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Abstract

The present study focused on 212 5th graders' situational interest trajectories during an intervention with a digital mathematics game called Number Navigation. Our aims were to explore the development of situational interest whilst playing the game and to investigate the relationship between situational interest and individual math interest. Growth mixture model analyses showed that in the whole sample situational interest was stable within sessions but decreased across sessions. Three different situational interest trajectories were found. Situational interest trajectories were predicted by pre-test individual interest. In turn, situational interest had an effect on post-test individual interest. Students whose situational interest trajectories were stable (either high or low) presented no changes in individual interest, yet the individual interest of students whose situational interest was triggered but not maintained markedly decreased from pre- to post-test. Results suggest that it is important to use game-based learning not because games are believed to be "motivating"; rather, games with proven learning outcomes should be carefully selected.

Keywords: individual interest, situational interest, motivation, game-based learning, mathematics

Introduction

One of the main arguments for using games in education is the assumption that game-based learning can spark students' engagement and interest in curricular content (e.g. Plass et al. , 2013). In this study the term game-based learning refers to pedagogical contexts where games are used deliberately for defined learning outcomes. Interest signifies a person's "psychological state of engaging or the predisposition to reengage with particular classes of objects, events, or ideas over time" (Hidi & Renninger, 2006, p.112). Research on interest often contextualizes it as a particular aspect of motivation research (Hidi & Harackiewicz, 2000), grounding it in Eccles and colleagues' expectancy-values model, a model of achievement motivation often used in educational sciences due to its utility predicting a person's future performance, persistence, and task choice (Eccles & Wigfield, 2002; Eccles, Wigfield, & Schiefele, 1998; Wigfield, 1994; Wigfield & Cambria, 2010; Wigfield & Eccles, 2000). Interest is one of the *value* parts of the model; interest or intrinsic value indicates how enjoyable a person finds a task. Hidi and Renninger's conceptualisation of interest includes both affective and cognitive components and results from the interaction between a person with potential towards interest and a specific context, which will define the direction of the interest. Interest defined in this way may refer to either situational interest – attention and affection of unknown duration resulting from environmental stimuli – or to individual interest – an enduring predisposition to reengage particular content over time and its resulting psychological state (Hidi & Renninger, 2006). Many studies on the motivational effects of educational games in and out school context have focused on features of situations that trigger situational interest, but there is still a lack of studies on the different trajectories of situational and individual interests in game-based learning (e.g., Ronimus, Kujala, Tolvanen, & Lyytinen, 2014). This study focuses on the development and interaction of students' situational interest during a six-week period in which a digital game was used as part of mathematics teaching in Finnish elementary schools.

Hidi and Renninger (2006) proposed the idea that interest develops cumulatively and progressively from situational to individual interest. In their Four-Phase Model of Interest Development, they described four distinct and sequential phases: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest. According to this model, situational interest supports the development of individual interest. However, many researchers have shown that pre-existing individual interest can also predict situational interest (Krapp, 2002; Tapola, Veermans, & Niemivirta, 2013; Schiefele, 2009), as learners have pre-existing levels of individual interest that influence their approach to situations (Durik & Harackiewicz, 2007).

According to Rotgans and Schmidt (2014), situational interest is triggered when individuals are confronted with a novel situation that makes them become aware of a knowledge deficit in themselves that they wish to counter. Many studies on game-based learning have referred to novelty effect as a source of triggered interest (Annetta, Minogue, Holmes & Cheng, 2009; Bressler & Bodzin, 2013). In their study about situational interest during educational game play Ronimus and colleagues (2014) pointed out that if situational interest is triggered only by the novelty of a situation (e.g., digital game), it cannot last over a long period of time. In other words educational games must have other features than novelty in order to maintain situational interest. An important distinction for understanding effects of game-based learning was made by Linnenbrink-Garcia and colleagues (2010) who claimed that triggered situational interest develops in response to how material is presented whereas maintained situational interest develops in response to the content itself. Previous studies have shown that features such as the presentation of the learning content (e.g., decorative or surprising game elements) (Magner et al., 2014) can trigger situational interest but it is the gradually increasing difficulty or challenge of the content which maintains situational interest in game-based learning (Sharritt, 2008).

Individual interest in the content is believed to support learning (Murphy & Alexander, 2002; Alexander, Kulikowich, & Jetton, 1994). Previous research in schools and higher education indicates that individual interest is related to students' future performance, persistence, and task choice (Berger & Karabenick, 2011; Eccles & Wigfield, 2002; Wigfield & Cambria, 2010) and highlights the importance of promoting student interest (Hidi & Renninger, 2006). This is particularly important in the area of mathematics, as it has been shown that interest in mathematics decreases throughout the school years (Fredricks & Eccles, 2002; Frenzel, Pekrun, Dicke, & Goetz, 2012; Hidi, Renninger, & Krapp, 2004; Krapp, 2002; Watt, 2004) indicating that conventional mathematics education (particularly in western countries) often fails to make mathematics learning meaningful and relevant (Brown , Brown & Bibby, 2008). In the Finnish educational context the decrease of students' mathematic achievement in international evaluation studies is connected with negative changes in mathematics motivation (Tuohilampi & Hannula, 2013).

