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Teacher perceptions of the value of game-based learning in secondary education

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ABSTRACT

Teachers' perceptions of the usefulness of digital games might be a reason for the limited application of digital games in education. However, participants in most studies of teaching with digital games are teachers who do not use digital games regularly in their teaching. This study examined the practice-based perceptions of teachers who do teach with digital games - either playing or creating games - in their classroom. Semi-structured interviews were conducted with 43 secondary education teachers. Our findings showed that most teachers who actually use games in class perceived student engagement with a game and cognitive learning outcomes as effects of the use of games in formal teaching settings. Fewer teachers mentioned motivational effects of learning with digital games. The implications of these findings for the use of digital games in teachers' educational practice are discussed.

1. Introduction

Research suggests that digital games have potential as learning tools (e.g., Gee, 2007; Squire & Barab, 2004; Wideman et al., 2007). Recent reviews seem to confirm this potential of digital games to support students' learning and their motivation to learn (Clark, Tanner-Smith, & Killingsworth, 2015; Jabbar & Felicia, 2015; Wouters, Van Nimwegen, Van Oostendorp, & Van der Spek, 2013). Despite the many studies of the learning and motivational effects of digital games, teaching with digital games is not yet widespread in secondary education (Bourgonjon et al., 2013; Proctor & Marks, 2013; Sandford, Ulicsak, Facer, & Rudd, 2006). Proctor and Marks (2013) reported that only 25.2% of teachers in secondary education use games in the classroom, whereas 60.6% of teachers in primary education use games. Negative teacher perceptions can be an important barrier to technology integration in general and to using digital games for learning, in particular (De Grove, Bourgonjon, & Van Looy, 2012; Ertmer, 2005). Teacher perceptions are important because teachers play a crucial role in selecting, implementing and evaluating educational games for their students (Hanghøj & Engel Brund, 2011). Insights into teachers' perceptions of the benefits of digital games for student learning, based on actual experience, may therefore provide us with a better understanding of teachers' decisions to use digital games in their practice. However, insight into how teachers evaluate the usage of digital games as part of their usual teaching practices is currently lacking. Therefore, this study focuses on how secondary education teachers, who are actually using digital games in their classrooms, evaluate the value of digital games for learning.

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The aim of this study was to gain insight into what secondary education teachers regard as the learning and motivational outcomes of using digital games in the classroom.

2. Digital games and teachers' perceptions

2.1. Digital games in education

The following commonalities can be found in the definition of digital games (e.g., Abt, 1970; Dempsey, Haynes, Lucassen, & Casey, 2002; Juul, 2003; Kinzie & Joseph, 2008; Prensky, 2001; Salen & Zimmerman, 2004):

Each game has:
1) a goal, an objective to achieve;
2) game activity, which refers to the fact that the game is an activity, a process, an event; the player is doing something;
3) game rules, which means that there are some rules that need to be followed, a game is rule-based;
4) outcome(s), which refers to a numerical score and particular game actions result in gaining or losing, for example, points or virtual money;
5) conflict or competition, which means that there is some kind of contest, either with the system or with other players, or even with game players themselves by aiming to improve their own score.

Our study is limited to *digital* games, which are games being played with a digital device. We also distinguish between teachers' perceptions of the learning and motivational outcomes of students *playing* a game and students *creating* a game.

2.2. Effects of digital games

Generally, claims about effects of the use of digital games in formal learning settings can be grouped into cognitive learning outcomes and motivational outcomes. Several types of cognitive learning outcomes can be distinguished, such as learning factual knowledge, cognitive skills and metacognitive skills (e.g., Elshout-Mohr, Van Hout-Wolters, & Broekkamp, 1999; Ettekoven & Hooiveld, 2010; Omrod, 2011; Presly & Harris, 2006; Schraw, 2006). In this study, we distinguish between factual and cognitive skills as potential learning outcomes of learning through digital games (cf. Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Wouters, Van der Spek & Oostendorp, 2009). Motivation is a broad, multifaceted term (see e.g., Fredricks, Blumenfeld, & Paris, 2004; Perry, Turner, & Meijer, 2006). In this study, we looked at two facets of motivation: 1) Students being engaged in the game (enjoying it, having fun, not being distracted, wanting to play), which we refer to as engagement. 2) Students having a positive attitude towards the game content or the school subject in which the game is used, which we refer to as motivation to learn. Wouters et al. (2013) performed a meta-analysis of 39 studies comparing students playing serious (digital) games (games where the entertaining quality is used for a serious purpose, such as education or health) with regular instruction methods and found that serious games were more effective in terms of learning knowledge and cognitive skills. These findings comply with the findings from the review study of Connolly et al. (2012). Furthermore, findings from the review study of Connolly et al. (2012) show evidence for positive effects of playing games for student engagement, but findings to support effects on motivation to learn were inconclusive.

