Digital game-based learning in secondary education

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Publication date
2017

Document Version
Final published version

License
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Link to publication

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Jantina Huizenga

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UNIVERSITY OF AMSTERDAM

DIGITAL GAME-BASED LEARNING
IN SECONDARY EDUCATION

Universiteit van Amsterdam

Research Institute of Child Development and Education ico

Cover Design: Monique van Hootegem
Cover Illustration: Elsbeth Leeffers
Printed by Ipskamp Drukkers B.V., Amsterdam
ISBN: 978-94-028-0661-8

DIGITAL GAME-BASED LEARNING IN SECONDARY EDUCATION

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
prof. dr. ir. K.I.J. Maex
ten overstaan van een door het College voor Promoties ingestelde
commissie, in het openbaar te verdedigen in de Agnietenkapel

op woensdag 21 juni 2017, te 14.00 uur

door

Jantina Catharina Huizenga

Geboren te Kollumerland en Nieuwkruisland

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VOORWOORD

Circa tien jaar geleden was ik bij een bijeenkomst over *serious games*, het was een interessante middag. Wat zou het leuk zijn als ik de tijd had me daar verder in te verdiepen, dacht ik. Nog geen jaar later was daar de vacature 'promovendus *digital game-based learning*', de ideale gelegenheid me verder te verdiepen in het onderwerp.

Met mijn proefschrift sluit ik voor mijn gevoel een heel tijdvak af. Een bewogen tijdvak, waarin ik mede door mijn dissertatie een nieuwe taal ben gaan leren (om te kijken of dat nu echt werkt via een spel) en Amsterdam meer ben gaan waarderen. Een tijd waarin ik leuke nieuwe dingen opgepakt heb, zoals roeien, maar ook een tijd waarin ik tijdens mijn mysterieuze infectieziekte mijn vertrouwen in o.a. de medische wetenschap en mijn lijf ben kwijt geraakt. Dat laatste heb ik gelukkig weer herwonnen. Wat jammer blijft, is dat door mijn ziekte destijds mijn review die bijna af was bleef liggen en pas ruim na mijn ziekte afgemaakt kon worden. Toen was hij helaas te gedateerd geraakt volgens reviewers en kon om die reden niet gepubliceerd worden. Inmiddels waren er te veel game-based learning reviews uit om nog veel werk in een update te gaan steken. Jammer, want de review is ontzettend veel werk geweest en volgens mij (en gelukkig ook volgens anderen in het veld) is het een gedegen, waardevolle review geworden. Ik ben dan ook blij dat hij in mijn dissertatie nu een mooie plek krijgt en dat ik met deze dissertatie de laatste gevolgen van mijn ziek zijn achter me kan laten.

Ik zeg wel eens, mijn dissertatie bestaat uit zes onderzoeken, vijf hoofdstukken en nog minder artikelen. Eén onderzoek moest last-minute compleet anders uitgevoerd worden dan gepland en dit onderzoek heb ik maar niet tot een hoofdstuk uitgewerkt. Ik heb het uiteindelijk beschouwd als een (erg arbeidsintensieve) pilotstudie voor het hoofdstuk over het maken van games. Wat dat betreft, heb ik wel de nodige pech gehad tijdens mijn proefschrift, maar ook wel weer veel geluk. Ik heb altijd vlot feedback gekregen van mijn promotoren. Onze gesprekken waren regelmatig een fijne mix van zakelijkheid en ontspanning. Geluk ook met fijne collega's te ILO, ICLON en HvA die het werken aangenaam maakten, mee dachten en soms zelfs mee hielpen (lezen en feedback geven, formatting) en zorgden voor gezelligheid als ik de tijd nam om te lunchen. Ik ga geen namen noemen, want dat wordt een enorme rij.

Voor mijn (schoon)familie is het schrijven van mijn dissertatie iets ondoorgrondelijks geweest, gelukkig kon ik heel soms kleine Nederlandstalige stukjes over mijn onderzoek opsturen. Dank jullie wel dat jullie me niet dood gegooid hebben met de vraag "wanneer is het eindelijk klaar". Mijn speciale dank aan mijn neefjes en nichtjes, fijn dat ik bij jullie altijd heerlijk mijn hoofd leeg kan maken en me alleen maar bezig hoef te houden met speeltuinen, flesjes, etc. Jullie vertelden me regelmatig letterlijk wat ik moest doen, dus zelfs daar hoefde ik niet over na te denken. ☺

Dank ook vooral aan mijn vrienden (inclusief mijn paranimfen) voor alle steun. Er hebben nogal eens activiteiten moeten sneuvelen, zodat ik aan mijn proefschrift kon werken. Bijvoorbeeld mijn last-minute gecancelde Rijksmuseum-uitje ooit met

Diana en Marjolijn, afgezegd om het coderen van een artikel af te ronden voor de zomervakantie van mijn promotoren. En Elsbeth bedankt voor de leuke tekening.

En last, but not least: Rob, dank je wel voor de vrijheid die je me gaf om zo veel tijd te steken in niet alleen mijn proefschrift en ander werk, maar ook in mijn contact met vrienden en collega's. En af en toe trok je me er juist even helemaal uit door samen op vakantie te gaan. Om mijn promotor Wilfried te citeren: "werk is maar werk, ook al werk ik heel veel"… Een belangrijk onderdeel van dat vele werken is nu afgerond. Ik heb er de eerste jaren met plezier aan gewerkt, de latere jaren naast drukke banen ben ik dat nog wel eens kwijt geweest. Hoe interessant ik onderzoek naar *digital game-based learning* ook blijf vinden, ik zet nu met plezier een punt achter mijn proefschrift. PUNT

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CHAPTER 1

INTRODUCTION

Tell me and I forget,
Show me and I remember,
Involve me and I understand.
Ancient Chinese proverb
Confucius (551-479 BC)

In the 1970s, the first digital games emerged that were played by a public beyond that of computer scientists. Simple games such as the digital ping pong game called Pong and the game Breakout (where bricks are destroyed by bouncing a ball) reached mainstream. Nowadays, home gaming has become a popular pastime, the games have become more complex and interest has grown in developing the use of digital games for education (Kirriemuir & McFarlane, 2004). This interest in games is based on the observation that children become totally immersed in the games and can play them for hours. The children are enthusiastic and motivated to make progress. Secondary education teachers would like to see this enthusiasm in their students' learning because research shows that students' motivation to learn decreases when they transition from primary to secondary education (Peetsma & Van der Veen, 2015). Low motivation might also play an important role in student drop-out in secondary education (Fan & Wolters, 2012). One of the causes of low student motivation in schools is the incongruity between students' school environments and their personal worlds, in which peer interaction and the use of new media have a more central role compared to schools (Shaffer, 2008; Thoonen, Sleegers, Peetsma, & Oort, 2011; Van der Veen & Peetsma, 2009). The use of games in education might thus help to enhance students' motivation by making learning more enjoyable in a way that fits with students' personal worlds (cf. Charsky & Ressler, 2011; Gee, 2003; Klopfer, Osterweil, Groff, & Haas, 2009). Games have the potential to not only motivate students but also support student learning because they have been found to promote students' active learning (Gee, 2014; Shaffer, 2006; Wideman et al., 2007). Therefore, implementing games as a teaching method in secondary education could help to motivate students' learning in school by increasing their active involvement with the school content.

When I started my dissertation in 2007, expectations of the value of digital games for education were high, and many claims were expressed on the benefits of digital games for teaching and learning. While these claims indicated the possible benefit of using games in education, thorough research supporting these claims was often lacking (Mishra & Foster, 2007). This dissertation aims to contribute to the growing body of research on digital game-based learning (DGBL) by providing insights into the benefits of DGBL on motivation and learning.

1. DGBL AND THE SCOPE OF THIS THESIS

The aim of this dissertation is to contribute to insights in the benefits of DGBL. However, as we need to establish what constitutes a digital game, I first define digital games and then present a review of the existing literature on DGBL and its rise. Finally, I elaborate on the scope of this thesis and explain the choices I made in the focus on *motivation* and *learning*.

1.1 Definition of digital games

There are many definitions of games and discussions about the differences between games and simulations. A simulation is generally understood as a virtual world, model or system that simulates the real world, model or system, whereas in games elements such as fantasy and competition play a role. Based on Dempsey, Lucassen, Haynes, and Casey (1996) and Prensky (2007), I define games as follows: 'organized play, involving one or more players, with goals, constraints, rules, interaction, challenges, pay-offs and their consequences, and aspects of competition (with another player or oneself). A narrative, story or fantasy elements are involved and the game should provide enjoyment and pleasure'. While researchers agree on many elements of games, according to Van Eck and Dempsey (2002), competition is not always seen as an integral element of games. I consider a game digital if it is being played on a computer, game console or mobile device.

1.2 DGBL

I speak of DGBL when the goal of using a digital game is to promote learning. One of the first persons to use the word DGBL was Marc Prensky in his book, *Digital Game-Based Learning*, published in 2001. Prensky (2001) saw great potential in the use of digital games for student motivation and learning, and while there seems to be some scientific basis for his writing (e.g. research in the military), his references to quotations from individual persons outnumber those to empirical studies. This type of literature (anecdotal evidence, lacking descriptions of methods,) was omnipresent in the late 1990s and early 2000s. However, with the growing interest in DGBL, the amount of empirical studies examining this subject also grew, and many case studies were carried out, such as that by Barab and colleagues (Barab, Sadler, Heiselt, Hicky, & Zuiker, 2007), which showed that the multi-user virtual environment Quest Atlantis engaged students and supported the process of learning science content. Several researchers conducted a quasi-experimental study. For example, Annetta, Minogue, Holmes, and Cheng (2009) conducted a quasi-experimental study, which showed that students did not learn significantly more from reviewing genetics information by playing a genetics game than from reviewing the information using traditional instruction. However, the authors found that students playing the game were significantly more engaged than those receiving the traditional instruction (Annetta et al., 2009). Recent reviews tend to confirm the potential of DGBL for learning and motivation (e.g. Clark, Tanner-Smith, & Killingsworth, 2016; Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Wouters, Van Nimwegen, Van Oostendorp, & Van der Spek, 2013). For example, Wouters et al. (2013) confirmed their hypotheses that the serious games yield higher learning gains and a higher level of retention than conventional instructional methods. However, in contrast to what they expected, learners playing individually or in a group learn more than those in the conventional teaching group, and learners playing games in a group learn more than those playing individually. Additionally, although motivational appeal is mentioned as an important reason to use serious games, serious games were not found to be more motivating than conventional instructional methods. Wouters et al. (2013) raised the question whether the way motivation is measured, usually by questionnaires and surveys after gameplay, is a sensible method of measurement. Wouters et al. (2013) thus proposed measures, such as eye tracking and skin conductance, which can be used during game play.

Wouters et al. (2013) also researched several moderator variables and found that serious games are more effective when played in groups. They also mentioned that with an effect size of $d = 0.66$ "serious games are particularly effective in language" (Wouters et al., 2013, p.10). Games that used to be played behind a computer, can now be played on handheld devices (such as Nintendo) or other mobile devices (such as a smartphone). The context sensitivity of mobile devices (i.e. their capacity to gather data that is unique to the current time and location and may be either real or simulated) is one of the properties – according to Klopfer, Squire, and Jenkins (2002) – that makes mobile devices so well-suited to the support of learning activities. Four other properties that are assumed to make mobile devices particularly useful for educational purposes concern their portability; their social interactivity, because face-to-face interaction and the exchange of data between learners is made possible; their connectivity; and their individuality, because the support for different activities can be tailored to the needs of specific learners (see Klopfer et al., 2002). The properties of mobile games allow the incorporation of real world factors into a game. For example, mobile games that make use of the location where they are played, such as historical or geographical sites, are called mobile location-based games. Several researchers have conducted research into these kinds of games to show the their potential for learning, motivation and/or engagement (e.g. Squire & Jan, 2007; Squire & Klopfer, 2008; Rubino, Bharberis, Xhembulla, & Malnati, 2015). Ardito, Costabile, De Agneli, and Lanzilotti (2012) investigated an excursion game called Explore! in which archaeological parks were enriched with contextual sounds and mobile technology. Data were collected on gameplay strategies, engagement and learning. Regarding engagement and learning, the results showed that students were engaged and enjoyed the collaborative nature of the game, stating that they learned historical facts and notions related to life in Roman times. Students also answered significantly more test questions correctly after they were debriefed than before, showing the importance of a debriefing phase. Additionally, contextual sounds helped players to orient, navigate and understand the ancient functions of degraded places. However, the students explained that they often ignored 3D reconstructions of places and objects because of time constraints; their first goal was to win, and the game stimulated their competitiveness.

Up to now, I have talked about DGBL by discussing the use of playing games in education, but there is also a growing amount of literature on creating games. Hayes and Games (2008) identified four main purposes of making games for learning:

1) to learn computer programming,
2) to interest girls in computer programming,
3) as a route to learning other academic domains, and
4) to understand design concepts.

Several studies have shown that having students create games can be beneficial for learning and motivation (e.g. Akcaoğlu, 2013; Greenhill, Pykett, & Rudd 2008; Robertson & Howells, 2008; Thomas, Xe, & Greene, 2011). Vos, Van der Meijden, and Denessen (2011) showed that creating games might be more beneficial than playing games. In their study comparing playing games with creating games, Vos et al. (2011) found that students constructing games had a higher intrinsic motivation (measured by Ryan and Deci's subscales competence, interest and effort, 2011) than students playing the game (on each subscale), and they scored higher on the use of deep learning strategies.

1.3 The use of games in education

Despite the apparent benefits of using games for teaching and learning, the application of games in education is not yet widespread. Horizon reports in 2009 and 2010 forecasted the time to adoption of using games in education in two to three years from the publication (Johnson, Levine, Smith, & Smythe, 2009; Johnson, Smith, Levine, & Haywood, 2010). However, in several studies, a minority of the teachers reported using games or an intention to use them in the near future (e.g. Bourgonjon et al., 2013; Proctor & Marks, 2013), but other studies report more positive figures. For example, Allsop, Yildirim, and Screpanti (2013) reported that 57% of Turkish teachers and 89% of teachers in the UK incorporate games into their classroom activities. Egenfeldt-Nielsen (2011) also found that 60% of the teachers they surveyed in Denmark, Finland, Norway, Portugal and the United States use computer games in their teaching (mostly in lower grades), while Wastiau, Kearney, and Van den Berghe (2009) found that 71% of the teachers they surveyed from 27 different European countries use games. However, according to Proctor and Marks (2013) and Sandford et al. (2006), the game adoption rate is slower in secondary education.

1.4 Scope of this thesis

The aim of this thesis is to contribute to research that is useful for the context of secondary education and focus on DGBL in formal educational settings. As DGBL research has indicated that the use of digital games has potential for learning and motivation, I focus on these concepts in this dissertation. Garris, Ahlers, and Driskell (2002) considered learning a multi-dimensional construct comprising three main learning outcomes.

1) Skill-based learning outcomes: the development of motor skills or technical skills.
2) Cognitive learning outcomes: knowledge of a fact and data required to perform a task, knowledge about how to perform a task and the ability to apply rules and strategies to general, distal or novel cases.
3) Affective learning outcomes: beliefs or attitudes regarding an object or activity.

Motivation can be seen as an affective learning outcome (Wouters, Van der Spek, & Van Oostendorp, 2009). However, because motivation is a broad, multifaceted term (see e.g. Fredricks, Blumenfeld, & Paris, 2004; Perry, Turner, & Meijer, 2006), when people refer to games being motivating, often it is not clear what kind of motivation is meant. In this dissertation, I examine two ways in which games can be seen as motivating:

1) Students being engaged in the game (enjoying it, having fun, not being distracted, wanting to play). In this dissertation, this type of motivation is called *engagement*.
2) Students having a positive attitude towards the game content or the school subject in which the game is used. In this dissertation, this type of motivation is referred to as *motivation for learning* or *motivation to learn*.

I therefore focus on engagement and motivation to learn.

2. RESEARCH AIM AND QUESTIONS

This dissertation, which comprises five studies on DGBL, aims to gain insight into the benefits of DGBL. My main research question is 'How do digital games contribute to learning, engagement and motivation to learn?'

The main research question is divided into five sub-questions, each addressed by a specific study.

1) How does existing literature describe the effects of DGBL on students' engagement in the game, motivation for the subject and learning outcomes? (Study 1)
2) What are the motivational and learning effects of DGBL? (Study 2)
3) Do students' game activities explain the differences in students' motivation for learning, perceived learning outcomes and game performance? (Study 3)
4) How do teachers use game creation in their teaching practice, and does creating games affect students' classroom motivation and their perceived learning outcomes? (Study 4)
5) 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? (Study 5)

3. OUTLINE OF THE THESIS

The following chapters present each of the five studies on DGBL, and the final chapter discusses these studies and presents the conclusions.

Chapter Two presents the literature review. This systematic review provides an overview of the effects of DGBL learning outcomes and motivation. I analysed 92 studies and examined the claims made by authors regarding engagement in gameplay, motivation for the content of the game and the school subject, and learning outcomes of games (factual knowledge and cognitive and metacognitive skills). The review aimed to ascertain whether the claims are substantiated and whether the reported effects were positive, negative or non-significant.

Chapter Three describes the results of the first field study (Study 1) on playing games in education to show the motivational and learning effects of DGBL. A quasi-experimental design was used to compare students playing the mobile history game Frequency 1550 with students receiving regular project-based lesson series. Of 458 students involved in this study, 232 were in the experimental group and 226 were in the control group. The study investigated whether the students in the experimental group had higher motivation for History and particularly the topic of the Middle Ages, as well as whether they had higher knowledge gains, compared to the students in the control group. Motivation and historical knowledge of Amsterdam was measured using a questionnaire with a knowledge test and by observing whether the students were engaged when playing the game.

Chapter Four presents the results of the second field study (Study 2) on playing games in an educational setting, which in this case was a mobile city game about debt. The aim of this study was to investigate whether students' game activities could explain the differences among students' motivation to learn the subject of debt, their perceived learning outcomes and their team game performance. In total, 181 students took part in the study. Questionnaire data on motivation to learn and perceived learning outcomes were examined in relation to the student game activities to establish whether a relationship exists with the outcomes on learning and motivation.

Chapter Five presents the results of a third field study (Study 3), which required students to create games in an educational setting. Students created mobile games during 12–14 lessons. The aim of this study was to investigate how teachers use game creation in their teaching practice and whether creating games affects students' classroom motivation and their perceived learning outcomes. In total, 74 students and two teachers participated in this study. Questionnaire data were used to measure the students' perceived learning outcomes, motivation for learning and attitudes. Of the 74 students, 27 were also interviewed briefly about motivation and perceived learning. The two teachers were interviewed to establish why they worked with the game creation platform 7scenes and to find out their opinions about student learning and motivation.

Chapter Six reports the results of an interview study with teachers to investigate teachers' practice-based perceptions of the value of digital games. Forty-three teachers participated in the study, and data were collected through semi-structured interviews. The analysis of results focused on what teachers said they saw in the classroom when students were working with games to elicit what teachers perceive as effects of digital games on engagement, motivation to learn, learning about the subject and learning general skills.

Finally, Chapter Seven presents a summary of the findings of the studies followed by my reflections on the outcomes of the thesis. This chapter also includes a discussion of the strength and weaknesses of the methodology used, practical implications of the outcomes of this thesis and suggestions for future research.

CHAPTER 2

CLAIMS ABOUT GAMES: A LITERATURE REVIEW OF A DECADE OF RESEARCH ON THE EFFECTS ON LEARNING AND MOTIVATION

This study aims at critically reviewing a decade of research into learning and motivational effects of digital game-based learning. We looked at claims made by authors regarding engagement in game-play, motivation for the content of the game and the school subject, and learning factual knowledge and cognitive and metacognitive skills. Eighty-one of the 93 claims made are grounded and discussed in this article. In general the claims that game-based learning is engaging have been proven. The results regarding motivation are more ambiguous. Claims about learning are usually proven, but when compared with other ways of learning, claims about learning more are not always proven. Several important design elements are mentioned. Two educational games are looked at in more detail. Whilst working on this review it became clear that in several studies information was lacking, for example about how long interventions lasted and effect sizes. This would be valuable information in assessing when game-based learning is or is not effective, as the question should not just be *whether* it is effective, but *how* and for *whom.*

1. INTRODUCTION

Some of the more persistent educational problems facing students today are underachievement as well as learning, behavioral, and emotional difficulties that eventually lead to many students dropping out of school (Battin-Pearson, Newcomb, Abbott, Hill, Catalano, & Hawkings 2000; Jonassen & Blondal, 2005). School dropout is theorized to be a gradual process of student disengagement and alienation, marked by a chronic cycle of tardiness, absenteeism, failing classes, suspensions, and transitions between schools (Bridgeland, Dilulio, & Burke Morison, 2006; Finn, 1989). Even among students who finish the required years of schooling, some research has found high rates of boredom, alienation, and disconnection with schooling (Larson & Richards, 1991). Studies have characterized high-school students especially as bored, staring out of classroom windows, counting the seconds for the bell to ring, and pervasively disengaged from the learning process (Goodlad, 1984). Students do not, however, experience alienation and disconnection during all encounters with school learning. Certain conditions may promote excitement, stimulation, and engagement in the learning process leading to meaningful learning. Using games in education, in particular, is assumed to be an excellent way to combine meaningful learning with fun (cf., Gee, 2003; Huizenga, Admiraal, Akkerman, & Ten Dam, 2009; Schwabe & Göth, 2005; Shaffer, 2006; Shaffer, Squire, Halverson, & Gee, 2005).

