Problem solving and interactive educational games: a case study of Year 6 children

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Problem solving is an important skill children need to learn. It helps them to adapt to the ever-accelerating changes of the twenty first century. Advancements in technology have changed our world, how we teach and learn. Almost all of UK children play video games. However, teachers do not use interactive maths games to teach problem solving skills since the role of games is a source of controversy. This paper reports on a PhD pilot study carried out on problem solving and interactive games with seven Year six children from Greater Manchester. This qualitative case study explores how interactive maths games can be used in a small group setting to support children's problem solving skills. Children completed various maths challenges on five games over a five-day period. Multiple data collection methods were used: interviews, direct observations and documents. The data shows how children used problem solving skills whilst playing games.

Keywords: problem solving; interactive educational games; games and learning; interactive computer games; maths video games

Introduction

Problem solving skills are some of the most important skills in the 21st century education (Wismath, Orr & MacKay, 2015). Many countries emphasize these skills in their school curriculum. For example, in the new English National Curriculum (DfE, 2013), reasoning and problem solving are two of the three overarching aims. The Core Curriculum in the United States, also states that children should develop skills that help them to adapt to the changing world (MA DoE, 2011). Some of these skills are problem solving and reasoning. One of the main reasons many schools include problem solving in their schools' mathematics curriculum is that it is recognized as an important life skill that involves analysing, interpreting, predicting, reasoning, evaluation and reflecting (Anderson, 2009). So, the emphasis is on children being able to solve problems themselves rather than teaching them facts.

The advancement in technology has had a direct impact on how we teach and learn maths as well as the production of knowledge. Computers are changing the way we play, work, communicate and learn (Shaffer, Squire, Halverson & Gee, 2005). For example, more than 31 million people in the UK are gamers (McGonigal, 2011). Over 98 percent of school age children play video games in the UK (IAB, 2011) and games let players think, talk and act in new ways (Gee & Hayes, 2009). So, why don't we take advantage of the enormous potential of gaming technology to support children's problem solving skills and develop children's mathematical concepts?

Though there is no standard definition of a game, for this research, interactive maths game is taken to mean the use of educational digital games designed to support children to learn about a mathematical concept and, or skill. The definition of educational digital games is adopted from de Freitas as "applications using the

characteristics of video and computer games to create engaging and immersive learning experiences for delivering specific learning goals, outcomes and experiences," (2006, p.9). The four characteristics of a game are that they have a goal, rules, a feedback system and that participation is voluntary (McGonigal, 2011). For example, the use of a series of interactive games like Mathletics to teach addition, subtraction, multiplication and division, the use of Minecraft to teach problem solving skills, the use of 'Hit the Button' to practice quick recall of multiplication tables or the use of schemes such as 'Active Learn' that have a series of interactive games for children to play. In all of these interactive games the challenges are embedded and children solve the challenge while they play the games.

This research project provides information and some evidence to raise awareness of how interactive maths games can help children to develop problem solving skills with those who are directly or indirectly involved in children's educational progression, such as parents, teachers, teaching assistants, curriculum developers, educational game designers and policy makers. This research aims to explore how interactive maths games can be used in a small group setting to support children's problem solving strategies. Based on this objective the overarching research question is: In what ways can interactive maths games support children's problem solving skills?

Method

A qualitative case study method was employed to investigate how playing interactive maths games supports children's problem solving skills. Qualitative case study research designs can work well with relatively small number of cases (Yin, 2014; Robson, 2011). The participants for this pilot study were seven Year six children of age ten or eleven. A purposive sampling strategy was used to identify both a primary school in Greater Manchester and the children based on the following criteria: schools that volunteer and participants' willingness; children's attainment levels (a range of students as selected by a class teacher). A qualitative research approach provides the researcher with the opportunity to gather multiple sources of data such as interviews, direct observations, documents and artefacts rather than relying on a single data source (Creswell, 2014). In addition to the children the researcher also interviewed the selected children's teacher.