In addition to learning and motivational outcomes, several authors also mention soft skills (Connolly et al., 2012) or communicative skills (Wouters, van der Spek, & Van Oostendorp, 2009) as potential outcomes of playing games. When students learn with games, they can learn about the subject that the game addresses, but they can also learn general skills, e.g., collaboration or reflection skills.

Several studies on students *creating* games demonstrate that creating games may have additional benefits over playing games. Kafai (1996) showed that by designing games, students not only learned *about the design* of games but also learned to actually *design* games "and reached a level of reflection that went beyond traditional learning and thinking" (p. 94). Greenhill, Pykett, and Rudd (2008) found learning outcomes that go beyond skills and knowledge of designing games. They demonstrated that in a scientific design process of creating scientific micro games (short games) students not only acquired scientific concepts, but also developed their digital literacy and engagement in the design process. This outcome of student engagement was confirmed in another study. Khalili, Sheridan, Williams, Clark, and Stegman (2011) found that by creating games, students developed a sense of ownership of their game and a responsibility to make the game aesthetically attractive, engaging, and scientifically accurate. Furthermore, the students learned to question and to articulate their own knowledge (Khalili et al., 2011). In a study comparing playing games with constructing games, Vos, Van der Meijden, and Denessen (2011) found that students constructing games were more motivated and used higher-level cognitive strategies. These outcomes are confirmed in other studies that compare creating and playing games (Arici, 2008; Papastergiou, 2009).

2.3. Teachers' perceptions of and experience of teaching with digital games

Whether the use of games actually leads to positive learning and motivational outcomes might be highly dependent on teachers' perceptions of and experience of teaching with games. Several studies examined teachers' views on digital games

in education (e.g., Allsop, Yildirim, & Screpanti, 2013; Bourgonjon et al., 2013; Dickey, 2015; Egenfeldt-Nielsen; 2011; Proctor & Marks, 2013). In these studies, three aspects are frequently mentioned: 1) teachers' perceptions of the value of teaching with games; 2) their ideas about barriers to using games in school; and 3) their acceptance of games as part of their educational practice. In the current study, we will focus on the first aspect, as this might be conditional for the other two.

Many studies that examined why teachers value teaching with games show that the main reason teachers report for using digital games in their class is to enhance student motivation (Allsop et al., 2013; Can & Cagiltay, 2006; Ince & Demirbilek, 2013; Li, 2013; Pastore & Falvo, 2010; Ruggiero, 2013; Sandford et al., 2006; Schrader, Zheng, & Young, 2006; Wastiau, Kearney, & Van den Berghe, 2009). In addition, teachers also mention students' acquisition of knowledge and cognitive skills as a reason for using (or wanting to use) games in their lessons (Allsop et al., 2013; Can & Cagiltay, 2006; Ince & Demirbilek, 2013; Sardone & Devlin-Scherer, 2008; Schrader et al., 2006). These beliefs regarding learning opportunities have the strongest direct effect on teachers' intentions to use games (De Grove et al., 2012). However, participants in these studies were mostly teachers who do not teach with games yet or teachers who use games in the context of a particular research project. This study takes a different approach. We deliberately selected teachers that used digital games in their classroom teaching on a regular basis, because these teachers' perceptions of the use of digital games in their teaching practice is based on their direct experience.

3. Focus of this study

In the current study, we focus on the perceptions of teachers who actually used digital games in their teaching and investigate what they see as the games' effects on learning and motivation. We deliberately did not define the word digital game for the teachers, as we were interested in what teachers themselves call a game and wanted to see what games are being used in education. The following research question guided our study: *What are teachers' practice-based perceptions of the value of digital games with respect to students' engagement with the games, their motivation to learn, and their cognitive learning outcomes?*

4. Methods

4.1. Design

This study applied an exploratory multi-case study design (Yin, 2003). The focus of our study is on the perceptions teachers, experienced in the use of games in their teaching practice, have about the value of digital games for student learning. The unit of analysis guiding the analysis of the data thus was *teachers' practice-based perceptions of the value of digital games for learning and motivational outcomes*.

4.2. Participants

We sampled secondary education teachers in the Netherlands from the general education and (pre-)vocational education tracks. To be included in the study, a teacher needed to use digital games to teach subject matter in the school year in which they participated or in the previous year. Teachers were approached in several ways (e.g. through the Internet, flyers, and meetings; through contact with game producers and game publishers; through schools that were mentioned in research publications; and through the national network of Information and Communication Technology in education).

In total, 46 teachers who registered and met our criteria were asked to participate in this study. Of these teachers, 44 agreed. One dropped out because of personal circumstances, and thus 43 teachers were interviewed.