Many claims have been made about digital game-based learning (DGBL) in terms of learning and motivation. Mishra and Foster (2007) report over 250 claims about the psychological or physiological effects of game-based learning. However, they argue that most of these claims have not been validated empirically. A literature review of research on game-based learning could provide insight into how claims about games are grounded in the empirical data. Meta-analyses by Mitchell and Savell-Smith (2004) and Ke (2009) indicate several problems with research on game-based learning, for example, that while the studies carried out to date show a positive overall picture of game-based learning, many are methodologically flawed, rarely experimental and often present contradictory results. Some reviews also cover non-empirical research (e.g. anecdotal or opinion-based articles) and low-quality research, or leave out qualitative research. Moreover, the review methods are not precisely described. In this study, we will present a systematic literature review of empirical research, published in the last decade, on game-based learning in elementary and secondary education. Our focus is on claims about games with respect to students' engagement in playing a game, their motivation for the game subject and content, and their learning outcomes.

2. DIGITAL GAME-BASED LEARNING AND TYPES OF GAMES

Digital game-based learning can take the form of stand-alone instructional multimedia accessible on a desktop computer or game console, to online multi-user environments and virtual worlds (MUVE). Apperly (2006) describes the following game genres: simulation games (simulating sports, flying, driving, etc.), strategy games (where decision making is crucial), action games (which emphasize physical action, e.g. so-called shooter games) and Role Playing Games (where the player takes the role of a character). An example of the latter is World of Warcraft, a Massively Multiplayer Online Role Playing Game (MMORPG). Another genre is Augmented Reality Games (ARG) which enable players to interact simultaneously with both the fictional world and the real world (Cavanaugh, 2009).

Clustering by the platform (e.g. computer, play station, the Internet) on which the games are played is another categorization of game genres (Apperly, 2006). There is a growing interest in location-based games that use mobile technology (UMTS, GPS). Mobile equipment is seen as a suitable vehicle for learning by doing, easily accessible (relatively low costs and many students have such equipment) and makes it possible to mix the game world with the real world (Evans, 2009; Klopfer & Squire, 2008).

A frequently mentioned problem regarding games in education is that the educational objectives are not well integrated into the game; the learning is often separated from game-play, e.g. in a separate quiz (Becker, 2008). Another problem is that educational games are not as entertaining as commercial games (Verheul & Van Dijk, 2009). Attempts to combine the fun of commercial games and the learning facet of educational games often result in games being neither of these (Bruckman, 1999). However, in education the games that are mostly used to trigger students' engagement, motivation and learning are educational games, as commercial games are rarely used in schools. Teachers find it difficult to identify the relevance of games to their teaching and, when they can, they do not see the connection between much of the game content and their methods (Kirrimuir & McFarlane, 2003). Research on how commercial games might be used in classroom settings is necessary to understand their potential as learning tools (Sandford, 2006), as is research on educational games.

In this current review, we will present an overview of the effects of both commercial (also sometimes referred to as COTS games - commercial off the shelf games) and educational games that are used in elementary and secondary education on students' engagement, motivation and learning.

3. METHOD

The following questions guided our systematic literature review of empirical research on game-based learning in elementary and secondary education:

- How are the effects of digital game-based learning (DGBL) on students' engagement in the game described?
- How are the effects of DGBL on students' motivation for the subject described?
- How are the effects of DGBL on students' learning outcomes described?

3.1 Data

We selected literature on game-based learning published from 1999 to 2009 by conducting five searches at the end of 2009:

1) The following databases were searched.
    a) The Eric databases, University of Amsterdam catalogue, UvA-Dare, Picarta and Web of Science. Academic Search Premier and Scopus were searched simultaneously using the University of Amsterdam digital library (http://digitaal.uba.uva.nl). We used the search terms Game* and Learn* in the subject field, and Educat* in the field called "all words". We used the asterisk as a joker referring to any combination of subsequent characters.
    b) The Digiplay online database (http://digiplay.info/wikindx3/index.php) of academic and research articles was searched for articles containing the words Learn* or Educat*.
2) Four journals on technology and education (three frequently found in step 1 and a recently launched journal) and a handbook on gaming were searched:
    a) Computers and Education (C&E) using the advanced search option with the search terms *Gam** AND *Learn** in the Title, Abstract and Keyword fields;
    b) Simulation and Gaming (S&G) using the advanced search option and the search terms *game** and *learn** in the Abstract OR Keywords fields AND *educat** in all fields.
    c) Journal of Computer Assisted Learning (JCAL) by reading the abstracts as the journal does not have advanced search options.

   d) Journal of Gaming and Virtual Worlds (G&VW) by reading the abstracts as not many articles had been published then in this relatively new journal (of 2009).
   e) Handbook of Research on Effective Electronic Games in Education (Ferdig, ed. 2010) by reading the abstracts.
3) To find research that had not yet been published, some recent conference proceedings were searched by reading the abstracts.
   a) M-learn 2008
   b) ICLS 2008
   c) ECGBL 2009.
4) The snowball method was used: all the literature reviews found in the previous steps were used to find relevant studies.
5) Studies mentioned in game discussion lists (seriousgames@listserver.dmill.com and GAMESNETWORK@uta.fi) were added if the discussion indicated they might be relevant. Articles continued to be added until June 2010.

3.2 Selection criteria

This literature review focuses on empirical research on the use of digital games in education, which means that anecdotal or opinion-based articles have not been included. To determine the relevance of each study we defined games as organized play, involving one or more players, with goals, constraints, rules, interaction, challenges, pay-offs and their consequences, and aspects of competition (with another player or oneself). A narrative, story or fantasy elements are involved and the game should provide enjoyment and pleasure (based on Dempsey, Lucassen, Haynes, & Casey, 1996; Prensky, 2001). Another element determining the relevance of each study was whether the games had been used in elementary or secondary education. We then selected literature on cognitive learning (not the learning of sensory or motor skills) in the school curriculum of students aged from 4 to 18. Dissertations were only included if we had found no other work by the authors. We have restricted our review to articles written in English, German or Dutch. This literature search resulted in 92 articles.

3.3 Analyses

3.3.1 Minimum quality of each study

As the field of game-based learning is relatively new we included not only peer-reviewed articles, but also for example reports, book chapters and non-peer-reviewed articles. To guarantee a minimum standard we only selected articles that at least report:

- the number of participants and their age or school year;
- the method of data collection, and
- the method of data analysis.

Two raters applied the three categories in a subset of 16 randomly selected articles with a reliability in terms of Cohen's kappa (k) of 0.90 (with a 95% reliability interval of 0.73 k≤1). Then all articles were coded. Of the 92 articles 17 did not meet these criteria and were deleted from our selection, leaving 75 articles[1] in our review.

3.3.2 Determining possible claims

Research questions or a problem establish the scope and direction of research and therefore the possibility of finding claims about engagement, motivation or learning. Of the 75 articles that remained after determining the quality of the various studies, 57 articles were selected with at least one relevant research question.

3.3.3 Determining the relevance of claims

In the 57 articles we operationalized the 'claims about games' as authors' conclusions based on the research results. We therefore searched the discussion and conclusions sections for claims about motivation or learning. Eleven of the 57 articles were excluded as we could not find any claims on motivation or learning (although they do include research questions that point in this direction).

3.3.4 Coding the content of claims

The next step was to indicate the content of a claim. We differentiated between claims about students' motivation and their learning outcomes. Motivation is a broad, multifaceted term (see e.g., Fredricks, Blumenfeld, & Paris, 2004; Perry, Turner, & Meijer, 2006). In this review, we differentiated between students being engaged in the game (enjoying it, having fun, not being distracted, wanting to play) and having a positive attitude towards the game content or the school subject in which the game is used. We refer to these as *engagement in the game* and *motivation for the content* respectively. In the learning outcomes in the context of schooling we distinguished between *factual knowledge, cognitive skills* and *metacognitive skills* (cf., Elshout-Mohr et al., 1999; Ettekhoven & Hooiveld, 2010; Omrod, 2011; Presly & Harris, 2006; Schraw, 2006).

We have coded the claims about games by five variables: engagement, motivation, learning factual knowledge, learning cognitive skills and learning metacognitive skills. All the authors' conclusions were coded on the basis of the one or more variables they refer to. In addition each conclusion was coded as referring to a positive, negative or non-significant effect. The combination of these two codes (for the content and for the positive, negative or non-significant direction of the conclusion) formed the claim. When game-based learning was studied by comparing it with other forms of instruction we coded the claim with the term "more" to distinghuish

[1] As Habgood's dissertation comprises four empirical studies each with its own group of respondents and description of methods, results and conclusions, we counted this dissertation as four articles.

the claims in these studies from the claims of studies where no control groups had been used.

3.3.5 Checking the quality of the claims

To determine the rigor of the claims, we checked whether the claims are:

- grounded in design (match between results and design);
- grounded in analysis (match between results and the analyses performed), or
- grounded in results (match between the authors' conclusions and results).

3.3.6 Summarizing the results

Only the claims that are grounded (as stated immediately above) in the 46 articles that ultimately remained in our review have been included in the results. We have summarized these results by identifying the claims, the games used and the school subjects. If the authors specified their results for specific groups of students, we have included this in our summary, even when they only specify these groups in their results and not in the formulation of their claim.

4. RESULTS

Ninety-three claims about games were made in the 46 articles included in this literature review. Table 1 gives an overview of these claims. In total 81 of the 93 claims could be considered as grounded, leaving 41 articles in this review. The other claims were not grounded in the results except for one that was not grounded in the design. Reasons for considering claims not to be grounded included authors' generalization to too large a population, insufficient information to decide whether the claim was grounded or not, and the inclusion of non-significant results.

The following sections present the results on claims about games on engagement in game-play, motivation for the content or school subject, and learning factual knowledge, cognitive skills and metacognitive skills. The results are based on the 81 claims that can be considered as grounded.

Table 1. Number of claims

Type of claims	Grounded	Not grounded in design	Not grounded in analysis	Not grounded in results	Total
Motivation (n=35)					
Engagement in game	21	0	0	1	22
Motivation for content	12	0	0	1	13
Learning (n=58)					
Factual knowledge	8	0	0	0	8
Cognitive skills	38	1	0	8	47
Metacognitive skills	2	0	0	1	3
Total	81	1	0	11	93

4.1 Claims on engagement in the game

Table 1 of the Appendix presents the studies with claims about games on engagement in playing games. Three of the studies are about engagement in *making* games. Playing or making games to engage students is used in a wide variety of subjects, but mostly in math.

Engagement is understood as the appeal of the game (Papastergiou, 2009; Serrano & Anderson, 2004), fun while playing it (Habgood, 2007; Jonker, Wijers, & Van Galen, 2009; Muwanga-Zake, 2007; Rosas, et al., 2003; Solomou & Vrasidas, 2008; Tuzun, 2008; Ulicsak, 2004; Verheul & Van Dijk, 2009), student satisfaction (Cheung, 2008), time spent playing the game (Habgood, 2007; Virvou & Katsionis, 2008), playing the game voluntarily in or out of class (Arici, 2008; Greenhill, Pykett & Rudd, 2008; Jonker et al., 2009; Owston, Wideman, Ronda & Brown., 2009), time spent on the task or proportion of on-task behavior (Annetta, 2009; Arici, 2008; Greenhill et al., 2008; Ota & Du Paul, 2002), being absorbed in the game or experiencing a state of flow (Lim, 2008; Papastergiou, 2009) and feelings of enthusiasm (Arici, 2008; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007; Greenhill et al., 2008; Papastergiou, 2009; Robertson & Howels, 2007; Solomou & Vrasidas, 2008). All the claims show that students found the use of games engaging. We found six studies which compared students using games with another group of students, mostly non-gaming students. Four of these studies make a positive claim, one a negative claim and one is non-significant.

The authors provide several explanations for their claim that the use of games in education is engaging. In their study on game-making, Greenhill et al. (2008), for example, mention five key sources of engagement: authorship, ownership, playful/experimental learning, the social value of the game, and involvement in real research and development activities (Greenhill et al., 2008, pp. 38-39). Other explanations are the challenge of the tasks or game (Robertson & Howels, 2008), and competing against each other (Habgood, 2007; Owston et al., 2009). Teachers in Owston et al.'s study (2009) reported that making games for a particular target group and playing each other's games motivated students. Moreover, promising to make games later stimulated students to persist with other non-game work. Lim (2008) saw an increase in engagement after the third lesson with Quest Atlantis and hypothesizes that this might be caused by the additional scaffolding provided by teachers after this session, immersion in the story and familiarization with the Quest Atlantis space. Ang and Rao (2008) show that children want to play games because they want to solve puzzles, to complete missions and to know what happens at the end of a game. Comparing the intrinsic version (learning content by playing) of Zombie Division with the extrinsic one (learning content in a separate quiz), Habgood (2007) found that the recurring reasons for children preferring one version to the other were quick progress, the ease of the game, fun and learning. Having to read instructions is a less engaging aspect of educational games, which is therefore frequently ignored (Habgood, 2007; Ulicsak, 2004).

A few authors analyze their general claims on engagement in relation to differences between boys and girls. Ke (2008b) and Papastergiou (2009) found no significant gender differences in engagement in game-play. In his third study, Habgood (2007) did find some minor gender differences. Although both boys and girls prefer the intrinsic version of the game Zombie Division to the extrinsic version (in which questions are not integrated into game-play), girls played the intrinsic version for significantly longer than boys did. In Habgood's second study, boys played both versions significantly longer than girls did.

4.2 Claims on motivation for the game content or school subject

As shown in Table 2 in the Appendix, all the claims about games on motivation are formulated in a positive way, except for three of the studies using a control group. In these three studies, no significant differences were found (Huizenga, Admiraal, Akkerman, & Ten Dam, 2009; Ke, 2008a; Verheul & Van Dijk, 2009). Six of the 11 articles (Huizenga et al., 2009; Lim, 2008;; Ke, 2008a, 2008b, 2008c; Ke & Grabowski, 2007) cover students' motivation for the school subject and the other five articles are about motivation for the learning tasks or the content of the game. Lim's (2008) is the only study that measured both kinds of motivation showing that motivation to learn the content of the games had improved from pre-test to post-test, but motivation for the subjects English, math and science and motivation for learning in general did not change significantly. Three of Ke's studies (Ke & Grabowski, 2007; Ke, 2008a, 2008c) on motivation for a school subject compare game-based learning and 'regular' learning. In two of these studies, the author found a significant difference. One of Ke's studies (2008c) compared students in three computer-game conditions (individualistic, competitive and cooperative classroom) with students in three similar paper-and-pencil drill groups. In the second study Ke and Grabowski (2007) compared two groups of game-playing students (cooperative and competitive) with a control group. In both studies, students in the computer-game condition showed the highest motivation for math. These differences were completely due to the cooperative game-playing condition. In Ke's third study (2008a), she claimed that there was a non-significant effect as the educational game by itself did not reinforce motivation for math; only game-based learning in combination with the cooperative classroom condition did. So cooperative learning seems to be one of the design principles that make game-based learning motivating.

Four studies formulate claims about games on motivation for particular groups of students. No differences were found between boys and girls (Ke & Grabowski, 2007; Ke, 2008a, 2008c) and between students with and without gaming experience (Verheul & Van Dijk, 2009). In one study (Ke, 2008c), prior ability was found to be related to learning outcomes including motivation, but the article did not state whether the direction of this relation was positive or negative and there was no interaction effect with the six treatment conditions. Finally, one study (Ke & Grabowski, 2007) did find an interaction effect of social-economic status. Economically disadvantaged students showed a higher motivation for math (corrected for the pre-test) in the cooperative game-playing condition than in the competitive and individualistic game-playing and control conditions (Ke & Grabowiski, 2007). Moreover, the competitive game-based learning condition was the least effective in promoting math motivation for them, whereas no significant difference has been found for students without an economic disadvantage.

4.3 Claims on learning factual knowledge

The studies summarized in Table 3 in the Appendix all formulated positive claims about games on learning factual knowledge. These claims address a variety of school subjects. Examples of factual knowledge learned by using games in geography lessons are topological knowledge about countries, knowledge about population and language of countries, and other cultural characteristics (Tüzün, Yilmaz-Soylu, Karakus, Inal, & Kizilkaya, 2008, p. 7) and historical knowledge about sites and buildings of medieval Amsterdam (Huizenga et al., 2009) and facts about Greek heroes (Solomou & Vrasidas, 2008) in history lessons.

Two studies formulated claims about students with different cognitive abilities learning factual knowledge. Virvou, Katsionis and Manos (2005) found that poor-performing students learned more facts by using games compared to high-performing students. Huizenga et al. (2009) found the opposite. Games proved to be most effective for students with higher cognitive ability, which led to the authors concluding that the game might have been too difficult for the other students.

Papastergiou (2009) paid a lot of attention to the design of the game she studied. The game (LearnMem1) has rules, clear but challenging goals, a fantasy linked to the student activity, progressive difficulty levels, interaction and a high degree of student control, uncertain outcomes, and immediate, constructive feedback. Every time students answer a question, they are not only given feedback; if they give a wrong answer; a life is subtracted from their score to encourage reading, thinking and then trying, instead of a trial and error approach. The game is realistically designed, but heavy 3D graphics were avoided to deal with the practical limitations of gaming in a school environment. In addition, the overall complexity is relatively low and the plot comparatively simple. Papastergiou states that it is important to look for "an optimal balance between, on the one hand, the level of sophistication and complexity of a game (in terms of multimedia design and storyline) and, on the other hand, its learning effectiveness and motivational appeal" (Papastergiou, 2009, p.11).

4.4 Claims on learning cognitive skills

Table 4 in the Appendix summarizes the 28 studies making claims about digital game-based learning and learning outcomes with respect to cognitive skills. Eight of these 28 studies address science and 14 address math. They focused on the math skills of addition, subtraction, multiplication and division, but also comparing and simplifying expressions, solving quadratic equations (Redfield, Gaither, & Redfield, 2007), comparing quantities and magnitudes, locating and identifying points on a coordinate plane (Ke & Grabowski, 2007; Ke, 2008a; Ke, 2008c), and algebraic thinking, such as describing and analyzing patterns, relationships, graphs, symbols, and functions (Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers, 2006). Other cognitive skills not related to math include critical thinking, reasoning, socio-scientific inquiry (Arici, 2008; Chuang & Cheng, 2009, Hickey, Ingram-Goble, & Jameson, 2009; Solomou & Vrasidas, 2008) understanding science concepts (Arici, 2008; Hickey et al., 2009, Squire, Barnett, Grant, & Higginbotham, 2004; Zuiker, Anderson, Lee, & Chee, 2008) and digital literacy skills (Owston et al., 2009).

Five authors explicitly stress the role of the teacher (Annetta et al., 2009; Owston et al., 2009; Robertson & Howels, 2008; Squire et al., 2004; Solomou & Vrasidas, 2008). The teachers' role, for example, should change from instructor to coach or facilitator; they should teach the students the skills they need to perform their tasks and guide conversations. Moreover, some studies emphasize the need for feedback. This may be feedback from the teacher, but can also be feedback built into the game and which is therefore an important design element. The feedback should be formative and not only summative and students should be encouraged to use it (Hickey et al., 2009; Jonker et al., 2009; Ke, 2008a). Hickey et al. (2009) made some changes in their game to improve the feedback from the Lab Technician and the teachers were given a three-point rubric with examples of feedback to use in the ranger Bartle role. Habgood (2007), in his fourth study, concludes that student reflection on the game-play and outcomes was beneficial to the learning gains. Squire et al. (2004) used logsheets and structuring from the teacher to promote critical thinking and Sedig (2008) fostered learning by providing scaffolding (an arc and ghost image) with Super Tangrams and started with playful gaming (with no need for understanding) with a gradual shift later towards representations of the educational concept (requiring understanding). Several other authors have stressed balancing play and learning. Vogel et al. (2006) state that the learning materials must be presented in an organic manner and should not be disruptive to the game (and that it probably was disruptive in their study, resulting in worse scores in the GBL condition), whereas Annetta et al. (2009) stress attention to the embedded instructional content and less emphasis on animation, text and audio that do not assist learning. Jonker et al. (2009) agree by stating that the game and goals should be aligned.

Four studies formulate the effects of games on the learning of cognitive skills by students with different cognitive abilities and/or prior knowledge, with ambiguous conclusions. In Banerjee et al.'s study (2007), the weaker students improved the most in math, whereas in Greenhill et al.'s study (2008) the moderate students learned the most about understanding the concepts of gravity, friction and electric charges. Bottino (2007) found that the poor-performing students achieved *less* well in medium-level exercises compared to other students. Ke (2008c) reports that students with less prior knowledge about the game content especially needed the support of an instructor or facilitator. No effect of socioeconomic status (SES) was found (Ke & Grabowski, 2007; Ke, 2008c), except for a weak interaction effect between treatment and SES. The economically disadvantaged students in the cooperative and the competitive game-based learning groups had significantly higher math scores (corrected for the pre-test) than those in the control group. For students without this disadvantage, the individualistic game-based learning condition worked significantly better (corrected for the pre-test) than the other learning conditions (Ke, 2008a).

4.5 Claims on learning metacognitive skills

In Table 2 claims of Ke's study (2008c) are presented. This study is the only one with grounded claims on metacognitive skills. These skills (e.g. self-monitoring) were measured by thinking-aloud procedures and by the Junior Metacognitive Awareness Inventory (version A), a 12-item self-report questionnaire. Although no significant differences in metacognitive awareness were found between students using computer games and students who did paper-and-pencil drills, the think-aloud data show that game-playing students were relatively more frequently engaged in metacognitive regulation processes.

Table 2. Claims on metacognitive skills (with + for claims indicating a positive effect, - for claims indicating a negative effect and 0 for claims indicating a non-significant effect)

Study	Name and type of game	Subject	Age/grade and number of participants	Direction of the claim	Compared to control group
Ke (2008c)	ASTRA EAGLE: a series of Web-based games designed as drill-and-practice programs for math	Math	358 students from 18 fifth-grade classes	+	0

5. TWO EDUCATIONAL GAMES FROM THE STUDIES IN THE REVIEW

To illustrate the kind of games that are used in educational settings and whose effects have been studied, we will describe two games in more detail. These descriptions, including the main results, are based on two dissertations included in the current review (Arici, 2008; Habgood, 2007).