An increasing number of studies provide evidence for the belief that interest can be promoted through the use of technology assisted learning (Ainley, 2006; Chen et al., 2016; Mitchell, 1993). Digital games, for instance, constitute an environment in which students can explore and practice content extensively, making them particularly suitable as tools for supporting learning activities that are difficult to carry out in traditional classroom teaching (Lehtinen et al., 2015). While many teachers and researchers believe that game-based learning may help motivate students (Annetta,et.al., 2009; Klemmetti, Taimisto, & Karppinen, 2009), there is a lack of empirical data to substantiate this belief (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Wouters, van Nimwegen, van Oostendorp, & van der Spek, 2013). Therefore it is important to carefully select games for their content. In his widely cited paper Prensky (2001) proposed that newer generations are "digital natives" who will by default enjoy games and find them motivating. However, it has been argued that this is not the case for all students (Bennet, Maton, & Kervin, 2008; Kirschner & van Merriënboer, 2013; Meyer & Sorensen, 2009; Whitton, 2009), or that even in cases where students enjoy a game, they do not necessarily play it as frequently as expected (Ronimus et al., 2014). Nevertheless there are various different features of games and gameplay modes that may trigger situational interest (e.g. Rowe, Shores, Mott, & Lester, 2010).). This study focused on the interest development when students are playing a digital strategy mathematics game called Number Navigation Game (NNG). NNG is a digital strategy game which was developed by the mathematics learning research group of the University of Turku for enhancing learning of flexible and adaptive arithmetic strategies. The target group of the game is upper elementary school students (10-12 years). Adaptive and flexible arithmetic strategies have been highlighted as aims for mathematics education but there are only a few systematically elaborated pedagogical approaches for teaching adaptivity with arithmetic (Baroody, Purpura, Eiland & Reid, 2016; McMullen et al., 2016). To our knowledge NNG is the only educational game developed for supporting the learning of adaptive number knowledge beyond the very basic arithmetic strategies. NNG has been shown to have very positive effects on students' advanced arithmetic skills (Brezovszky et al., 2015; submitted; Rodríguez-Aflecht, Hannula-Sormunen, McMullen, Jaakkola, & Lehtinen, 2016), but only a minor and unexpectedly negative effect on their overall math motivation, as measured through a questionnaire based on Eccles and colleagues' (2002) expectancy-values model (Rodríguez-Aflecht et al., 2015). Thus it is important to explore deeper how the game is related to mathematics interest.

Based on Hidi and Renninger's (2006) Four-Phase Model of Interest Development theoretical framework, the first aim of this study was to explore the development of students' situational interest throughout an intervention with NNG. The effects of novel activities such as games and simulations on situational interest have been explored before, but because of methodological challenges situational interest is usually measured only immediately after the activity (Chen et al., 2016; Hong et al., 2015; Ronimus et al., 2014), and sometimes only at one time point (Plass et al, 2012; Plass et al., 2013). With few exceptions (such as Tapola, Jaakkola, & Niemivirta, 2014), rarely is situational interest measured while students are on-task. Ainley, Hidi, and Berndorff (2002) noted that it is important to measure situational interest at different time points in order to understand its stability which is crucial for differentiating triggered and maintained situational interest. Therefore we are interested in studying the development of situational interest both within and across play sessions. Also, thus far studies on motivational effects of game-based learning have not placed enough emphasis on individual differences. In this study, students' situational interest trajectories while playing NNG were analyzed to explore the development of their situational interest. Finally, the relationship between situational interest and individual interest was explored in order to find out whether students' pre-existing individual math interest predicted their individual situational interest trajectories, and whether situational interest trajectories in turn have an effect on math interest after an intervention.

Research Questions

This study aimed to answer the following research questions:

1) How does situational interest develop in an intervention with a digital mathematics game?

Chen and colleagues (2016) argued that while immersive technologies such as games and simulations have the potential to serve as a "hook" for students' situational interest in the learning environment, research has shown that the effects of technology on the situational interest do not last long for all students.

H1. We expected to see a novelty effect, that is, we expected situational interest to decline across sessions for the whole sample.

2) Can different situational interest trajectories among students be identified and how these are related to the game performance?

Previous research highlights the importance of exploring variations among participants in the development of situational interest, as by focusing only on the whole population we would have risked losing information regarding the complex trajectories of different groups (Jung & Wickrama, 2007). Students' acceptance of educational technologies such as digital games in the classroom cannot be taken for granted (Bourgonjon, Valcke, Soetaert, & Schellens, 2010; Lee, Cheung, & Chen, 2005), and there are differences in how students perceive technology-based learning environments such as digital games (Bennet et al., 2008; Ronimus et al., 2014; Whitton, 2009).

