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The influence of a number sense game on intrinsic motivation towards counting

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Preface and acknowledgements

In this paper I will describe the process and results of my Master's research. My decision to participate in this project stemmed from my personal experience that I could recite whole passages from my favorite books after only reading them once, yet some of my schoolbooks I had to read over and over and in the end I'd still have no idea what it all had just been about. I always wondered if there was a way to combine those things, by making the learning more fun. This project gave me exactly that opportunity: it's aim being to combine modern day technique with crucial elements of the school curriculum. Designing and carrying out the research has been a wonderful and sometimes hectic experience.

As the entire process had to start from scratch, with six students and three responsible project supervisors, setting up the project turned out to be very chaotic. Brainstorming sessions with ideas of how to construct games that would be fun to play for young children and that would, somehow, still be educational, eventually transformed into a delightful product. The children were very enthusiastic to be able to play those games and, at least as important, they actually loved playing them.

It has taken hard work and a great deal of dedication on everyone's part, but in the end the game was created. For this, I wish to thank my supervisors, who were basically 24/7 available to solve the hurdles that were encountered along the way.

I also want to thank the teachers from the primary schools that agreed to participate. And I especially want to thank the teachers of those classes where I conducted my part of the data collection: they were very flexible and kind, and really enthusiastic at being a part of this research. And of course I want to thank them for the group of lovely children they had in store for me. Although children at the age of six do not care much for scientific research nor do they always behave like we had planned, it has been a lot of fun to get to know them and to play games with them during this entire process.

Finally I wish to thank everyone that has proofread my thesis and provided me with feedback, I have benefited a great deal and learned a lot from it.

Abstract

The current research investigates whether intrinsic motivation for counting within young children can be improved through playing number sense games on tablets. A total of 54 children, aged 5 and 6 years, have played games during eight sessions. Self-reported motivation and perceived fun while playing the games, as well as arithmetic skills before and after playing the games were obtained. Two versions of the game were tested, containing perceptual and epistemic types of curiosity. No difference of game version on motivation or fun scores was found. After the eight playing sessions, no significant increase in motivation was found. Self-reported fun correlates slightly and significantly with motivation increase, Pearson's $r = .298$, $p < .05$. Arithmetic performance did not seem to correlate with motivation increase. Although no significant increase in motivation was seen in the current study, the total playtime of the children may have been too short to generate an effect. It is recommended that this will be investigated further in future studies.

Keywords: intrinsic motivation, counting, number sense game, educational game, serious game

Samenvatting

Het huidige onderzoek beoogt te onderzoeken of de intrinsieke motivatie van jonge kinderen om te tellen verhoogd kan worden door middel van het spelen van *number sense* spellen op tablets. In totaal hebben 54 kinderen van 5 en 6 jaar meegedaan aan het onderzoek. Al deze kinderen hebben gedurende acht sessies spellen gedaan op de tablets. Hierbij werd middels zelfrapportage de intrinsieke motivatie gemeten, evenals de plezierbeleving van de kinderen. Tevens werden de getalbegripvaardigheden van kinderen voor- en achteraf vastgesteld. Twee spelversies zijn opgesteld, elke versie bevat elementen van perceptuele of epistemische nieuwsgierigheid. Er bleek geen effect te zijn van spelversie op de motivatie, of op de plezierbeleving. Binnen dit onderzoek is geen significante toename van intrinsieke motivatie gevonden na de acht speelsessies. De zelfgerapporteerde plezierbeleving van de kinderen correleert in lichte mate en significant met de toename van motivatie, Pearsons $r = .298$, $p < .05$. Een toename van scores op het gebied van de rekenkundige vaardigheden blijkt niet te correleren met de toename van motivatie. Het gebrek aan toename van motivatie wordt mogelijk verklaard door de korte duur waarin de kinderen de spellen hebben gespeeld. Het effect van een langere periode waarin de kinderen kunnen spelen, dient onderzocht te worden in toekomstig onderzoek.

Keywords: intrinsieke motivatie, tellen, *number sense* spel, educatief spel, *serious game*

Introduction

School performance at primary school is a predictor of high-school performance and university graduation (Özmert et al., 2005). Contrary to popular belief stating that school performance is mostly dependent on IQ factors, research has shown that self-discipline is a better predictor of academic performance than IQ (Duckworth & Seligman, 2005). In addition, it has been found that increased motivation leads to increased self-discipline (Moreno-Murcia, Sicilia, Cervelló, Huéscar & Dumitru, 2011). If students have little or no motivation at all, they will display apathetic behavior and will lack engagement with their school-work (Vansteenkiste, Lens, Donche & Van Petegem, 2011). For this reason, motivation is widely recognized as vital for academic achievement (Pintrich, 2003). This research will therefore focus on trying to improve students' motivation, specifically in the field of counting.

Background

Soon after babies are born, they possess number sense: a sensitivity towards quantity. This sensitivity towards quantity includes the ability to oversee a limited number of grouped objects at a single glance (Ruijssenaars, 2011). As those babies grow older and develop, they learn the concept of numbers; they learn how to count and they start calculating and manipulating numbers until they reach a stage where they can solve complex arithmetic problems. During this process, number sense is a very important factor in adequate mathematics development (Jordan, Glutting & Ramineni, 2010).

It is also important for a child's mathematical development that he observes how people in his environment use numbers to represent quantities of objects. (Ruijssenaars, 2011). Simplified: they need to experience the link between numerosity and its verbal representation. This means that, as a child grows and explores more of the world, he automatically comes in contact with numbers and amounts often used in society. Older siblings and parents play an important role in this learning (Braams & Denis, 2003). Although families differ in their casual uses of phrases such as 'more', 'less' or 'twice as much', all children will learn something about amounts and, to some extent, numbers. The process of growing up in a world with numbers helps to automate simple mathematical facts. Deficiencies in this readily available knowledge of mathematical facts lead to delays in the process of mathematical development, as well as increases in working memory use (Ruijssenaars, 2011).

Regardless of their experiences in early infancy, almost all children in modern Western countries will come across arithmetic as soon as they go to school, since it plays a well-established role in our society. Those who have poor numeracy earn less money, are more likely to get sick, are more often in trouble with the law and need more help in school (Parsons & Bynner, 2005). It is therefore quite important that children learn how to perform mathematical tasks.

As stated before, motivation is a very important factor for succeeding in school. There are many types of motivation. It is common to distinguish between intrinsic and extrinsic motivation. Intrinsic motivation refers to the engaging in activities for the sake of deriving pleasure and satisfaction from participating in that activity (Ryan & Deci, 2000). Related to the topic of academic learning, an intrinsically motivated student will learn just for the joy of learning and satisfying a curiosity for knowledge about a certain topic (Vansteenkiste, Soenens, Sierens, & Lens, 2005). Extrinsic motivation on the other hand refers to engagement in activities for the sake of deriving instrumentalities different from the activity itself (Ryan & Deci, 2000). In a school situation this might mean that a student wants to achieve a good result because his mother promised him a videogame as an incentive for doing well. The instrumental reward the student seeks in this case, lies outside the student and is therefore externally located (Vansteenkiste, Soenens, Sierens, & Lens, 2005).

Controlling environments, where students are pressured into learning, often lead to passive and external forms of motivation, whereas a focus on the pursuit of intrinsic goals is more likely to yield optimal development (Deci & Vansteenkiste, 2004). ‘Wanting’ to study, which is a form of intrinsic motivation, is linked with engagement and interest in schoolwork. The ‘need’ to study, which is a representation of extrinsic motivation, is linked with giving up in case of difficulties, with superficial interest and with generally not feeling well at school (Vansteenkiste, Sierens, Soenens & Lens, 2007). In other words: emotional engagement improves academic performance (Park, Holloway, Arendtsz, Bempechat & Li, 2012).

Among the variety of factors that can influence school performance, it has been shown that environmental expectations, as well as personal expectations, influence child performance (Brysbart, 2006 as cited in Ruijssenaars, 2011). This would indicate that a child, when feeling more competent about himself, will obtain higher academic achievement than a child feeling less competent, even though their actual level of competence is the same.

To summarize: it has been showed that motivation, engagement and success experiences are linked to improved academic performances. For this reason this research will focus on finding a way to improve these factors in the field of number sense.

Current research

Most children are able to link the correct symbolic representation to a non-symbolic array when they have reached the age of six (Mundy & Gilmore, 2009). For this reason it can be concluded that most of the related learning processes take place in the months to years prior. The ages of four to six are seen as the most beneficial in implementing an intervention that focuses on improving the motivation of children on the topic of counting.

For children, especially when they are young, playing and learning are natural and interwoven. In addition, both are part of their everyday live. Hence it is believed that play holds an important part in the way young children learn (Samuelsson & Carlsson, 2008). Where ‘play’ is already an important aspect of the lives of children, games have even caused an increase in engagement and motivation in learning new information in adults (Whitton, 2011).

Low-grade primary school teachers are experienced in working with children. Despite their aim being to increase the fundamental knowledge that children encompass, they are often uncomfortable with using highly systematic forms of arithmetics education. They feel it would not fit with the everyday perception of young children (Leenders, 2009). This leads to the fact that at a young age, children often get very limited mathematical education (Greenes, 2004). This poses a problem, seeing how their natural developmental path suggests it is the opportune moment to educate them in the field of arithmetics.

In an attempt to stay close to the world of children and at the same time provide them with a systematical way to increase their knowledge, the intervention chosen here is a game. One of the most important factors in making educational games is the integration of learning and play (Egenfeldt-Nielsen, 2011). In developing the games, attention will be paid to making sure that counting knowledge is needed for succeeding in the game. This is done by either having the children counting (‘small’ numbers) or estimating (‘big’ numbers) the correct answer. Providing children with consecutive tasks will do this. The child cannot proceed to the next task if he has not provided the correct answer.