5.1 Quest Atlantis

The game environment of Quest Atlantis was the subject of research by several authors in our review. It is a 3D multi-user environment and designed for use in education (by students aged 9-12). The goal is to introduce students to the socio-scientific complexity underlying many scientific decisions that take place outside the laboratory, "in real-world contexts where people, opinions and stakeholders are enmeshed in scientific issues. In the process, Questers encounter scientific domain concepts such as pH, turbidity, eutrophication, etc." (Arici, 2008, p.55). Figure 1 shows a screenshot of the main page of the game.

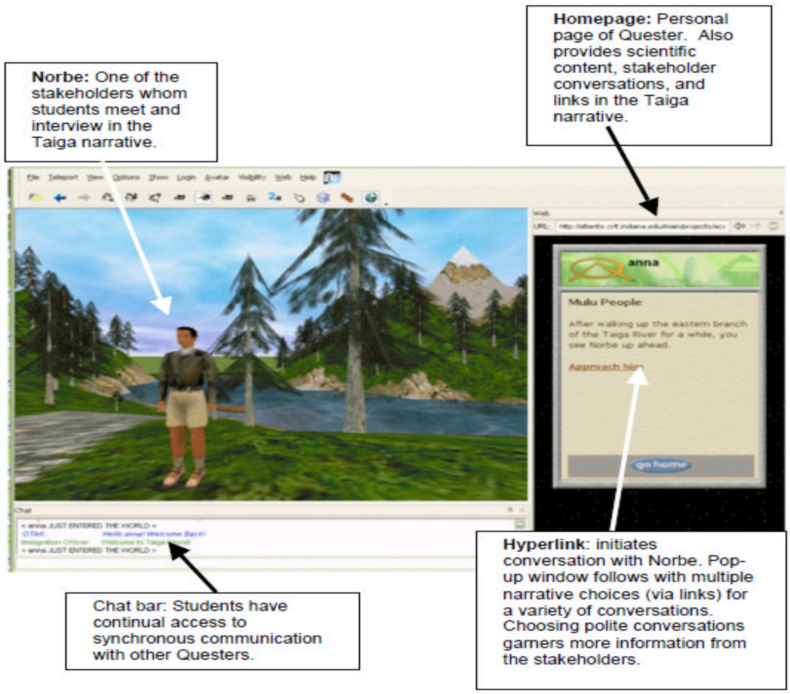

Figure 1. Screen capture of the 3D virtual environment in Quest Atlantis: the Taiga Park environment (from Arici, 2008).

The back-story of the game is that knowledge has been lost in Atlantis and the players have to help the Council to restore the lost knowledge. Players can travel to virtual places and talk with each other through the chat bar, or they can talk to Non-Player Characters (NPCs). An NPC is a bot (a computer program) pre-programmed to say and do specific things to guide and structure the game. One of the NPCs in

Quest Atlantis is Norbe, who is depicted in Figure 1. A hyperlink initiates the conversation with him.

Quest Atlantis has several virtual worlds. One of these worlds is about a virtual aquatic habitat called Taiga. Here the students receive a letter from the NPC ranger Bartle describing a recent decline in fish in the Taiga Park. Students are asked to help. By investigating the cause of the fish decline students learn about water quality. In the Taiga scenario the students take the role of scientists and engage in processes like water sampling and data analysis. They can test the water sample by clicking on a machine, which generates a pop-up window with a complete data table.

Arici (2008) examined Quest Atlantis and reported two claims relevant to this review. The first claim is about engagement. The Quest Atlantis context engaged students more than the regular curriculum. The second is about learning. The author concludes that the Quest Atlantis multi-user environment (MUVE) effectively supports learning science concepts, compared to traditional teaching. Students in the Quest Atlantis MUVE condition showed significantly more cognitive skills learning, both in the post-test and the retention test.

5.2 Zombie Division

Zombie Division is a game for learning math, division in particular, by game-playing (for students aged 7-11). Habgood (2007) examined two versions of the game: one where the educational content is integrated into the game (intrinsic version) and one where it is included in a multiple-choice quiz at the end of each level (extrinsic version). The back-story is about an ancient Olympic curse on athletes. The skeletons are the cursed athletes; their curse can only be dispelled by magical attacks by the player.

Figure 2: Intrinsic version of Zombie Division: screenshot of a divisor-based question in the challenge level (from Habgood, 2007).

Figure 2 shows a screenshot of a typical situation in the game. Skeletons have numbers displayed on their chest which indicate the number of magic bones they have. To defeat them the player uses one of the three available weapons (see Figure 2, top left) to divide the number of magic bones into groups of equal size. (For example, in Figure 2 the player must choose weapon 2 to divide the skeleton's 18 magic bones equally, which is not possible with weapons 5 or 10.) This restores their magical balance so that their souls can finally rest in peace. However, if the player tries to divide them into unequal groups, they attack with increased strength. In the intrinsic version, a multiplication grid helps the player choose the right weapon. (For example, in Figure 2, the multiplication grid shows which numbers can be divided by 5.) The player also can leave via an unlocked door, but is then prevented from making progress. The game progresses from being able to ignore a skeleton and having enough time to think about what action to take, to being pursued by several skeletons simultaneously.

Habgood (2007) has conducted four experimental studies of Zombie Division, two on learning cognitive skills and two on engagement. In study 1 there was no significant difference between the groups (intrinsic, extrinsic, control) in learning math. All the students improved significantly, but only on the conceptual questions. Studies 2 and 3 are about engagement in the game, measured as time-on-task for different versions of the game. In study 2 there were no significant differences in engagement in the intrinsic or extrinsic version. Students could also play a non-educational game, but chose to play Zombie Division for 65% of their optional playing time, with boys playing significantly longer than girls. In study 3 the children could only choose between the intrinsic and extrinsic versions and here the intrinsic version proved to be significantly more engaging for both boys and girls, but the girls played the intrinsic version for significantly longer than the boys. Study 4 was also about learning and there were significant learning gains for all groups (extrinsic, intrinsic and control), but the intrinsic group's percentage scores were significantly higher than either of the other two groups in the delayed post-test. Moreover, only the intrinsic group performed significantly better than the control group in percentage scores for dividend-based questions. This is an indication that the intrinsic version might be best for learning.

Between study 1 and the other studies several changes were made to the game and methodology to improve the game's potential and measurements. These changes include the use of a multiplication grid; an improved save-game system allowing students to easily resume where they left off; a computer-based testing system to reduce the possibility of high pre-test scores; a game-based transfer test to provide a direct comparison between questions in the test and game conditions; and a delayed test to measure long-term gains.

6. DISCUSSION AND CONCLUSIONS

The use of digital game-based learning seems to provide a solution for tackling student disengagement, which is one of the most pressing problems confronting education today. Moreover, many authors argue that digital game-based learning improves the learning results of students. Although it is widely claimed that games in education provide excellent ways of combining meaningful learning with fun, a systematic review of the empirical basis of this claim is still lacking. In this article we have reviewed claims about engagement in game-play, motivation for the content of the game and the school subject, and learning outcomes. The review is based on studies which meet basic criteria of rigor. In general, these studies confirm the claims that using games in elementary and secondary education does engage students. Using games triggers enthusiasm, and supports students' on-task concentration. Instructional design elements mentioned in relation to why games are engaging emphasize students' authorship and ownership, stimulating playful/experimental learning, accentuating the social value of the game and involving students in authentic research and development activities, including challenging tasks and competitive elements, making games for a particular group and the possibility of playing each other's games.

The results regarding the claims about games on students' motivation for the content or school subject proved to be more ambiguous. Several studies seem to provide evidence that using games in education triggers student motivation, but this is not always confirmed in studies which compare a game intervention with other educational interventions. Ke's studies indicate that cooperative learning is a design principle that contributes to motivation for math through game-based learning.

We have distinguished various types of learning outcomes regarding the claim about games on learning outcomes. In our review, the claims that using games improves factual knowledge can be confirmed, as all the studies include empirically grounded claims. However, the claims that using games in education improves students' cognitive skills cannot be fully confirmed. Only 81% of the claims were based on studies that were rigorous enough, and of these 39 claims only 26 were based on significant effects. One of these claims was that children in the GBL condition learned significantly *less*. The claims about metacognitive skills appear to be under-researched, as only one study (with two claims) examined metacognitive skills. For learning it is important that there is a good balance between game elements and learning elements. The game must be fun but it is important that game elements do not distract from learning. Useful feedback is necessary and the constraints of the educational environment should be addressed.

Some studies present claims that are specific to particular groups of students. In spite of what is often assumed, gender does not seem to influence the effects of games on engagement, motivation and learning, with no differences being reported between boys and girls. Cognitive ability only mattered for learning outcomes, albeit with unclear results. In some studies games appear to work best for poor-performing students, in others for the well-performing students. Two studies reported significant interaction effects regarding social-economic groups depending on whether the game was individualistic, cooperative or competitive.

6.1 Some critical remarks

Strengths of this review study include the empirical underpinning of claims about games regarding engagement, motivation and learning results. Nevertheless, some critical remarks should be made concerning the generalization of our conclusions on the use of game-based learning in education. Firstly, the use of games in education is burgeoning, and most empirical research has been published recently. There was a significant increase in research publications on game-based learning at the end of the period covered by our review (1999-2009). A systematic review requires a considerable amount of time and our findings should be understood in this context. However, on the basis of recently published articles in journals, such as Computers & Education and Computers in Human Behavior, and listserves, such as Gamesnetwork, we are of the opinion that our conclusions still hold. Secondly, we had to base our analyses on authors' texts which are published in peer-reviewed journals and dissertations. As a result some manuscripts that omit crucial information about the method or results (in tables or in the text) were not selected because of our criterion of methodological rigor. Thirdly, non-significant results are under-represented. When analyzing whether the conclusions of the studies in our review were substantiated we noticed that many authors do not include their non-significant results in the discussion and conclusions sections. Owing to the omission of these results from the conclusions, they were not coded as claims, therefore resulting in the under-representation of claims with non-significant results mentioned above.

Regarding the question what makes 'game-based learning' work, we were limited by the information given in the articles. Very often we could not ascertain how long the interventions lasted. (Sometimes only the period was mentioned, sometimes only how long one session lasted.) When time was mentioned we were often unsure whether this was purely game-playing time or that maybe teachers intervened in this time too and if so, we did not know how. This would be valuable information for determining whether game-based learning is effective or not. Moreover, in most cases no effect sizes were mentioned and hence we had no idea whether the effects were substantial or not. We were also not certain whether the effects found were due to using games in education or due to introducing something new – a novelty effect - as barely any long-term studies were included. In some cases the studies were possibly too short to find effects. Nevertheless, we hope that this review has contributed to a better understanding of the learning and motivational effects of DGBL and the state of research.

6.2 Implications and future research

It is clear that games for use in education have to be well designed from an instructional point of view. To engage students in a game - which seems to be a prerequisite for motivating them and for their learning – students should feel ownership and authenticity and they should perceive sufficient challenges and possibilities for competition. But technology alone does not seem to be enough to trigger effects on students' learning. Students need input from teachers in the form of instructions, guidance and feedback, and enough opportunities for reflection. It is also necessary to be aware that too many embellishments in the game design can distract students' attention from learning.

To utilize the full potential of games we need to know more about *how* games work and for *whom*. One way would be to systematically manipulate design elements to examine their impact on engagement, motivation and learning. Moreover, longitudinal research could establish retention effects. Finally, research is needed on how game-based learning works for different school subjects and different groups of students. Only when we have this information can we safely conclude that students are engaged and motivated while playing games and do indeed learn more than in regular instructional settings.

APPENDIX

Table 1. Claims on engagement in game-play (with + for claims indicating a positive effect, - for claims indicating a negative effect and 0 for claims indicating a non-significant effect).

Study	Name and type of game	School subject	Age/grade and number of participants	Direction of the claim	Compared to control group
Annetta et al. (2009)	A teacher-created Multiplayer Educational Gaming Application (MEGA)	Biology	4 general biology classes at a single high school. N= 129 (66 game, 63 control), aged 14-18		+
Arici (2008)	Quest Atlantis: a 3D MUVE (multi-user environments and virtual world) video game designed for education (Taiga).	Science content	Approx.120 students, aged 11-12		+
Barab et al. (2007)	Quest Atlantis: a 3D MUVE (Taiga)	Science: socio-scientific inquiry	28 students (16 females) in a fourth-grade gifted class	+	
Cheung et al. (2008)	Farmtasia: an online game based on VI-SOLE (a Virtual Interactive Student-Oriented Learning Environment, VR)	Interdisciplinary: biology, govern-ment, economics, technology, produc-tion system and natural environment	16 secondary-four students (comparable with K-10)	+	
Greenhill et al. (2008)	Newtoon: mobile microgame creation	Science: physics	1 year-seven class	+	
Habgood (2007) Study 2	Zombie Division: action-adventure game, attacking skeletons	Math	46 mixed-ability students, aged 7 years 10 months - 8 years 8 months (mean 8 years 2 months), 18 females and 28 males (data on 2	(+)	0

			students lost owing to damaged data storage)		
Habgood (2007) Study 3	Zombie Division: action-adventure game, attacking skeletons	Math	16 students, aged 9 years 10 months - 11 years 2 months (mean 10 years 4 months) in an after-school club		+
Jonker et al. (2009)	Crack the Number Safe: a mini-game designed for exploring division	Math	18 fourth and sixth-grade students	+	
Lim (2008)	Quest Atlantis: a 3D MUVE	English, math and science	80 fifth-grade students at a school open to technological innovation	+	
Muwanga-Zake (2007)	Zadarh: an adventure game that explores photosynthesis, respiration, genetics and evolution	Biology	26 teachers and 129 twelfth-grade students	+	
Ota & Du Paul (2002)	Math Blaster: commercial math software with game format	Math	3 male, Caucasian, fourth, fifth, and sixth-grade students exhibiting ADHD behaviors	+	
Owston et al. (2009)	Education Games Central: a game-shell for making games	Social studies	Fourth-grade classes at nine public elementary schools	+	
Papastergiou (2009)	LearnMem1: computer game on basic computer memory	Computer science	88 students at two high schools, 46 males and 42 females, aged 16-17		+
Robertson & Howels (2008)	Neverwinter Nights game-making toolset: NWN is a Dungeons and Dragons style 3D role-playing game	Interdisciplinary: Scotland's curriculum for excellence	Class of 30 students, aged 9-10	+	
Rosas et al. (2003)	Simple low cost video-game platform, gameboy appearance	Math and reading (also tests spelling)	1274 first and second-grade students	+	
Serrano & Anderson (2004)	Food Pyramid Games (and songs): a bilingual nutrition software program for Mac	Nutrition	115 students from four schools and nine fifth-grade classes	+	
Solomou & Vrasidas (2008)	Age of Mythology: a commercial strategy simulation computer game	History	24 sixth-grade students	+	
Tüzün et al. (2008)	Quest Atlantis: a 3D MUVE (Global Village):	Geography	24 fourth and fifth-grade students at a K-8 elementary school	+	
Ulicsak (2004), only final study in review	Astroversity: game for 12-14 year olds, extension Virtual Multi-User Learning Environments project	Cross-curricular with science focus	Year-nine (top) class, 8 females and 10 males	+	

Verheul & Van Dijk (2009)	Oblivion: a single-player offline RPG (COTS)	Vocational education (one subject being English)	43 students (but a pre-test and post-test for only 34), aged 16-26, the majority aged 16-19		-
Virvou & Katsionis (2008)	VR-ENGAGE: a virtual reality educational game (similar to DOOM)	Geography	50 students aged 11-12 (15 novice, 20 intermediate, 15 expert)	+	

Table 2. Claims on motivation for the subject (with + for claims indicating a positive effect, - for claims indicating a negative effect and 0 for claims indicating a non-significant effect).

Study	Name and type of game	Subject	Age/grade and number of participants	Direction of the claim	Compared to control group
Ang & Rao (2008)	Reconstructors: a web-based educational game	Drugs	100 students, 50 aged 15-18 and 50 aged 19-35		+
Huizenga et al. (2009)	Frequency 1550: a mobile location-based game	History	458 students in first year of secondary education, aged 12-16, mostly 13		0
Ke (2008a)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	160 participants from 8 fifth-grade classes		0
Ke (2008b)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	15 students enrolled in a summer math program, aged 10-13	+	

Ke (2008c)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	358 students from 18 fifth-grade classes		+
Ke & Grabowski (20007)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	125 fifth-grade students from six classes		+
Lim (2008)	Quest Atlantis: a 3D MUVE	English, math and science	80 fifth-grade students at a school open to technological innovation	+	
Sedig (2008)	Super Tangrams: interactive game on geometry concepts, based on Chinese Tangrams puzzle activity	Math	58(/59) sixth-grade students, 20 from a control group at another school	+	
Solomou & Vrasidas (2008)	Age of Mythology: a commercial strategy simulation computer game	History	24 sixth-grade students	+	+
Tüzün et al. (2008)	Quest Atlantis: a 3D MUVE (Global Village)	Geography	24 fourth and fifth-grade students at a private K-8 elementary school		+
Verheul & Van Dijk (2009)	Oblivion: a single-player offline Role Playing Game (COTS)	Vocational education (one subject being English)	43 students (a pre-test and post-test for only 34 students), aged 16-26, the majority aged 16-19		0

Table 3. Claims on factual knowledge (with + for claims indicating a positive effect, - for claims indicating a negative effect and 0 for claims indicating a non-significant effect).

Study	Name and type of game	Subject	Age/grade and number of participants	Direction of the claim	Compared to control group
Chuang & Chen (2009)	Fire Department 2, Fire Captain: a 3D, real-time strategy computer-based video game	Fire-fighting	115 third-grade students, 61 males , and 54 females		+
Cheung et al. (2008)	Farmtasia: an online game based on VISOLE (a Virtual interactive student-oriented learning environment, VR)	Interdisciplinary: biology, government, economics, technology, production system and natural environment	16 secondary-four students (comparable with K-10)	+	
Huizenga et al. (2009)	Frequency 1550: a mobile location-based game	History	458 first-year secondary students, aged 12-16, mostly aged 13		+
Papastergiou (2009)	LearnMem1: computer game on basic computer memory	Computer science	88 students at two high schools, 46 males and 42 females, aged 16-17		+
Serrano & Anderson (2004)	Food Pyramid Games (and songs): a bilingual nutrition software program for Mac	Nutrition	115 students from four schools and nine fifth-grade classes	(+)	+
Solomou & Vrasidas (2008)	Age of Mythology: a commercial strategy simulation computer game	History	24 sixth-grade students	+	
Tüzün et al. (2008)	Quest Atlantis: a 3D MUVE (Global Village)	Geography	24 fourth and fifth-grade students at a K-8 elementary school	+	
Virvou et al. (2005)	VR-ENGAGE: a virtual reality educational game (similar to DOOM)	Geography	90 students aged 9-10 in first part of the experiment, 30 good students in second part, 30 mediocre in third part and 30 poor in fourth part (no overlap)		+

Table 4. Claims on cognitive skills (with + for claims indicating a positive effect, - for claims indicating a negative effect and 0 for claims indicating a non-significant effect).