Five interactive maths games were chosen from Active Learn Primary for this study (Pearson Education, 2015). The interactive games fulfil most characteristics of Rice's (2007) video game higher order thinking skills. The selected games were based on the skills required the children to perform problem solving skills while they were playing maths games. Children played the selected maths games for five days in their lunch time for half an hour each day. All activities were video recorded with participants' consent and children's assent since the study involved human participants, based on Creswell (2014) & Yin (2014).

Analysis, discussion and conclusion

A preliminary analysis of the data shows children used two main problem solving approaches: the systematic approach and the trial and error approach. Six out of seven children played the games in a systematic way. These children, at the start of the games, familiarized themselves with the rules of the games by playing with specific examples and then arrived at generalized concepts about the challenges they tried to solve. However, one of the children used the trial and error approach for the majority

of the time. For instance, in the Power Stations game, the children were challenged to produce at least 2000 megawatts of energy for Scotland and to find out the largest amount of energy that can be produced with five new power stations while they keep the amount of carbon dioxide as low as possible. In this game child UR got an answer just by randomly clicking five power stations at the start of the game. In such cases the teacher (tutor) needs to give attention to guide the child to achieve the lesson objectives. However, at the end of the lesson, it appeared that all of the participants managed to produce 5500 megawatts and they all kept the amount of pollution at a medium level. The six children who approached problem solving systematically demonstrated the following skills while they were playing interactive maths games: they interpreted and analysed the given data to make decisions, they also reasoned out and applied multiple criteria to solve complex problems and to get multiple solutions for the challenges.

Analysis of the collected data also shows that children attained the objectives of the interactive maths games at a high level. In the Farming Field game children need to install an irrigation system of pipes to water a large amount of farmland for growing crops on. The challenge was to make a profit from a crop grown based on the pipe work that had been laid. In this game, child TR managed to irrigate 80% of the total field and earned a profit of GBP 26,600. He doubled his profit and improved his score significantly since he started with irrigating only 39% of the total field and earned half of the profit. Similarly, in the Apple Picking game where children use fruit pickers to pick all the apples in the orchard, around the end of the lesson children figured out the inverse relationship between the numbers of people they allocated and the average time taken to pick all the apples as the following conversation with child AM shows:

R: You finished at one hour and 9 minutes now. [She used 25 people and she finished on average in 2 hours and 41 minutes]. What is happening here?

AM: It is going up.

R: Going up. Because…?

AM: Because I used less people.

All children had successfully completed all the activities with some assistance from their peers. Children stated that learning from their peers and the motivation they got while playing the given interactive maths games played a significant role in solving the given challenges. For example, Child BB explained it in this way, "When you play it by yourself you like, you are by yourself, but when you play with another person, you use their strategies." Thus, it appears that the more children play the games, the more they engage in solving embedded complex problems.

Finally, the analysis shows that children learn from each other when they play interactive maths games together. The following conversation between BB and TR shows collaborative learning.

TR: We are putting the band in the middle.

BB: Yeah. Half way point. Right over here. It is supposed to be here.

TR: You have to put it before this. I think you should put it at the side. Exactly.

BB: Yeah. I'd put it across here.

TR: Exit over here. Isn't it? [Pointing his figure toward the exit].

BB: Yeah. Shall I put it close together?

TR: No. It would be too loud.

BB: Over here.

TR: Just put them at the back so if the people can't hear. Then the disabled people at the back.

BB: Yeah. But look here first.

TR: This is the exit. Then you'll block the exit.

BB: No, I won't. Which one is better? [Pointing at the screen] This one. You have the seating first, then the people at the back and then the disabled behind the seating and then the people who are standing.

TR: But you'll block the exit.

BB: No I won't. [Noise] Seating OK, so which one is better? This one?

TR: No that!

BB: Where it'll go?

TR: I'd put at least one there.

BB: Right there?

In conclusion, although this study was small in scope and administered over a short period of time, a summary of the data analysis suggests that playing interactive educational games may have a positive impact on children's problem solving skills and engage them in advanced mathematical thinking. However, to make a more robust claim about how interactive maths games support children's problem solving skills a longitudinal case study with more interactive educational games is needed. This is currently in progress.

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