H2. We expected that there are inter-individual differences in students' triggered interest at the beginning of game-based learning. We expected that for most students, situational interest would be triggered, but only some of these students would progress from triggered situational to maintained situational interest. In other words, based on Hidi and Renniger (2006), we expected to find distinct trajectories of students' situational interest. We also expected that maintained situational interest would be related to good gaming performance (Sharritt, 2008)

3) Does previous individual math interest predict situational interest during the game play?

Many researchers have shown that pre-existing individual interest can predict situational interest (Knogler, Harackiewicz, Gegenfurtner, & Lewalter, 2015; Krapp, 2002; Tapola, Veermans, & Niemivirta, 2013; Schiefele, 2009), as learners have pre-existing levels of individual interest that influence their approach to situations (Durik & Harackiewicz, 2007). There is some evidence that initial individual interest in the content has an effect on situational interest in technology based learning environment (Chen et al., 2016). However, there is a lack of research on the relationship of individual mathematics interest and situational interest when students are facing new challenges in a mathematics game context.

H3. We expected pre-existing individual math interest to predict students' situational interest.

4) Do different situational interest trajectories predict individual math interest after the gaming period?

Previous research has shown that individual interest is relatively stable (Eccles & Wigfield, 2002), so we do not expect drastic changes in students' individual math interest after the intervention.

However, Hidi and Renninger’s (2006) Four-Phase Model of Interest argues that if situational interest is triggered and maintained it will have an influence on subsequent individual interest.

H4. We anticipated that students whose situational interest was both triggered and maintained would have a more positive development of individual math interest than other students.

Method

Number Navigation Game.

The NNG consists of 64 maps distributed over four levels of increasing difficulty. Pictured on the maps are archipelagos superimposed on a grid of numbers corresponding to a hundred square. Players are in control of a ship, which they need to navigate to collect materials dispersed throughout the sea of numbers. To navigate, players use a number pad to input location-dependent equations in order to move from one number to another. In the image below (Figure 1), a ship is anchored at number 100 and the player needs to retrieve a material which appeared at number 45. By inputting -55 so that the equation reads 100-55, the ship would reach the material in one step. One of NNG’s scoring modes is to retrieve materials using the least number of steps. In the second scoring mode, players are encouraged to use multiplication and division and combine different types of operations by limiting the amount of “energy” they may expend; in order to save energy, players must use small magnitude numbers to complete equations. In the example above, in which the number entered into the number pad was 55, the material was reached using 55 energy points. Players could however reach the same location for example first by subtracting ten (100-10=90, 10 energy points) and then dividing by two (90÷2=45, 2 energy points), using a total of 12 energy points to get there. Based on the quality of players’ performance within a map, they would be awarded either a bronze, silver, or gold coin so that bronze indicates acceptable and cold close to optimal solution. (Lehtinen et al., 2015)

