Combining Inclusion and Individually Adaptive Learning in an Educational Game for Preschool Children

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Abstract

Digital educational games have been around for a long time and have shown to be pedagogically valuable. Unfortunately most games do not utilize technology to the extent that is possible. Not the least this applies to mathematical educational games for younger children.

This work aims to combine several educational scientific approaches using current technologies, which traditionally had been very difficult or not economically viable in the non-digital context. Especially we focus on combining Inclusion with Adaptive Learning, while simultaneously use the beneficial properties that Learning by Teaching offers and find additional synergies to improve mathematical learning in preschool children.

No studies have yet been carried out with this system, but it has opened up for several potential studies and offers a mean to carry out cost effective cross-cultural studies.

1 Introduction

Mathematics is important. If you fall behind at an early stage it can be very hard to get back on track, but it can also halter development in other learning areas, directly or indirectly.

One of the more important reasons to make sure that young children develop an awareness of learning is that failing to do so may result in that the children develop an Entity Theory of Intelligence. Having this fixed view of one’s intelligence can fundamentally influence achievement goals and thus inhibit learning. This can be devastating if the teachers don’t discover this and let it go even further, instead of aiding the children to develop an incremental view of intelligence.

This work aims to teach mathematics to children, while preventing some students to fall behind, using today’s technology with educational scientific approaches. More specifically it will make use of Teachable Agents, Inclusive Pedagogy and Adaptive Learning using computers and automatic processes.

The educational game that has been developed runs in modern web browsers. This will let the game be readily accessible for a wide range of users while the system can be easily maintained and updated, keeping the costs down. The game aims at identifying students who tend to fall behind compared to other students by collecting data from the players in a structured way. The data will be presented for the teachers and supervisors to enable them to get an easy overview of the students’ progression and development.

Additionally, the game uses adaptive difficulties to keep challenging the students at their individual level of knowledge and mastery. This is implemented by collecting game data when the student plays the game and then analysing the data on the server and then adjusts the difficulty on the next game based on previous performances. This will also let several children play the exact same game, independently of their individual skill, which will not exclude some students from doing the same learning activity as the other students.
2 Theories and Methods

2.1 Number Sense

Longitudinal studies have shown that children that are late adopters of Number Sense may have difficulties coping with mathematics in school [9, 12, 14, 13, 11]. Children that fall behind at an early stage may have severe problems repairing this in school and may be out of phase for years to come. It has also been shown that children who develop their mathematical skills early on will perform better when starting to attend regular school [10]. Therefore it is essential to develop a basic understanding of numbers: their magnitude, how they relate to each other, that they can be manipulated and how that can be done — which is known as Number Sense.

One of the most fundamental virtual representations of numbers and their relation is the number line [10]. A number line can support one performing various operations on numbers, as well as understanding the order of magnitude of a number. Since this is such a fundamental piece of knowledge it is essential that we emphasize the knowledge and learning of this. Studies have shown that children are often able to learn to adapt the concept of a number line and these children proved to perform better in school [10].

2.2 Theory of Intelligence

Studies have shown that one can perceive ones intelligence in mainly two ways: as fixed (Entity) and as something that can grow (Incremental). Having an Incremental Theory of Intelligence means to view one’s intelligence as something under development where one can expand ones current level of knowledge and understanding by learning. Having an Entity Theory of Intelligence means to view intelligence as a fixed depth of understanding and knowledge. A child’s theory of intelligence can fundamentally influence his or her achievement goals [7].

This may prove to be dangerous if a child believes to not be smart enough or is perceived this way by others, e.g. a parent. Ones ability to learn might be inhibited and will then risk to fall behind other students. This can be the start of a vicious circle, especially since this is highly self fulfilling [16]. By relatively easy means it is possible to change from one mindset to the other, at least temporarily [8].

2.3 Teachable Agents

Integrating a Teachable Agent, TA, into the game can prevent the development of an Entity Theory of Intelligence, or overcome if it already have been developed. It can further improve a student’s learning by offering new ways of thinking and reasoning.