Yet at the same time, the game needs to retain its fun element. If not, it will just be another mathematical assignment. ‘Fun’ is a major factor in what makes a game engaging (Prensky, 2002). Another element that naturally influences the learning of children is curiosity; curiosity can motivate both thought and action (Brand, 2009). Two different types of curiosity are commonly distinguished: perceptual and epistemic curiosity (Berlyne, 1966). According to Berlyne (1966), perceptual curiosity stems from new or unusual sensory information, which leads to the desire to explore more of this. Epistemic curiosity on the other hand, stems from cognitive or intellectual unknown factors, leading to behaviour that attempts to uncover the unknown. It is however not known whether perceptual or epistemic curiosity holds a greater influence on intrinsic motivation, and which type is perceived to be more fun. For this reason, both types will be implemented in two different versions of the game.

Seeing as to how children like to play and consciously choose to pursue play, it is hypothesized here that an educational game with a substantial fun element would improve motivation and engagement in children. Currently it is unknown if games can actually improve intrinsic motivation in such a way.

Should an increase in intrinsic motivation prove to be true, it could have a great many implications for educational practices. If there is a way to increase fun in all of the learning for children, it could very well improve their overall performance in many areas. Hence it is necessary to investigate the potential benefits of educational games on the perceived motivation due to increased positive experiences with the subject.

Results from prior research lead to the following hypotheses.

Hypothesis 1: due to the casual and playful environment that exists while playing a game, children will associate counting with fun and feelings of competence. Consequently, playing a number sense game improves intrinsic motivation on the subject of counting.

Hypothesis 1.1: type of curiosity (perceptual or epistemic) influences the intrinsic motivation towards counting.

Hypothesis 2: the level of perceived fun enhances this effect.

Hypothesis 2.1: type of curiosity (perceptual or epistemic) influences the level of perceived fun.

Hypothesis 3: improvement in counting performance (feelings of competence) leads to the improvement of intrinsic motivation.

Methods

The goal of the current study is to investigate the effects of playing a number sense game on the intrinsic motivation towards counting. Additionally, mediating effects of perceived fun and performance improvement will be observed. This study will compare the results of 54 children. Enhancing the generalizability of this study, the children tested will come from six different schools. This enhances the likelihood that the prior level of school education differs between the children. The study is quasi-experimental in design: it compares data from pre- and post-intervention.

Participants

A total of 54 Dutch children participated in this study. Of these children, 29 were boys and 25 are girls. All children were either five or six years old (M = 5 years and 7 months, SD = 3.8 months). The youngest participating child was 5 years and 2 months, the oldest child 6 years and 9 months. The children were recruited from six different schools.

The advantage of using different classes was that this ensured that six groups of children have experienced a different educational curriculum. This was done to maximize the probability that effects are due to the game instead of the influence of a certain type of education experienced by the children. With a sample of $n > 30$, a normal distribution can be assumed (Gravetter & Wallnau, 2009). This number will be sufficient to be able to draw conclusions about effectiveness.

All children were randomly appointed to either the perceptual or epistemic game version. Every child also continued to play the same type of game during all sessions.

Instruments

The data will consist of scores on intrinsic motivation towards counting, scores on number sense skill and perceived fun on each game post-intervention.

Intrinsic motivation towards counting. Intrinsic arithmetic motivation will be measured by adapting an existing questionnaire on this subject intended for children aged five to seven

(Vosse, 2002), see appendix 1. The existing questionnaire is internally consistent, with reliability measures ranging between .84 and .89 (Vosse, 2002).

Number sense skill scores. Number sense will be measured using adapted elements of a test specifically designed for investigating number sense, the Early Numary Test (ENT; van Luit & van de Rijt 2009). The elements have been adapted in such a way that they could be used on tablets. The ENT has reliability scores around .90 and COTAN reviews the validity as satisfactory. In addition, several self-designed tests will be used as well. These self-designed tests will be 'Lines' and 'Comparing', each consisting of two subtests. See appendix 2 for screenshot of these tests. Lines 1-10: children get 9 questions in which they have to point to where they think a certain number will be on a number-line ranging from 1 to 10. Lines 1-100: children get 20 questions in which they have to point to where they think a certain amount of dots will be on a number line ranging from 1 to 100 dots. Comparing 1-10: children get 20 questions where they have to choose the highest value between two numbers ranging from 1 to 10. Comparing 1-100: again, the children get 20 questions where they have to choose the highest value between two groups of dots ranging from 1 to 100.

Perceived fun. Perceived fun will be explored via elements of the Fun Toolkit (Read & MacFarlane, 2006) after completing each sub-game. The Fun Toolkit was designed to obtain the opinion of children aged six to ten about the amount of fun they experience while playing games. Here, only the ones that were effective for obtaining information from the youngest children (aged six and seven) are used: both the Smiley-o-meter and the Again-Again table, see appendix 3. The Fun Toolkit has been shown to be indicative of the amount of perceived fun in children (Read & MacFarlane, 2006).

Procedure

In order to recruit participants, schools have been asked to partake. Six schools agreed to participate with (part of) a class. Parents agreed to the participation of their children.

The study involves a number of individual pre- and post-tests regarding intrinsic arithmetic motivation and number sense performance. It also contains post-tests of perceived fun during gaming. All data is collected during casual conversations or play settings to prevent the children from giving socially desirable answers. In order to keep the setting as comfortable as possible for the children, they are taken to a quiet place within the school for all testing.

The pre- and post-tests contain the ENT tests, both versions of Lines and Comparing, as well as the intrinsic motivation questionnaire.

The intervention itself consists of every child playing three of the six sub-games on a tablet. They get to play until the game is completed. At least one day is scheduled between each session. Every child gets to play eight times, so twenty-four games in total. During playing the children are isolated from other children by taking them out of the classroom, or placing them in a quiet corner.

Intervention: the games

The game sessions consist of standard elements in children's games, in order to make the game fun. Sounds, images and game elements such as a 'dangerous object' fit for children of this age group will be implemented within the game as it is developed. All of the games will be played on tablets. This relatively new technology is something that almost all children have encountered and know how to use already. Also, playing the games on tablets allows for a very direct level of interaction: with just a touch, objects can move or react. At the same time, children automatically associate the tablets with playing since that is often the only experience they have with it.

have moving or moveable parts that react when children touch the screen. In three of the games, the children have to catch flying targets. To ensure that children benefit optimally from interacting, feedback is also included in the games (Egenfeldt-Nielsen, 2011).

In order to be able to generalize the conclusions, different forms of arithmetic problem solving will be used in six different sub-games, with varying degrees of difficulty. For screenshots of the games: see appendix 4. In the first game children have to combine a spoken number with a shown number symbol (Giraffe). In the second game (Frog), they view an amount of dots and have to search for the corresponding number symbol. In the third game, children will be asked to combine a certain amount of objects to a specific number symbol, which then has to be found and placed on a number line (Monkey). In the fourth game (Chameleon), they view a number symbol and have to find the correct amount of dots that corresponds with that. In the fifth game (Fishes), children need to combine a relatively large decade (up to 100) with a shown array of objects. The purpose of this is that they estimate the quantity of shown objects. In the sixth and final game (Elephant), children must cumulatively collect a quantity of objects that corresponds with the number symbol which is shown, and then place it on a number line.

Every game has three difficulty levels. For all games, with the exception of the last game, the difficulty level implies that the number range increases from 1-5, to 1-10, up to 1-20. In the fifth game (Fishes), where children have to compare quantities, an increase in level means a decrease in the difference of the amounts between the two options. All children will start at the lowest level and proceed to the middle level after two sessions of playing. The last two sessions will be played at the highest level. During each session it will be observed whether the children can perform at the current level. If it proves to be too difficult (children do not know the numbers or take more than ten minutes per game to complete), they will go down one level. The next time, they will proceed with the higher level again.

See Table 1 for an overview of the gaming sessions.

Table 1

Overview of gaming sessions

Session	1	2	3	4
Games	Giraffe (1)	Chameleon (4)	Giraffe (1)	Frog (2)
	Frog (2)	Fishes (5)	Fishes (5)	Chameleon (4)
	Monkey (3)	Elephant (6)	Monkey (3)	Elephant (6)
Level	Low	Low	Medium	Medium

Session	5	6	7	8
Games	Giraffe (1)	Chameleon (4)	Giraffe (1)	Frog (2)
	Frog (2)	Fishes (5)	Fishes (5)	Chameleon (4)
	Monkey (3)	Elephant (6)	Monkey (3)	Elephant (6)
Level	Medium	Medium	High	High

The two different types of curiosity are implemented by adding certain elements to the game. To arouse the perceptual, sensory oriented type of curiosity, moving objects are added to the games. Those elements are not a response to actions performed by the children and include things like butterflies or clouds flying trough the screen. To arouse the epistemic or cognitive type of curiosity, elements that did require child actions were added. This was done by covering some of the targets, leading children to think ‘how can I see what’s under there?’ or ‘what will happen if I tap this?’.

Data-analysis

Data necessary to test the given hypotheses are: scores of pre- and post-test intrinsic motivation towards counting, scores on perceived fun and pre- and post-test number sense scores. An explanation of how these data will be acquired is shown below.

To obtain a score on the motivation questionnaire, all scores from the motivation questionnaire will be valued, with 0 being assigned to the answer showing no motivation, 1 representing the answer that displays a little motivation and 2 representing the answer that shows the highest motivation towards counting. As the questionnaire consists of 9 questions, the lowest possible score is 0, the highest being 18.

An increase in motivation will be measured by subtracting the motivation scores of the pre-test from the scores of the post-test.

Scores of perceived fun will be calculated by valuing the given answers as well. After every game the children were asked to rate if they wanted to play the game again (Yes = 2, maybe = 1, no = 0) and how much fun the games were (☺ = 2, 😐 = 1, ☹ = 0) resulting in two scores: the fun scores and the again-again scores. With three games per session and eight sessions in total, the minimum value of each total is 0, whereas the maximum value is 48.

On the ENT and Comparing tests, children get one point if they give the correct answer. If they do not, they get zero points. Scores of game improvement on the ENT and Comparing tests will be obtained through subtracting pre-test scores on all five tests from post-test scores. This generates five ‘improvement scores’, which can be used to review the progress children have made during the testing period.

Scores of game improvement on Lines test will be acquired by looking at the absolute differences between the target number and the answer given by the child. Then, the mean overall score on the pre- or post-test is calculated. After subtracting the pre-test from the post-test scores, a score indicating increase is generated.