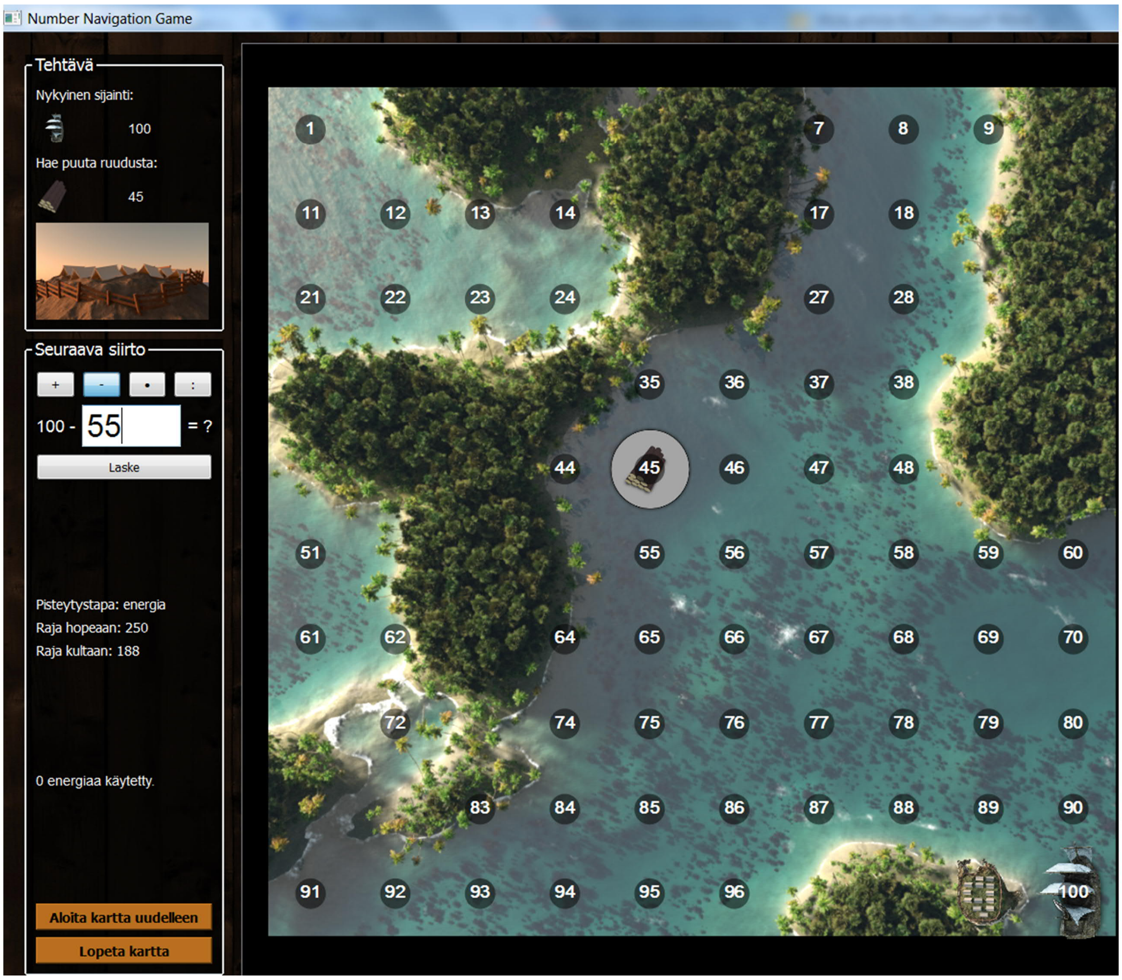

Figure 1 *Screenshot of the Number Navigation Game*

Participants.

The data was collected in the frames of a larger experimental study. Voluntary teachers teaching in comprehensive schools in three cities in southern Finland were asked to participate in the mathematics game experiment. The five schools are located in urban and rural areas and parents of the students represent typical distribution of socioeconomic background of the country. In Finland there is a joint comprehensive school without ability based tracking for the whole age group during the first 9 school years and the differences in mathematics achievement between the schools are very small

(Vettenranta et al., 2016). Finnish comprehensive schools have good technological resources but games are not widely used in teaching (Mikkonen, Vähähyyppä & Kankaanranta, 2012)

The participants of the present study were 212 fifth grade students (*M* = 11 years 2 months; *n* = 91 girls, *n* = 121 boys) who completed at least one map and played the game individually. Students came from twelve classrooms.

Procedure.

In the larger study the individual mathematics interest of the participants were measured three times: in the beginning of February, in mid-April, and in mid-May. Only the second and third measures were used in this study. In between the second and third measurement points, students played NNG during a six-week period. Before the first measurement, teachers were invited to a session in which the learning aims and game mechanics of NNG were presented. However, as the aim of this experiment was to explore how students independently use the game, teachers were not instructed to support students during the play. It was recommended that students play two class periods or sessions per week and that sessions last at least half an hour. The actual amount of total time played ranged from 46 minutes to 17 hours and 30 minutes, and the mean playtime was three hours and three minutes (*SD* = one hour and 37 minutes). The total number of sessions (when a student completed at least one map on a given date) varied from two to ten sessions (*M* = 6.25, *SD* = 1.92).

Measures.

Individual Interest.

Students' individual math interest was measured through three items originally developed by Berger and Karabenick (2011) as part of a larger motivation scale measuring the math-expectancy value including interest, utility, attainment value, self-efficacy, and cost sub-scales. Items measuring individual interest consisted of statements ("I like math," "I enjoy doing math," "Math is exciting to me") on a five-point Likert scale ranging from 1 (*completely disagree*) to 5 (*completely agree*). Individual interest was measured as "liking" something. Interest items had good reliability, with Cronbach's α >.90 at each of the three measurement points.

Situational Interest.

Students' answers within and across multiple sessions were used as a measure of their situational interest. Upon completing a map during game play, a pop-up window appeared asking students to self-report on their level of agreement with the statement "I like this game" (ranging from 1 (*completely disagree*) to 5 (*completely agree*). Responses were saved in the game log data files. Only one item was used in order to avoid disrupting students' engagement or immersion in the on-going activity. Ronimus and colleagues (2014) also measured situational interest through one item due to their participants' young age. Also like Ronimus et al. (2014) our item, "I like this game" (In Finnish: "Pidän tästä pelistä"), framed interest as "liking/enjoying" because the literal translation of "interested" in Finnish (*kiinnostunut*) would have been a more unusual term for our participants.

Gaming performance.

Quality of the gaming performance was measured by the number of gold coins students were awarded by the game. The number of gold coins of each student was collected from the log-data.

