THE PLAYGROUND IN THE CLASSROOM – FRACTIONS AND ROBOT TECHNOLOGY

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ABSTRACT
What happens when the digital playground is brought into the class room and is it possible to transform it into a valuable educational tool? The paper describes the changing process from climbing rack to indoor educational tool. The climbing rack became a math tool in the area of fraction calculation for children in the age of eight to ten years. The transformation was done in cooperation with the company PlayAlive A/S. The design method used is inspired of design based research and action research and the tool and suggested didactics are developed in five iterations. A group of children from second grade have participated in all iterations of development as testers. The children are using their body while, learning and the educational tool can be labeled as a serious game and exertainment.

KEYWORDS
Learning, didactical design, technology in education, reflected learning, serious games, exertainment.

1. INTRODUCTION
What happens when the digital playground is brought into the class? And is it possible to transform it into a valuable educational tool? The children who play outdoors in the playground are often engaged, absorbed and full of passion (Majgaard and Jessen, 2009). Children learn various things in the playground without thinking too hard. Is it possible to bring the children’s engagement from the school yard into classroom by transforming a digital climbing rack from the school yard into an artifact used in math? The paper describes how an outdoor robotic climbing rack was transformed into an educational tool through interventions with a target group. The target group is children in the age of eight to ten years.

This educational tool is to be used in the second or third grade. The game is a fraction game and is called "Fraction Battle". The game and the suggested didactics combine reflected learning, engagement, immediate feedback and physical exercise. The educational tool can be labeled as a physical serious game or exertainment. The concept separates the tool and the didactics.

The development and didactical use of the tool is inspired of former examples in the field of physical serious games done by e.g. Papert and Resnick. Papert (Papert, 1993) is known from combining interactive technology and educational tools. Papert developed a geometry game where children intuitively learned how to form geometrical shapes. The children programmed the motions of an artificial floor turtle which draw the lines as it moved (Papert, 1993:56). The children got an intuitive knowledge of geometry in terms of angle of degrees shapes like rectangles circles and triangles. Paperts ideas of learning are very much related to Piagets constructional ideas of learning. Resnick (Rusk 2008) has done research in relation to LEGO MINDSTORM and PicoCricket. These educational tools involve building, programming and testing interactive robots in iterations. The learning philosophy in these former examples involves being explorative, being active, constructing things using intuition, adapting and constructing knowledge.
“Fraction Battle” is inspired by both Paperts and Resnicks examples. This tool really is designed for making the children active and explorative during their learning process. But “Fraction Battle” also differs from the above examples by giving immediate feedback and by making the children physical active.

In Paperts example the learner sees the consequences of given action when he decides to execute the program. LEGO MINDSTOM and PicoCrickes also work in sequences of instruction and consequences of these instructions. In this way there is a delay between stimulus and response. The experienced children work deliberately in states of planning the specific response pattern and in testing if this occurs (Majgaard 2009). The fraction tool establishes a more direct form of feedback.

The development is done in cooperation between the Mærsk Mc-Kinney Møller Institute, Knowledgelab at the University of Southern Denmark and PlayAlive A/S (www.playalive.dk). PlayAlive has contributed with the technology from their outdoor digital playground. The robot technological bits and parts from the playground have been taken into the classroom and these parts have been the basis for the development process. The development is a part of a larger project ”Robots at Play” which is connected to the Robot festival 2009 in Odense, Denmark. The children and their math teacher from 2.b in Rosengårdsalskolen in Odense have participated in all iterations.

The question explored in this paper is: Which learning qualities are present in the robot technological fraction game? How can the elements of play and bodily activity enrich the quality of learning? And what does it demand from didactical planning and design to release these potentials?

The analysis inquires into the contextuality of the game. It is a major point that the potentials of the game are not inherent qualities of the specific robot technological tool. Robots and games can be used in many ways in differing contexts, and there is no guarantee that they shall enrich the learning activities. What makes the difference is how the tool is used in the pedagogical practice. The focus is therefore the interplay between the tool under development, the didactical design, and the practice in the classroom.

First is a description for the research method and description of the design of the fraction game and its didactical use. This is followed by an analysis of the learning qualities in the light of the theoretical contributions by Bateson and Papert. This includes a discussion of how the fraction game enhances traditional education.

2. RESEARCH AND DESIGN METHOD

The used scientific method is inspired by action research (Fuglsang 2004) and educational design research (Van Den Akker 2007), where the researcher through interventions with the participating target group and developer team develop the product and changes a social practice.