It should be noted that an increase in score on ENT and Comparing means that the child has started to perform better. On the other hand, an increase in scores on Lines means that the child has diverged further from the target. Therefore – on this test – a negative score stands for a better performance.

Since both tasks of Comparing aim to measure the same skill, both tasks will be grouped into a single model when carrying out an ANOVA. The same will apply for both tests of Lines.

The influences of the game version (perceptual or epistemic) on motivation and perceived fun will be measured by carrying out repeated measures ANOVAs. In both cases, attention will be paid first to determining whether an effect can be found. If this effect cannot be found, further analyses will be carried out as if there were no difference between the game versions.

Results

Results of the data analysis are listed below.

Hypothesis 1.1: Type of curiosity (perceptual or epistemic) influences the intrinsic motivation towards counting.

To determine the effect of game version on intrinsic motivation towards counting, a repeated measures ANOVA was used. To determine the effects, an α of .05 was used, along with a confidence interval of 95%. There was no significant difference in intrinsic motivation based on the game version played by the child, Wilks Lambda = .989, $F(2,51) = 1.032$, $p = .314$.

Cohen's *d* was calculated to obtain an effect size. Criteria from Field (2009) were used with $d = .20$ indicating a small effect, $d = .50$ indicating a moderate effect and $d = .80$ indicating a large effect. For the perceptual group, $d = .28$, for the epistemic group, $d = -.03$. This indicates that there is a (very) weak, non-significant effect of game version on intrinsic motivation outcome scores.

Hypothesis 1.1 is rejected, game version did not significantly influence intrinsic motivation.

Hypothesis 1: There will be a significant increase in motivation scores on the post-test, compared with the pre-test.

In order to compare pre- and post-test intrinsic motivation towards counting scores, a one-tailed paired t-test was used. Although there is no random sample, as $n > 30$ it can be assumed that the sample will show a normal distribution (Gravetter & Wallnau, 2009). An α of .05 was used.

There was no significant difference in the scores of the pre-test (*M* = 13.02, *SD* = 3.553) and the post-test (*M* = 12.69, *SD* = 3.956); *t*(53) = .762, *p* = .225. Therefore, the first hypothesis was rejected: no significant increase in motivation was found between pre- and post-test.

Hypothesis 1 is rejected, intrinsic motivation towards counting did not significantly increase after the gaming sessions.

Hypothesis 2.1: type of curiosity (perceptual or epistemic) influences the level of perceived fun.

To determine the effect of game version on intrinsic motivation towards counting, multivariate ANOVA was used. An α of .05 was used. No significant difference in again-again or fun-scores was found based on the game version played by the child, Wilks Lambda = .972, *F*(2,51) = .730, *p* = .487.

Hypothesis 2.2 is rejected, game version did not significantly influence the level of perceived fun.

Hypothesis 2: Perceived fun correlates with motivation scores towards counting.

This hypothesis was tested via linear regression. The mediating influence of perceived fun was obtained using Pearson's correlation coefficient and an ANOVA. In order to interpret Pearson's *r*, criteria from Field (2009) were used, with *r* = .10 indicating a weak correlation, *r* = .30 indicating a moderate correlation and *r* = .50 indicating a strong correlation. An α of .05 was used to determine the level of significance. Simple linear regression was used to determine the mediating influences of perceived fun and performance growth on motivation.

Increase in motivation and quantity of the fun score were correlated with *r* = .289, R^2 = .089. The main effect of the fun score on an increase in motivation was significant, *F*(1,52) = 5.085, *p* = .028.

Increase in motivation and quantity of the again-again score were correlated with *r* = .126, R^2 = .016, indicating a weak correlation. However, the main effect of the fun score on an increase in motivation was not significant, *F*(1,52) = .842, *p* = .363.

Hence, the second hypothesis is accepted: for fun scores there was a weak to moderate and significant correlation.

Hypothesis 3: Counting improvement correlates with increased counting motivation scores.

This hypothesis was also tested via linear regression. In this case the mediating influences of counting improvement on intrinsic counting motivation were obtained using Pearson's correlation coefficient and ANOVAs.

Motivation increase and increase on ENT was correlated with $r = .085$, $R^2 = .007$, which indicates a very weak correlation. The main effect of ENT on motivation increase was not significant, $F(1,52) = .382$, $p = .539$.

Motivation increase and increase on Comparing was correlated with $r = .042$, $R^2 = .002$, which also indicates a very weak correlation. The main effect of Comparing on motivation increase was not significant, $F(1,52) = .042$, $p = .956$.

Motivation increase and increase on Lines was correlated with $r = .108$, $R^2 = .012$, which again indicates a weak correlation. The main effect of perceived fun on motivation increase was not significant, $F(1,52) = .298$, $p = .743$. Please note that the effect that was measured turns out to be a positive number. As indicated before, an increase in score here actually means a decrease in skill. A negative correlation would have been expected. Concluding, the third hypothesis is rejected: there is no significant correlation between counting improvement and counting motivation increase.

For an overview of the results, see Tables 2, 3 and 4.

Table 2

Effects of game version

	Wilk's Lambda	*F*	*df*	*Sig.*
Motivation	.989	1.032	51	.314*
Perceived fun	.972	.730	51	.487*

*$p < .05$

Table 3

Increase in intrinsic counting motivation over time

Mean	*SD*	*t*	*df*	*Sig.**
.333	3.216	.762	53	.255**

**$p < .05$

Table 4

Correlations with intrinsic counting motivation

Model	*r*	R^2	*F-ratio*	*Sig.*
Fun score	.298	.089	5.085	.028*
Again-again score	.126	.016	.842	.363*
ENT	.085	.007	.382	.539*
Comparing	.042	.002	.042	.956*
Lines	.108	.012	.298	.743*

*$p < .05$

Conclusion and Discussion

The hypothesized effect of playing number sense games on intrinsic motivation towards counting was not found. Motivation scores did not increase over time. This was unexpected, but the lack of increase in motivation may be explained by the relatively short span of the research. The children had only a total of eight playing sessions and most of them were done with all three of the sub-games of each session within 10 minutes. It is recommended that the children are allowed more total playing time, to determine if this has, in any way, a measurable effect on their motivation.

Another possible explanation may be that the children are too young to accurately reflect on their intrinsic motivation. Young children tend to be positively biased in their self-reflection (Verschueren & Gadeyne, 2007). A possible solution is having the children's teachers assess the motivation, as they may have a better insight at this young age. It remains questionable though, how accurate their assessment would be, and if this is indeed a reliable way to determine the children's motivation.

Lowman (1990) states that, in order to increase motivation, feedback and evaluation should be carefully monitored. Establishing a controlling environment (for example by saying 'you need to play this game right now', or 'I want you to collect them this way'), generally decreases students' intrinsic motivation. Rather, in an effort to increase interest, encouraging instructions and feedback should be given without posing a threat to the students (for example: ‘I would like to play this game with you now’, or ‘have you thought about collecting them this way?’). By doing so, playing the games will feel more like a choice and less like an assignment.

Other research indicates that students’ intrinsic motivation generally declines during the school year, as the lessons start to focus more on mastering subjects and less on the process of learning (Henderlong Corpus, McClintic-Cilbert, & Hayenga, 2009). This effect may have influenced the results that were acquired within this research. It may very well be possible that the children became more intrinsically motivated by playing the games, but they at the same time also became less intrinsically motivated due to the approaching end of the academic year.

Motivation and perceived fun were not found to be influenced by the type of curiosity that was implemented in the game. Though it may be possible that both perceptual and epistemic curiosity influence the motivation and fun to the same degree, it is more likely that those types of curiosity were not present enough in the game. It should therefore be explored whether additions do reveal a favor for either perceptual or epistemic types of curiosity. Another possibility is that the types of curiosity should not be offered separately, but rather should be combined (for example: a tap on the screen is followed by a certain ‘funny’ sound).

Although there was no significant increase in motivation scores, the amount of fun experienced by the children correlated significantly with an increase in motivation. This suggests that the games were currently not fun enough to generate a significant effect for the whole group. Logically, this should be solved by making the games more fun in future studies. A storyline or bigger goal (other than completing the game), for example, might engage the children more and thereby cause significant results.

Increase in skill did not correlate with an increase in motivation. As mentioned above, the limited playing time may have been the cause for the absence of any effect found in the field of skill increase. The children may not have had enough time to actually learn something from the games, not allowing for a growth in feelings of competence. Two of the eight sessions comprised, for the better part, of nothing more than getting to know the sub-games, at a very low level. The games may simply not have been challenging enough for the majority of the students to have an opportunity to learn anything. Hence, the students did not have any success stories where they would see themselves improve: competently completing a game later on that had been very tough in the beginning.

It is clear that the limited time-span of this study has proven a limitation. The self-reflective skills of young children may also pose a threat in accurately measuring intrinsic motivation at this young age. A very valuable aspect of the current research has been the diverse sampling pool, which makes the results more generalizable to the Dutch population.

Though a significant improvement of intrinsic motivation towards counting could not be found in this study, it remains important that ways are found to engage students and make them eager to learn more about subjects. With society changing, education should change as well in order to complement the natural path of development that children follow these day.