Study	Name and type of game	Subject	Age/grade and number of participants	Direction of the claim	Compared to control group
Annetta, et al.(2009)	a teacher-created Multiplayer Educational Gaming Application (MEGA)	Biology	4 general biology classes at a single high school. N= 129 (66 game, 63 control), aged 14-18		0
Arici (2008)	Quest Atlantis: a 3D MUVE video game designed for education (Taiga)	Science content	Approx.120 students, aged 11-12	(+)	+
Banerjee et al. (2007)	CAL: year 1 internally developed and COTS educational games, year 2 additional company-developed software	Math (& language, but this is not a target of CAL)	The CAL intervention in 2002-2003 in 55 schools in grade 4, 56 comparison, crossover design with switch in 2003-2004		+
Barab et al. (2007)	Quest Atlantis : a 3D MUVE (Taiga)	Science: socio-scientific inquiry	28 students (16 females) in a fourth-grade gifted class	+	
Chuang & Chen (2009)	Fire Department 2, Fire Captain: a 3D, real-time strategy computer-based video game	Fire-fighting	115 third-grade students, 61 males and 54 females		+ 0
Din & Caleo (2000)	Light Span (Sony PlayStation) with CDs	Tests math, spelling & reading	47 students, aged 5-6		+ 0
Greenhill et al. (2008)	Newtoon: mobile microgame creation	Science: physics	1 year-7 class	+	
Habgood (2007) study 1	Zombie Division: action-adventure game, attacking skeletons	Math	64 students, aged 7 years 6 months - 9 years 7 months (mean 8 years 8 months), 32 females and 32 males	(+)	0

Habgood (2007) study 4	Zombie Division: action-adventure game, attacking skeletons	Math	58 students, aged 7 years 1 month - 8 years 10 months (20 intrinsic condition, 20 extrinsic and 18 control)	+	+
Hickey et al. (2009)	Quest Atlantis	Science	8 classes, including 2 control classes	+ +	0
Jonker et al. (2009)	Crack the Number Safe: a mini-game designed for exploring division	Math	18 fourth and sixth-grade students	+	
Ke (2008a)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	160 participants from eight fifth-grade public school classes		+
Ke (2008c)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	358 students from 18 fifth-grade classes		0
Ke & Grabowski (2007)	ASTRA EAGLE: a series of web-based games designed as drill-and-practice programs for math	Math	125 fifth-grade students from six classes		+
Ota & Du Paul (2002)	Math Blaster: commercial math software with game format	Math	3 male, caucasian, fourth, fifth and sixth-grade students exhibiting ADHD behaviors	+	
Owston et al. (2009)	Education Games Central: a game-shell for making games	Social studies	Fourth-grade classes at nine public elementary schools, either two fourth-grade classes or only one fourth-grade class and one with third and fourth-grade students	+	+
Redfield et al. (2007)	Math Blaster Algebra: a game package focusing on using many types of numbers	Math	42 ninth-grade algebra students	0	
Robertson& Howels (2008)	Neverwinter Nights game-making toolset: NWN is a Dungeons and Dragons style 3D role-playing game	Interdisciplinary: Scotland's curriculum for excellence	Class of 30 students, aged 9-10	+	
Rosas (2003)	Simple low-cost video-game platform, gameboy appearance	Math and reading (also tests spelling)	1274 first and second-grade students		0

Sedig (2008)	Super Tangrams: interactive game on geometry concepts, based on Chinese Tangrams puzzle activity	Math	58(/59) sixth-grade students, 20 from a control group at another school	+	
Serrano & Anderson (2004)	Food Pyramid Games (and songs): a bilingual nutrition software program for Mac	Nutrition	115 students from four schools and nine fifth-grade classes		+
Solomou & Vrasidas (2008)	Age of Mythology: a commercial strategy simulation computer game	History	24 sixth-grade students	+	
Squire et al. (2004)	Supercharged!: an electromagnetism 3D simulation game	Science: physics (electro-statics)	96 students in five different classes all with the same 8th grade teacher (35 in control, 61 in experimental group)		+
Sung et al. (2008)	SoRT: Software for Rebuilding Taxonomy, several multimedia games	Taxonomic concepts	60 students, aged 3½-5½	(+) (+) (0)	+ + 0
Verheul & Van Dijk (2009)	Oblivion: a single-player offline RPG (COTS)	Vocational education (one subject being English)	43 students (but a pre-test and post-test for only 34) aged 16-26, the majority aged 16-19	+ +	
Vogel et al. (2006)	A Virtual Reality learning program based on a computer-assisted instruction program	Math	44 students, aged 7-12 at a public school (25 females, 19 males)		- 0
Wilson et al. (2006)	The Number Race: an adaptive computer game for remediation of dyscalculia	Math	Final sample 9 students aged 7-9 from 3 schools	+	
Zuiker et al. (2008)	Escape from Centauri: a multi-user serious game; students assume the role of stranded astronauts	Science: physics	36 males, volunteers, aged 14-15, private all-boys secondary school	+	

CHAPTER 3

MOBILE GAME-BASED LEARNING: EFFECTS ON ENGAGEMENT, MOTIVATION AND LEARNING[1]

Using mobile games in education combines situated and active learning with fun in a potentially excellent manner. The effects of a mobile city game called Frequency 1550, which was developed by The Waag Society to help pupils in their first year of secondary education playfully acquire historical knowledge of medieval Amsterdam, were investigated in terms of pupil engagement in the game, historical knowledge, and motivation for History in general and the topic of the Middle Ages in particular.
A quasi-experimental design was used with 458 pupils from 20 classes from five schools. The pupils in 10 of the classes played the mobile history game whereas the pupils in the other 10 classes received a regular, project-based lesson series. The results showed those pupils who played the game to be engaged and to gain significantly more knowledge about medieval Amsterdam than those pupils who received regular project-based instruction. No significant differences were found between the two groups with respect to motivation for History or the Middle Ages. The impact of location-based technology and game-based learning on pupil knowledge and motivation are discussed along with suggestions for future research.

1. INTRODUCTION

While schools are aimed at the education of pupils and qualification of pupils for the labour market, they are not always successful today. In the school year 2005-2006 in the Netherlands, for instance, about 19% of the pupils in secondary education left school without a diploma. The majority of the pupils dropping out of the first classes of secondary education came from pre-vocational education (OCW, 2007). The pupil drop-out issue is an issue, moreover, in not only the Netherlands but also all other European countries (Herweijer, 2008; Jonassen & Blondal, 2005) and the USA as indicated by the many newsletters of the Association for Supervision and Curriculum Development. It thus appears that education is not meeting the needs of certain pupils sufficiently. According to Prensky (2001) and others (e.g. Beck & Wade, 2006; Klopfer, 2008), one of the reasons for this failure is that a new generation of pupils is largely being educated with old paradigms and methods. The present generation of pupils is growing up with Information and Communication Technology

[1] This chapter has been published in a slightly adapted form as: Huizenga, J., Admiraal, W., Akkerman, S., & Ten Dam, G. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning, 25, 332-344.* doi: 10.1111/j.1365-2729.2009.00316.x

(ICT) embedded in their daily lives. Such pupils handle digital information on a daily basis, are connected to each other via mobile technologies, work interactively, often perform several tasks more or less simultaneously and play games to a greater extent than previous generations (Beck & Wade, 2006; OCW, 2007). According to Van Eck (2006), the popularity of games together with ongoing research on the power of digital game-based learning, on the one hand, and increased disengagement of the so-called 'net generation' or 'digital natives' from traditional instruction, on the other hand, are factors which explain the widespread interest in game-based learning. This interest in game-based learning holds not only for digital natives, but also for a broad group of pupils and researchers today as well as for teachers and parents (Kirriemuir & McFarlane, 2004; Sandford, Ulicsak, Facer & Rudd, 2006). It is thus quite possible that game-based learning may more adequately address the manner in which youngsters learn nowadays and engage them more successfully in meaningful learning than traditional learning methods (Gee, 2003; Shaffer, 2006; Prensky, 2001; Van Eck, 2006). Though some studies report success in learning with games with traditionally disengaged groups of students (see e.g. Egenfeldt-Nielsen, 2005; Squire, 2004) and that using games in lessons is motivating (see e.g. Sandford et al., 2006) the empirical basis for claiming that game-based learning may more adequately engage pupils is still rather thin and far from conclusive.

2. GAME-BASED LEARNING

During the last 20 years, the importance of fostering meaningful learning has been elaborated upon under the general heading of situated and active learning (Brown, Collins, & Duguid, 1989; Lave & Wenger, 1991; Lombardi, 2007). So-called mobile and location-based technologies provide opportunities to embed learning in authentic environments and thereby enhance engagement and learning outside traditional formal educational settings. With handhelds, it is possible to mix virtual data with real-world data (i.e., locations and contexts) and thereby connect a virtual world to real life (Klopfer & Squire, 2008). Similarly, games can be played in the real world with the support of such digital devices as Personal Digital Assistants and cell phones, which make it possible to create a fictional layer on top of a real world context and thus an *augmented reality*. Location-based augmented reality games, for instance, are played in specific real-world locations which may include historical or geographical sites. Along these lines, the MIT Teacher Education Program created a game called Environmental Detectives in which handheld computers with a Global Positioning System (GPS) are used to augment the experience of the user with additional text, audio and video data (Klopfer, Squire, & Jenkins, 2002). Under such circumstances, the user experiences his or her environment in a new way and situated, active learning is stimulated. The context sensitivity of mobile devices (i.e., their capacity to gather data which is unique to the current time and location and may be either real or simulated) is one of the properties — according to Klopfer et al. — which makes such mobile devices so well-suited for the support of learning activities. Four other properties which are assumed to make such mobile devices particularly useful for educational purposes concern their portability, their social interactivity as both face-to-face interaction and the exchange of data between learners is made possible, their connectivity and their individuality as the support for different activities can be tailored to the needs of specific learners (see Klopfer et al., 2002). Given all the possibilities of game-based learning, the question which arises is whether it actually lives up to all of the expectations or not.

Research on mobile game-based learning tends to focus on the motivational effects of the methods. One of the main reasons for this is that when people play such games, they are generally found to be very engaged in the game: They are totally immersed in the game and can play for hours on end with little or no awareness of the more general world around them (Shaffer, 2006; Beck & Wade, 2006). Such a state of complete absorption in a task is referred to as 'flow' (Csíkszentmihályi, 1990). Flow theory is important for motivation in instruction (Watson, 2007). Having motivated learners is what many teachers desire. In fact, a motivated learner is easy to describe: enthusiastic, focused and engaged. A motivated learner shows a clear interest in what he or she is doing and enjoys what he or she is doing, tries hard and persists over time (Garris, Ahlers, & Driskell, 2002). Many studies of games and motivation are based upon the motivation work of Malone and Lepper (1987) who proposed a link between motivation and intrinsic learning. More specifically, seven factors which include both *individual* and *interpersonal* factors have been postulated to promote intrinsic motivation. The individual factors are challenge, curiosity, control, fantasy, competition, cooperation and recognition. According to many authors, many of these factors are triggered by games (see, e.g., Egenfeldt-Nielsen, 2006; Garris et al., 2002; Prensky, 2001).

In their evaluation of mobile game-based learning, Schwabe and Göth (2005) indeed found that technology enables immersion into a mixed reality and thus provides highly motivating learning experiences. In their words, the MobileGame they studied moved the pupils 'into a state where they are mentally ready for learning and where they are in the right environment for learning' (p. 215). However, the authors also admit that they cannot claim that the game actually enhanced pupil learning. There is a need to more thoroughly evaluate the cognitive benefits of mobile game-based learning despite the fact that both the cognitive and motivational effects of game-based learning have been previously studied (see, e.g., De Freitas, 2006; Egenfeldt-Nielsen, 2006; Fletcher & Tobias, 2006; Gros, 2007; Habgood, 2007; Hays, 2005; Mitchel & Savell-Smith, 2004). While the reviews conducted to date show a positive overall picture, many of the relevant studies are nevertheless methodologically flawed, rarely experimental and often present contradictory results. According to De Freitas (2006) in her review of the literature on game-based learning, games and simulations certainly have substantial potential for learning but certain challenges 'in terms of setting and assessing specified learning objectives' (p. 58) in particular must be met in order to effectively use the potential of learning from games and simulations.

In the present study, the motivational and learning effects of a mobile city game called Frequency 1550 were thus examined. Frequency 1550 can be considered as a game, following the definition of Dempsey saying that a game is "a set of activities involving one or more players. It has goals, constraints, payoffs and consequences. A game is rule-oriented and artificial in some respects. Finally a game involves some aspects of competition, even if that is competition with oneself" (Dempsey et al., 1996, p.2). Although the game Frequency 1550 has won an award as the world's most innovative e-learning application, the educational value of the game has yet to be documented systematically. The effects of the mobile game on pupil knowledge of medieval Amsterdam and their motivation for the study of History in general and the Middle Ages in particular will therefore be examined in the present study in addition to the engagement of the pupils while playing the game.

3. THE FREQUENCY 1550 GAME

Introduction to the game. The Frequency 1550 game was developed by the Waag Society, which is a Dutch ICT research foundation working in the social and cultural domain. Frequency 1550 is a game about medieval Amsterdam to be played during a single school day. At the start of the game day, the pupils gather at the main location, namely the Waag building or 15th century weighing house in the city of Amsterdam. The pupils are introduced to the game, the tasks, the tools to be used and the objective of the game: To gain citizenship in the city of Amsterdam via attainment of the required 366 points or 'days of citizenship' which represent the medieval year-and-a-day rule which requires residence within the Amsterdam city walls for this period of time to earn civil rights. Groups of four or five pupils are formed, and the pupils are randomly assigned the identity of a beggar or a merchant who have different rights and a different status (i.e., order) in the game. The part about earning citizenship and being in an order is called the main story line or the back story. With the help of the Internet, smart phones, video phones and GPS technology, Amsterdam becomes a medieval playground.

Group and team structure. Each group of four or five pupils is divided into a city team (CT) consisting of two or three pupils who walk through the city and a headquarter team (HQT) consisting of the other two or three pupils who operate from behind the computer in the main building. After the lunch break, the teams switch places so that each pupil has participated in both the CT and HQT at the end of the day. The CT is assigned one of six areas (see below) as the starting point for the conduct of small, location-based media tasks to explore, map and gain knowledge of each of the areas and their associated themes. The CT can view a map of medieval Amsterdam (Figure 1) on their smart phones and zoom in on a particular part of the map. The HQT can use two maps: one about medieval Amsterdam and one about present Amsterdam; both maps have coloured dots indicating the routes the six CTs are walking. The HQT digitally follows the route of the CT by means of GPS and guides them towards and through the required learning tasks using various sources of information, including the videos in the game and internet resources.

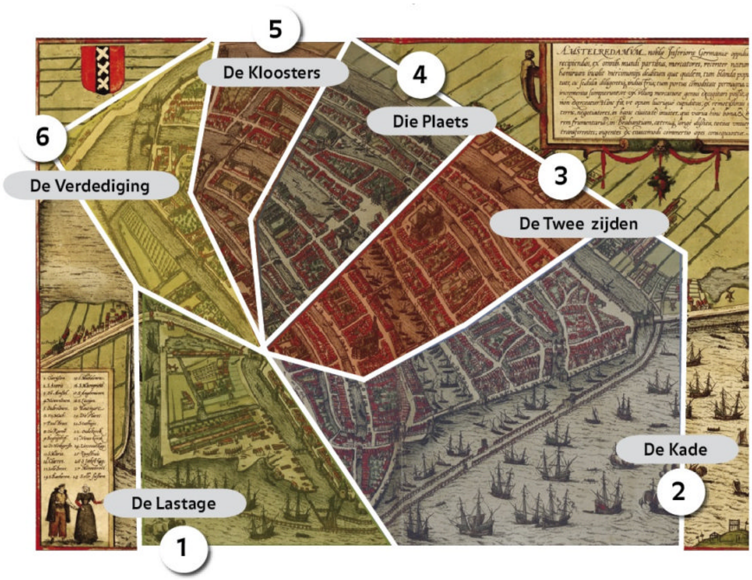

Figure 1: Map of medieval Amsterdam. © *Waag Society*

Six areas and associated themes. The old city of Amsterdam has been divided into six areas in which six different themes from medieval times are addressed. The six themes are: 1) labour in the area called *Lastage*; 2) trade in the area called *de Kade*; 3) religion in the area called *de Twee Zijden*; 4) rules and government in the area called *die Plaets*; 5) knowledge in the area called *de Kloosters*; and 6) defence in the area called *de Verdediging*. Each theme is introduced with the name of the area via an introductory video clip displayed in a telephone message which is sent to the pupils as if it came from the year 1550 as soon as they enter a new area. Each clip presents words which can help the group complete the assignments for the area; the audio background presents the sounds of medieval activities in the area (e.g., the sound of manual work, sawing). After the presentation of key words, the video clip zooms in on a few pages from a diary. The diary for the area *Lastage* reads as follows:

> Tuesday. A few sisters' dresses are worn out and I need yarn. The best yarn can be found in Lastage because they make rope out of yarn there. Lastage is a long walk from the monastery because it is located outside the city wall. As soon as you pass the city wall, you will hear hammering in the distance where manual labour is conducted (…) the area is being protected by the new defence tower which lies on the outer boundary of Lastage. It is situated at the intersection of the water of the Amstel and the water of the IJ.

In order to receive assignments, the CTs must try to find a certain area, the so-called hidden location. Following the diary pages, a closing text is presented by the main narrator providing clues about the hidden location:

> The hidden location can be found on the outskirts of Lastage. It is situated at the intersection of the water of the Amstel and the water of the IJ. The hidden location is a tower on the east side of Lastage.

Assignments. As soon as the GPS data shows a CT has reached a particular location, three video assignments in addition to the introductory video are automatically sent from the server in The Waag to the video phone. For each area, there are three similar types of assignments: an orientation assignment, an imagination assignment and a symbolic assignment. Each assignment consists of three parts and is concluded with a final multiple choice or open-ended question which often requires the CT and HQT to combine their knowledge to find the answer.

The orientation assignment includes texts and tasks which are intended to trigger environmental awareness. This may be done via the creation or selection of photos, the answering of questions about the site.

The imagination assignment includes texts and a task which are again intended to trigger environmental awareness via the creation or selection of photos and the answering of questions about the site but also the imagination of historical actions, events and the work of historical characters. For this assignment, the CTs are asked to act out particular idioms/sayings such as 'this is monks' work,' which is the equivalent of 'this is sheer drudgery' in English and refers to the days when monks meticulously copied books by hand. The acting out of the sayings is videotaped, while the HQTs are asked to find out what these sayings mean.

In the comprehensive assignment, the CTs are asked to search for several details – such as a plaque with the medieval name of the area – and take pictures of the details while the HQTs are asked to select the correct picture from various pictures on the Internet or somewhere else. Similarly, the CTs may be asked to take a picture of something such as a depiction of the emblem for a guild while the HQTs have to find out more about the guild itself.

Each group, consisting of a CT and a HQT, can gain points which help them to win the game via the completion of assignments. Each CT also has to decide whether to stay away from the other CTs or enter into a confrontation in which their "order" determines the winner with merchants having a higher order than beggars. The winning group receives points (i.e., days of citizenship) from the losing group. Team members can also drop virtual medieval rats (i.e., the equivalent of a virtual bomb) on the other team which causes the screen of the smart phone to go blank and thus disables the use of this phone temporarily.

Completion of the game. At the end of the day, all of the pupils gather at the main building where the HQTs are located. Each of the groups is invited to briefly present some of their collected media to the other groups. An educational staff member of the Waag Society is also present to guide this process and ask questions. Finally, every group is told how many points they have earned and the group with the highest score is announced. With 30 minutes of introduction, a one hour lunch break and almost one hour of presentations at the end of the day, two hours are left of play in a CT and two hours left to play in a HQT.

4. METHOD

Given that the aim of the present study was to enhance insight into both the motivational and learning effects of game-based learning, hypotheses regarding the motivation and knowledge gains of the pupils in the different research conditions were formulated first.

1) The motivation of the pupils playing the Frequency 1550 game for History in general and the topic of the Middle Ages in particular will differ from that of the pupils receiving the regular project-based lesson series.
2) Those pupils playing the Frequency 1550 game will show different knowledge gains with regard to medieval Amsterdam than the pupils receiving the regular project-based lesson series.

The above hypotheses were formulated non-directional as the literature did not provide conclusive evidence regarding the effects of game-based learning.

Research by Clark and Feldon (2005) and Kanfer and McCombs (2000) suggests that pupil interest in a topic, their prior knowledge with regard to the topic and their learning preferences (i.e., learning styles) may affect their choices and persistence to learn a subject. Given that the majority of the pupils dropping out of secondary education are in pre-vocational secondary education (OCW, 2007), it may be that education is not appealing enough for these pupils and that the Frequency 1550 game may work differently for pre-vocational pupils than for other pupils. Two pupil characteristics, in particular, may interact with the playing of the Frequency 1550 game, namely: the pupil's prior History ability and the pupil's level of education — which can be understood to reflect various aspects of general cognitive ability, motivation and learning style. In keeping with the above, the following two hypotheses were thus formulated.

Pupils with an initially low History ability will generally attain different knowledge of medieval Amsterdam results after playing the Frequency 1550 game than after receipt of a regular project-based lesson series.

Pupils from pre-vocational secondary education will generally attain different knowledge of medieval Amsterdam results after playing the Frequency 1550 game than after receipt of a project-based lesson series.

As pupil engagement in a game is an important condition for learning and having fun we will measure their level of engagement as well.

The regular project-based lesson series of two class hours was designed by the researchers in strong co-operation with five history teachers from the participating schools. The content of the game Frequency 1550 has been used in the design of the regular project-based lesson series, which means that the content of both conditions (games and lesson) was similar. We checked the realisation of this design with teacher reports. However, the instruction of the assignments, the pedagogy and the time devoted to each topic are different between both conditions as these are part of the educational design. In the game condition, the instruction of the assignment is more 'game-like' and narrative-based, the pedagogy has a focus on pupil-centered learning, and the time devoted to each topic was 4 hrs. maximum, including time to navigate through the city, social talk, and attempts to connect with the headquarters.

4.1 Participants

The participants in the present study were pupils who ranged in age from 12 to 16 years with the majority having an age of 13 years. The pupils were all in the first year of secondary education in the Netherlands: 14 classes with a mix of pre-vocational secondary education pupils and 6 classes with a mix of upper general and pre-university secondary education pupils. Of the 458 pupils, 232 played the Frequency 1550 game and 226 followed the regular project-based lesson series.

Ten of the classes played the mobile history game in the last week of May and the first two weeks of June 2007. Seven of these classes were pre-vocational; the other three were a mix of upper general and pre-university secondary education. The pupils in these classes form the experimental group. The other 10 – again seven pre-vocational and three upper general and pre-university secondary education – classes followed the regular project-based lesson series which was specifically designed for this research during the same period. The pupils in these classes form the control group.

4.2 Measures

Engagement. Every CT went into Amsterdam with a guide who observed the game, assisted with small technical issues and saw to the pupils' safety in the busy traffic of Amsterdam. The observation forms included items on just how often specific game activities occurred or how actively pupils were involved in a certain game activity (on a 5-point Likert scale with 1 indicating 'not at all' and 5 indicating '=very often/very strong'). Examples are: 'How actively is the HQT involved in the conduct of the assignment?' and 'How actively is the CT involved in the exploration of the surroundings?'. At the Waag building where the HQTs were located, the activities of each team were also observed by a guide who helped the HQTs with technical issues. In most cases, one guide was observing and helping two HQTs. All of the guides completed observation forms and, at the end of each day, both the guides for the CTs and the HQTs came together to orally report on the day. These guides were staff members of Waag Society or volunteers from outside Waag Society. Morover, the three researchers made notes on the pupil engagement.

Motivation for History and the topic of the Middle Ages. Motivation was measured using a 6-item questionnaire similar to one available to measure motivation for Math (Cito, 1987). In fact, the word 'Math' was replaced by 'History' and an additional item was included to assess the pupil's motivation for the topic of the Middle Ages. The questionnaire was administered directly before (pre-test) and one week after (post-test) playing the Frequency 1550 game or attending the lesson series. The questionnaire items were responded to along a 5-point Likert scale with 1 indicating *(almost) never* and 5 indicating *(almost) always*. Examples of the statements to be rated are: 'I like the subject of History' and 'I learn a lot from the subject of History.' The homogeneity of the questionnaire was found to be satisfactory with a Cronbach's α of 0.78 (pre-test) and 0.84 (post-test). Motivation for the topic of Middle Ages was measured using only the item: 'I think the Middle Ages are interesting.'