Analysis

To explore the development of situational interest within and across sessions, we used descriptive statistics. Split-half reliability (Spearman-Brown coefficient) was used for testing the homogeneity of situational interest ratings during the sessions. As the data collected from 12 different classrooms were nested in nature, before answering the second research question, we first conducted Variance Component Analyses on SPSS to verify whether there was a need to explore classroom effects. We carried out growth mixture model analyses (GMM) using M*plus* version 7.0 (Muthén & Muthén, 1998-2015) and employing the Maximum Likelihood Robust Estimator (MLR) to model different growth trajectories in students' situational interest development. GMM is a flexible way of grouping participants in which the probability for an individual to belong to a class as well as the mean growth curves and growth factor variance of each class are estimated (Kreuter & Muthén, 2008; Muthén & Muthén, 2000; Muthén, 2003). We used statistic indicators such as Log Likelihood values, Akaike Information Criteria (AIC), Baysian Information Criteria (BIC), entropy, class proportions, average latent class posterior probabilities, and most importantly, the actual fit to the data and substantive theory to decide about the number of latent classes which is used in the study (Kreuter & Muthén, 2008).

To carry out a multinomial logistic regression analysis, we used pre-test math interest factor scores (counted on the basis of the three individual interest items) as a predictor variable by using the auxiliary function R3STEP on the original GMM in M*plus* (Asparouhov & Muthén, 2014). This provided the odds ratio of a student being assigned to one latent class rather than another one based on their pre-test math interest. The mean values of pre-test math interest for each of the classes were calculated using the auxiliary function BCH on M*plus*. These mean values are weighted by the accuracy of the classification or the posterior probabilities for being in certain class. Finally, a one-way repeated measures ANOVA was carried out in SPSS for analyzing the effects of time (pre- and posttest) and situational interest class membership on individual math interest. When appropriate, post hoc comparisons using Bonferroni correction were conducted to investigate the differences between different classes.

Results

The Development of Situational Interest.

Students rated their situational interest after each completed map. Within sessions, situational interest ratings did not change much. Spearman-Brown reliability coefficients for ratings within sessions from the first five session were .894, .849, .924, .918 and .912. Averages of sum scores of the ratings within sessions (divided by the number of the measurements of each student) were used as variables describing situational interest of the five sessions in subsequent analyses. The number of maps completed within a session steadily decreased during the 6-week play period, indicating the difficulty level increase. Likewise, the number of participants across sessions decreased, indicating the variability of the time different students used for playing. We used the fifth session as a cut-off point as 80.75% of participants (*n* = 172) completed at least five sessions, with only 64.79% and 44.13% of participants completing six and seven sessions, respectively. Table 1 shows the situational interest averages within the first five sessions. Across sessions, the trend was for situational interest to decrease ($F=22.03$, $p<.001$.)

Table 1 *Descriptive Statistics of Average Situational Interest Within the First Five Sessions*

	Session														
	1			2			3			4			5		
Map	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*	*n*	*M*	*SD*
1	212	3.85	1.20	212	3.27	1.44	207	3.15	1.55	194	3.27	1.45	172	3.15	1.52
2	163	3.69	1.31	183	3.29	1.49	172	3.24	1.57	178	3.26	1.51	146	3.21	1.52
3	96	3.70	1.46	114	3.29	1.54	121	3.40	1.58	124	3.34	1.61	106	3.25	1.60
4	49	3.49	1.66	66	3.53	1.52	69	3.61	1.49	71	3.41	1.48	65	3.35	1.60
5	17	4.24	1.39	34	4.12	1.07	36	3.78	1.55	39	3.28	1.52	27	3.89	1.72
6	10	4.30	1.34	14	4.14	1.35	18	4.22	1.35	13	3.08	1.19	10	3.60	1.71

7	4	4.50	1.00	6	4.00	1.26	6	3.67	2.07	2	2.50	2.12	1	5.00
8	2	4.00	1.41	3	2.67	1.53								
9	2	4.00	1.41	1	4.00									
10	1	3.00												
11	1	3.00												
12	1	3.00												

Situational Interest Trajectories.

GMM were carried out to explore distinct growth trajectories in students' situational interest across the first five sessions. Students' situational interest was represented by their mean responses for all maps completed in each session. First, a basic latent growth curve was fitted; then, an increasing number of classes were explored. The log-likelihoods, BIC, AIC, entropy estimates, class proportions, and average latent class posterior probabilities of the different classes are presented in Table 2. The three-class model (Figure 2) was chosen because, even though it is statistically not as strong as some of the other options, it is the most parsimonious from a theoretical standpoint, as it serves for identifying whether students' situational interest was triggered or not, and whether that situational interest was maintained or not. In comparison, in the four- and five-class models, the additional classes were fairly small.