The development method is inspired by interaction design (Sharp 2007), Scrum (Sutherland 2004) and Extreme Programming (Beck 2000). The techniques focus in user involvement, iterative development and prototyping. And one important idea in scrum is that not all requirements are present at the beginning of the project. The requirements are expressed during the so-called sprints. Sprints are iterations and in the each sprint the present running software is evaluated by the target group.

3. TECHNOLOGICAL STARTING POINT

The starting point was an outdoor digital climbing rack which was situated in the schoolyard, where it was well-known to the children who took part in the development process. All the electronical parts of the climbing rack was copied and put into a big suitcase and named the robotic octopus (see figure 1). The robotic octopus consists of 12 waterproof so-called intelligent satellites. Each satellite consists of a touch sensor, 16 programmable light diodes, sound and a microcomputer. The satellites are physically interconnected by power and data communication wires.
The software architecture is distributed. Thus one satellite is the server and the rest are clients. The clients execute the client part of the code and the server the controlling part where points are summed and the game menu controlled etc. The code is written in the third generation language C. The system is developed by PlayAlive and has before been used in an outdoor playground.

The octopus system has initially the games developed for the digital climbing rack. The first game is the “red-green game” where two teams compete in who fastest press the buttons in the teams color. The second is in the same genre. The third game is a memory game where the player is supposed to remember where specific color pair is hidden. The initial games are used as inspiration for the new educational games.

4. DESIGNING THE EDUCATIONAL TOOL

The target group for the educational tool is for children in the second and third grade meaning children between eight and ten years old. The idea is that the game should be used as a supplement in the math curriculum. A second grade class and their math teacher at Rosengårdsskolen in Odense Denmark were chosen. The class and their teacher participated in the development by testing the running prototypes and by suggesting ideas for new educational games.

The games and the didactic were developed in four - five iterations the so-called sprints. In each sprint the children and their teacher tested and commended the games. Each test lasted approximately two hours and was taped on video (see figure 2). The themes of each sprint as shown below:
- 1st sprint: The technological starting point was evaluated by the target group.
- 2nd sprint: Brainstorming for ideas and deciding on the fraction game
- 3rd sprint: The first version of the fraction game containing two variations
- 4th sprint: Four variation of the game is implemented. A didactical framework is developed and evaluated in combination with the four variations.
- 5th sprint: A variation is added where it is possible for the children to create their own fractions. The variation should become a small game where the children can challenge each other in fractions. The sprint is not implemented yet.

Initially the children tried out the technology indoor. The children were already familiar with the technology for the outdoor version of the digital playground. The children and their teacher came up with ideas for new educational games. The directions of the ideas took many directions and they were often well known games.
from computers and board games. The ideas in a mathematical direction were e.g. calculus puzzles, "memory" using numbers, equal-unequal number game, prime number game, rows etc. It was decided to develop a tool that covered fractions, addition and subtraction. The decision was based on the innate design of the satellites; each satellite already looked like an interactive fraction sketch. And the developers wanted to explore the already made physical design. Subsequently the first version of the educational game became about fractions and the fractions were represented as pieces of the circular satellites.

Description of the first version of the fraction game: The goal is that all 16 light diodes in the master satellite become green meaning 16/16 = 1 whole. This goal is reached by adding and subtraction fractions. The slave satellites show different fractions and each fraction is represented by the number of lit diodes e.g. 1, 2, 4 and 8. The children then hit the buttons until the master satellite is all green. The combination could be the following 4/16+4/16+4/16+2/16+1/16+1/16 = 16/16. If the children hit too many slave satellites and the fraction becomes e.g. 18/16, this is represented by two read light diodes in the master satellite. To get the number down the children must subtract. This is done by pressing the required fraction satellite e.g. 2/16 down for approximately 10 seconds. The adding and subtracting is done until the result is 16/16 = 1 whole.

Through the following sprints different variations of the fraction game was developed and tested. In the latest version were the following four variations implemented: (1) The children construct the fractions 16/16 = 1 whole by adding and subtracting fractions in different colors. (2) The children construct 16/16 = 1 whole by adding and subtracting fractions in the same color. (3) The master satellite shows a random fraction, and the children construct this fraction by pressing one or more slave satellites. (4) The master satellite shows a random fraction for 20 seconds, and the children then reconstruct the fraction by hitting one or more fractions. The different variations offers different levels of difficulty and the variation can be chosen freely.