Knowledge of medieval Amsterdam. Historical knowledge of Amsterdam was measured using three multiple-choice questions and two open-ended questions for each of the six themes concerned with medieval Amsterdam: a total of 30 questions. However, none of the groups of pupils were found to have played the Frequency 1550 game for all six themes by the end of the game day. This meant that the test score for each pupil was corrected for the themes and assignments a pupil completed. So, only the scores for those questions for which the pupils had received the necessary information were considered in the test score on knowledge of medieval Amsterdam. The test items were exactly the same for pupils for both groups (game and lesson).

Background variables. The school administration provided us with information on the age, gender and level of education for the pupils. The teachers of the pupils estimated the pupils' initial History ability (knowledge or skills regarding the subject of History) along a scale of 1 to 5 with higher scores indicating greater ability. History ability was then recoded as low, medium or high initial History ability.

Given that the playing of the Frequency 1550 game draws upon collaborative learning, the pupils were asked to respond to five statements indicating their attitudes towards collaboration ($\alpha = 0.78$). The questionnaire used to do this was similar to the questionnaire used to assess the pupils' motivation for History in general and the Middle Ages in particular; the same five-point Likert scale was used to respond to the questions. An example of an assessment statement is: 'When I collaborate, I understand things more quickly.' None of the several existing questionnaires we reviewed were found suitable to the group of students we were going to work with, therefore we made our own collaboration scale. We formulated 8 items on collaboration. After a factor analysis we selected those 5 items which loaded on the factor as intended and showed sufficient reliability.

Analyses. The oral reports provided by the guides at the end of the Frequency 1550 game day were all transcribed. In a grounded-theory approach, the transcriptions of the oral reports, the observation notes from the researchers and the notes of the guides from 110 observation forms were used to inductively discern the theme engagement (Strauss & Corbin, 1998). Sentences with words which indicate (dis)engagement (e.g., fun, concentration, (de)motivation, enthusiasm, boredom, effort) were marked and the frequencies of comments indicating engagement or disengagement were then counted.

To assess the four hypotheses regarding the motivational and learning effects of playing the game versus following regular lessons, univariate analyses of covariance were performed. For the first two hypotheses regarding the pupils´ motivation and knowledge, the independent variable was the intervention (Frequency 1550 game or regular project-based lesson series); the dependent variables were motivation for

History in general and the topic of the Middle Ages in particular (hypothesis 1) and knowledge of medieval Amsterdam (hypothesis 2). Educational level (pre-vocational vs. upper general secondary and pre-university education), initial level of History ability (transformed into low, medium or high), pre-test motivation for the subject of History in general and the topic of the Middle Ages in particular and attitude towards collaboration were entered as covariates. For the hypotheses regarding the interaction effects, the independent variables were initial level of History ability, level of secondary education being followed and intervention; the dependent variable was knowledge of medieval Amsterdam; and the covariates were pre-test motivation for the subject of History in general and the Middle Ages in particular and attitude towards collaboration.

5. RESULTS

5.1 Engagement in the game Frequency 1550

The game was mostly played as planned, but with a few exceptions. There was not much elaboration of back story: Pupils were often just told to gather as much points as possible, with no reference to earning civil rights. Moreover, pupils were not always informed about their identities as beggar or merchant. This meant that a certain competitive element of the game was removed. In addition, the technology did not always work as planned. On particularly the first three game days, there were problems with the GPS which either showed the wrong position for the pupils or no position whatsoever. The sending of photographs and videos took a very long time on some days which prevented the pupils from moving on to the next assignment. The pupils could not, thus, progress in the game and therefore completed fewer assignments than expected. These technical problems might have negatively influenced the engagement of the pupils. On about 50% of the 56 occasions when the guides mentioned something negative about the engagement of the pupils, the guide also mentioned a technical problem. Examples of statements where engagement was related to technical problems are: ‘media doesn’t arrive, causing a lot of delay leading to demotivation’; ‘some problems starting up the technique, they get impatient, start chasing each other and playing around’; ‘technical problems tested pupils’ patience and diminished concentration/attention’; and ‘the ladies want to, but get demotivated by technical problems.’ The pupils were not always demotivated in cases of technical problems and the guides sometimes explicitly noted that the pupils were motivated despite the occurrence of technical problems. There seem to be differences in engagement between the HQT and CT. The HQT generally had to wait less than the CT, and some of the guides mentioned that the pupils appeared to like to be in the HQT more than the CT. This higher engagement of the HQTs seemed to be related to the many different tasks of the HQT and their overview of the game play. This image of engagement derived from the observation forms is supported by the oral reports provided by the guides and researchers at the end of the day.

The quantitative observation data obtained from the guides showed the pupils to have a strongly active engagement in the solution of assignments but a bit more for the HQTs than for the CTs.

In general, most of the pupils appeared to like the game and to be engaged by the game. Pupils who were not engaged regularly showed off-task surfing for YouTube videos or other things not relevant to the game or the assignments. Illustrative of observation that pupils were engaged is a teacher mentioning of the fact that he could not normally get his pupils to work and that they now stayed focused for six hours, children being too busy to act up, best friends now able to live without each other for an entire day and some quiet pupils suddenly taking charge of the phone.

Below, we present the results regarding the four hypotheses we formulated. The means for the dependent variables are presented in Table 1 along with the numbers of participants in the analyses of covariance we performed.

Table 1. Mean scores on knowledge of medieval Amsterdam, motivation for the subject of History and motivation for the topic of the Middle Ages for intervention and control group

	Frequency 1550 game		Regular project-based lesson series	
	N	Mean	N	Mean
Knowledge of medieval Amsterdam	211	60%	200	36%
Motivation for History subject	141	3.02	136	2.80
Motivation for topic of Middle Ages	139	2.80	134	2.52

5.2 Motivation for History and the topic of the Middle Ages

In our analysis of covariance no significant differences were found between playing the game versus attending regular lessons with respect to motivation for the subject of History in general or the topic of the Middle Ages in particular. As technical problems might have influenced the motivational results, the analyses were repeated for the data when split into days 1-3 and 4-10, but still no significant differences were found for the game versus regular instruction groups. Hypothesis 1, namely that the motivation for History in general and the topic of the Middle Ages in particular would differ for those pupils playing the Frequency 1550 game versus those pupils receiving a regular project-based lesson series, can thus be rejected.

5.3 Knowledge of medieval Amsterdam

A significant effect of the intervention (playing the Frequency 1550 game versus the receipt of a regular project-based lesson series) was found for knowledge of medieval Amsterdam in the analyses of covariance ($F(1, 410)=153.6$; $p\leq0.001$). The 211 pupils who played the Frequency 1550 game generally attained higher scores on the knowledge test (with 60% of the questions answered correctly on average) than the 200 pupils who received regular project-based instruction (with only 36% of the questions answered correctly on average). Almost 28% of the variance in the scores on the knowledge test was explained by the intervention, and this can be judged to constitute a large effect (effect size f=0.62; see Cohen, 1988).

In light of the fact that the majority of pupils dropping out of secondary education come from pre-vocational education (OCW, 2007), we expected that the Frequency 1550 game might work differently for pre-vocational pupils than for the pupils from upper general secondary/pre-university education. The research of Clark and Feldon (2005) and Kanfer and McCombs (2000) also gave us reason to expect that a pupil's initial History ability and level of education might interact with the learning effect. For this reason, the two variables which indicate a pupil's ability level – namely, their level of education (pre-vocational vs. upper general secondary or pre-university) and initial History ability (low, medium, or high) were analyzed in interaction with intervention (game vs. regular project-based lesson series). The analyses revealed still a significant main effect of intervention and significant two-way interactions of educational level with intervention and initial History level with intervention. The results of the two-way interactions are graphically presented in Figures 2 and 3.

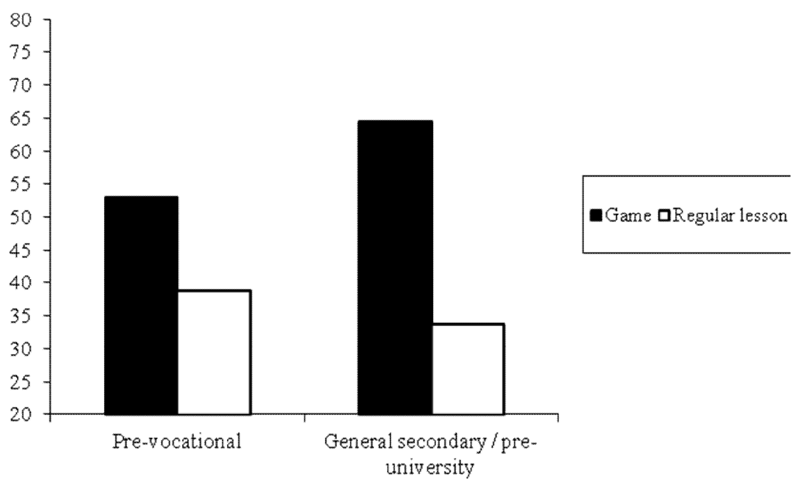

Figure 2. Two-way interaction between intervention (game vs. regular lesson) and educational level (pre-vocational vs. upper general secondary or pre-university).

Pupils from the higher educational level (i.e., upper general secondary and pre-university education) appeared to benefit *more* from playing the Frequency 1550 game than pupils from the lower educational level (i.e., pre-vocational education) (see Figure 2). After playing the Frequency 1550 game, those pupils in pursuit of a higher level of education attained relatively higher scores for knowledge of medieval Amsterdam than pupils in pursuit of a lower level of education. Conversely, after receipt of regular project-based instruction, pupils with a lower educational level attained relatively higher scores on the test of knowledge of medieval Amsterdam than pupils with a higher educational level ($F(1, 410) = 19.6$; $p \leq 0.001$).

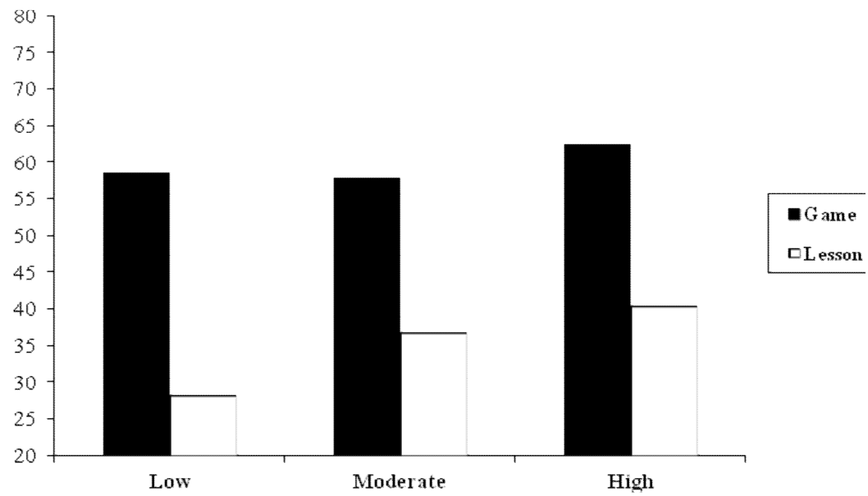

Figure 3. Two-way interaction between intervention (game vs. regular lesson) and initial History ability (low, moderate, high).

From Figure 3, it can be seen that pupils with an initially low History ability benefitted *most* from playing the Frequency 1550 game; the difference between playing the game versus attending a regular project-based lesson series is larger for this ability group than for the other two ability groups ($F(2, 410) = 3.3$; $p = 0.04$).

From Figures 2 and 3, it is clear that a large significant effect of intervention in favour of playing the Frequency 1550 game still remains ($F(1, 410) = 138.7$; $p \leq 0.001$). Some 26% of the total variance in the scores on the knowledge of medieval Amsterdam test is explained by intervention alone. The interaction effects depicted in Figures 2 and 3 can be understood as small effects and indeed explain only 5% and 2% of the variance in the knowledge of medieval Amsterdam test scores, respectively.

6. DISCUSSION

The use of mobile games in education may be an excellent way to combine situated and active learning with fun. The learning potential of mobile and location-based technologies lies in the possibility to embed learning in an authentic environment, enhance engagement and foster learning outside traditional formal educational settings. Although research on game-based learning constitutes an expanding research domain, claims that mobile games really enhance pupil learning still lack solid empirical evidence (De Freitas, 2006). Despite the various studies conducted to date, there is clearly a need for more thorough evaluation of the motivational and learning effects of mobile game-based learning. Experimental studies in which mobile game-based learning is compared to regular — possibly project-based — learning are needed direly. In this article, we have presented the results of an experimental study involving the mobile city game called Frequency 1550 in which pupils in the first year of secondary education can playfully acquire historical knowledge of medieval Amsterdam. Pupil engagement in the game was investigated in addition to the effects of playing the game on the historical knowledge of the pupils and their motivation for the subject of History in general and the topic of the Middle Ages in particular when compared to pupils receiving a regular project-based series of lessons.

The results showed playing of the Frequency 1550 game to produce a clear learning effect in terms of knowledge of medieval Amsterdam. Those pupils who played the Frequency 1550 game generally attained higher scores on the knowledge test when compared to those pupils who received a series of regular project-based lessons. The pupils in the mobile game intervention presumably gained greater knowledge of medieval Amsterdam because the information was presented in a more realistic, meaningful context and because the pupils had to actively work with the learning content within the context of medieval Amsterdam.

Although we also expected to find motivational effects of playing the game, no significant differences were found between the different interventions with respect to motivation for History in general or the Middle Ages in particular. This is striking in light of the fact that motivation is commonly considered *the* argument for the use of game-based learning in education. However, our definition of motivation was much more specific than the definitions used in the research we read. That is, we specifically examined motivation for the subject of History, whereas researchers define motivation in terms of fun and/or engagement (e.g., Schwabe & Göth, 2005).

In retrospect, it might be that playing the Frequency 1550 game for only *one* day is simply not enough to establish clear motivational effects. It is also possible that the technical problems may be partly responsible for the lack of effects on pupil motivation although separate analyses for those days with lots of technical problems versus those days with considerably fewer technical problems produced about the same results. Nonetheless, technical failures were clearly observed to be responsible for many instances of disengaged behaviour throughout the study days. In future research, more and earlier tests of technology should be performed in order to prevent technical failures to intervene with learning and motivational effects. Finally, many of the pupils did not complete one of the post-tests as it simply was not administered in six of the 20 classes. Given that the missing data was evenly distributed across the two interventions, however, we do not think that the validity of the present results and the conclusions to be drawn was damaged. More data might have revealed some smaller but significant effects, however.

In light of the hypothesis that game-based learning might work differently for pupils with a low level of education or initially low History ability, we also investigated the possibility of interaction effects. The results showed pupils from the higher levels of education to benefit *more* from playing the Frequency 1550 game than pupils from the lower levels. Stated differently: those pupils with a lower level of education benefitted *less* from the Frequency 1550 game than those pupils with a higher level of education. Conversely, those pupils with an initially low History ability benefitted *more* from playing the Frequency 1550 game than pupils with a higher level of initial History ability. That is, the Frequency 1550 game appears to be particularly worthwhile for pupils with an initially low History ability, and for pupils attending higher educational levels.

While the present study was not about the efficiency of teaching, it should be noted that the regular project-based lesson series involved only two class hours (of fifty minutes each), whereas the Frequency 1550 game involved the entire day. Despite the fact that the pupils who played the Frequency 1550 game required time for explanation of the technical aspects of the game and considerable time for navigation through the city and the search for the areas of the city, the pupils playing the game probably still had more learning time than those receiving the regular lesson series. In the present study, however, we were primarily interested in the effectiveness and not the efficiency of game-based learning.

While the Frequency 1550 game was shown to clearly promote knowledge of medieval Amsterdam, it is not clear which elements of the game contributed to pupil learning. For example, was the 'digital part' of the game accountable for the results, or was it primarily the 'location part', the opportunity for pupils to learn in location? The use of ICT in education has been influenced by several learning theories including behavioural learning theory, cognitive learning theory and social learning theory and thus has roots in work of Dewey, Piaget and Vygotsky. In their constructivist approaches to learning with technology, Jonassen, Peck, and Wilson (1999) and Barak (2006) have described learning principles which involve a synthesis of several learning theories. It is argued, for example, that ICT may only promote meaningful learning when the learners are actively engaged in learning which is constructive, contextual, reflective and social. Unravelling games — and perhaps mobile games in particular — into their constituent learning principles should thus be part of future educational research as only then, in our opinion, can we claim that mobile games constitute an excellent means to combine situated, active and constructive learning with fun.

For future research, it is suggested that the effects of game-based learning when pupils not only play the game but are also involved in the creation of the game, which allows more space for individual story construction and the addition of elements of own interest, be studied in particular. Such learner-centred production was not a part of the design of the Frequency 1550 game as pupils played a game which was developed by someone else with rules, goals, objectives, identities, a story line and assignments which could only be minimally influenced by the player/learner. The potential of *game creation* for educational purposes has yet to be addressed, thus, while it is just this which has taken the newly developed Games Atelier — which allows pupils to create and play their own games in their own urban environment via mobile phones, GPS and the Internet — one step further. Players-as-producers obviously emphasizes the more creative and constructive role of the learner and may therefore enhance learning effects and also trigger greater motivation on the part of pupils relative to the Frequency 1550 game, thus.

In conclusion the present research has shown a mobile game-based learning strategy to be highly effective when compare to a regular project-based instructional trajectory and highlighted promising new directions for future research along these lines.

ACKNOWLEDGMENTS

We would like to thank Gijs Determeijer, Josephine de Groot, Aske Hopman, Kristel Kerstens and Henk van Zeijts of the Waag Society Amsterdam for their help with this research. We would also like to thank Hein Butteling, Martin Rodermans and Mark Souwer who were the co-ordinators for the schools involved and Wim Aerns, Merwien Best, Neline Kuipers, Carlien Moeljono and Huibert Teekens who were the teachers in the schools involved.

CHAPTER 4

MOBILE GAME-BASED LEARNING AND STUDENTS' GAME ACTIVITIES

Insights into the relation between what students are doing during a game and the outcomes of playing a game are lacking because research on this topic is scarce. Therefore, in this study, students' game activities while they play the game No Credit, Game Over (NCGO) are described and related to their motivation to learn, perceived learning outcomes, and game performance. Moreover, effects of playing NCGO on students' self-reported motivation and learning outcomes are examined. In NCGO, students use their tablets to combine virtual information regarding debts with assigned tasks in urban spaces. Information was gathered from 181 students who completed questionnaires concerning their game activities, motivation to learn and learning outcomes. The data analysis showed that some game activities are related to motivation to learn, learning outcomes and team game performance. The extent to which the students were engaged with the game characters appeared be negatively related to perceived learning outcomes and motivation to learn.

1. INTRODUCTION

Mobile learning can be a promising way to improve students' learning achievements, school motivation and subject-matter interests (Furió, Juan, Seguí, & Vivó, 2015; Hsu & Ching, 2013; Shin, Sutherland, Norris & Soloway, 2012; Sung, Chang & Liu, 2016). Mobile learning in schools is mostly applied in environmental education or out-of-class schooling (Chiang et al., 2015). This type of mobile learning has been made possible by the addition of equipment to mobile devices, such as wireless network connections, cameras, RFID readers and GPS (Jeng, Wu, Haung, Tan, & Yang, 2010), which expand learning with games from the screen to learning in a mixed-reality environment by using urban spaces as a game board. These types of games are called mobile location-based games or urban games when they are played in an urban environment (De Souza e Silva & Hjorth, 2009).

Game-based learning, including learning with mobile games, can be beneficial for both students' learning outcomes and their motivation (e.g., Jabbar & Felicia, 2015; Wouters, Van Nimwegen, Van Oostendorp, & Van der Spek, 2013). Enabled by technological developments, mobile game-based learning is emerging, and it fits with students' personal worlds. However, much information remains to be discovered regarding the processes that play a role in mobile game-based learning (Iten & Petko, 2016). Insights into the relation between what students are doing during a game and the outcomes of playing a game are currently lacking because research on this topic is scarce. The present study is a case study that examines the activities of students while they play a game and how these activities relate to their motivation to learn, perceived learning outcomes, and game performance.