Table 2 *Fit Statistics for GMM with 1–6 Classes*

n of classes	Log likelihood	BIC	AIC	Entropy	Class proportions	Average latent class posterior probabilities
1	-1403.18	2854.58	2824.37	1.00	1.00	1.00
2	-1378.70	2821.67	2781.39	0.81	.22/.78	.93/.94
3	-1365.85	2812.05	2761.70	0.78	.27/.14/.59	.88/.84/.93
4	-1352.12	2800.66	2740.24	0.83	.14/.54/.23/.09	.91/.93/.88/.87
5	-1336.92	2786.33	2715.84	0.83	.07/.40/.11/.25/.17	.87/.92/.88/.88/.81

6	-1315.20	2758.95	2678.39	0.87	.14/.13/.14/.18/.14/.26	.97/.82/.86/.90/.93/.93

In Session 1, the situational interest of the students in the *High* and *Triggered not maintained* classes (classes together *n* = 155) was high, which indicated that their situational interest was triggered. This constituted 73.11% of participants. Students in the *High* class (*n* = 125) maintained a high initial level of situational interest throughout the five sessions. Students in the *Triggered not maintained* class showed a constant decrease in situational interest, so for these 30 students situational interest was triggered but not maintained. The situational interest of the students (*n* = 57) included in the *Low* class was never triggered, and it remained low throughout all five sessions.

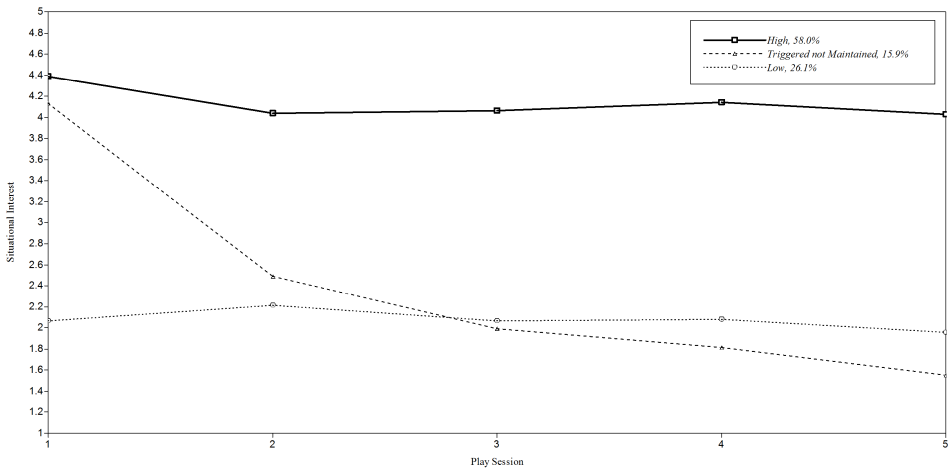

Figure 2: *Three-Class Growth Mixture Model*

Students belonging to the different situational interest trajectory classes performed significantly differently in the game, $F(2, 209) = 4.56$, $p = .011$. Mean of the gold coins of the High class was M=10.58, the Triggered not maintained class M= 6.77 and the Low class M= 8.54. According to the Post Hoc comparisons only the difference between the High and the Triggered not maintained classes was significant ($p<.05$).

Pre-test individual interest and situational interest class membership.

A multinomial logistic regression analysis was used to investigate the importance of pre-test math interest in situational interest based class membership. Pre-test math interest was significantly associated with the difference in probabilities between belonging to the *High* class and both the *Triggered not Maintained* class, OR = 0.46, Wald = -4.61, $p < .05$, and the *Low* class, OR = 0.32, Wald = -15.21, $p < .001$. Pre-test math interest was the lowest for students in *Low* class (Mean= -0.46, S.E. = 0.13) and highest for students in the *High* class (Mean = 0.29, S.E. = 0.09), with students from the *Triggered but not Maintained* class falling somewhere in between (Mean = -0.20, S.E. = 0.20).

Situational interest class membership and changes in individual interest.

A repeated measures ANOVA, with situational interest class (*High* vs. *Triggered not maintained* vs. *Low*) as a between-subjects factor, was conducted to determine whether the mean change from pre- to post-test in students' individual math interest differed between the classes. There was a main effect for class membership $F(2,173) = 14.22$, $p < .001$, $\eta p^2=.14$, suggesting the individual math interest differences between the classes remained throughout the tests. Bonferroni post-hoc analyses showed that students in the *High* class had significantly higher individual interest than students in the *Triggered not Maintained* class (Mean difference = 2.15, $p = .001$) and in the *Low* class (Mean difference = 2.14, $p < .001$).