The 43 teachers (30 males and 13 females) ranged in age from 25 to 61 years (mean age was 42) and came from 36 schools in the Netherlands. The participants had between 4 and 40 years of teaching experience, with a mean of 15 years. Approximately one-third of the teachers did not play games at home, whereas the others did. The majority of the teachers (28) taught with games once a year. Only six teachers taught with games throughout the school year. All teachers except one used the games in class, either working with one specific game or with several games. Usually, the teachers gave a short introduction, and then the students started playing the game while the teachers walked around and answered questions. A few teachers also directed the students to play at home as a homework assignment. The teachers' educational goals pertained to relating theory to practice, experiencing theory, visualization, increasing awareness, gaining insight, ensuring involvement, and/or recognizing relationships between concepts. The goals mostly focused on acquiring insights and minimally addressed the acquisition of factual knowledge. In the subject of information science, becoming acquainted with programming was a frequently cited educational goal. Three teachers explicitly reported the improvement of collaborative skills as an educational goal. The educational goals of teachers in general secondary education tracks did not differ from those in the (pre-)vocational tracks, with the exception of the teacher using the game *Later is Nu*. She was the only teacher whose goal was to confirm students' career choices.

Table 1 provides an overview of the subjects/domains taught, the number of teachers teaching a particular subject, and the games they used. As Table 1 shows, economics and information science are the two school subjects in this study in

which games were most frequently used. All teachers of information science except one used game-making tools; the focus in these classes was mostly on creating games. Two of these teachers also directed their students to play games using software other than the game-creation software. In all other subjects, students played games. Six games were used in more than one subject/domain: *SplitsZ*, *Sims 3 in de Klas*, *Enterprise*, *7scenes*, *Wereldhandelsspel* and *Markt Voor Vrede*. See the Appendix for a list of the games that were used (in alphabetical order), short descriptions of the games, and links to websites.

4.3. Data collection

Since we were primarily interested in teacher perceptions we conducted one-on-one semi-structured interviews to examine the teachers' views on using digital games in their classes.

The interview scheme consisted of questions on broad topics covering a wide variety of aspects of using games in the classroom, such as the games used, the educational goals that were addressed, the activities of the students and teacher, the perceived outcomes and the teacher's general ideas about teaching with games. The teachers were prompted to tell their stories about their experiences with the use of games, and the topics mentioned above were used as a checklist. The teachers were also invited to provide examples. Each interview was audiotaped and transcribed. The teachers were asked to review and approve the transcripts of their interviews.

4.4. Data analysis

The process of data analysis started by looking at how teachers value (positively and negatively) student learning and motivation when using games. Teachers differed in how specifically they talked about this. Three main codes were derived from the data: *general views* (teachers' general views on the use of digital games in the classroom), *estimated value* (teachers' general ideas about what the use of games in the classroom could achieve) and *perceived effects* (teachers' evaluation of outcomes of *their own use* of digital games in the classroom). Event sampling was used to select the coding units: when the subject changed, a new coding unit started. Therefore, the coding units varied in length; they could consist of one or several sentences.

The codes were discussed using three of the 43 interviews by three researchers. This resulted in an improved definition of the codes, which one of the researchers used to code the interviews. Later nine other interviews were randomly selected for rating by a second rater. Inter-rater reliability was analyzed using Cohen's kappa coefficient to determine the consistency between the main codes of the two raters ($\kappa = 0.70$, with a 95% confidence interval of $0.59 < \kappa < 0.81$). This can be considered a substantial or good agreement compared to several benchmarks (Emam, 1999). In this study, we focus on *perceived effects* because this part of our research addresses a niche: research addressing practice-based evaluations of teachers using games in classrooms is rare.

Table 1
Subjects taught, games used and number of teachers.