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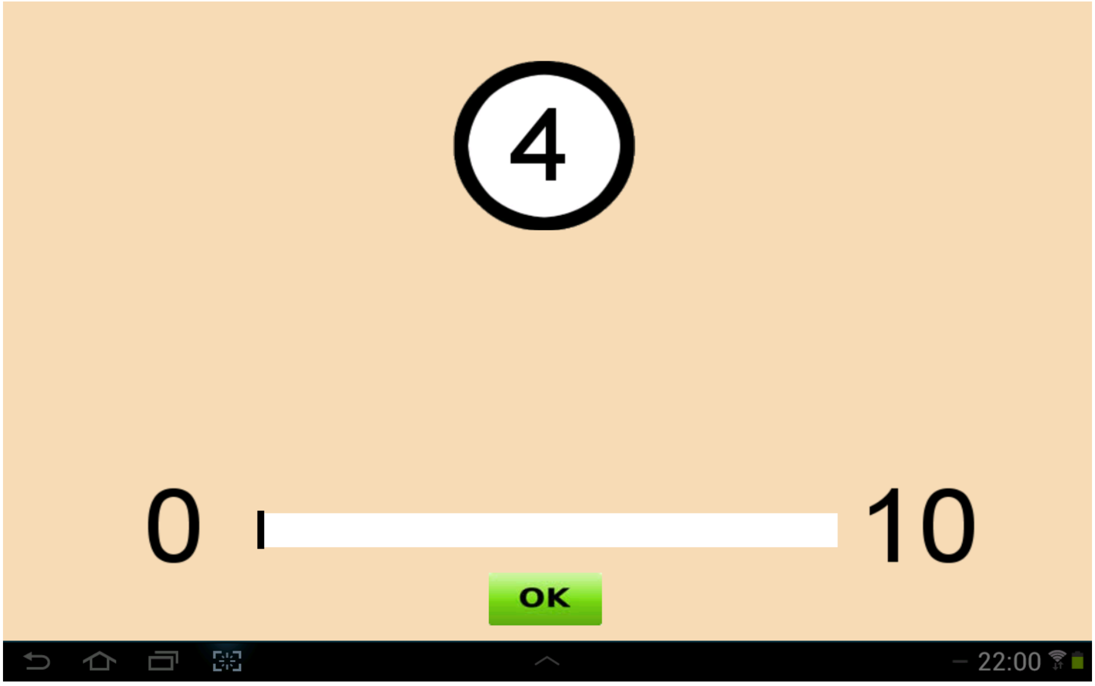
Appendix 1 – intrinsic counting motivation questionnaire

Telmotivatievragenlijst

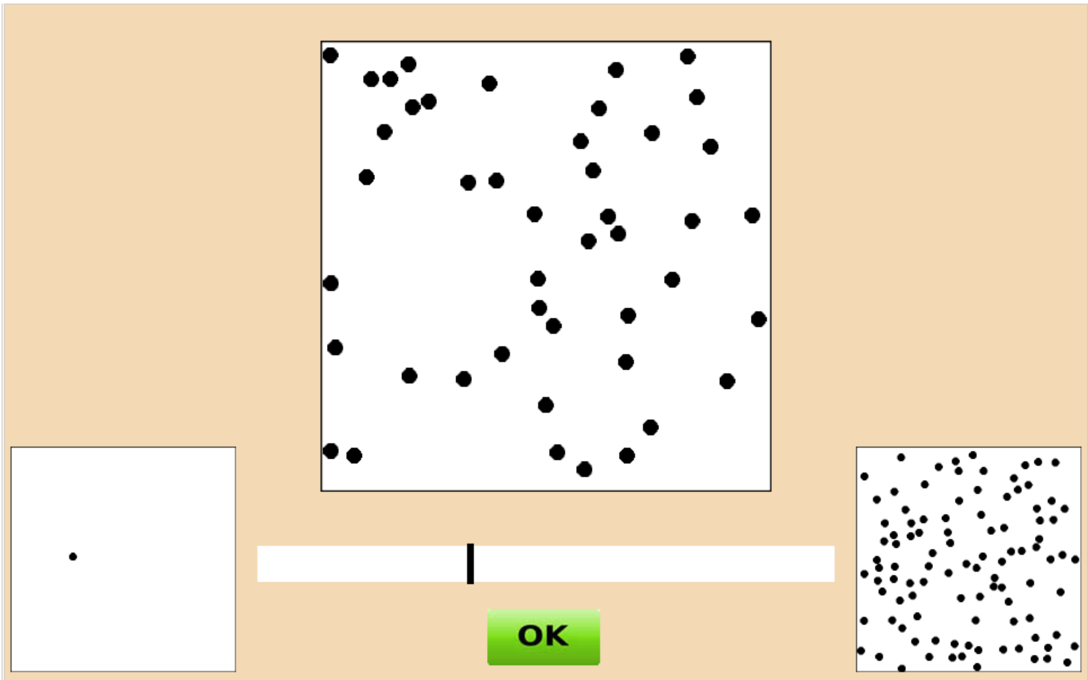
Voorbeeldvraag Buitenspelen op school is leuk	Altijd Soms Nooit
1. Tellen op school is leuk	Altijd Soms Nooit
2. Tellen is makkelijk	Altijd Soms Nooit
3. Tellen is vervelend	Altijd Soms Nooit
4. Zou jij meer willen tellen op school?	Heel graag Maakt niet zoveel uit Liever niet
5. Ben je blij als je mag tellen op school?	Altijd Soms Nooit
6. Tellen is saai	Altijd Soms Nooit
7. Ben jij goed in tellen?	Heel erg Een beetje Nee
8. Tellen is leuk	Altijd Soms Nooit
9. Heb jij een hekel aan tellen?	Altijd Soms Nooit