The ANOVA revealed also a significant interaction effect between time and class, $F(2,173) = 4.94$, $p < .01$, $\eta p^2 = .054$, suggesting pre- to post- change in individual interest differed between the classes. In order to examine the interaction effect more closely, repeated ANOVAs, with Bonferroni corrections, were run for each pair of classes (*High* vs *Low*, *High* vs *Triggered not Maintained*, and *Triggered not Maintained* vs *Low*). This revealed a significant interaction effect between time and condition between the *Triggered not Maintained* class and both the *High* and *Low* classes, but not between the *High* and *Low* classes, (*Triggered not Maintained* vs. *High*: $F(1,173) = 6.33$, $p = .01$, $\eta p^2 = .046$; *Triggered not Maintained* vs. *Low*: $F(1,173) = 6.48$, $p = .01$, $\eta p^2 = .047$; and *High* vs. *Low*: $F(1,173) = 0.00$, $p = 1.00$, $\eta p^2 = .001$). These results can be seen in Figure 3. Individual interest decreased notably from pre- to post-test in the *Triggered not Maintained* class, whereas in *Low* and *High* classes it remained virtually unchanged.

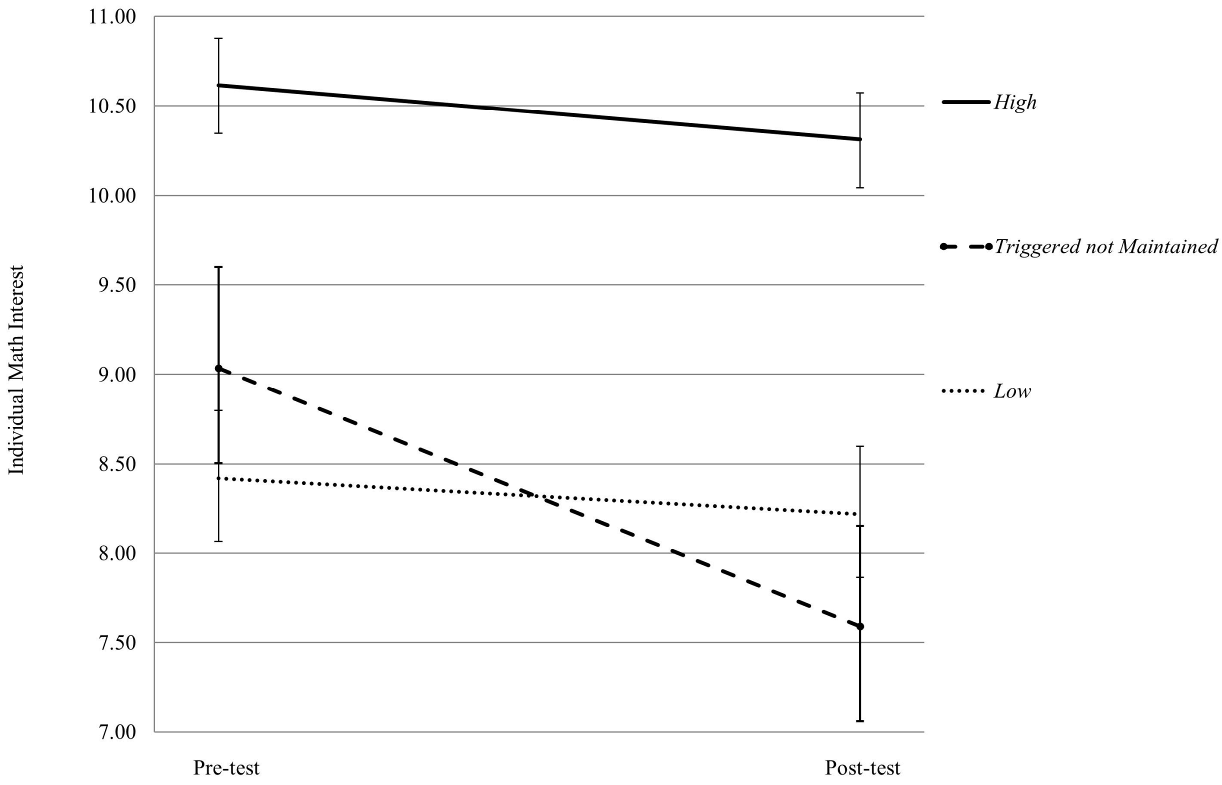

Figure 3: *Individual Math Interest by Situational Interest Class*

Discussion

The aim of this study was to analyze the development of situational interest throughout an intervention with a digital mathematics game and explore the relationship between situational interest and individual interest. Across sessions, the mean values of situational interest decreased, which is in line with our first hypothesis (H1) regarding a novelty effect. However, the results suggest that the game was nevertheless able to trigger and maintain the situational interest of over half the participants, corroborating the argument that situational interest may persist as long as the content remains meaningful to a person (Hidi & Renninger, 2006). The fact that the situational interest of many students was either not triggered or triggered but not maintained supports claims that game-based learning will not be unequivocally motivating for all students, and supports also our hypotheses (H2) by showing there were different trajectories of students' situational interest, which could be seen already at the triggering stage at the beginning of game-based learning. Students' high prior individual mathematics interest predicted high and maintained situational interest during the game play. High and maintained situational interest resulted in high individual mathematics interest also after the game period, whereas triggered and not maintained situational interest predicted a strong decrease in students' later individual mathematics interest.