Subject/domain (number of teachers)	Games used[a] (number of teachers), for more information on the games, see the Appendix
Information science (8)	*Gamemaker (6)*, SplitsZ (1), *Alice (1)*, *Scratch (1)*, Mscape (1), Power Up (1), *Francogrid (1)*, Second Life (1), *3D game studio (1)*, *Greenfoot (1)*, SimCity300 (1), Railroad Tycoon (1)
Economics (8)	Bizzgames Production Company (2), Wereldhandelsspel [Global Trade Game] (2), Plaza Challenge (2), Scholenstrijd [School Battle] (1), Markt Voor Vrede [Market For Peace] (1), Aandelenmarktspel [Stock Market Game] (1), Bizzgames Handel & Wandel [Bizzgames Trade & Walk] (1), Miniconomy (1), ProSim Advanced (1)
Geography (3)	Waterbusters (1), Terraclues (1), Minecraft (1), SimCity (1), Third World Farmer (1), Stop Disasters (1)
Biology/general natural sciences (3)	The Great Flu (1), Cellcraft (1), Immune Attack (1), Sims 3 in de klas [Sims 3 in the classroom] (1), Race the Cell (1), Mighty Mutation Maker (1), DNA the double Helix (1)
Entrepreneurship (3)	Enterprise (3)
Civics (2)	Markt Voor Vrede [Market For Peace] (1), Wettenstrijd [Battle of the Laws] (1)
Tutoring (2)	Poverty Is Not a Game (1), On the Ground Reporter (1), Later is Nu [Later is Now] (1)
Arithmetic (2)	Nintendo Math Trainer (1), several iPad apps, e.g., Math Expert Lite (1), Motion Math HD (1), Math Kid (1), Penguin Math (1)
History (2)	Civ IV (1), The Planning The Game (1), 7scenes (1)
Engineering/technology (2)	Villa Elektra (1), Sims 3 in de klas [Sims 3 in the classroom] (1)
Office sales work (1)	Enterprise (1), Check Out (1), Embargo (the last two were used only once by the teacher) (1)
Math (1)	Bollen Schieten (Shooting Spheres) (1), Derivative Puzzle (1)
Chemistry (1)	Dr O'Too (1)
Visual Arts – focus on new media (1)	7Scenes (1)
Care (1)	SplitsZ (1)
Export (1)	Wereldhandelsspel [Global Trade Game] (1)
Physics (1)	Serious game Space Challenge (1)
Interdisciplinary theme week on ICT and media literacy (1)	SplitsZ (1)

[a] Game-making tools in italics. In brackets behind the name of the game the number of teachers using this game for the subject/domain mentioned.

As a second step in our analysis we selected all texts coded as *perceived effects*. This code implies that teachers spoke about their observations regarding students' learning, engagement, and motivation to learn, when using a specific game in the classroom. These texts were analyzed in greater detail, based on effects mentioned in the literature on game-based learning (see section 2.2): *learning about the subject, learning general skills, motivation to learn* and *engagement*. We used these terms as codes to differentiate between perceived effects, and looked for both positive and negative examples. Several coding units were discussed between three researchers to refine the definition of the codes. One researcher then coded all the interviews. An inter-rater reliability was calculated using the same nine interviews mentioned before, to determine the consistency of the four sub-codes for perceived effects ($\kappa = 0.83$, with a 95% confidence interval of $0.65 < \kappa < 1$). All the coding was performed using Atlas.ti. This way every coding unit could be matched with meta-information on the subject and teacher, which enabled organization of the results into the subjects and identification of which coding units corresponded to a particular teacher. Table 2 provides examples of the (sub-)codes of perceived effects, definitions of these codes and the events that were samples.

The coding units were sorted and summarized according to the codes. This summary was the basis for the additional analysis of the statements of teachers who used game creation with the statements of teachers who used playing games in their teaching. We found some differences, which will be addressed in the findings.

5. Findings

The findings concern how teachers value teaching with games in relation to the effects they perceive on students' engagement with the game, their motivation to learn, and their cognitive learning outcomes. We discuss the findings for all types of secondary education together, because there were generally no differences related to the type of education.

5.1. Engagement

Engagement during game playing was cited as an effect of game use in class by nearly every teacher (41 teachers mentioned these effects). The teachers observed that all or most of their students were enthusiastic. This was the case for students playing games, as well as for students creating games. According to the teachers, the high level of engagement is shown in the time students put into playing and creating a game; students show perseverance and sometimes pride (when they create games they can be proud of the game they made, when they play games they can be proud of their game score). Teachers mentioned that competition seems to trigger students' engagement when playing the game.

Teachers observed that students generally were willing to invest time in playing or creating games. They were eager to start with the lesson and the teachers attributed this to the digital game, as stated by one teacher (Teacher 20, information science) whose students played the game SimCity: "*What I like most is when they run into the classroom and get started immediately. That happens more quickly with computer games.*" Not only were students eager to start working with the game, often students were willing to continue playing or creating games even when school was finished:

Table 2
Examplary subcodes of perceived effects, subcode definition and events.

