita & Schwarz [3] focus on a correspondence to the above third (iii) phase of teaching, but substantially broadens the perspective of Bargh & Schul [1]. They underline that there are other types of feedback than the student’s questions that may positively affect the teacher’s learning, for instance “non informative” utterances such as: “I think I understand” and “Oh I didn’t know that”. Furthermore, non-verbal information such as observations of the student’s actions is a form of feedback that can be highly useful for the teacher’s learning [3].

Also in another respect, Okita & Schwarz [3] expand the perspective compared to the framework of Bargh & Schul [1]. Besides proposing possible cognitive mechanisms involved in the pedagogical idea of learning by teaching, they also point to possible affective or motivational mechanisms such as a teacher becoming engaged by a student’s performance, and a teacher feeling responsibility towards the student. These affective or motivational mechanisms can be intertwined with cognitive mechanisms and e.g. increase the teacher’s attention towards her student’s answers and actions.

The work in progress presented in this article is primarily concerned with affective aspects of “Learning by Teaching” henceforth abbreviated LBT. Next, two versions of

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a digital learning environment are discussed; one of them but not the other based upon LBT. Finally, a pilot study and a current study in progress are presented.

2. Design of learning environments

_Graphical Arithmetic Microworld_ (GAM) [4] is a suite of math games where mathematical operations and rules are mediated through graphical animated representations.

In the standard version of GAM, students play either against one another or against the computer. The _LBT_ version of GAM is extended with _a teachable agent (TA)_ [2], which is a form of educational technology that explicitly builds upon learning by teaching as a pedagogical framework. Here the student teaches the TA, and depending on the teaching the TA constructs a mathematical model by means of artificial intelligence algorithms. The TA’s mathematical knowledge is continuously reflected in its skill to play the different games. Depending on the TA’s skill the student can revise the agents’ knowledge (and her or his own).

There are a number of possible pedagogical gains in adding a TA to GAM. The underlying pedagogical strategy in GAM is to ground a mathematical understanding in more intuitive experiential spatial relations that are gradually connected to more formal mathematical representations. Teaching a TA, and receiving feedback on one’s explanations by experiencing how they affect the TA’s gaming skill, can increase the student’s impetus to work on integrating spatial notions with the more formal representations. An affective engagement in “one’s student” (the TA) may also intensify the focus on what happens and why in the game. The ultimate goal is to support the teaching student to develop a more structured understanding of the mathematical concepts rather than “just playing” in the sense of merely manipulating spatial representations in a game.

The two versions of the games, _with_ and _without_ a TA, make it possible to investigate the pedagogical concept of _Learning by teaching_. Below, a pilot study and the current extended study are presented.

3. Pilot study comparing GAM with and without a TA

Twenty-one students, 10-11 year olds, in a 4th grade class at a Swedish school, participated. Prior to the study, the students completed a mathematics pretest that was used to balance them evenly between the two conditions: _without TA_ and _with TA_. All students started with a first session where they played against each other in pairs. In the second session the _with TA_ group taught a TA to play the games, and the _without TA_ group played against the computer. In the third session the _with TA_ group retrained their TAs and let them play against each other, whereas the _without TA_ group played against the computer. The details of the study and its results are reported in [5].

The observations from the pilot study that are followed up in the current study are the following: (i) students in the _with TA_ condition appeared to spend more time thinking and seeking to understand compared to students in the _without TA_ condition, (ii) more involvement in the games, together with a lesser tendency to become bored, was observed in students in the _with TA_ condition – in particular these students showed intense involvement when watching their agents perform against each other, (iii) some
differences in the mathematics test performances were noticed comparing pre and post tests, with slightly larger improvement for the with TA group.

4. The current study

The aim of the current study in progress is to scrutinize the observations of the pilot study regarding affective differences in the two conditions. This will be achieved by using a set of behavioral measurements in a more controlled fashion, the observations of the pilot study regarding affective differences in the two conditions. Eventually there is an interest in investigating if and how such possible variations align with variations in the development of conceptual understanding.

The current study involves eight pairs of students in the same age span as in the pilot study. All pairs of students will use both versions of the games, with and without TA, and sessions will be recorded by video and logged. Pre and post mathematics tests as well as attitude assessments will be conducted, and students will be interviewed after the sessions.

The number of participants is relatively low, however the possibility to compare one and the same pair with itself increases the chance of observing relevant behavioral differences. The measurements used in the study are quantitative as well as qualitative behavioral comparisons of: gestures (amount, intensity), pointing at the screen (amount, direction/target), discussions (game related vs. not), affective utterances (amount, content), gaze (direction/target). The interpretation of these data will be based on correlations to what is actually completed on the screen. An underlying goal is to seek forms of measurements that may respond to qualitative phenomena such as engagement, focus, attention, etc. To support this ambition the interviews will be structured in order to gain insight in the students’ experiences of the two different versions of the game.

A limitation due to the time perspective of the study is that an affective aspect such as feeling responsibility towards – and developing a relationship with – one’s student, is probably less likely to appear. Hopefully there will be options to look into such aspects in later phases of the project, which as a whole will run over several years. A further ambition is to look closer at the possible relations between affective and cognitive mechanisms for the development of conceptual understanding within the paradigm of Learning by Teaching. Ultimately, we aim at increased knowledge of how to implement this seemingly powerful pedagogical framework and how to use learning technology that exploits and aligns with this knowledge.

References