2. MOBILE GAME-BASED LEARNING

Mobile game-based learning can be different from traditional game-based learning if the game is being played on a handheld device and includes the environment outside the classroom. Studies on mobile game-based learning mostly focus on the usability of these games or on motivational and learning effects (Rubino, Barberis, Xhembulla, & Malnati, 2015; Squire & Jan, 2007; Klopfer & Squire, 2008). Wake (2013) stated there was a research gap between convictions that mobile games can facilitate learning and an understanding of the role these games have for learning and what their role in education is (Wake, 2013, p. 9). In his dissertation project, he developed, deployed and researched a mobile location-based game for teaching and learning history called *Premierløitnant Bielke.* He concluded that learning by playing mobile location-based games was a motivating and engaging way to learn. However, he also noted some constraints of current pedagogical practices, such as for instance working in class hours of 45 minutes and that a ten hour intervention is probably difficult to realize. Not many studies on location-based games go beyond the effects on learning or motivation and also investigate why students become motivated to learn or why these effects are lacking by examining the game process. Gurbibye, Wake, and Wasson (2014) studied what students do during game play of *Premierløitnant Bielke* and found that there is sometimes a contradiction in the educational game they researched. Winning the game was about using as little time as possible and resulting in that sometimes learning opportunities were missed as students would not take time to dwell and reflect upon historical surroundings. Ardito, Costabile, De Angeli, and Lanzilotti (2012) found a similar result. They examined students' game experiences with an emphasis on how students explored the mobile excursion game *Explore!*, integrated information from real and virtual sources and acquired knowledge on archaeology and life in Roman times. The game creates an augmented reality environment that is based on 3D models of places and objects and uses contextual sounds to enrich the physical environment. *Explore!* was designed to stimulate students' interest in archaeological sites and to facilitate history learning during site visits. The students explored the environment in small groups and needed to identify meaningful places in an archaeological site to solve the game's mission. Two second-year middle school classes played two versions of *Explore!*, one with contextual sounds and one without. In a between-subjects design, the authors reported positive experiences with both versions of the game, but unexpectedly, the 3D reconstructions of places and objects in their original state were often ignored by the students. The students explained that their first goal was to win, and due to time pressure, they skipped the 3D reconstructions, which decreased their opportunity to learn about the objects and places in their original state. So the desire to win the game can have negative effects on learning, but this does not necessarily have to be the case. For example, Admiraal, Huizenga, Akkerman, and Ten Dam (2011) studied the game process of *Frequency 1550*, a mobile city game concerning medieval

Amsterdam. In particular, they investigated the game activities of student teams and their effects on team game performance and student learning outcomes. The game was used in history classes and played by 216 secondary school students, most of whom were 13 years old. The game was played in groups of four students, who had to complete assigned tasks. Two students navigated the city by using a medieval map of the city and completed the assignments. The other two students stayed behind in a room with computers and searched for information, collected the completed assignment and guided the city students with the use of a contemporary city map that displayed the location of the city teams. The study showed that when the students were more engaged in competition, they learned more about the medieval history of Amsterdam. Furthermore, when the students were less distracted by solving technological problems, team performance was better, and they learned more. The other distractive activity, navigating, had a significant negative effect on team game performance.

Hwang and Chang (2015) had a more specific focus than Admiraal et al. (2011) and Ardito et al. (2012) and examined whether competition in mobile game-based learning mattered for learning. They designed a peer competition-based mobile learning system for conducting and learning from local cultural activities. In this system, there was a board game interface with a map where ‘each location on the map is associated with a real-world learning target with a set of relevant questions’ (p.4). During a field trip, two fifth-grade classes that used the mobile game-based learning system were compared: one class with peer competition and one class without competition. The students in the peer competition-based approach were more motivated to learn and had a more positive learning attitude and local cultural identity (valuing local culture) than the student group without competition.

3. THE CASE: THE GAME OF NO CREDIT, GAME OVER

The game that was examined in the current study is a serious urban game called ‘No Credit, Game Over’ (NCGO) and was created by the ‘[ew32]’ organization (http://www.ew32.be/about/about-ew32-english-version/). The game is designed to offer an interactive learning context about debt, and it is played in a city by using a tablet. The goal of the game is to decrease the amount of debt.

Secondary school students played the game in groups of two or three students (occasionally four). Each team was assigned a tablet in on this tablet information could be found about a specific character with a debt of €1,400. There were ten different characters, each with his/her own reasons for being in debt, such as frequently calling a boyfriend abroad or having a gambling addiction. To decrease their debt, the student teams needed to find ways to earn money and reduce expenses. They started the game by going into the city (in real life) to interview passers-by regarding their opinions of people in debt and advice to get out of debt and then went to visit organizations that could help. Organizations such as banks, job centres, unions and social organizations participated in the game. In every participating organization, one or more of the employees were informed that students may come to their organization. The organizations were indicated on a map on the tablet. The teams presented themselves with the name and background of their character. The teams also had to consider options to reduce their expenses while they walked through the city.

During the game, the game master offered the teams an additional option to change the amount of debt by calling one of the team members who pretended to be either a drug dealer or an employer. The drug dealer offered the teams a quick way to earn money by keeping a package in their apartment that contained soft drugs. The employer offered undeclared work with a higher wage than regular jobs. However, in both scenarios, the teams could get caught either with doing undeclared work or with possessing a drug package. If caught, the teams received a fine, which increased the debt. The actual score of a team was updated in real time and was accessible to the teams. The game was played in three stages; see Table 1.

Table 1. The three stages of the game No Credit, Game Over

Stage	Duration (minutes)	Description
Introduction	30	Introduction at the headquarters of the game
Play	120	Interview at the starting location in the city followed by visiting organizations and looking for options to save money
Debriefing	30	Discussing the scores and decisions at headquarters

The goal of the current study was to obtain insight concerning the relation between students' game activities in the NCGO mobile game and students' motivation to learn, perceived learning outcomes, and game performance. We also wanted to know if students' perceived learning outcomes and motivation to learn changed after playing the game. Accordingly, we formulated the following six research questions:

1) Do students' perceived knowledge of the subject of debt and perceived interest in the subject of debt change after playing the game?
2) Does students' character immersion explain the differences among students in their motivation to learn the subject of debt?
3) Do students' team game activities explain the differences among students in their motivation to learn the subject of debt?
4) Does students' character immersion explain the differences among students in their perceived learning outcomes?
5) Do students' team game activities explain the differences among students in their perceived learning outcomes?
6) Do students' team game activities explain the differences in team game performance?

4. METHOD

4.1 Participants

The participants were 181 students who played the game in the Flemish city of Oostende. The students (66 males, 115 females) varied in age from 15 to 22 years. Most students (169) were in the fifth to seventh grades from four schools of secondary education. The students played the game in teams (N=69 teams). The teachers of the students had signed their students up to play the game. Most of the teachers had their students play the game as a part of the secondary education subject PAV (Project Algemene Vaardigheden, literally translated: project general skills). This is an interdisciplinary subject/course that integrates learning contents of several subjects; financial literacy is one of the themes discussed in this context.

4.2 Procedures

The students completed a pre-game questionnaire when they entered the headquarters. The game was introduced by the game master, an employee of the organization. The students started the game by going to their appointed starting location in the city; then, they conducted an interview and worked on reducing their debt. Halfway through the game and at the end of it, each student team completed an online questionnaire regarding game activities as a team.

Immediately after the debriefing at headquarters, the students completed the post-game questionnaire.

A pilot study of the questionnaires was conducted with 24 secondary education students who had played the game approximately two weeks before. The information from this pilot study was used, along with the additional feedback of colleagues, to improve the questionnaires.

4.3 Students' game activities

Character immersion. Each student was assigned a character with a certain reason for being in debt. We wondered if during the game students would be immersed into the character and whether this would affect learning and motivation. Students' immersion with their character was measured by 7 items in the post-game questionnaire (e.g., 'I was able to imagine myself as my character well' and 'When playing the game, I felt like I was the character'). The items were answered on a four-point Likert scale with 1=*completely disagree* and 4=*completely agree*. The reliability in terms of Cronbach's alpha was .73, after 3 items were deleted and the Spearman-Brown correction for test length (to six items) was conducted. The mean score was 2.14 (*SD*=0.62, *N*=177).

4.4 Team game activities

Team game activities were measured during the playing of the game by an online questionnaire with nine 'activities' in which the students could be engaged (see Table 2 for an overview of the activities and their mean scores and standard deviations). We included activities that were part of the game, such as visiting organizations, as well as other activities, such as busy doing something other than the game. As students were supposed to work in teams and deliberate (with the rationale of being able to learn more this way), this was also an activity in the questionnaire. To see if students were engaged in competition we asked whether thy looked at the score. Each team of students rated on a five-point scale how often they had performed this activity in the past hour, with 1=*almost never* and 5=*almost the entire time*. The team game activities were measured at two moments. In general, there were no significant differences between the scores of the two time points, except for the activity '*We were looking to see whether we scored better than our fellow students*' ($t(64)=-3.68$; $p<.001$), which had a higher score at time 2. The mean scores of times 1 and 2 together were used in further analyses.

Table 2. Team game activities

Activity	Time 1 (*N*=65) Mean (*SD*)	Time 2 (*N*=69) Mean (*SD*)	Mean time 1 and 2 (*N*=69) Mean (*SD*)
We were busy thinking how to save money	3.76 (1.24)	3.87 (1.25)	3.80 (1.12)
We were imagining ourselves as our character	3.62 (1.21)	3.71 (1.29)	3.65 (1.18)
We were busy looking at the route	3.54 (1.31)	3.74 (1.27)	3.64 (1.22)
We were deliberating	4.68 (0.75)	4.56 (0.81)	4.62 (0.74)
We were looking up information on the internet	1.82 (1.21)	1.71 (1.18)	1.74 (1.08)
We were busy doing something other than the game	1.49 (0.94)	1.62 (1.03)	1.56 (0.86)
We had technical problems	1.91 (1.31)	1.86 (1.18)	1.90 (1.15)
We were looking to see whether we scored better than our fellow students	2.00 (1.38)	2.48 (1.52)	2.21 (1.31)
We were busy visiting organizations	3.91 (1.24)	3.88 (1.17)	3.89 (1.07)

4.5 Motivation to learn and perceived learning outcomes

Immediately before the start of the game and after the game, motivation to learn and perceived learning outcomes were measured by 15 questionnaire items. All items were answered on a four-point Likert scale with *1=completely disagree* and *4=completely agree*. After a principal component factor analysis with varimax rotation, three factors were extracted that explained 46% of the variance (rotated component matrix, included in the supplementary material). The reliability and descriptive statistics of these three factors are included in Table 3. Motivation to learn is operationalized as *interest in the subject of debt*. Perceived learning outcomes was originally operationalized as *knowledge about the subject of debt* and *conscious spending behaviour*. However, for the scale *conscious spending behaviour,* the alphas were unsatisfactory; therefore, this scale was excluded in further analyses, and perceived learning outcomes was operationalized only as *knowledge about the subject of debt.*

Table 3. Three factors regarding motivation and learning outcomes that were extracted from the factor analysis

Scale	No. of items	α pre	α post	Pre (*N*=180) Mean (*SD*)	Post (N=179) Mean (*SD*)	Example item
Interest in the subject of debt	5	.82	.85	2.80 (.65)	2.99 (.63)	I'm interested in the causes of debt
Knowledge about the subject of debt	3	.73	.77	2.23 (.67)	2.87 (.56)	I know which organizations can help me if I have debt
Conscious spending behaviour	6	.55	.57			I think hard before I borrow money

Note. The reported Cronbach's alphas are the alphas after the Spearman-Brown correction for test length to six items.

4.6 Team game performance

Each team started with a debt of €1,400 (a score of minus 1400). The goal was to get rid of the debt. During the game, the students had to send all of their choices (e.g., the job they chose, the options to save money and how much money this would be) to the game master. One group had to restart because of technical problems, and this score was not included in the analyses. At the end of the game, the average debt of the teams was increased to €1,665 (SD=€761); the highest score was a surplus of €273.59, and the lowest score was a debt of €3,062.68.

5. ANALYSES

To validate the self-reported data on game activities, the first author randomly chose a team of students to observe their game activities for each of the nine times that the game was played. The self-reported data from the students concerning their activities was mostly consistent with the researcher's observations, except for technical problems, which seemed to be over-represented in the self-reported data. This over-representation was caused by the students' broad interpretation of technical problems. They indicated having to switch between applications (for instance from the map to the character information) and not knowing what to find where as a technical problem.

To examine whether perceived knowledge of the subject of debt and perceived interest in the subject of debt changed after playing the game paired sample t-tests were performed.

To examine the relation between motivation to learn the subject and perceived learning outcomes (the dependent variables at the student level) and character immersion (the independent variable at the student level) as well as team game activities (the independent variables at the group level), multi-level regression analyses were performed. For each of the dependent variables, two models were calculated, namely, one variance component model and one model with the student game activities. The pretest score was a predictor.

For the relation between team game activities and team game performance, a multiple regression analysis was performed because all of these variables are at the group level.

6. RESULTS

Students' perceived learning outcomes and motivation to learn There was a significant difference between knowledge of the subject of debt before playing the game (M = 2.23; SD = 0.67) and after playing the game (M = 2.87; SD =0.56); t(178) = -13.55 , p = .000; 95% CI [-0.73,-0.55]. Students' knowledge of the subject of debt was higher after playing the game than before.

There was also a significant difference between interest in the subject of debt before playing the game (M = 2.79; SD = 0.64) and after playing the game (M = 2.98; SD =0.63); t(178) = -5.48 , p = .000; 95% CI [-0.26,-0.12]. Students' interest in the subject of debt had increased after playing the game.

Student game activities and interest in the subject of debt. The pretest and posttest scores of *interest in the subject of debt* were significantly positively related (see Table 4). The individual student scores on *character immersion* showed a significant negative relation to motivation: when the students individually identified more with their character, their interest in the subject of debt was lower. Finally, a significant negative relation was found to the team game activity *'We were busy doing something other than the game'*: when the students were more occupied doing something other than the game, they were less interested in the subject of debt.

Student game activities and knowledge about the subject of debt. The pretest and posttest scores were significantly positively related (see Table 4). The individual student score on *character immersion* was negatively related to the posttest score, which means that when the students identified more with their character, their score on self-reported knowledge about the subject was lower. Moreover, none of the team game activities were significantly related to the posttest scores concerning *knowledge about the subject of debt.*

Team game activities and team game performance. Team game performance was significantly related (α=0.05, N=68) to two team game activities, specifically visiting organizations (B= 329.43, *s.e.* 113.04) and looking at the route (B=-235.74, *s.e.* 95.09). When the teams visited organizations more and looked at the route less, team game performance was higher.

Table 4: Multilevel regression analysis with the dependent variables of interest in the subject of debt and subject knowledge

	Model 0 interest in the subject of debt	Model 1 interest in the subject of debt	Model 0 subject knowledge	Model 1 subject knowledge
	Variance components	Final	Variance components	Final
	N=179	*N*=167	*N*=179	*N*=167
	B (s.e.)	*B (s.e.)*	*B (s.e.)*	*B (s.e.)*
Fixed effects variables at the student level				
Pretest		**0.68** (0.05)		**0.34** (0.06)
Character immersion		**-0.18** (0.06)		**-0.17** (0.06)
Fixed effects variables at the team level				
We were busy thinking how to save money		0.06 (0.04)		0.08 (0.05)
We were imagining ourselves as our character		0.00 (0.04)		0.05 (0.05)
We were busy looking at the route		0.02 (0.04)		-0.03 (0.04
We were deliberating		0.03 (0.06)		-0.08 (0.06)
We were looking up information on the internet		0.03 (0.04)		0.03 (0.04)
We were busy doing something other than the game		**-0.09 (0.04)**		0.00 (0.05)
We had technical problems		0.06 (0.03)		0.02 (0.04)
We were looking to see whether we scored better than our fellow students		-0.00 (0.03)		0.05 (0.03)
We were busy visiting organizations		-0.07 (0.05)		0.02 (0.04)
Random effects				
Level 2 (group) $\sigma^2 u_{0j}$	0.00 (0.00)	0.00 (0.00)	0.09 (0.07)	0.00 (0.00)
Level 1 (student) $\sigma^2 e_{0ij}$	0.40 (0.04)	0.16 (0.01)	0.22 (0.07)	0.21 (0.02)
2*log likelihood	341.90	165.83	297.57	214.22

Note. N=number of students included in the model; 's.e.'=standard error. Significant fixed effects (with α=0.05) are printed in bold.

7. DISCUSSION

To provide insight into the relation between students' game activities and the game's outcomes, we examined whether students' character immersion and team game activities were related to motivation to learn, perceived learning outcomes and team game performance. Also, we wanted to know if after playing the game students' perceived learning outcomes and motivation to learn had changed.

Both the scores on perceived learning outcomes and on motivation to learn were higher after playing the game than before. We are not sure whether this is due to the game, as we do not have a control group. However, the time between pretest and posttest was only a few hours and not much more than the game has happened in these hours. It is also possible that students might have given socially desirable answers, but there were no clues for this when comparing observations with questionnaires.

For both perceived learning outcomes and motivation to learn, character immersion was a significant predictor but unexpectedly, a negative one. Considering the importance of roles and characters in game design and role-playing in game-based learning Dickey, 2007; Souter & Hitchens, 2016), this result merits further research.

For perceived learning outcomes, none of the team game activities were significantly related. Other researchers (Admiraal et al., 2011; Ardito et al., 2012; Hwang & Chang, 2015) have found relations between game activities during the game and learning outcomes, for instance for competition. Students' knowledge about debt was higher after playing the game, but it might be that in this game the students may have learned the most during the debriefing phase. This phase is understood as an important phase in game-based learning for student learning (Ardito et al., 2012). In the current study, game activities were measured only during the game. Maybe if the posttest had taken place before the debriefing relations with the game activities would have been different.

For motivation to learn, the only significant relation was to the team game activity 'W*e were busy doing something other than the game'*. This outcome does not raise questions, as it seems logical that students who are not interested in the subject of debt spend more time doing something other than a game about debt as students who are interested in debt. Two team game activities were related to team game performance, namely, visiting organizations and looking at the route. Visiting organizations was positively related to team performance, so a good way to get rid of the debt. We would have thought that probably being busy thinking how to save money might have this effect as well, but it did not. Maybe because the saving options reduce the debts by smaller amount than visiting organizations (finding a job makes a larger difference than saving on groceries) and also busy thinking about it does not necessarily mean that students were succeeding in saving. Looking at the route showed a negative relation to game performance. It might be that some students had trouble reading the map and took a lot of time traveling from one organization to another and as visiting organizations contributed to game performance, being able to visit less organizations due to looking at the route might be an explanation for why this activity negatively influenced team game performance.

7.1 Limitations and future research

Our study has shown that some student game activities in mobile location-based games are related to game outcomes. In our study, we measured team game activities by surveying students through an online questionnaire on a tablet that students shared. One possible route for future research is to measure students' game activities in more detail and at an individual level. In this way, more varied insight into student activities can be established. Measuring these activities in more detail may be accomplished by using GPS logs, for example, to examine exactly which organizations students visit and when. With detailed insight into students' game activities at individual and group levels, we expect to find more relations between game activities and game outcomes.

CHAPTER 5

STUDENT LEARNING BY CREATING LOCATION-BASED GAMES IN SECONDARY EDUCATION

Handheld location-based games can be used to engage students by connecting virtual worlds with real life, thereby situating learning in students' immediate environments. Two secondary school teachers worked with a game creation platform in which 74 students (8th-graders) created and played educational mobile games. Students collaborated in small groups of two to four students. We conducted a descriptive case study and closely followed the teaching-learning process to determine whether creating and playing games affected students' motivation for learning and their subject-related knowledge. In interviews, students reported that they learned to create a game and that they enjoyed creating the game, but creating the game did not seem to improve their subject-related knowledge. Students who created their own games in small groups had higher scores on perceived learning outcomes and motivation for learning than did students who contributed to the creation of a collaborative game for their class.

1. INTRODUCTION

One of the causes of low student motivation in schools is the incongruity between students' school environments and their personal worlds, which involve more peer interaction and the use of new media (Shaffer, 2008; Thoonen, Sleegers, Peetsma, & Oort, 2011; Van der Veen & Peetsma, 2009). The use of games in education might help to enhance students' motivation by making learning more enjoyable (cf. Charsky & Ressler, 2011; Klopfer, Osterweil, Groff, & Haas, 2009). Games have the potential to not only motivate students but also support student learning because they have been found to promote students' active learning (Gee, 2014; Shaffer, 2006; Wideman et al., 2007). Several studies on students *creating* games demonstrate that creating games may have additional benefits over playing games for learning and motivation (e.g. Kafai, 1996; Vos, Van der Meijden, & Denessen, 2011). Therefore the present research examined students who create games rather than students playing the game. Little is known about how students create games as part of their regular subject classes and how they experience this process. We followed two teachers whose students learned by creating games to understand how teachers adopt this approach in practice and whether this method of teaching affects students' classroom motivation and their perceived learning outcomes.

1.1 Game-based learning

Interest in using games for education is increasing, in part, because of their assumed effects on learning and motivation. Empirical evidence for the effects of games on learning and motivation can be found in several reviews (Connolly, Boyle, MacArthur, Hainey, & Boyle, 2012; Girard, Ecalle, & Magnan, 2013; Perrotta, Featherstone, Aston, & Houghton, 2013; Sitzmann, 2011; Tobias, Fletcher, Dai, & Wind, 2011; Vandercruysse, Vandewaetere, & Clarebout, 2012). Wouters, van Nimwegen, Van Oostendorp, and Van der Spek (2013) performed a meta-analysis of 39 studies comparing serious games with regular instruction methods and found that serious games were more effective in terms of learning and retention. Serious games were also associated with higher motivation, but this effect was not significant. Learners playing serious games acquired more knowledge and cognitive skills when they worked in groups, when multiple training sessions were involved, and when games were supplemented with other instructional methods. Wouters and Van Oostendorp (2013) showed that the effect of instructional support was largest for cognitive knowledge and skills and when instructional support was used for the cognitive process of selecting relevant new information. Wouters and Van Oostendorp also classified instructional support based on categories of support. They found that reflection, modeling, collaboration, modality, feedback, and personalization all affected learning positively, but other categories support (e.g., advice) did not have statistically significant effects on learning. Reflection is described as stimulation to think about answers and/or explain these answers; modeling involves describing how a problem is solved; collaboration involves discussion, often with the aim of explicating implicit knowledge; modality is the use of the audio channel to limit visual search; feedback involves information about whether and/or why an answer is correct; and personalization involves adapting a context to the personal interests of the player (Wouters & Van Oostendorp, 2013, p.414). The literature we have reviewed thus far demonstrates that game-based learning can improve students' learning and motivation, sometimes more than teaching without games (e.g., Arici, 2008; Papastergiou, 2009).