Subcode	Subcode definition	Example event
Engagement	When the teacher talks about students on a roll, in a flow, continuing after school bell rings, being enthusiastic about playing the game, etc.	I see how enthusiastic they get, how proud they are making this game, how hard it sometimes is and how they are willing to overcome that, because they feel it is important to finish the game. (…) sometimes they return here after two years and still have the game, look how often it is played.
Motivation to learn	When the teacher talks about liking the subject more, getting a more positive attitude, understanding the value, becoming interested in the subject, bringing the subject closer to the student, making it more realistic, the student becoming interested by playing, wanting to understand and asking questions.	[… when calculating index numbers the students..] often wonder: what am I doing now? With Bizzgames it comes back and they see […] a bank react on a certain index value and see it makes sense, it becomes more present and [I] think this is useful.
Learning about the subject	When the teacher talks about learning subject specific content or skills.	[Both with Gamemaker and with Scratch] they don't learn to program yet, but they learn the basics. (…) With Gamemaker they knew what events and actions were, you use that a lot. Buit if I asked to make an IF-ELSE construction they didn't know that well. If I ask that with [students using] Scratch now, they know that. How to create a repeat. (…) On a conceptual level Scratch is stronger I think.
Learning general skills	When the teachers talks about learning general skills that are not specific for a subject, but more interdiscplinary, such as collaborative skills.	Next to learning economical elements they also learn how to cooperate. In a natural way roles are divided. Someone who knows more about the numbers and someone who knows more about the rapport and someone coordination. That element plays an important role, cooperation. (…) you are dependent on what others do [and in their report they have to analyze what contributed to their score in the game]. I think that is an important learning moment. That they have to explain this is what we did, this happened, how is that possible (…).

"I can barely get them out of the classroom; it is just fun. Like, this morning, I was stuck in traffic just like you. I told my intern that the students could leave after a certain time, but then when I arrived, three-quarters of the students were still there." (Teacher 24, information science, creating games)

Teacher 5 (information science) observed that this engagement leads to persistence and pride in the game they create:

"I see how enthusiastic they get, how proud they are working on the game, how hard that sometimes is, and that they want to overcome those obstacles, as they feel it's important to finish that game. They don't have homework here, but you notice that they are working here on weekdays with that game, and that is a huge gain in my eyes."

Competition as a game characteristic was mentioned by nine teachers (eight playing games, one creating), who had noticed that competition helped the students to stay engaged because of their desire to win the game. For instance teacher 1 (economics), who used Bizzgames Trade & Walk reported:

"… the first lessons, they are all very enthusiastic. After that, you see that [the enthusiasm] decreases for the ones who find it too hard. However, they stay active, as it annoys them if they score less than others; you just see that. Intuitively, as I don't remember the exact number, looking at my classes, I think nine out of ten really like it. They are intrinsically motivated to do something."

In combination with competition, pride again plays a role, as observed by teacher 7 (economics), who used the game Production Company:

"And next to that, there are those who like to show that they did better in a competition than others. So that competition element is important, of course. If another round is being played and you enter the classroom at the next lesson, then you hear that right away as students shout 'Sir, we did well.'"

Teachers said that when there was no competition built into the game, the students sometimes created their own competition by comparing their own progress with that of their classmates. One teacher mentioned a lack of competition as a shortcoming of a game. This teacher (9, biology) reported that his students were disengaged because in the game they did not earn points and were therefore not motivated to continue playing. He gave as an example that students were improving the appearance of their avatar instead of progressing with the game.

Six teachers explicitly stated that a minority of their students did not like games or that enthusiasm decreased after the first lessons. These teachers mentioned various reasons for students' disengagement during game playing, such as technical difficulties that frustrated students and students who did not like the readings connected to the game.

5.2. Motivation to learn

Regarding the students' motivation to learn, 17 teachers mentioned that playing or creating games helped students to become more interested in the subject and to better understand the value of what they learned. This was the case with both playing and creating games. We extracted three reasons that, according to the teachers, contributed to students' motivation to learn through games: 1) an authentic context; 2) experiencing the value of theory in practice; and 3) competition (regarding playing games). These three aspects are explained below.

Motivation related to an authentic context and experiencing the value of theory in practice was mentioned by teacher 6 (economics). He stated that, by running their own MP3 player production company in the game Bizzkids Production Company, the students realized that an index number is not just a number that they need to calculate but that banks use this number in their daily practice. He indicated that this trigger of awareness was the added value of the game. Similarly, Teacher 4 (Economics) also felt that playing the game Plaza Challenge helped students to value the subject. In this game, students ran their own store and they had to make decisions regarding this store related with what they learned in class: "*At a certain moment, you notice that in that way, they are interested and have become enthusiastic about the subject of economics.*"

Some teachers observed that games visually depicted the link between theory and its practical use in daily life and that this link helped students to understand the value of the topic they were studying. For instance, Teacher 35 (biology) explained that when students played the game *Cellcraft* the visual aspect helped him to start a dialogue with the students about what they see in the game: "*That way, enthusiasm arises, and you notice that, that they really want to understand how a cell is composed. It is, of course, the first time they see a cell at work. It is very visual.*" This visual aspect was also mentioned as a motivational element of creating games. Teacher 13 (information science) reported his experiences with students programming the movements of an ice skater. The visual aspect helped students to understand the steps needed to model such a complex movement. He reported that students experienced the value of learning to program immediately.