Appendix 2 – screenshots of the pre- and post-tests

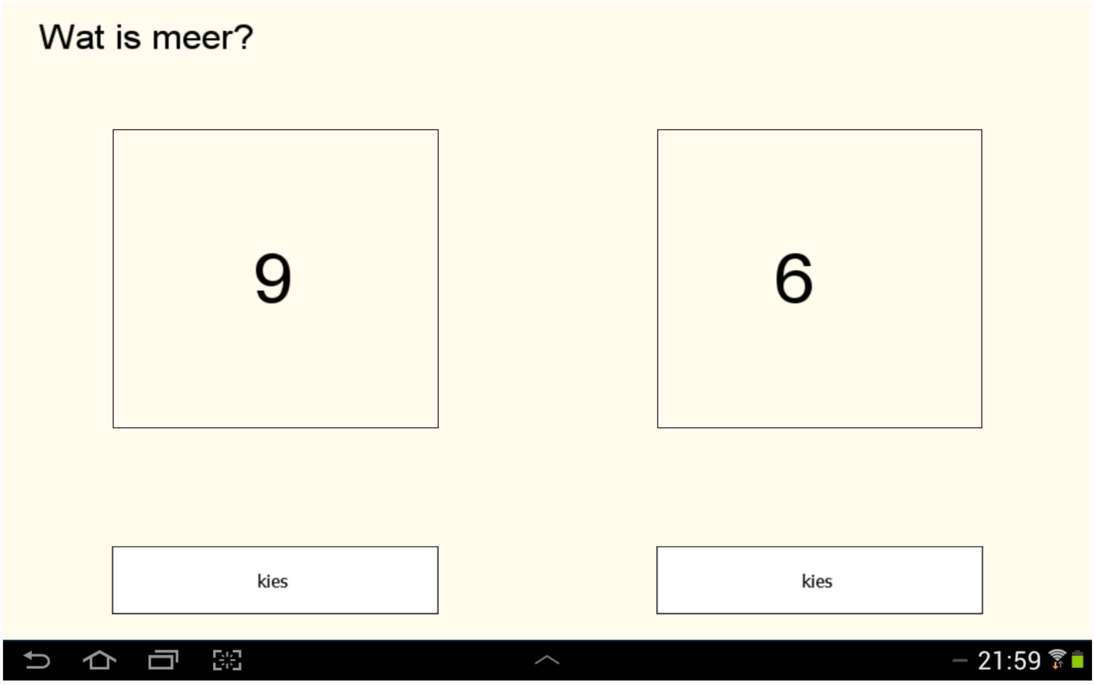
Lines 1-10



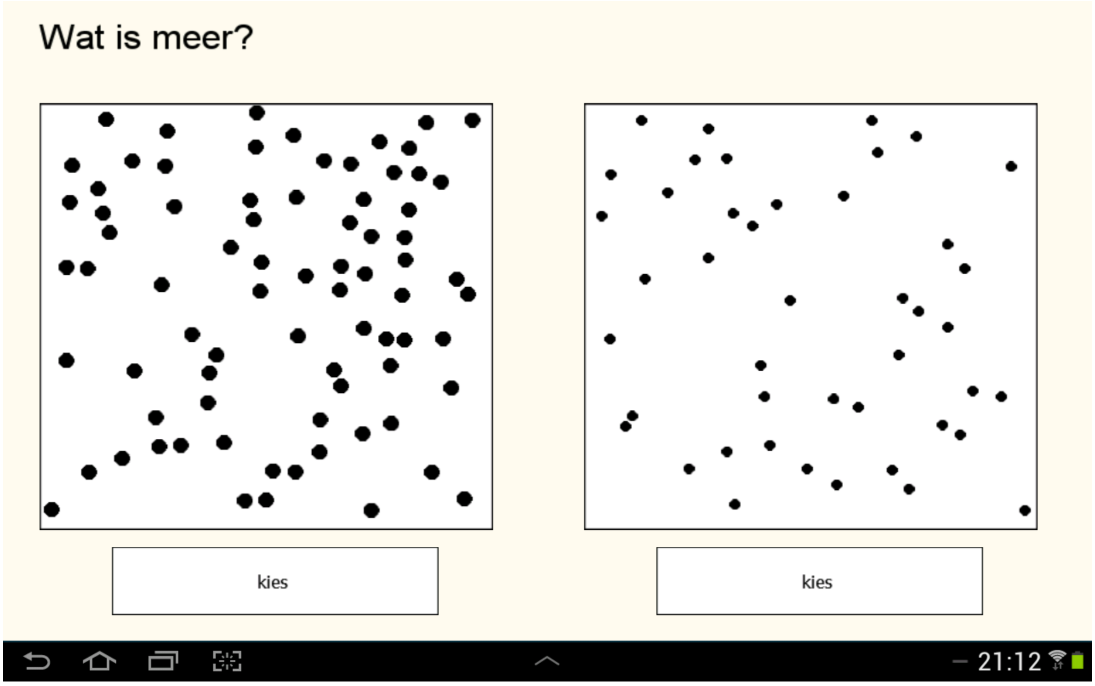
Lines 1-100



Comparing 1-10



Comparing 1-100



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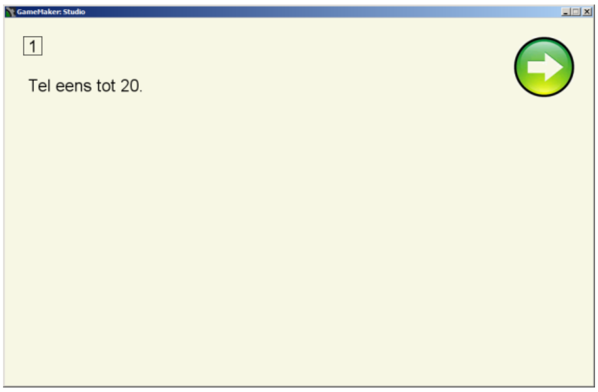
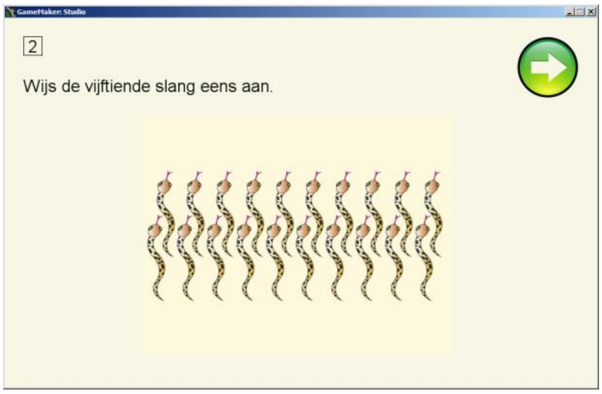
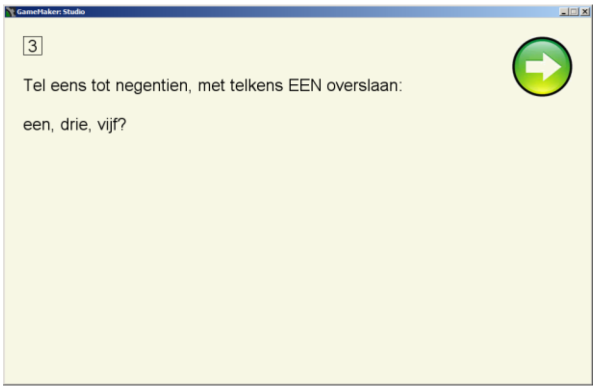
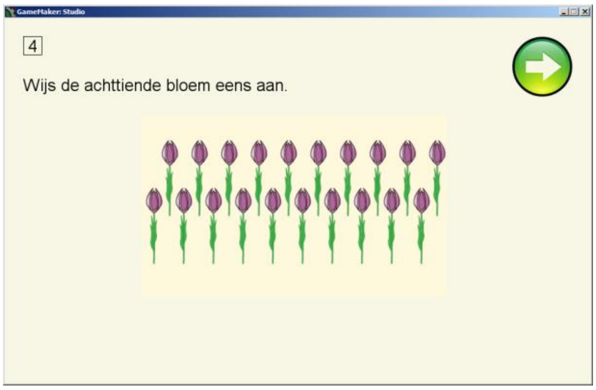
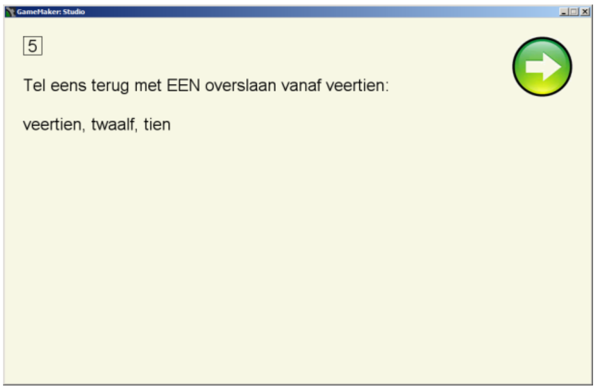
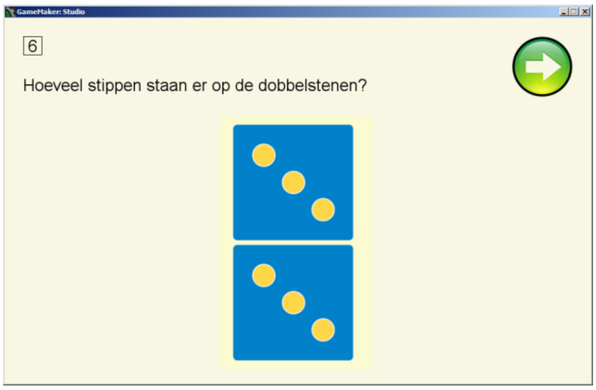