A specific type of games are location based-mobile games. These games can be played in real-world locations, which may include historical or geographical sites, and virtual data can be added to these locations or to real-world contexts (Klopfer & Squire, 2008). In their study on the location-based mobile game Frequency 1550, which focuses on the history of medieval Amsterdam, Huizenga, Admiraal, Akkerman, and Ten Dam (2009) evaluated the effectiveness of this method of learning. Compared to students who participated in regular lessons, students who played Frequency 1550 learned significantly more about medieval Amsterdam. Although positive effects were found with playing games in other studies on mobile game-based learning as well (e.g. Ardito, Costabile, De Angeli, & Lanzilotti, 2012; Hwang & Chang, 2015), we agree with Lim that "it is only when students are empowered to take charge of their own learning by co-designing their learning experiences with teachers and other students that they are more likely to engage in their own learning process" (Lim, 2008, pp. 1002–1003).

2. GAME CREATION

Several studies on game creation demonstrate that creating games may have additional benefits over playing games. Kafai (1996), for example, showed that by designing games, students not only learned *to design* games but also learned *about the design* of games "and reached a level of reflection that went beyond traditional learning and thinking" (p. 94). Games (2010) also showed that students can learn about game design by creating games, including learning how to analyze game designs and how to articulate their own versions of design problems and solutions. Creating games and other media might help students to increase their understanding of media and to become critical participants in and designers of games (Peppler & Kafai, 2007).

In their study, Robertson and Howells (2008) used game creation as a powerful learning environment and analyzed the learning that took place during game creation with respect to the themes outlined in "A Curriculum for Excellence". They found that students became successful learners based on their display of the following aspects of successful learning identified in the curriculum: "motivation and enthusiasm for learning; determination to reach a high standard of achievement; and skills in independent learning, learning in a group, and linking and applying learning in new situations" (Robertson & Howells, 2008, pp. 567–568). Robertson and Howells also noted the cross-curricular potential of game creation, which can be implemented in a wide curriculum through an interdisciplinary approach that incorporates subjects such as creative writing, drama, and design. Greenhill, Pykett, and Rudd (2008) demonstrated that students not only acquired scientific concepts by creating games but also developed their digital literacy and engagement in a scientific design process of creating scientific microgames. While creating these games, the students went through a cycle of designing, testing, refining and completing the design of the microgame. In the process of creating these scientific microgames, the students were "scientists" in the sense that they observed a situation, developed hypotheses, identified and manipulated variables, observed outcomes and evaluated their understanding. Furthermore, students enjoyed creating the microgames. Key factors that seem to lie at the source of this engagement were students' authorship (they could create their own content) and ownership (the locus of control was transferred from the teacher to the student) as well as playful learning (the students enjoyed playing in the environment and liked to see what would happen while creating games) and the social value of the game. Good games were widely played and attracted the attention of other students for the author (Greenhill et al., 2008). Khalili, Sheridan, Williams, Clark, and Stegman (2011) also found that by creating, students developed a sense of ownership of their game and a responsibility to make the game aesthetically pleasing, engaging, and scientifically accurate. Furthermore, the students learned to question their own knowledge and to articulate their knowledge (Khalili et al., 2011). Therefore, it seems that creating games, like playing games, might have a positive influence on students' motivation as well as their learning outcomes.

Vos et al. (2011) compared playing games with constructing games and found that students were more motivated and used higher-level cognitive strategies when constructing games than when playing games. These authors compared playing and creating games as well as creating games and teaching without games. According to the teachers in the study by Owston, Wideman, Ronda, and Brown (2009), students who learned from game creation showed greater engagement than they would have showed if the teachers had not used games in their teaching. The students' understanding that classmates would play their games and the ability to play their classmates' games increased the students' motivation and desire to complete the task (Owston et al., 2009).

Wake and Wasson (2011) researched the creation of mobile location-based games by students to learn history. Students learned about local history through creating games and gained additional knowledge by playing games created by another group. Wake and Wasson are convinced that learning by creating mobile location-based games is a motivating and rich way to learn and a promising approach that should be studied further.

In summary, both playing and creating games can be powerful tools for promoting students' learning and motivation for learning. However, these studies did not examine how teachers use game creation in their regular classes. In most studies, researchers have implemented games and sometimes even taught with these games. This approach might bias the findings of these studies in a positive way. Therefore, in our study, we examine how two teachers begin using game creation in four secondary school classes. Using a game creation platform, students can play and create a mobile location-based game. Our research questions are as follows:

1) How do teachers use game creation in their teaching practice?
2) Does creating games affect students' classroom motivation and their perceived learning outcomes?

3. METHOD

3.1 Participants

Two teachers from a school that was a partner in a former game project piloted game creation and invited the researchers to monitor and evaluate their teaching practice. The other participants were 74 eighth-grade students (35 male, 39 female) from four classes in a school for pre-vocational secondary education in a large city in the Netherlands. The students, who were 13–15 years old, created games on the subject of Care (33 students) or Physics-Chemistry (41 students) during their Computer Science classes. In the Netherlands, Care is a subject based on the traditional subjects of home economics and health education and includes topics such as relationships, the environment, leisure activities, and volunteer work (Volman & Ten Dam, 2007). Physics-Chemistry is a subject that combines the two subjects of physics and chemistry.

Two Computer Science teachers provided instruction in two classes each. One teacher had some experience using the game creation platform (see next paragraph), and the other did not. They wanted to use new media to make the educational experience fit the students' real-life experience by trying 7scenes in class. They wanted the students to collaborate while creating games because this would encourage students to explicate their thoughts by talking to each other about the assignments they created. In this process, students needed to share information with each other. The students were required to create the assignments on paper before working on the computer because the teachers wanted the students to focus on thinking about the assignments.

3.2 The platform used for creating games

The teachers used a platform called 7scenes (http://7scenes.com), developed by Waag Society (https://www.waag.org/en). Students created games in a simple template (see Table 1 for the templates) into which details about the game were inserted and rules were set. They created assignments and simply dragged tasks and media onto a Google map. When the students finished their game, it could be published for others to play.

Table 1. Templates of 7scenes

Secret Trail/Free Play (simplest template)	Collect & Trade	Adventure (most complex template)
A discovery route on which various spots in the environment are visited by following hints and completing assignments that pop up on the mobile phone. In a secret trail, the order of assignments is set; in free play not.	The players have a mission to collect a specific combination of objects hidden in the environment. Players can trade objects with each other.	Set-up is a role-playing game in which teams receive certain identity characteristics at the start of the game. These characteristics determine their power and skills in the game. Various assignments for different identities are placed at certain locations.

The game platform consisted of a web-based environment and location-based phone applications (see Figure 1). Students could use the 7scenes web-based environment on their computers to create location-based games that could then be played on smart phones with a 7scenes application, GPS, and an internet connection. When playing a game, students could see where they and other players were on the map via colored dots that depicted their positions. The GPS triggered assignments to pop up when the player reached the location where the creator of the game had placed these assignments on the map. After playing the game, the students or their teacher could use a review tool (on the desktop) with a playback option to see their scores, the route that they walked, and their completed assignments. During gameplay, the game provided feedback on whether an answer was correct. The students who created the game could assign hints to be provided when the player chose an incorrect answer.

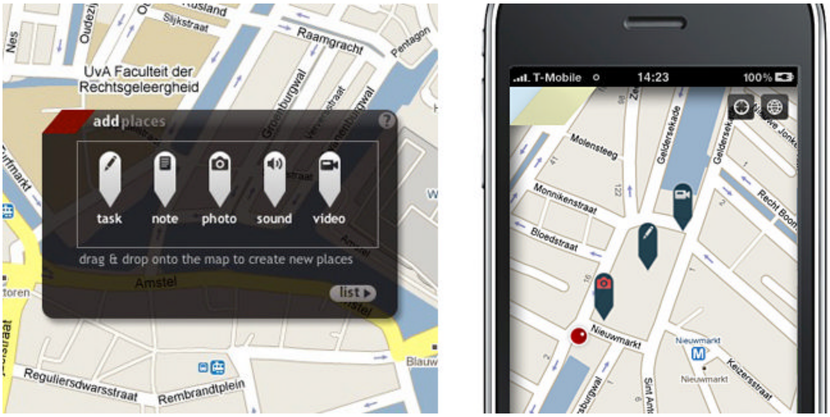

Figure 1. Map of 7scenes platform as shown on the computer (left) at the development stage when the places are entered and on a mobile phone (right) at the final stage as a playable game (source http://7scenes.com).

3.3 Procedure

We observed the lessons from the first lesson, in which the students received the assignment, to the last lesson, in which they played the games that had been created. In total, 12–14 lessons of 50 minutes were observed. The teachers were free to choose how they would approach working with the platform. Our observation focused on how the platform was used in practice and students' motivation for learning.

3.4 Measurements

For this descriptive study, a mixed-methods research design was used. All lessons were videotaped, observation notes were taken, and the games that were created were saved with screenshots. Students were asked to answer questions about their background (e.g., their age) prior to the project and to complete a questionnaire at the end of the project measuring three topics: their perceived learning outcomes of the lessons, their motivation for learning, and their attitudes toward schoolwork collaboration with their peers. The questionnaire included 28 statements that could be answered on a five-point Likert type scale, with "1" indicating "does not apply at all" and "5" indicating "applies completely". All of the statements on perceived learning and motivation for learning had to be answered twice. In the first half, the statements referred to the lessons in which students created and played a game; in the second half, students answered the same statements with reference to the school period before the project. In this way, we were able to compare students' motivation and learning experiences between game creation and regular teaching. To prevent a sequence effect, half of the students answered the statements in reverse order. More information on the scales of the questionnaire can be found in Table 2. To compute the reliability for scales with five items, we used Spearman-Brown's correction for test length (lengthened to six items).

Table 2. Questionnaire on learning, motivation, and collaboration

Scale	No. of items	α *	Example statement
Perceived learning outcomes of lessons with 7scenes	6	0.74	I felt the lessons with 7 scenes were useless
Motivation for the lessons with 7scenes	5	0.83	I liked 7scenes
Perceived learning outcomes of lessons in this past school year	6	0.82	I felt the lessons this past school year were useless
Motivation for lessons in this past school year	5	0.76	I liked school this past school year
Attitudes toward collaboration with peers	6	0.75	I prefer to work alone

* *Alpha after Spearman Brown's correction for test length.*

Students worked in groups of two to four students, with 11 groups in the two Care classes and 17 groups in the two Physics-Chemistry classes. One student from each group was randomly selected for a short interview (max. 15 minutes) about his/her experience with creating and playing games. In the interview, we asked the students about their motivation and perceived learning, such as, "What did you like or not like about the project?" and "Why?" The topics of the interview were the attractiveness of working with 7scenes, ease of use, technical issues, the time needed for creating games, the integration of subject matter in the game, perceived learning and collaboration. In total, 27 students from the 28 groups were interviewed because one group (from a Care class) could not be reached before the summer break.

Both teachers were also interviewed regarding the extent to which they liked working with 7scenes, why they began using 7scenes, and their opinions about their students' learning and motivation during the project.

4. ANALYSES

The first research question, about how teachers use the platform for creating games in practice, was answered by summarizing the observation notes and teacher interviews. Videotapes were used as backup for the researchers' field notes. The second research question, about whether creating games affects students' classroom motivation and perceived learning outcomes, was answered by analyzing the questionnaire and the interview data. Descriptive statistics were used for the questionnaire data. Differences between the students' perceptions of learning with 7scenes and school learning in general were tested with a paired-sampled t-test ($\alpha = 0.05$). The interviews were transcribed. Each question was directly related to a topic, and these topics were used to summarize the interviews, so each question topic received a code (e.g., answers to the question about whether it was easy or difficult to place assignments were coded “ease of use”). Finally, screenshots of the games were used to check whether the assignments were about the subjects involved and whether they were related to the physical environment because one would expect a relationship in location-based games between the assignments and the environment.

5. RESULTS

Both teachers had the same main set-up for the lessons. The teachers wanted their students to create and play an educational game about part of their curriculum (either Care or Physics-Chemistry). They wanted their students to work on their knowledge in an appealing way.

The teachers grouped the students into small subgroups based on the underlying idea that the students should match socially. The teachers stated that the students had to create the assignments about the subject on paper before working on the computers.

5.1 Implementation of game creation in the lessons

In the Care classes, the students focused on the theme of love. In the Physics-Chemistry classes, the subject matter was organized around subthemes related to the subject, including traffic, movement, sound, electricity, weather, temperature, light, and shadow. Students could choose one of these subthemes, but they could also choose to focus on the subtheme of collaboration, which is a general school theme at their school.

The first two or three lessons were used to introduce students to game design and to play a small mobile game created with 7scenes as an example. In the remaining lessons, the students worked on the assignments in the teacher’s presence. The teacher monitored the groups of students to observe what they were working on and asked questions. In addition to the lessons dedicated to working in small groups, the students spent one morning testing their games and playing a game created by another group. At the end of that morning, in two classes (one Care and the other Physics-Chemistry), the games were briefly reviewed using the playback option of the review tool in the platform. In the other classes, the teachers decided to skip the review of the game sessions because of the high temperatures in the classroom.

One important difference was identified in the way the teachers worked with the platform. In the Care classes, each group of students created their own game, whereas in the Physics-Chemistry classes, each group of students chose a theme and worked on a set of assignments to create one overall class game. Thus, in this collaborative game, all themes were represented. In each Physics-Chemistry class, one group acted as a coordination group and did not work on a theme. Instead, the group coordinated the assignments of the other groups and, together with the teacher, added these assignments in 7scenes. Because this difference in approach (as well as the differences between the subjects and teachers) might lead to different student experiences, we present the results as two separate cases.

5.2 Case 1: each student group creates a game

The following results are related to the two classes in which each student group created a game on the subject matter of Care.

5.2.1 Evaluation of the implementation

Most students (seven out of the ten interviewed) indicated in their interviews that the software was quite easy to use and that they could easily add text and pictures to the game template. Of the students who thought it was difficult to work with the software, one had a hard time deciding where to place the assignments, and another did not initially know how to place the assignments. Regarding the game play, four students found working with the game phone to be difficult, mostly because adding media worked differently than on their own smartphones.

Six students thought that playing a small game before they began creating their game helped them to create their game in 7scenes and to play others' games. The example game helped them to understand what a game should look like, what the player was supposed to do in a game, and how the game phone worked. The students liked collaborating with their peers because they were able to generate and share more ideas and because doing so involved less work. They also reported that collaborating was more fun than working alone. The quantitative data show that students agreed with the statement that they enjoyed collaborating (mean = 3.99, sd = 0.72). All but one of the students who were interviewed liked having to work on paper before using a computer. The students explained that this approach helped them to focus on thinking about the assignments, and it was easy to show to the teacher what they had produced.

In choosing locations, the students searched for assignment locations that were close to their starting locations. In general, the students did not actually select locations on the basis of their relevance to the subject matter. Six students attempted to incorporate the subject matter into their assignments by asking questions about what they learned in their Care classes; some of these students (re)read their Care textbook to facilitate this process. Eleven games were created. The screenshots show that the games were all related to the theme of love, such as assignments about romantic things to do, homosexuality, and loverboys (boys that seduce girls, with presents and attention, to prostitute herself for him), but not all of the games were related to the material on Care. For example, there was a game with the goal of winning the love of Sandy, a female character in the Spongebob Squarepants cartoon series, by answering questions about her. These assignments, like most assignments in the games, seemed to be unrelated to the location and could have been used in a game anywhere. The few assignments that involved location were mostly not about the theme of love but were about non-relevant facts, such as the number of busses passing by or the date of a slavery monument in a park.

The teacher of these two classes was involved in the development of 7scenes and had previously worked with the software. He argued that there was no time available in class to reflect on the issues raised in the games. The teacher also did not believe that the review tool in 7scenes sufficiently stimulated reflection because the information was not arranged by assignment. Therefore, the tool was not helpful in discussing specific assignments. The students in the class in which the teacher had used the review tool liked it because they were curious about their scores and enjoyed seeing everyone's pictures and the routes that they walked. The teacher reported a desire to work with 7scenes again in closer cooperation with the subject-matter teacher in order to better integrate the subject matter into the game that students created.

5.2.2 Motivation and learning

Except for one student who did not like computers and games, all of the students stated that they would like to work with 7scenes again for other school subjects. They thought that learning for school by using 7scenes was fun. The observation notes show that the students particularly enjoyed being allowed to determine the subject and the assignments, to place the assignments on the map and to collaborate with each other. They asked several times if they were completely free to make these decisions.

Six students reported in the interviews that creating the game taught them how to create a game, use the 7scenes software, use a map, and collaborate with other students. Furthermore, they said that they learned more about the theme of love. Three students explicitly stated that they had learned more by using 7scenes than in regular lessons because it was a more active way of learning. However, four students indicated that they did not learn anything by creating games.

Five students felt that creating a game could be more effective for promoting learning than playing a game. The students who elaborated upon their answers explained that when creating a game, they had to search for information to create a question for each assignment. However, four students reported that playing a game could be more effective than creating a game. One student elaborated that when he played someone else's game, he was asked questions to which he did not know the answers.

The mixed results from the interviews are confirmed by the t-test (Table 3). No significant differences (with $\alpha = 0.05$) in reported motivation or perceived learning were found between the game lessons and the regular lessons.

According to the teacher, the students learned how to use the technology. Moreover, the teacher reported that students spent a substantial amount of time on the theme of love, with fruitful discussions. The students were somewhat demotivated because they expected a game resembling the commercial computer games they played at home. However, after this initial disappointment, the students worked hard and for long periods of time on their games, and most of them enjoyed illustrating their games with pictures.

Table 3. T-test of perceived learning outcomes and motivation for the past school year versus the 7scenes lessons for students creating individual games

Scale	Past year	Scale	7scenes	*t*	*p*
Perceived learning outcomes	3.72 (0.91)	Perceived learning outcomes	3.42 (0.85)	1.34	1.90
Motivation for the lessons	3.42 (0.85)	Motivation for the lessons	3.72 (0.88)	0.57	0.58

Note. df = 32 for both analyses. Standard deviations appear in parentheses below means.

5.3 Case 2: student groups create a collaborative game

The following results are related to the two classes in which the student groups worked collaboratively on one class game on the subject matter of Physics-Chemistry.

5.3.1 Evaluation of the implementation

With the exception of the students of the coordination group, the students barely used the 7scenes tool. Students were allowed to place a few assignments in the 7scenes environment, mostly with the help of the teacher and the coordination group. All of the interviewed students felt that it was not difficult to place the assignments in 7scenes. Some students reported difficulties with the game environment and the map in particular (while playing the game, not everything in the park was shown on the map, or it was not clear which dot represented their group).

The screenshots show that in one class, all of the assignments were about the subthemes (in the other class, two assignments were not), although not always in the way the teacher intended. The subtheme of traffic, for example, was meant to include issues related to Physics-Chemistry, such as velocity and acceleration. However, the students created assignments on traffic rules and traffic signs. Compared to the Care classes, most assignments in the Physics-Chemistry classes seemed to be more closely related to the location, such as the temperature of a pond in the shade and in the sun.

In general, the students reported that they had sufficient time to create their assignments. Two of them mentioned they could have successfully created their assignments with less time, but two other students felt that they needed more time to complete the assignments properly. The teacher mentioned that it was helpful to play the example game first because she could subsequently refer to that experience.

5.3.2 Motivation and learning

Of the 17 students who were interviewed, eight reported that they would like to work with the platform again for another subject. The reasons they mentioned for wanting to work with the platform again were that they liked working with it and thought it was instructive or a combination of these two reasons. They noted that they particularly enjoyed the creative part of the game creation (inventing the assignments and, for the coordination group, inventing the story). Other positive effects that were mentioned by more than one student included being outside, working on computers, and collaborating with peers. Six students reported that they did not want to use 7scenes for other subjects because they did not think the game would be useful for other school subjects. Three students did not know whether they wanted to use the game for other subjects.

Of the 17 students interviewed, ten mentioned that they learned from creating the game. They acquired knowledge of temperature (becoming aware that they could measure water temperature and learning how to do so), traffic signs, and information and communication technology (becoming aware that they could create a location-based game, learning how to do so and learning that these games work with a satellite). They also reported that they acquired general skills, such as working together and listening to each other. Seven students reported that they did not learn anything.

Most students indicated that creating a game was more instructive than playing one. During the creation process, the students had to search for information to design a specific assignment.

All of the interviewed students thought that playing the short example game was helpful and that it clarified their goals. For several students, playing the example game also helped because it allowed them to learn how the game phone worked. In these classes, all of the students but one enjoyed collaborating. The students provided different reasons for enjoying the collaboration: working together was perceived as more pleasant, less work, faster, more informative, or better for creating assignments. The quantitative data show a mean of 3.73 (sd=0.79) for the question of how much students enjoyed collaborating.

The quantitative data do not confirm the positive results from the interviews regarding perceived learning and motivation. Table 4 shows that the students perceived that they learned less during this lesson series by creating and playing games than they did during regular lessons. We found similar results for students' school motivation.

Table 4. T-test of perceived learning outcomes and motivation for the past school year versus the 7scenes lessons for students creating a collaborative game

Scale	Past year M (sd)	Scale	7scenes M (sd)	t	p
Perceived learning outcomes of lessons past school year	3.49 (0.86)	Perceived learning outcomes of lessons with 7scenes	2.96 (0.80)	4.08	<0.001
Motivation for lessons in the past school year	3.37 (0.74)	Motivation for the lessons with 7scenes	2.99 (0.97)	2.62	0.01

Note. df = 40 for both analyses. Standard deviations appear in parentheses below means.

The teacher of the Physics-Chemistry classes had no previous experience with the 7scenes platform. She had to become familiar with the platform by using in class, which made it difficult for her to follow her students and support their learning process. Nevertheless, she reported a desire to use the platform again with more training. She noted that most of the students liked the project, although some were demotivated by spending too much time working at the computer or on paper. She reported that her students learned that location-based games could be easily made, but the students did not learn much about the subject-related themes on which they were supposed to base the assignments. In discussing the assignments, the teacher primarily taught the students how to phrase their assignments, and there was little discussion of the subject matter. When using the platform in the future, the teacher noted that she would more clearly indicate the subject matter the students needed to use and that she would monitor the process of game creation more strictly.