Consistent with their experiences with engagement, six of the teachers (all using playing games) considered competition important for increasing students' motivation to learn. For example, Teacher 23 (economics) stated:

"A competition element … is motivating and triggers the question 'how is this possible?' … I can explain [the inconstancy of the price and the unpredictability] five times or show them a movie, but by being motivated in the game, they are automatically stimulated to ask those questions."

Competition seemed to trigger students to ask questions. They also start discussing with each other, as Teacher 41 (civics) explained. He reported that students wanted to understand the stock market to win a game and therefore discussed with each other how stocks work and the best times to sell and buy. Another teacher (Teacher 39, engineering/technology) used competition deliberately to increase students' motivation to use their course materials. The teacher himself designed the game that he used in class, a game where students become a mechanic and have to renovate a villa. If students used the hints, they lost game points. Instead of using hints, students could consult their textbook. Teachers did not mention negative instances of motivation to learn.

5.3. Student learning

Most of the teachers (38) reported that the software they used in class for both playing and creating games supported student learning. They mentioned effects on learning the subject matter and general skills, mostly collaborative skills. From what teachers said about learning, we could discern important elements contributing to cognitive learning outcomes:

1) Learning in a safe environment: teachers mentioned that games created opportunities for students to try things out and start over without major consequences. The students could still continue to play the game and learn from their mistakes.

2) Receiving direct feedback from actions: while playing a game, students experience the consequences of their choices; for instance, after a certain decision in an economics game, they see the Gross Domestic Product (GDP) increase or decrease. When programming, students immediately know whether they programmed correctly or incorrectly; for example, they can see if a dancer they programmed performs the intended move or not.

3) Active learning (discovery): students learn by doing and making attempts. The above-mentioned aspect of receiving direct feedback from actions helps. Students experience the consequences of their decisions and actions, make different attempts and observe what occurs. The teachers said that student trial and error works better than telling students how to do something; students forget much of what they learn from direct instruction and remember a great deal more from self-directed discovery.

4) Visualization of processes by playing or creating games. This visualization was figurative, as described above (seeing the consequences of actions), but also literal, as in seeing cell division.

Some teachers were hesitant to state whether the students had learned something or not, because they had not assessed it. Yet they did have the impression that their students learned from playing or creating games. One teacher (Teacher 43) mentioned that she did not want to assess whether her students learned more because then she would need to teach one of her classes without using games and felt that she would then be withholding a highly effective learning activity from that class. Again, competition was mentioned by some of the teachers. Also, some teachers mentioned that using games in the classroom provided them with opportunities to pose questions to their students, and vice versa, which. according to the teachers, contributed to learning.

Next we present the results regarding learning the subject matter. Here, we make a distinction between the subjects of economics, and information science, and the other subjects. Then, we present the results regarding learning general skills.

5.3.1. Subject of economics

The economics teachers reported that their games helped students to: recognize the consequences of their actions (e.g., observing the effect of students' decisions on the liquidity of their enterprise); enhance their economical thinking and their understanding of the marketing mix and uncertainty in economics; and increase their awareness of economics phenomena. For example, Teacher 7 reported on playing Bizzgames Production Company:

> *"You see what happens if you make a certain decision and what the consequences are for the index numbers and liquidity and all those kinds of things and compare that with other enterprises for example. Well, that is […] the theory we explain in the class, it comes alive in another way I would almost say […] they get a picture of what it actually means."*

Teachers mentioned that playing a game and solving problems presented in a game makes the subject less abstract compared to teaching the subject in a regular lesson. According to Teacher 23, "*You create a situation for students where they are forced to think about the problem [at hand]."* The teachers also valued games because they contribute to subject learning by providing a safe environment. As Teacher 19 stated, students can go bankrupt in the game Enterprise; however, unlike in real life, students can easily start a new company in the game and learn from this. After half an hour of playing Enterprise, the students were encouraged to reflect on what had occurred. According to the teacher, during game play, the students participated more eagerly in reflection than they did normally in class because they wanted to know what they did wrong and thereby improve their results and defeat their classmates. This element of competition was also mentioned by two other economics teachers (Teachers 23 and 26). All economics teachers were positive about the learning effects they perceived.

5.3.2. Subject of information science

For all but one of the information science teachers, it was important to teach students programming in an enjoyable way. To do so, these teachers asked their students to create games using tools such as Gamemaker, Scratch, and Alice. According to the teachers, each of these tools for learning programming had their own value. One teacher (Teacher 34) reported:

"With Gamemaker they understood 'events' and 'actions', you use that a lot, but if I asked to make an IF-ELSE construction they did not understand that very well. But if I would ask that with the tool Scratch, they would know it. Create a repeat. That does not work with Gamemaker as well [as with Scratch], you have a 'step-event'[1] for that. On a conceptual level Scratch is stronger, I think."