1
Tel eens tot 20.

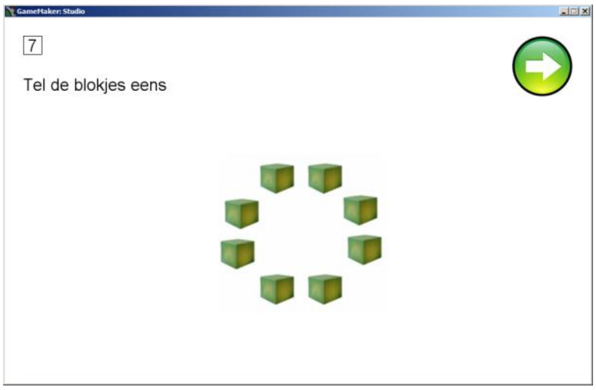

2
Wijs de vijftiende slang eens aan.


3
Tel eens tot negentien, met telkens EEN overslaan:
een, drie, vijf?

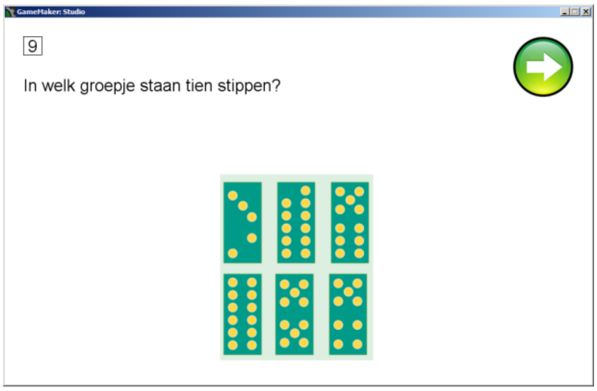

4
Wijs de achttiende bloem eens aan.


5
Tel eens terug met EEN overslaan vanaf veertien:
veertien, twaalf, tien


6
Hoeveel stippen staan er op de dobbelstenen?


7
Tel de blokjes eens

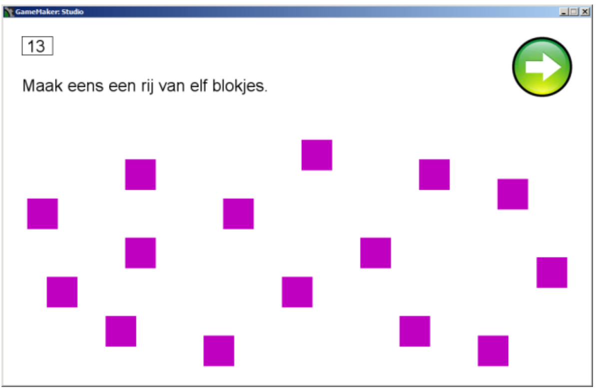

8
Kun jij vertellen hoeveel vingers er zijn opgestoken?

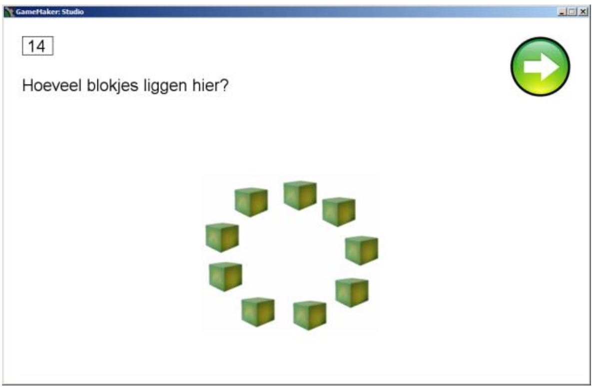

9
In welk groepje staan tien stippen?

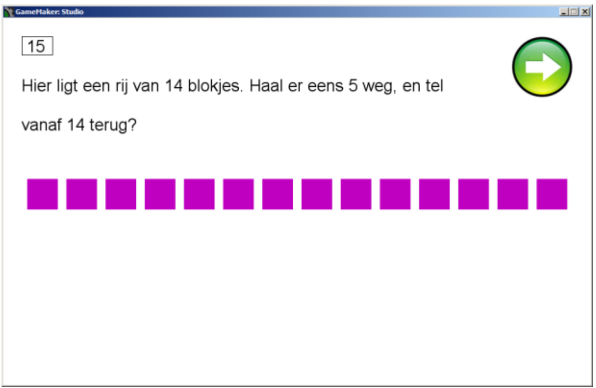

10
Tel de blokjes eens, je kunt ze ook verschuiven.

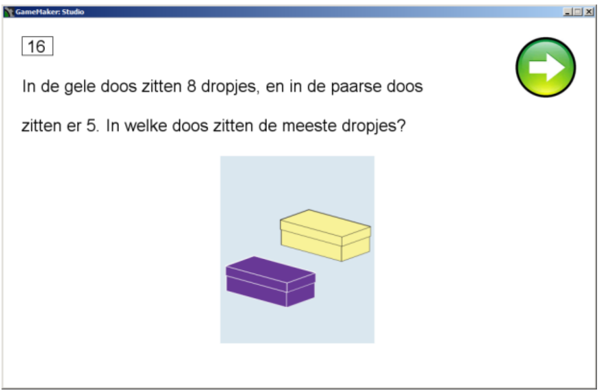

11
Ik doe 3 blokjes onder mijn hand. Dan leg ik er nog 2 bij.
Hoeveel blokjes liggen er nu onder mijn hand?

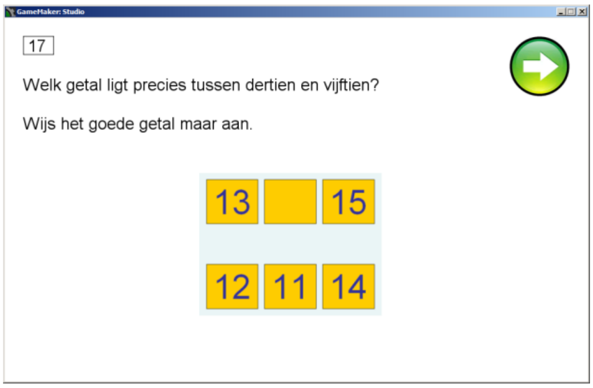

12
Weet jij welk kaartje met welk cijfer er mist?


13
Maak eens een rij van elf blokjes.

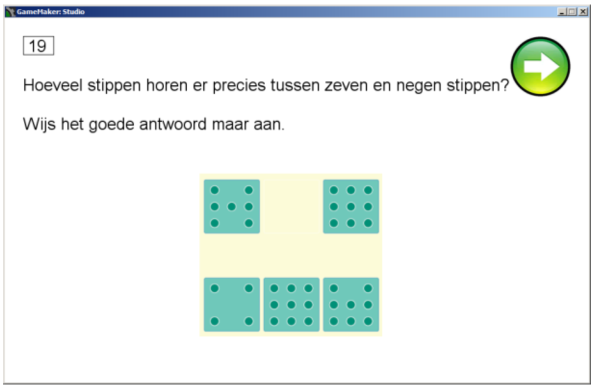

14
Hoeveel blokjes liggen hier?


15
Hier ligt een rij van 14 blokjes. Haal er eens 5 weg, en tel
vanaf 14 terug?


16
In de gele doos zitten 8 dropjes, en in de paarse doos
zitten er 5. In welke doos zitten de meeste dropjes?


17
Welk getal ligt precies tussen dertien en vijftien?
Wijs het goede getal maar aan.
13
15
12
11
14


18
Kijk eens hoeveel punten je hebt gegooid en wijs aan waar
de pion moet komen te staan.


19
Hoeveel stippen horen er precies tussen zeven en negen stippen?
Wijs het goede antwoord maar aan.


20
Je hebt 12 gebakjes. 7 gebakjes worden opgegeten.
Hoeveel gebakjes zijn er nu nog over?

Appendix 3 – elements from the Fun Toolkit

Spel 1:

Again-again:

Wil je dit spel opnieuw doen?	Ja	Misschien	Nee

Smiley:

Hoe leuk vond je dit spel?

Spel 2:

Again-again:

Wil je dit spel opnieuw doen?	Ja	Misschien	Nee

Smiley:

Hoe leuk vond je dit spel?

Spel 3:

Again-again:

Wil je dit spel opnieuw doen?	Ja	Misschien	Nee

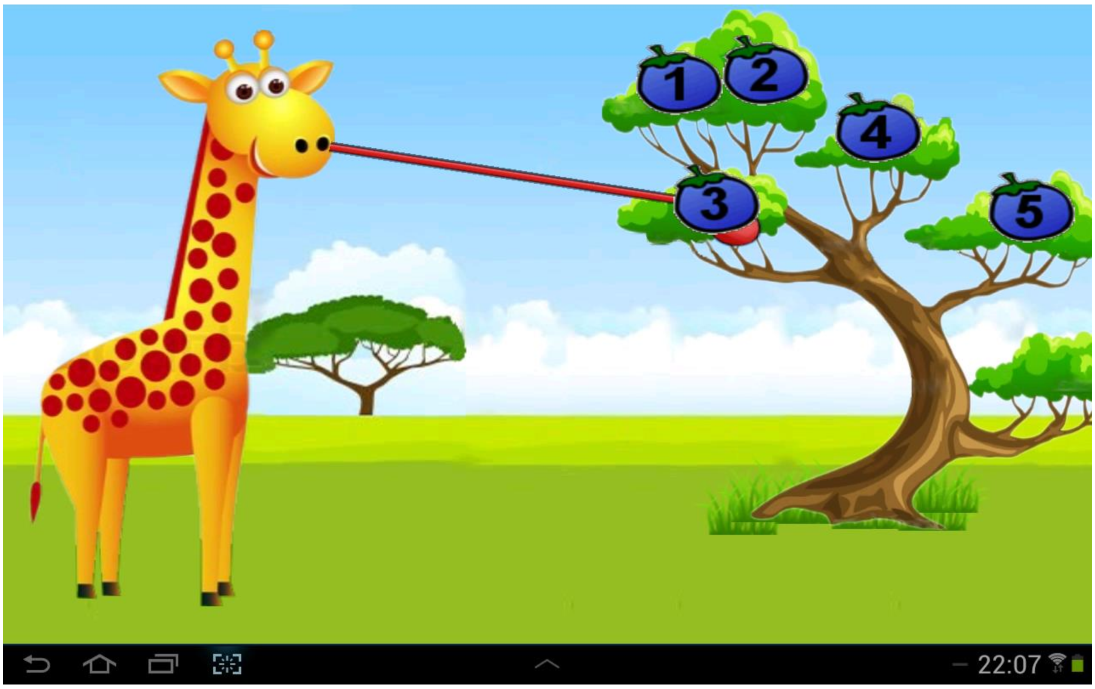
Smiley:

Hoe leuk vond je dit spel?