5. DIDACTICAL DESIGN AND EXPERIMENT

During the evaluation of the fraction game in the 3rd sprint it became clear that a didactical approach was needed.

No inherent didactics were built into the octopus. So it was up to the teacher and test staff to decide how to relate the fraction games to the objectives and to plan a meaningful lesson involving the tool. To make meaningful lessons it was therefore required to design a meaningful context for the robotic learning sequences.

The objectives in fractions were that the children should be able to understand the concept of fractions. The children should: a) understand graphical and numerical representation of fractions and be able to transform the fractions from one representation to the other. b) be able to add and subtract fractions that had the same denominator. c) be able to express a fraction as numerator and denominator. The objectives became clearer during each sprint. And it became clear that the educational tool itself did not cover the potential for representing the fractions using numbers. The tools best potential was the graphical representation. It was discussed to implement special numbering caps for the satellites but the final decision was to use the satellites for the graphical representation because of the physical nature of the robotic octopus. Instead it became crucial to develop a didactical context around the tool.

The requirements for the didactics were to show and test various different didactical approaches. In order to explore how big potential the tool had. Very often serious games are like a straightjacket for the teacher because a narrow didactical path has to be followed. In a classroom a lot of different this are going on and the children often have very different ways of learning and often at different academic levels. We wanted both to explore the potential of the tool and set the teacher free. We wanted to combine different didactical approaches in order to test what worked but also to test the combination.

It was important to manage the class so the children did not spend the lesson waiting for their turn at the octopus. We had also experienced that the children got excited and inspired to do physical exercise when
using the octopus. In order to keep the children’s mind on fractions it was decided that the lesson plan should work in slots of exercise at the octopus and slot of seated absorption and reflection.

It was crucial to make the children reflect on fractions. In order to do so the children were to use the same fractions in different contexts. We also wanted them to think ahead by planning ahead. Another way of forcing them to reflect was by using their already gained experience. The ideas of reflected learning are based on Bateson’s notion of different levels of reflections in learning (Bateson 1972).

To promote a deep and reflected learning we aimed at a didactical design combining many different approaches to learning in order to help the children to understand the many ways they can learn and develop their own learning strategies. The following didactical plan was made and carried out in the 4th sprint. The plan for the scenario looked like this:

1) Intuitive and pre-concept method. Warming up was the first step and the children used the first variation of the game. The children added and subtracted the colorful light diodes until the result became one whole.

2) Deductive method. A) The children got a piece of paper where circles are divided into fractions of 16. Using colors crayons the children planned how to solve the digital puzzle in variation two. B) The children tested their plan at robot technological octopus.

3) Inductive method. Variation three showed a random fraction and the children had to calculate the specific fraction. The children should also express the fraction in words.

4) Transforming satellite representation into paper sketches number and fraction lines. The children got a piece of paper where fractions were represented as circles already are premade, the children should now transform the representation into numbers divided by a fraction line. Afterwards they got fractions represented by numbers and fraction lines and now they had to transform them into fractions represented as satellites.

5) What did we learn? The octopus presented a random fraction and the lights are turned off. The children had to calculate the fraction. Variation four was used.

The didactical scenario is built by elements for intuitive and pre-conceptual understanding, sensomotoric understanding, deductive learning, inductive learning and transformative learning. The scenario is wrapped in at sandwich of warming up (1) and playing at the end (5).

The warming up (1) is an introduction to fractions where the children play and explore without knowing anything about fractions yet. During the warming up the children got a pre-conceptual and sensomotoric understand of fractions. The experience is physical because the children communicate by pressing the satellites and the satellites respond to the children’s actions. The idea is that that the children should get an embodied fraction experience before knowing the actual concept.

In the deductive learning process (2) the children were first to plan a solution and then tests it at the digital octopus. When using the deductive method the child is creating a hypothesis and then test it or said in other words you plan and describe an experiment and the conduct the a test. The method forced the children to reflect on their learning process by thinking ahead and planning the next step.

The next scenario (3) is inductive because the children are supposed to calculate the solution in the process without any beforehand planning. The children are presented a random fraction and they have to add its parts. The induction should be understood as the children during the process were developing the solution.

In this scenario (4) the children learned to transform fraction into different representations. The knowledge in fractions the children learned using the satellites are transformed in representative paper sketches and by numbers and fraction lines. The change of representation is change in context which also forced the children to reflect.