According to the teachers, students learned programming concepts by creating games, they learned by doing it, but it depended on the tool what concepts students actually learned. Although most of the information science teachers used games to teach programming, some used games for other IT-related skills (as well); for example, Teacher 20 asked students to play a simulation game to get them acquainted with simulation software.

5.3.3. Other school subjects

Consistent with the visualization mentioned earlier, the teachers of other school subjects reported that games can provide students with insights into relationships between concepts. For example, Teacher 11 (history) mentioned that in the games, relationships between causes and effects are represented clearly, and students therefore seemed to express these relationships better in their assessments. A similar instance of visualization, regarding DNA, was mentioned by Teacher 43 (general natural sciences):

"What they have learned is that they find it a bit unreal how fast protein synthesis occurs; they did not expect that. It is an 'a-ha moment', actually a really cool moment. [When they play the games], it becomes more visual, the whole function of DNA. You see that in the test results; that is really nice."

The teachers mention that by using games, students start to realize how things work and that games offer them the opportunity to discover these processes themselves. Having students play or create games offers teachers starting points for fruitful discussions about the subject. One teacher (Teacher 9, biology) explicitly reported that digital games had positive effects on students who were already doing well. but not on poorly performing students, whom he had hoped to help by introducing the game. The latter students kept improving the appearance of their avatars instead of progressing in the game and therefore did not learn much by playing the game. Teacher 35 (biology) reported that the game *Cellcraft* aligned better with his curriculum than *The Great Flu. Cellcraft* included a great deal of information that was in the textbook, whereas *The Great Flu* addressed subjects outside of the textbook and students only learned from the conversation about *The Great Flu* rather than from playing the game itself.

5.3.4. General skills

In addition to learning about a particular school subject, eight of the teachers emphasized that students also learned general skills by playing or creating games. Collaborative skills were mentioned most frequently; many games required students to collaborate and teachers reported students learning to do this. An example is game creation in which one student designed an avatar and another student worked on the background of the game. They had to collaborate in order to create one game. This collaboration was mostly an element added by the teacher, not an inherent game feature. In other cases teachers reported that students learned some other skills such as assessment skills, reflective skills and autonomous learning skills.

6. Discussion

The goal of this study was to identify teachers' practice-based perceptions of their students' engagement, motivation to learn, and learning effects when they taught with digital games. Research has shown that teachers ground their decisions about the use of technology in their teaching on their own experience and are convinced of the effects they perceive as the added value of technology based on these experiences (Voogt, Sligte, van den Beemt, van Braak, & Aesaert, 2016). Teachers' perceptions and experiences are thus important factors impacting on the actual use of digital games in teachers' educational practice. Therefore, the current study focused on teachers who had actually used games in their regular teaching practice. We asked them to report the effects they observed in their classrooms. Our findings showed that teachers who actually use games in class perceived student engagement and cognitive learning outcomes as effects of the use of games in formal teaching settings. According to their teachers what students learned differed: game creation was usually linked to learning programming, whereas game playing was used to achieve a variety of goals, such as gaining insight into economic processes, and understanding causes and effects. This difference in perceived cognitive learning outcomes is probably related to the subject and the teacher's goals with playing and creating games. Concerning game creation, teachers did not mention the benefits of game creation beyond that of learning programming (Greenhill, Pykett, & Rudd, 2008; Khalili et al., 2011). However the teachers did mention that creating games can be used very well for practicing collaborative skills.

[1] An 'event' in Gamemaker is comparable to 'if-then' code, the event is used to program 'if X then do Y'. For instance, if object A collides with object B (event) than add 10 points (action). A step event is used for looping or continuous action in the game, it continuously repeats the action, for instance having an object follow another object continuously.

Motivation to learn and the acquisition of general skills were also mentioned as an effect of playing or creating game, but less than engagement or learning a subject. Our findings suggest that motivation to learn is more often observed by teachers who used games to play than teachers who used games to create.

These findings corroborate results from previous research that studied teachers' intentions for using games in their teaching. These studies found that supporting student engagement, learning, and motivation to learn are important reasons for teachers to use games in their classes (e.g. Allsop et al., 2013; Can & Cagiltay, 2006; Ince & Demirbilek, 2013; Li, 2013; Pastore & Falvo, 2010; Ruggiero, 2013; Sardone & Devlin-Scherer, 2008). The findings from the current study confirms teachers' perceptions of the value of teaching with games in ecologically valid situations (e.g., the classroom).