One important aspect is that the player will share some of the responsibility with the TA. A so called Ego-Protective Buffer will thus shield the player from forming negative beliefs about themselves if they should perform poorly [6]. Another aspect is that the player wants to teach and develop the TA and the concept known as Learning by Teaching has shown great results [5].

Recent studies also indicate that the sole presence of a Teachable Agent can have positive effects on the student’s performance on tests [18] and that a social entity may reduce the effect of distraction a student is exposed for [2].

2.4 Adaptive Learning

Dynamic difficulty can be used to enhance the players learning efficiency [17]. With problem sets that are adjusted based on the players current level of knowledge and understanding, a system can attract a wider target audience as well as make it possible to follow each player for a longer time. This will result in having more accurate data, that can be used in the system to enhance the learning efficiency even further, as well as it makes it easier to do longitudinal studies. If the degree of difficulty is adequate enough, based on the current skill and mastery, the student will be able to stay focused longer — since a too easy, or too hard, task will make the student lose motivation.

To be able to adapt the difficulty level there’s a need to know the student’s current depth of understanding as well as to know how difficult the next problem should be in relation to that. This can be approximated with an approach known as Dynamic
Assessment. Furthermore there are approaches such as Vygotsky’s Zone of Proximal Development to take advantage of the knowledge of the player’s depth of understanding and Scaffolding to give support to the player.

2.5 Inclusion and the Golem Effect

One common occurrence in the classroom is the teacher labeling the students into different groups based on their performance and intelligence as judged by the teacher. This has proven to be very dangerous for children that are labeled as low performers by the teachers. When a student has low expectations it is very likely that the expectations are fulfilled, which is known as the Golem Effect [3].

To prevent this self-fulfilling prophecy there’s a need to make the student feel part of the group and not be treated differently. Inclusive pedagogy usually aims to mainstream people, often children with special needs, into groups with “normal” children [1]. Several studies have proven that inclusion in education yields great results [15, 4, 19].

3 Results and Implementation

There have been no studies carried out yet with the resulting system, but we have come a long way with enabling individual learning in an inclusive environment to enhance the development of Number Sense.

The goal of the game, from the student’s point of view, is to help a digital tutee to grow a garden by playing mini games. The look and feel in a mini game will always be the same, but its content can be changed to alter the difficulty of the assignment, depending on the individual’s current mastery and skill.

By adapting the difficulty level for each individual student, while keeping the same scene and appearance independent of the difficulty, the game looks very similar for both the developed student as for the late bloomer. With these small changes will the children not be able to see the differences easily. To further enhance the feeling of playing the same game there’s the concept of the garden. This will shift some of the focus to develop the garden from the actual contents of the game.

In this way all the children get the sense of playing exactly the same game, while in reality they are playing a game which is very individualized. This enables us to include children with mild disabilities in the same class as typically developed children.

Furthermore we enhance all students learning by adapting Learning by Teaching through Teachable Agents and challenge them with assignments within their Zone of Proximal Development. We also protect the children from developing an Entity Theory of Intelligence by presenting assignments that are manageable for the child and by the child sees that the Teachable Agents improves and learns.

The backend offers a Supervisor Zone where the teacher or supervisor logs in and be able to login and see information about his or hers students. The children’s progression through the difficulties, both individually and compared to each other, is easily visualized. This opens up for one important ability: to locate children that show tendencies to fall behind.

4 Discussion

Even though no studies have been carried out yet with this system we have managed to come a long way with combining Inclusion with Adaptive Learning in order to enhance learning. This work have resulted in theories about how inclusion can be realized with adaption of levels of difficulties, as well as a prototype webbased game with a back-end that implements this behavior.

Theoretically, this game seems to have managed to combine several educational scientific approaches that traditionally would have been very difficult to realize.

The prototype seems promising but there are several ways it can be improved. Most notably the ability to automatically identify children who shows tendencies to fall behind, and to further improve the supervisor zone. The system has opened up for several interesting studies and the webbased game is well suited to do cross-cultural studies.
5 References