The test of the didactical scenario took almost two hours. And the children worked together in groups of two children.

The test showed that the children found it easy to transform the embodied and preconseptual experiences into conceptual knowledge and transformative knowledge. Some of the children found the number and
fraction line representation quicker to use than the sketches. They could easily draw the sketches and make transformations between the different forms of representation. Some children could also “see” that 8/16 were the same as ½ and that 4/16 was the same as ¼ but this was the limit for the knowledge learned about fractions in that lesson. The math teacher was a bit surprised how easy the children picked up the concept.

The test also showed both the potential of the tool but also the potential of meaningful and well prepared didactic.

6. LEARNING QUALITIES IN THE EDUCATIONAL TOOL

There were no doubt that the children learned something about fractions during the didactical sprint and also the other sprints. They also gained experience in development processes and that they could influence such design processes. But how did the children learn or in other words what qualities were found in the learning process? Before answering the question it will be presented what makes the robot technological game unique.

6.1 What can the robot technological game do that a book cannot?

The unique thing in dragging a digital playground into the classroom can be covered by the following keyword: enhancement of differentiated approaches to teaching and flexible didactics, active use of children’s gaming competences, embodied understanding, physical exercise, learning levels, collaboration and technological understanding.

Technology in teaching is a means for the teacher to differentiate the academic approaches in a class. The technology makes it possible for the teacher to plan the lesson according to the children often very different competences. The learning sequences in the fraction games are at different conceptual levels and the children can use longer or shorter time and still get the same academic feedback from the system. The teacher can plan the lesson as a combination between traditional teaching and using the octopus for e.g. exploration or repetitive purposes. This tool does not cover the didactics the teacher still has plan an optimal lesson for his class. The teacher role is not taken over by an inflexible system.

The children used their experience from the world of computer games as a lever for gaining knowledge about fractions. The children knew the initial games and the cooperative and competitive game play. In the educational games the children could solve the puzzles correct but there were not implemented any game rules to enhance the game play. But the children quickly thought up rules for competing and thereby improved the game play. The children competed for example in who were quickest to go through the didactical scenario or who was quickest in getting the interactive fractions right.

It is a different experience to interact with the robot technological games than a book. The fraction games give immediate feedback and the children have to move around in the classroom in order to use the game. They use both their arms and legs in the learning situation. The physical exercise during the test suited the children well. In the above described didactical scenario, sequences of movement are followed by sequences of seated absorption are repeated. It was important to alternate else the pace both for learning purposes but also because of the group dynamics in the class room.

The use of the fraction game in a didactical context animated the children to collaborate between each other and also including the teacher. The children had to move in order to solve the puzzles and it was an advantage to distribute the tasks between the two children in the team. The partners discuss the assignment, problem and how to plan the solutions. Collaboration in groups of practitioners enhances the learning (Wenger, 2004)

The fraction games gave the children an understanding of technology in other images than computers, play station and mobile phones. This unique test group also got an insight to design of technology and they got the possibility to affect the design processes. This can have consequences for their relation to technology
in the future. They now know that technology can be shaped according to their needs and that they not all the time have to adapt to the whims of technology.

In the following clauses the learning qualities in relation to levels and physical understanding will be elaborated.

6.2 Technology, didactic and embodied understanding

The tool and its didactics was also designed to give the children a physical, playful and pre-conceptual experience. This relates a lot to Papert’s ideas. The keywords in Seymour Papert’s ideas of learning in a technological context are embodied understanding, active creative construction, feedback and didactic (Papert 1993).

The use of technology enhances the embodied and physical understanding of the field of learning (Papert 1993:xix). There should also be a natural relation between the content and the digital construction. In this case each satellite is formed like an interactive circular sketched fraction. The embodied understanding adds an extra dimension because the children touch the fractions and the fractions responds to their touch. The physical exploration is done without verbal concepts. When the verbal concept is presented the child will reference to the physical experience and the child can easily assimilate its knowledge.

Active creative construction builds on the concept of the being creative and constructive in learning processes. The physical construction corresponds relates to a more cognitive construction of knowledge (Papert 1993:121). The last sprint which has not been implemented yet is a game where the children create their own fractions. It’s a kind of “fraction battle game” where the children construct fractions and the opponents solve the quest by fraction calculation. In this way the children get an opportunity to compete which they often combine with digital games and in the same time they are constructing both fractions and knowledge.