The teachers in our study attributed the perceived motivational effects of the games to the authentic context (e.g., games simulating economic processes). In this authentic context, students could experience the value of connecting theory and practice because they needed to use what they learned in class to successfully play the game, thereby making what they had previously learned meaningful. The teachers' experiences confirmed what has been mentioned in earlier research as being the potential of games: teaching with games can be an excellent way to provide an authentic context in that they can simulate reality and help provide meaningful learning (e.g., Huizenga, Admiraal, Akkerman, & Dam, 2009; Gee, 2007; Van Eck & Dempsey, 2002; Wastiau et al., 2009).

One of the elements that, according to the teachers in this study, contributed to student learning, is that students could learn in a safe environment (e.g., one where the consequences of failure are mitigated). Gee (2007) calls this the sandbox principle. Similarly, the teachers attributed other elements of playing and creating games that contributed to students' learning: students were active, they received feedback on their actions, and the games made processes visual.

Competition during game play was cited by the teachers as an important factor in producing all three perceived effects, except for classes where students created games. The teachers noted that the students sometimes created their own competition by comparing their progress with that of their classmates in cases where competition was not built into the game. The perceived importance of competition is consistent with the study of Ruggiero (2013), in which teachers also mentioned competition as a positive aspect of using games in the classroom. However, although teachers view competition as an important element of a game that contributes to engagement, motivation to learn, and cognitive learning outcomes, the perceived effect of competition on learning and motivational outcomes is not self-evident. Van Eck and Dempsey (2002) and Vandercruysse, Vandewaetere, Cornillie, and Clarebout (2013) state that to date research on competition in games is inconclusive regarding learning outcomes and motivation. These researchers indicate a need for further research focusing on several forms of competition connected to the game or context elements that influence the behavior of different groups of students when playing digital games. In a meta-analysis Clark et al. (2015) found that the effects of digital games on learning outcomes were larger with single-player games without competition and with collaborative team-competition games than with single-player games with competition.

6.1. Limitations and suggestions for further research

This study has several limitations. First, the number of teachers participating in the current study was small and their perceptions were measured at one particular moment. As in several other countries (e.g., Bourgonjon et al., 2013; Proctor & Marks, 2013; Sandford et al., 2006), learning with digital games is also not widely applied in secondary education in the Netherlands. One of the reasons might be related to language: fewer games are available in Dutch than in other languages, such as English and Spanish. Because of this scarcity, we probably interviewed the pioneers of teaching with digital games in secondary education in the Netherlands. Therefore, the positive reports regarding the effects of teaching with digital games in this study might be positively biased. Secondly, although our teacher sample varied widely in terms of age, gender, teaching experience, gaming experience and subjects taught, language teachers were missing from the sample because none of these teachers met our criterion of recently having used a game in the classroom. Previous research has shown that the use of games can be beneficial for teaching languages (cf. Proctor & Marks, 2013; Wouters et al., 2013; Young et al., 2012). The absence of language teachers may have influenced our results in that these teachers may have used other games and in other ways than the teachers in our study. Thirdly, the availability and usability of educational digital games for various school subjects may have also influenced our results. Compared with other disciplines, a wide variety of suitable games is available for information science and economics. For future research, focusing on certain subjects and on how students learn when using a game might be useful.

6.2. Practical implications

Our research has shown that secondary education teachers using games in the classroom perceive playing and creating games as useful for stimulating students' motivation to learn, engagement, and learning. Based on this research, the authentic context of games, the safe environment, the presence of feedback, the possibility to visualize processes, and competition seem to be features that make games meaningful teaching tools for secondary education teachers. Teachers' perceptions and experiences are important in teachers' decisions about the actual use of digital games in the teaching and learning process. For this reason, research should focus on providing a better understanding of how these features of digital games may foster student learning. An example is the importance teachers attribute to competition, although research has not yet produced consensus on this aspect of game play.

The teachers in our study had positive perceptions about playing or creating games for fostering learning and motivational outcomes. However, our study did not focus on how teachers incorporate digital games in their teaching practice. Research shows that the effects of technology on student learning is realized when teachers deliberately create opportunities for students to reflect on their learning (e.g. Hämälainen & Oksanen, 2014). Therefore, teachers should create opportunities for interactions in the classroom about students' experiences when playing or creating games, by asking questions, having discussions and adding assignments. Young et al. (2012) argue about the need for research on teacher - student and student - student interaction to better understand how students can learn from games.

Not only do teachers need to choose the best game for their instructional goal, they also need to find the right way and the right moment to create interaction with their students. Teachers may need to be better prepared for these tasks, and this preparation could help achieve better use of games in secondary education.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.compedu.2017.03.008.

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