Students whose situational interest was triggered but not maintained showed a dramatic drop in situational interest after the first session, which steadily continued to decrease throughout sessions, conflicting with findings of an earlier study where initial connection to a task characterized later engagement (Tapola, Veermans, & Niemivirta, 2013). This indicates that in this group there might have been a novelty effect but later game-related unfulfilled expectations affected the drop of situational interest ratings. Difficulties experienced with the mathematical content and poor performance in the game might be one of the reasons for dropped situational interest. It is important to continue to explore factors that could lead to situational interest being maintained.

Based on the results of the multinomial logistic regression, pre-existing individual math interest is closely related to students' situational interest class membership. As anticipated (H3), students who were already previously interested in mathematics were more likely to have their situational interest triggered and maintained by the gaming activity. However when looking at the effect of situational interest class membership on the change of individual interest from pre- to post-test, the relationship between situational interest and individual math interest is not so straightforward. Although we had anticipated that students whose situational interest was both triggered and maintained would have a more positive development of individual math interest than other students (H4), results did show that individual interest remained on the same level from pre to post-test. When interpreting this result it is important to keep in mind that there is a general trend of decreasing mathematics interest both throughout the school years and throughout each academic year (Frenzel, et.al., 2012; Frenzel, Goetz, Pekrun, & Watt; 2010; Pajares & Graham, 1999). The post-test of this study was conducted at the end of the academic year and the results showed a clear overall decrease of individual mathematics interest. The decrease of individual interest is mainly concentrated in the group of students whose situational interest was triggered but not maintained by the gaming activity.

This finding strongly confirms the findings of other studies which state that pre-existing individual interest in a subject has an effect on a person's situational interest (Knogler, Harackiewicz, Gegenfurtner, & Lewalter, 2015; Krapp, 2002; Tapola, Veermans, & Niemivirta, 2013; Schiefele, 2009). The results are also in line with Hidi and Renninger's (2006) theory describing the role of situational interest in the formation of individual interest. If game-based learning manages to trigger and maintain situational interest for a longer time, it might have positive effects on the subsequent individual interest. The results leave several open questions for future research. Why was the gaming activity successful in triggering the interest of some, but not all, students? It could have be due to the features of the game or the nature of the mathematical tasks students had to solve during the game play. The game lacks many of the entertaining features of commercial games students usually play during their leisure time. On the other hand, the open ended and gradually more challenging mathematical tasks faced in the game were very different from conventional school tasks. It is possible that this kind of tasks were frustrating for some students who are used to solve more conventional well-defined arithmetic tasks.

Could new game features or an improved design hold these students' situational interest? Or would they need more pedagogical support in dealing with the novel open ended mathematical tasks of the game. And finally, how long must situational interest be maintained for it to result in improved individual interest, when every activity will lose its novelty eventually?

Limitations.

It is important to take into account several limitations to this study. First, the results relied on self-reported data. Teachers' informal feedback suggests that students were highly engaged compared to their regular mathematics lessons. Interviews or observations would contextualize and enrichen our understanding of students' interest. Second, since situational interest was measured upon successfully completing a map, results may underrepresent both students who struggled with the mathematical content as well as students who were uninterested to the point they did not bother to complete maps, particularly in the later sessions. This could be solved by making the prompts measuring situational interest appear in regular intervals regardless of in-game progress. Another issue with the measurement of situational interest is that participants' situational interest was not measured upon their initial exposure to the game, that is, when their teachers first introduced NNG. Situational interest could have been triggered already when presenting the activity to students, long before students completed the first map. While all teachers were volunteers and eager to implement digital game-based learning, they could have debriefed students with differing levels of enthusiasm, and they might have offered different levels of scaffolding support, which could have had an impact on the development of situational interest. While this study deliberately focused on the effect of the game play without teacher support, in future studies it is important to pay more attention to the pedagogical implementation of the game in classrooms and teacher scaffolding connected to the game play. Other motivational aspects might be important mediators of the relationship between situational and individual interest. Finally it is important to take into account that different games may differ substantially and more studies are needed about the motivational effects of specific game features of various games.

Conclusion.

This study indicates that a digital mathematics game was successful at triggering and maintaining situational interest and at strengthening individual mathematics interest in most but not all students. In this study, the gaming environment triggered situational interest only amongst those students who were already interested in the subject before the game-based learning period. These findings are in line with the comment of Meyer and Sorensen (2009) that it is questionable to use digital game-based learning based solely on the assumption that games are assumed to be unreservedly interesting to students. Our results indicate that in novel gaming environments, if situational interest is initially triggered but soon decreases, this can have negative long-term effects on the individual interest towards the subject. For this reason, when using digital game-based learning it is important to do so not exclusively because games are believed to be “motivating”; rather, games with proven learning outcomes should be carefully selected. Future research will explore whether improved digital game development better results in triggering and maintaining situational interest.

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