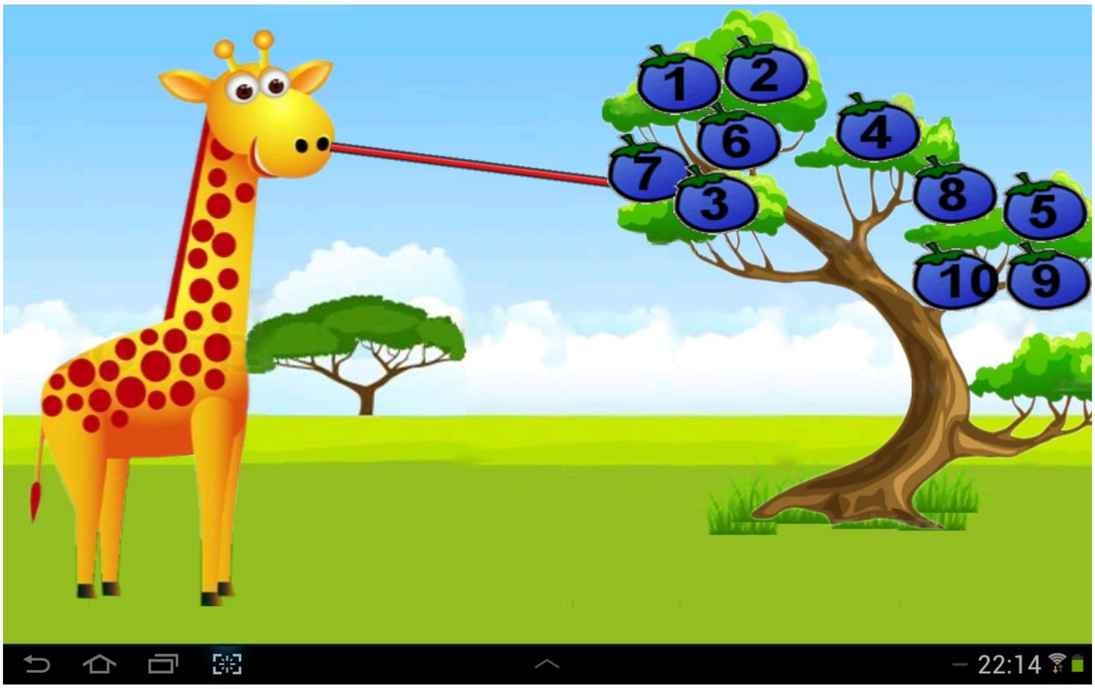
Appendix 4 – screenshot of the games

Game 1 – Giraffe

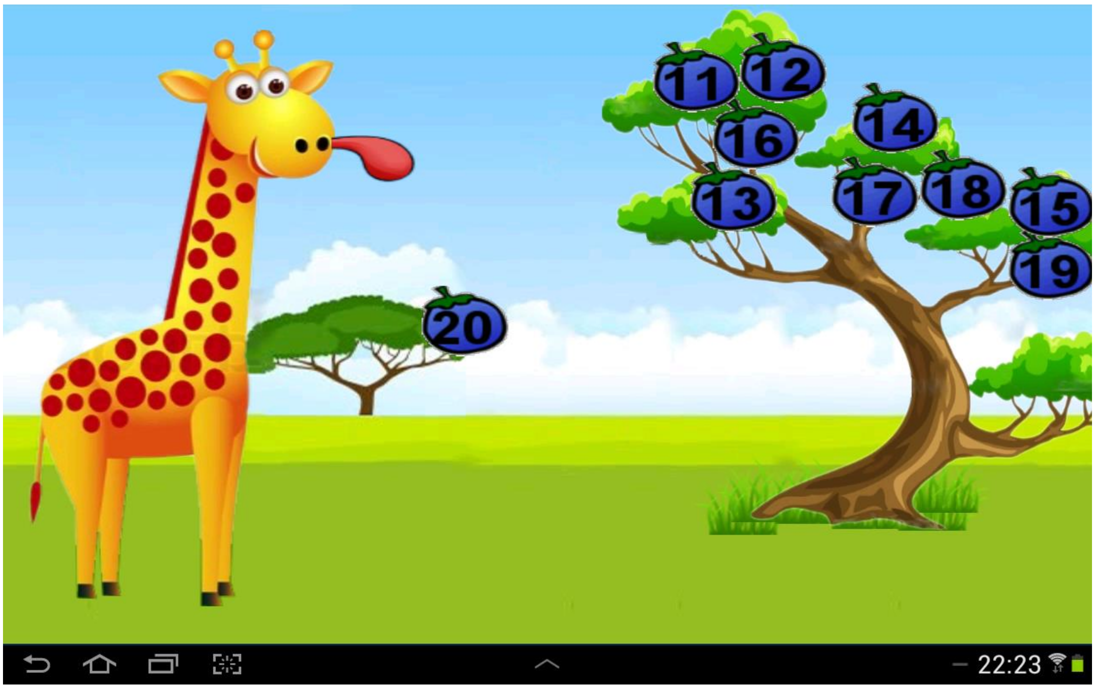
Difficulty level 1



Difficulty level 2



Difficulty level 3



Game 2 – Frog

Difficulty level 1 - Perceptual

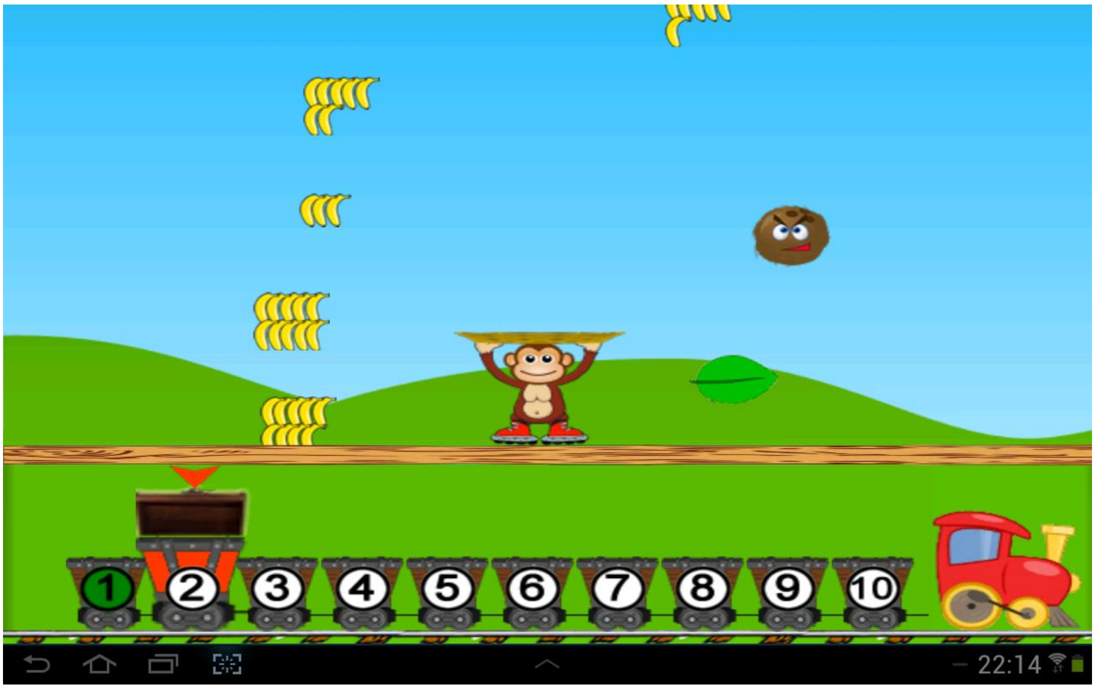
Difficulty level 2 - Perceptual

Difficulty level 3 - Epistemic

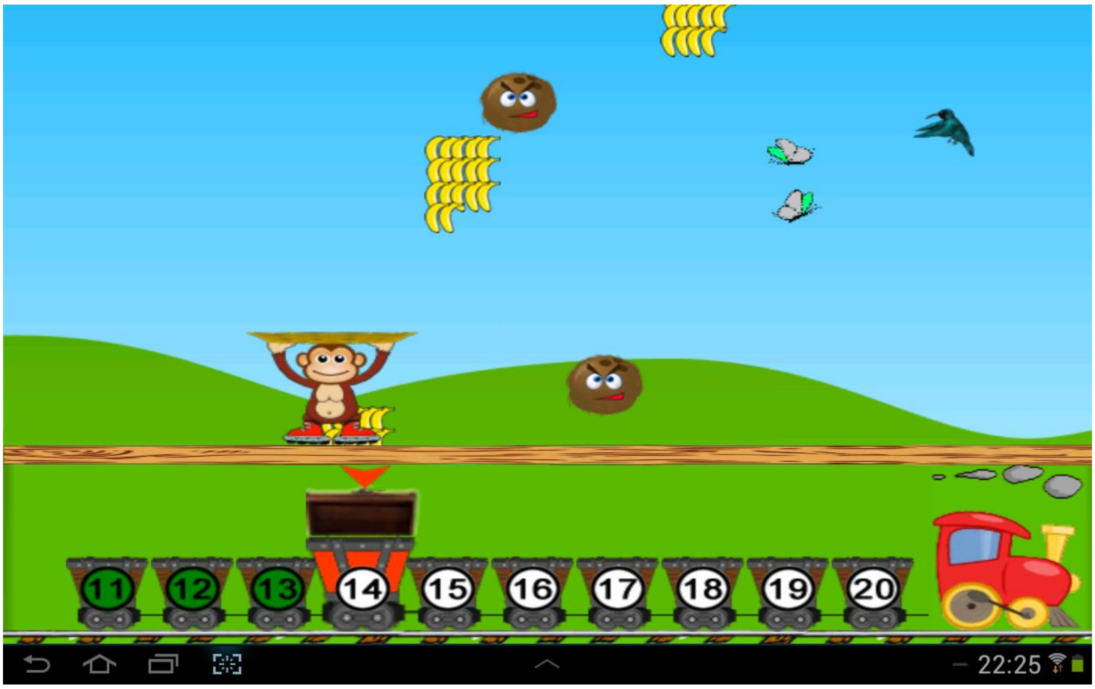
Game 3 – Monkey

Difficulty level 1 - Epistemic

Difficulty level 2 - Epistemic



Difficulty level 3 - Perceptual



Game 4 – Chameleon

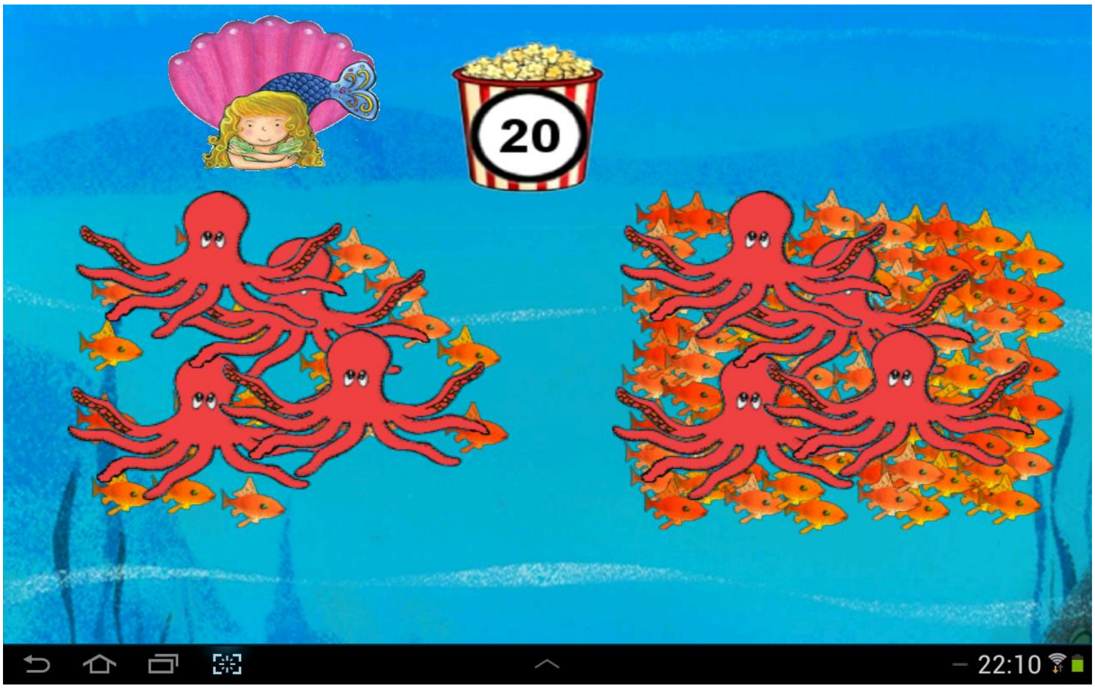
Difficulty level 1 - Perceptual