For a technological tool to be used optimal in the classroom it is important to combine the technology and meaningful well prepared didactics. In this case the technology can be used by the teacher to differentiate between the children’s different academic level in a way that a larger group of the children are challenged according to their skills and knowledge. Seymour Papert underlines the importance of meaningful didactics: “Technology in education is effective only if placed in a larger context that combines well-prepared teachers with integrated social services” (Papert 1993:vii).

The use of technology in teaching demands something extra at the teacher. In this project it has been a specific requirement that the technology should be as easy to use as taking a new book from the shelf. The games or learning sequences in the fraction game are brief that is why it is important to build up a meaningful didactics. The teachers can of course use the lesson plan from the fourth sprint or make their own plan. But the teachers are in charge of the didactics in the same way as when they plan normal lessons using a book. Some serious games from the world of computers have a built-in didactic to go with academic the theme. In this tool most of the didactics and the academic the theme are split. And this empowers the teacher as the didactic manager.

6.3 Reflective learning: adaptivity, contexts and experience

The didactical scenario and the educational tool were designed to support explorative and reflective learning.

But before the children is able to reflect the have to explore. Learning is as change in response over time (Bateson 1972: 283). This means that the children reacts in a new a different way on a given stimulus and the stimulus has in our case to do with fractions. This type of learning happens when a child explores the satellites to find out how the puzzles work. This corresponds to the warming up in the didactical scenario. The children have at this point no experience in fractions and their context. And the children would in the general case have no experience using the robot technological platform.
A more sophisticated type of learning happens when children have experience already and can be named meta-learning. The concept can be described as corrective optimized learning which is based on experience in the academic theme but also in one or more contexts (Bateson 1972:293). Various terms has be proposed for this phenomena “learning to learn” and “transfer learning”, “corrective learning” or “optimized learning” but all the terms involves some sort of reflection.

When the children have gained some experience they know what to expect and they can conscious or unconscious adapt their learning. Step two in the above didactical scenario describes how children actively can use the gained knowledge about fractions to construct sketches in paper and test the sketch plan using the fraction game. The robot technological platform is a context they now know and they know it can be used for math. In step two the children alternated between two contexts one of paper and one of robot technology. To work in more contexts improves reflection in learning. The didactical scenario in step four is an example where the children increase their understanding of fractions by moving context. In this case the fractions in the sketched context are replaced by numbers and fraction line context.

Third order learning has focus in awareness of learning strategies and how to change these. The children got experience in different ways of learning e.g. explorative, deductive or inductive. The children could use this experience later on.

7. CONCLUSION

The questions explored in this paper were: Which learning qualities are present in the robot technological fraction game? How can the elements of play and bodily activity enrich the quality of learning? And what does it demand from didactical planning and design to release these potentials?

The tool and it didactics combine explorative and reflected learning. The explorative learning is in the beginning tacit pre-conceptual and physical. The children use play and bodily activity as lever for the explorative learning.

The reflected learning is based on experience e.g. the physical explorative knowledge. The knowledge is made deeper by being transformed by different contexts.

The most important and surprising thing that came out of the development was realization of didactics and tool needed to be separated. This made the didactic flexible and to fit today’s differentiated approach to learning. It also made it possible to focus the software design into fitting the inherent physical design of the satellites. The focus could be in designing games and puzzles at various levels for an interactive graphical representation. When teachers are to use the tool they will of course be offered a lesson plan but it is up to them to decide how to use the tool in real life situations.

The fraction game enhances the teachers’ possibilities to plan a differentiated and rich approach to teaching math in a collaborative environment. And finally, the embodied a physical exercise becomes a natural part of the learning process.

REFERENCES


Robots Teach Fractions: Use these robots to make learning fractions fun! Create worksheets, tests, games or any resource you can think of for the classroom. Find this Pin and more on Future teaching ideas by Heather Fishpaw. Tags. Instant download these cute robots, and easily make your robot theme birthday party invitations. Also great for Back to School, lesson plans, signs, scrapbooking, crafts, cardmaking, cupcake toppers, and so much more. Total of. Erinintegration | Technology in the Elementary Classroom TEACHING. Op Art Lessons Art Lessons Elementary Drawing Projects Art Projects Zentangle Arte Elemental 6th Grade Art 3d Drawings Art Lesson Plans. a step by step. Kelly Holmes Optical Illusions.