Difficulty level 2 - Perceptual

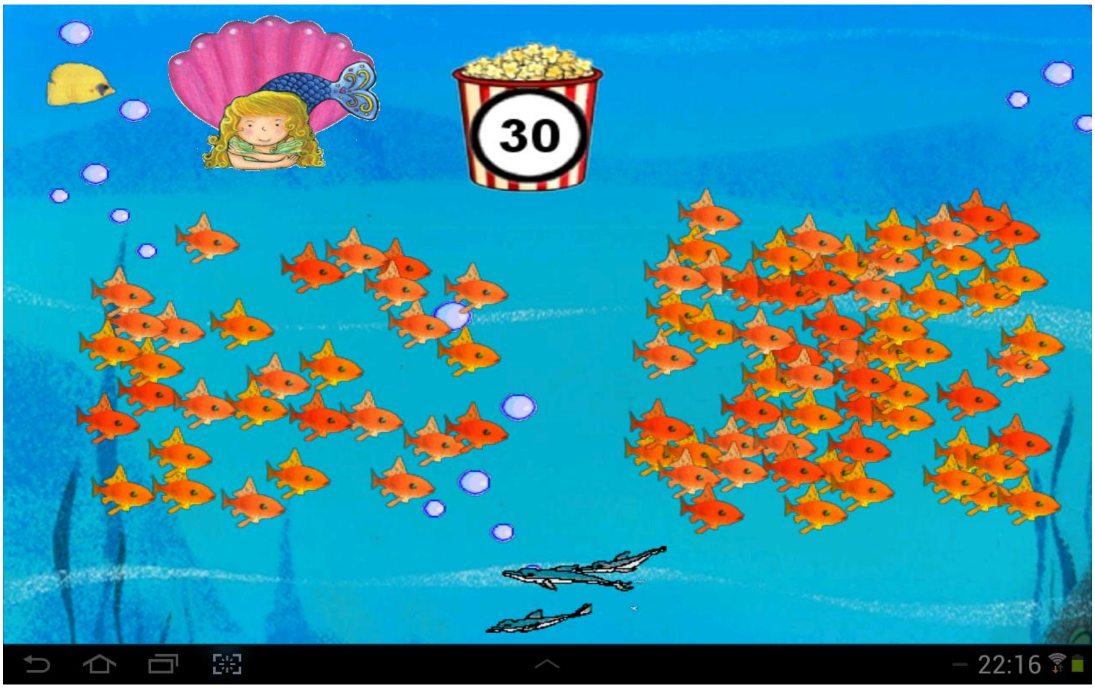
Difficulty level 3 - Epistemic

Game 5 – Fishes

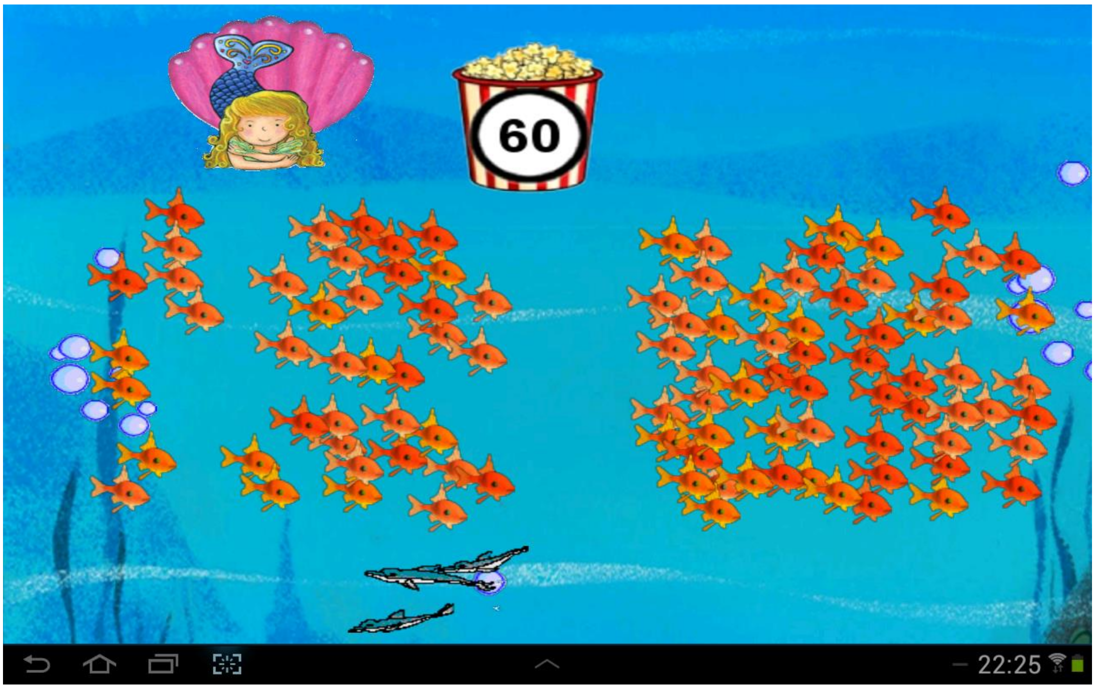
Difficulty level 1 - Epistemic



Difficulty level 2 - Perceptual

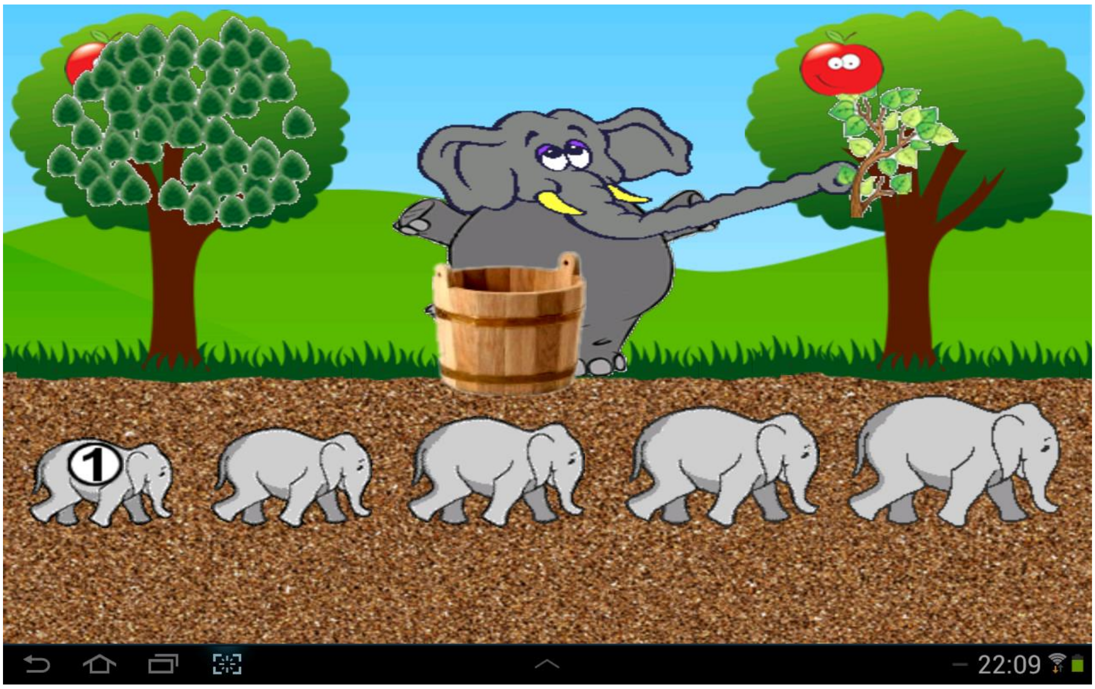


Difficulty level 3 - Perceptual



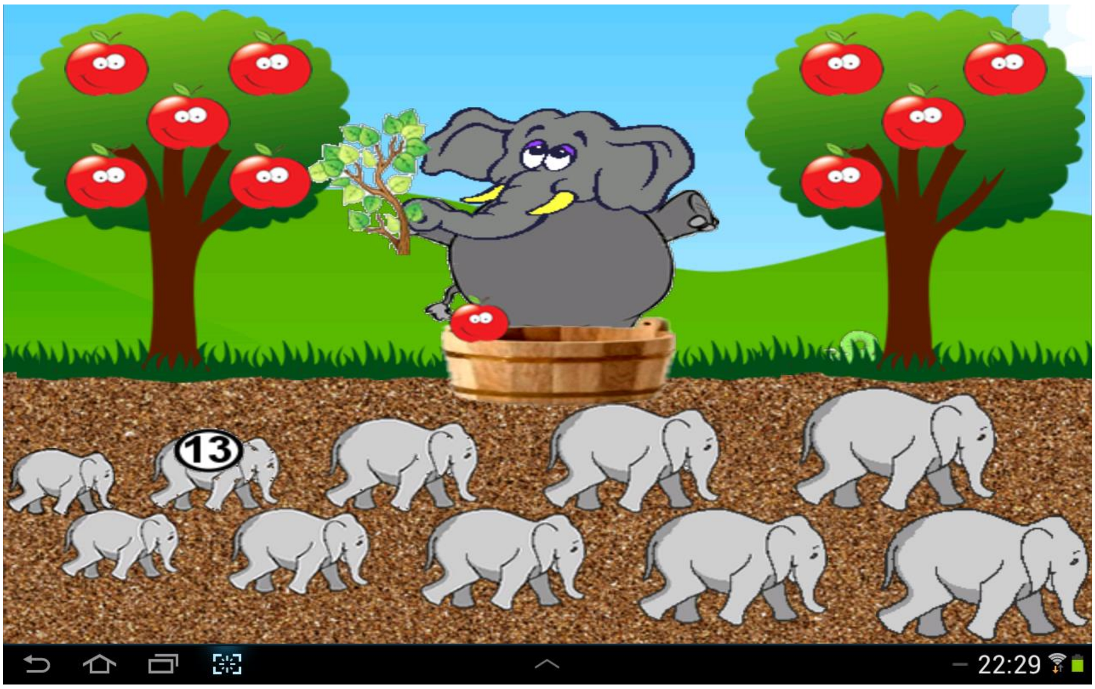
Game 6 – Elephant

Difficulty level 1 - Epistemic

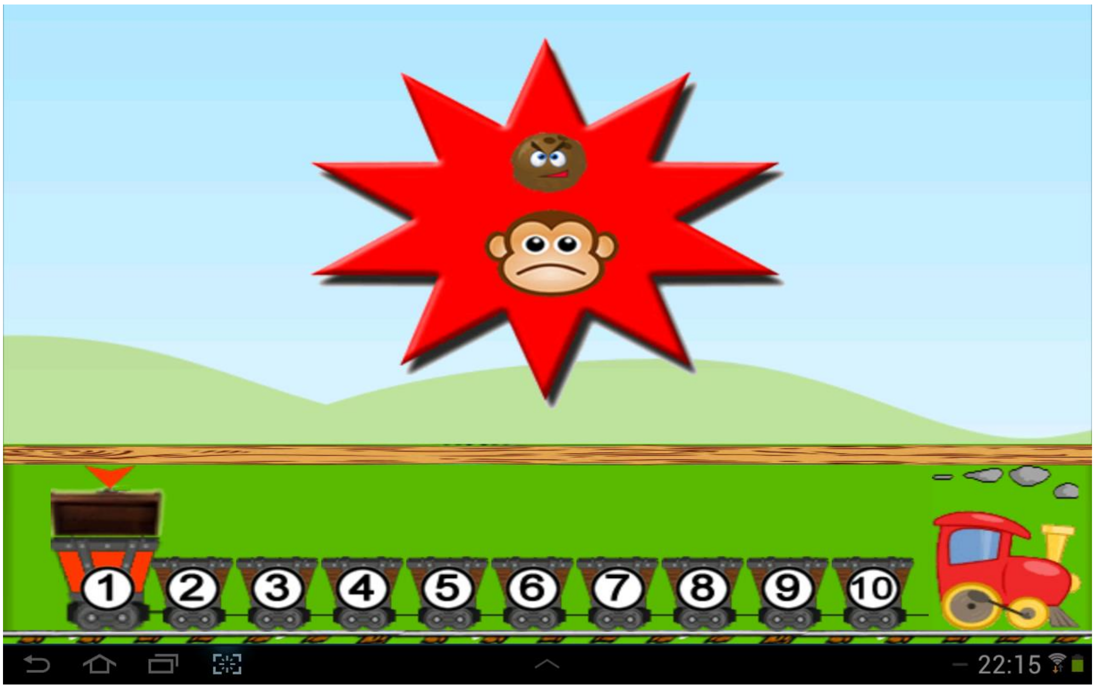


Difficulty level 2 - Perceptual

Difficulty level 3 - Perceptual



Examples of feedback (touched the 'dangerous object')



Example of completing a game successfully