We tested differences in perceived learning and motivation between the two different approaches of working with the platform. The students who created a game in a small group with 7scenes felt that they learned more than the students who created a collaborative game with 7scenes ($t(72) = 2.38$; $p = .02$). The students who used the small group approach scored higher on motivation as well, as indicated by the significantly different means between the groups ($t(72) = 3.46$; $p = .001$).

6. CONCLUSIONS AND DISCUSSION

6.1 Implementation

Our first research question asked how teachers use a platform for creating games in educational practice. The platform was used in two ways: 1) each group of students created their own game, and 2) groups of students worked toward the creation of one collaborative game. In both approaches, collaboration was considered important, and the teachers asked their students to work on paper before working on their computers. Moreover, in both approaches, a small example game was used and was perceived as helpful. Games were created in 12–14 lessons, but the teachers suggested that the games could have been created in a shorter amount of time.

6.2 Motivation and learning

Our second research question asked whether using a platform for creating games affected students' school motivation and perceived learning outcomes. Most students and both teachers reported positive experience working with 7scenes. The students liked the creative aspects of creating a game, including developing a story, creating assignments, and thinking about where to place these assignments on the map. The students positively evaluated the collaboration with other students on the assignments. The software was easy to use; most students liked working with it and expressed that they would like to use it for other school subjects. However, analyses of the quantitative data did not show positive effects for students' motivation or perceived learning of subject knowledge, especially for the students who created a collaborative game. This lack of a positive effect differs from the findings of other studies about game creation (e.g., Greenhill et al., 2008; Vos et al., 2011). Another difference is that Greenhill et al. (2008) found evidence that students' attitudes toward the subject (in this case, Physics) improved through the creation of the microgames, and Vos et al. (2011) found that students showed higher intrinsic motivation when creating games than when playing games. In our study, the results regarding motivation were less positive. The significantly lower motivation of the students who created a collaborative game might have been caused by contributing to a collaborative game instead of creating a game of their own. Greenhill et al. (2008) showed that authorship and ownership are important elements for promoting engagement. However, the students who contributed to the creation of a collaborative game also had a different teacher and focused on a different subject. Thus, it may be difficult to determine whether the students lacked motivation because of the different approach or because of other factors. The subject might have played a role in how well assignments were aligned with the physical environment. The selected park is a romantic spot and thus is an appropriate setting for a game on the theme of love, but in the Care classes, very few assignments were explicitly connected to this physical location. Most assignments could be completed anywhere. The Physics-Chemistry classes were different because there were more assignments tied to a specific location, such as a question about an electricity pole.

The students in the classes that created a collaborative game were less motivated and perceived that they learned more during their regular lessons preceding the project than during the project itself. For the students who created a game of their own, there were no significant differences regarding motivation and perceived learning between the game creation project and the regular lessons. However, among the students who were interviewed, approximately 40% of the students in both approaches felt that they had not learned anything from creating the game. The students may not have recognized what they had learned as learning because students sometimes believe that learning is only what is tested in class, as illustrated by the students who explained that they had not learned anything because they were previously tested on this school subject. Students may not have experienced talking about loverboys and homosexuality as learning about the subject, whereas the teacher felt that these were discussions with an important pedagogical goal. We did not obtain statements from the students on this issue, and our information from the interviews was less informative than we had hoped. The students easily answered the closed questions of the interview, but they had trouble answering the follow-up questions. They often answered "I don't know" when asked to explain their answers.

The majority of the students who were interviewed thought that creating games was more informative than playing them because they had to search for information in the former situation. However, several students almost exclusively used information that they already knew, thereby missing the opportunity to learn new information. Wouters and Van Oostendorp (2013) showed that the largest increase in learning occurred when students learned cognitive skills or knowledge and when the instructional support aimed to select relevant new information. In the process of creating games, the students might have needed more instructional support from the teacher in selecting new information for the assignments. When the students played the game, the only feedback provided was whether the answer was correct. More elaborative feedback might have helped the students learn by playing the game. In addition, approximately half of the students did not incorporate the subject matter into their assignments, and sometimes the assignments seemed completely unrelated to the subject. The students may have needed more guidance from their teachers to relate their games to the subject matter in the way the teacher intended. The literature shows that the role of the teacher is important in game-based learning to facilitate the game-based learning process and to create opportunities for reflection (Williamson, 2007; Robertson & Howells, 2008; Solomou & Vrasidas, 2008; Owston et al., 2009; Hämälainen & Oksanen, 2014). The teachers did not have time to reflect on the activities with the students, and one teacher felt that the review tool of the software was not useful. An lack of sufficient opportunities for students to reflect on their learning experiences may be detrimental to students' learning (Rieber, 2005). Teachers need to explicitly state what has been learned, and they need to mediate the learning process to ensure that the learning goals are integrated into the learning process (Brom, Šisler, & Slavík, 2010; Ulicsak, 2010).

ACKNOWLEDGEMENTS

We thank the students and teachers for their participation in this research.

CHAPTER 6

TEACHERS' PRACTICE-BASED PERCEPTIONS OF THE VALUE OF GAME-BASED LEARNING IN SECONDARY EDUCATION[1]

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, Owston, Brown, Kushniruk, Ho, & Pitts, 2007). Recent reviews seem to confirm this potential of digital games for supporting 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, De Grove, De Smet, Van Looy, Soetaert, & Valcke, 2013; Proctor & Marks, 2013; Sandford, Ulicksak, 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

[1] This chapter was published in a slightly adapted form as: Huizenga, J.C.; Admiraal, W.F.; Voogt, J.M., & Ten Dam, G.T.M. (2017). Teacher perceptions of the value of game-based learning in secondary education. *Computers & Education, 110, 105-115.* https://doi.org/10.1016/j.compedu.2017.03.008

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 for using 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. 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 a goal, an objective to achieve;
- game activity, which refers to the fact that the game is an activity, a process, an event; the player is doing something;
- game rules, which means that there are some rules that need to be followed, a game is rule-based;
- outcome which refers to a numerical score and particular game actions result in gaining or losing, for example, points or virtual money;
- conflict or competition 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' evaluations 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 et al., 1999; Ettekhoven & Hooiveld, 2010; Omrod, 2011; Pressley & 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, Van Nimwegen, Van Oostendorp, and Van der Spek (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 et al., 2009) as potential outcomes of game-based learning. 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 microgames (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 their own knowledge and to articulate their 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, De Grove, Smet, Van Looy, Soetaert, & Valcke, 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 implement games 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 how teachers value teaching with games show that the main reason teachers report for using digital games in their class is student motivation to learn (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, Kearny, & 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 frame 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 experience.

3. PROBLEM 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 Focus of this study

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 teachers) 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 educational goals of the teachers pertained to relating theory to practice, experiencing theory, visualization, increasing awareness, gaining insight, ensuring involvement, and 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 of 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.

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

Subject/domain (number of teachers)	Games used[1] (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][2] (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)

[1] 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.

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 specific 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 (κ = 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.

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 (κ =

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.

Table 2: Exemplary 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 (…).
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. But 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 (…).

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 in 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 mention 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:

> "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 of 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 Bizzgames 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 the one 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 student 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 will be 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 motivational aspect 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:

- 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.
- 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.

- 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.
- 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 ask questions to their students, and vice versa, which –according to the teachers- contributed to learning.

We will first 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 will 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. 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, a teacher 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 students the opportunity to discover these processes them-

[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.

selves. 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* fits 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 have 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 for 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 do not mention the benefits of game creation beyond that of learning programming (Greenhill, Pykett & Rudd, 2008; Khalili et al., 2011), however the teachers do mention that creating games can be used very well for practicing collaborative skills.

Fewer teachers mentioned motivation to learn and the acquisition of general skills, collaborative skills in particular as an effect of playing or creating games. 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 confirm teachers' perceptions of the value of teaching with games in 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., Authors, 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, i.e., 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 student learning: students received feedback on their actions, the games made processes visual, and students' active learning.

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 et al. (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. Second, 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 the 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 & Oksamen, 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.

APPENDIX

Games that the teachers used, with a brief description and URL for more information.

Game	Short description of the games	URL for the game or for more information about the game
3D Game Studio	An authoring system for interactive 2D and 3D applications	http://www.3dgamestudio.com
7scenes	An online platform to create location-based games and tours	http://scenes.com/
Aandelenmarktspel [Stock Market Game]	A stock market game; a flow of news updates influences the prices	http://www.aandelenmarktspel.nl
Alice	A 3D programming environment that makes it easy to create animation	http://www.alice.org
Bizzgames Production Company	A computer simulation game in which you own and operate a production company	http://www.bizzgames.com
Bizzgames Handel & Wandel [Bizzgames Trade & Walk]	A game in which you own a hot dog cart at a Saturday market	http://bizzgames.nl/clients-view/client-1/
Bollen Schieten [Shooting Spheres]	An online game in which the player shoots an arrow (with the correct slope) through the spheres in a grid	http://www.fisme.science.uu.nl/toepassingen/00065/
Cellcraft	An online game in which players build a cell, fight off viruses, survive harsh worlds, and ultimately save the platypus species	http://www.kongregate.com/games/cellcraft/cellcraft
Check Out	An online ESL game in which players are immersed in a native world where all written and spoken text is exclusively in English	http://www.ranj.com/content/werk/check-out#.VD1SlPlm9fw
Civ IV	A computer game in which the player constructs a civilization, with several modifications available	http://www.2kgames.com/civ4/
Derivative Puzzle	An online puzzle game in which the player needs to place the graph of the corresponding derivative below each graph	http://www.univie.ac.at/moe/tests/diff1/ablerkennen.html
DNA the Double Helix	An online game in which the player makes exact copies of a double-stranded DNA molecule and identifies the organism to which it be-	http://www.nobelprize.org/educational/medicine/dna_double_helix/dnahelix.html

	longs	
Dr O'Too	An online puzzle game in which the player must try to form the correct molecule with the given properties as quickly as possible	http://www.appdata.com/apps/facebook/329958953052-dr-o-too-city-of-chemistry
Embargo	An online game in which the players are reporters and practice reading comprehension by playing	http://www.ranj.com/content/werk/embargo#.VD1SBflm9fw
Enterprise	An entrepreneurship game in which the player operates his/her own business	http://www.ranj.com/content/werk/enterprise-the-game#.VD05Cvlm9fw
Francogrid	A French free-community grid comparable to Second Life	http://francogrid.org/
Gamemaker	A program for creating games	https://www.yoyogames.com/studio
Greenfoot	Software to learn Java programming by creating simple games	http://www.greenfoot.org
Immune Attack	An online game in which the player navigates a nanobot through a 3D environment of blood vessels and connective tissue to save a patient	http://immuneattack.org/
Later is nu [Later is now]	An online game about career orientation in which the player learns more about a career by completing assignments and reflecting on them	http://www.stichtingpraktijkleren.nl/actueel/item/bericht/doorlopende-leerlijnen/
Markt Voor Vrede [Market For Peace]	A fictitious online stock market matched with debate on conflict areas; this game has been replaced with the game Uexchange	http://www.marktvoorvrede.nl
Math Expert Lite	An iPad app; a calculation game with speed and concentration challenges	http://www.appster.org/app/ab-math-expert-lite-speed-and-concentration-challenge-425920600
Math Kid	An iPad app; a math game for kids	https://itunes.apple.com/nl/app/math-kid/id465213584?mt=8
Mighty mutation maker	A website that turns your name into DNA	the game website no longer exists
Minecraft	A 3D sandbox construction game in which players build creative structures, creations, and artwork by placing and breaking various types of blocks	http://minecraftedu.com/
Miniconomy	An online game in 8 languages in which players can trade with other players and create other careers	http://www.miniconomy.com
Motion Math HD	An iPad app game with a storyline about a fallen star that must return to its place; during the game, fractions appear	http://motionmathgames.com/
Mscape	A mobile media gaming platform to create location-based games (platform discontinued)	http://www.mscape.com/
Nintendo Math Trainer	A Nintendo-based game with educational activities (flashcards) for addition, subtraction, multiplication and division	http://www.personaltrainermath.com/
On The Ground Reporter	An online game with interactive quests in which players are sent as	http://www.butchandsundance.nl/work

	reporters on a mission to countries to return with a good story	
Penguin Math	An iPad app in which players lead their penguin through Antarctica by answering math questions correctly	https://itunes.apple.com/us/app/penguin-mathematics/id452948750?mt=8
Plaza Challenge	A massive multiplayer online management game in which players own and run one or more stores in a mall	http://www.plazachallenge.nl
Poverty Is Not a Game	An online game exploring poverty in which the main character becomes homeless because of certain circumstances	http://www.povertyisnotagame.com/?lang=en
Power Up	A 3D action strategy game exploring renewable energy and challenging teens to help save the planet	http://www.tryscience.com
ProSim Advanced	A modular simulation in which students act as the managers of trading companies (in English, German and Dutch)	http://www.businessgameshop.co.uk/business-games
Race the Cell	An online game exploring gene transcription, including RNA synthesis	The game website no longer exists, but a similar game is available at http://www.biomanbio.com/GamesandLabs/LifeChemgames/Protsynth.html
Railroad Tycoon	A computer simulation game in which players build and operate their own railroad company	http://en.wikipedia.org/wiki/Railroad_Tycoon
Scholenstrijd [School Battle]	A competition with a stock market game for economics, including teaching materials	http://www.scholenstrijd.nl/
Scratch	A program for creating games	http://scratch.mit.edu
Second Life	A free 3D virtual world in which users can socialize, connect and create using free voice and text chat	http://secondlife.com
SimCity	A computer simulation game in which players build and operate their own cities	http://www.simcity.com
SimCity3000	An older version of the SimCity computer simulation game in which players build and operate their own cities	https://en.wikipedia.org/wiki/SimCity_3000
Sims3 in de klas [Sims3 in the Classroom]	A Sims 3 game adapted by Codename Future in which the player tries to create an ideal sustainable world (only in Dutch)	http://sims.codenamefuture.nl/index.html
SplitsZ	An educational game on online citizenship (media literacy)	http://waag.org/en/project/splitsz
Stop Disasters	A disaster simulator in which players learn how to prevent disasters	http://www.stopdisastersgame.org
Terraclues	A Google Maps scavenger hunt game/puzzle with the objective of finding locations on a world map by solving a set of clues	http://www.terraclues.com

The Great Flu	An online game in which players follow the outbreak of a flu pandemic and obtain the means to control it by making decisions	http://www.thegreatflu.com/
The Planning The Game	A location-based game where the player tries to capture land by discovering hidden facts about the development of Haarlemmermeer	http://www.deplanningthegame.nl/indexEnglish.html
Third World Farmer	An online game exploring rural poverty in developing nations	http://3rdworldfarmer.com/
Villa Elektra	A computer simulation game in which a player becomes an electrician and must rebuild a villa	http://www.learninggames.nl/page/485/villa-elektra.html
Waterbusters	A home water conservation game in which players help find ways for the main character to save water, money and the environment	http://www2.seattle.gov/util/waterbusters/
Wereldhandelsspel [Global Trade Game]	An online game in which the player is a government officer and makes policy decisions regarding world trade	http://www.wereldhandelsspel.org/
Wettenstrijd [Battle of the Laws]	An online game on legislation processes in which players explore how it feels to be a member of the European Parliament	http://www.xmediapublish.nl/wettenstrijd/?lang=en

CHAPTER 7

SUMMARY AND DISCUSSION

Digital game-based learning in secondary education

With digital games becoming available to the larger public, teachers and researchers are focusing their attention on the potential of digital games for education. A decade ago the expectations of games in education for student motivation and learning were high; however, rigorous research supporting the claims was lacking (Mishra & Foster, 2007). In light of the expected value of using games for education, I examine the potential of digital game-based learning (DGBL) for engagement, motivation to learn and (perceived) learning. My main research question is 'How do digital games contribute to learning, engagement and motivation to learn?' I conducted five studies to contribute to the existing research on DGBL and to provide insights into its benefits for secondary education.

1. SUMMARY OF THE FINDINGS

In this section, I summarise the main findings of the five studies reported in this dissertation. The research questions for these five studies were as follows:

1) How does existing literature describe the effects of DGBL on students' engagement in the game, motivation for the subject and learning outcomes?
2) What are the motivational and learning effects of DGBL?
3) Do students' game activities explain the differences in students' motivation for learning, perceived learning outcomes and game performance?
4) How do teachers use game creation in their teaching practice, and does creating games affect students' classroom motivation and their perceived learning outcomes?
5) 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?

1.1 Study 1: Review of DGBL literature

The study described in Chapter Two reviewed a decade's worth (1999–2009) of empirical research into learning and motivational effects of DGBL and described the claims regarding motivation and learning. In this systematic review of the literature, 46 studies were selected. Of these studies, I analysed the claims made by authors regarding engagement in game-play, motivation for the content of the game and the school subject, and learning factual knowledge and cognitive and metacognitive skills. Eighty-one of the 93 claims made in these studies were grounded in the design, analysis and results and discussed in this article. In general, the claims that DGBL is engaging have been proven, and students are engaged by using games. However, the results regarding motivation are more ambiguous: games seem to motivate students for the content or school subject, but not more than other ways of learning. Claims about learning are usually positive, but when game-based learning was compared with other educational interventions only for factual knowledge, students learned more with game-based learning. Regarding cognitive skills, students did not always learn more than with other educational interventions and in one case even less. For metacognitive skills, there were two claims: (1) students learned metacognitive skills, but (2) not more than the control group. In conclusion, while games are engaging, motivating and enable learning, compared to other types of educational interventions, the effects are only higher with regard to engagement and learning factual knowledge.

1.2 Study 2: The game Frequency 1550

Chapter Three investigated the effects of playing a mobile city game called Frequency 1550. I examined pupil engagement in the game, historical knowledge and motivation for History, particularly for the Middle Ages. A quasi-experimental design was used to compare students playing the mobile history game Frequency 1550 with students receiving regular project-based lesson series. Of 458 students involved in this study, 232 were in the experimental group and 226 were in the control group. The results showed that pupils who played the game were engaged and gained significantly more knowledge about medieval Amsterdam than pupils who received regular project-based instruction. No significant differences were found between the two groups with respect to motivation for History or the Middle Ages. In conclusion, while the game Frequency 1550 did not lead to students being more motivated for History or the Middle Ages, students playing the game were engaged and learned more about history than students in regular project based lessons, which could be attributed to the activities students enjoyed while playing the game.

1.3 Study 3: The game No Credit, Game Over

Research into the relation between what students are doing while they play a game and the outcomes of playing a game is scarce. Therefore, in the study described in Chapter Four, the effects of playing a mobile city game called No Credit Game Over (NCGO) were investigated looking at students' game activities. I related the students' game activities while they play the game NCGO to their motivation to learn, perceived learning outcomes, and game performance to see whether differences in these outcomes could be explained by the students' game activities. In NCGO, students used their tablets to combine virtual information regarding debts with assigned tasks in urban spaces. Information was gathered from 181 students who played the game and completed questionnaires concerning their game activities, motivation for learning and learning outcomes. Some variables were measured on an individual level and others on a group level (due to students sharing a tablet). The results showed that some game activities relate to motivation for learning, learning outcomes and team game performance. These are the game activities: character immersion (students' immersion into the character of the game), doing something other than the game, visiting organisations and looking at the route. Doing something other than the game had negative effects on motivation for learning. Character immersion not only had a negative effect on motivation for learning, but also on (perceived) learning, while visiting organisations and looking at the route had positive effects on team game performance. Further research is needed to explain these effects.

1.4 Study 4: Creating games

Using games to attain engagement, motivation to learn and learning outcomes can be done not only by playing games, but also by creating games, maybe even more fruitfully, because students need to actively use their knowledge to create a game for others, and they need to reflect on their knowledge and apply it to new situations. I investigated how teachers use game creation in their teaching practices and whether creating games affects students' classroom motivation and their perceived learning outcomes. This study is described in Chapter Five. Two secondary school teachers worked with a game creation platform for 12–14 lessons. Seventy-four students (8th-graders) created and played educational mobile location-based games, and the students collaborated in small groups of two to four students. The students reported that they learned to create a game and that they enjoyed creating the game. However, creating the game did not seem to improve their perceived learning of subject-related knowledge or motivation to learn. Students who created games in small groups had higher scores on perceived learning outcomes and motivation for learning than did students who contributed to the creation of a collaborative game for their class. The students might have needed more guidance from their teachers to profit from creating games because they seemed to have problems relating the games to the subject matter.

1.5 Study 5: Teacher perceptions

Teachers' perceptions of the usefulness of digital games might be a reason for the limited application of digital games in education. The study in Chapter Six examined the perceptions of teachers. I interviewed teachers, who incorporate digital games into their classroom teaching, to find out their perceptions toward students engagement with the games, motivation for learning and learning outcomes. Semi-structured interviews were conducted with 43 secondary education teachers. The perceived effects were analysed focusing on engagement, motivation to learn and learning outcomes. Almost every teacher reported that DGBL engaged their students, students were willing to invest time in playing or creating games and that they enjoyed doing it. Most teachers also reported that DGBL influenced students' learning in various subjects. However, what the students learned according to the teachers 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. A few teachers observed positive effects on students' motivation to learn, more when students were playing the game than with students creating games. Competition seemed to have a positive role when students played games.

The aim of this dissertation is to provide an insight into how digital games contribute to learning, engagement and motivation to learn. The findings from the test results and teacher observations in the five studies indicate that DGBL can be beneficial for student's (perceived) learning because students are engaged when they play and create games. However, the results on motivation to learn are more ambiguous. In the next sections, I reflect on the outcomes and methodological issues and make some suggestions for future DGBL research.

2. CONCLUSIONS AND REFLECTIONS ON OUTCOMES

2.1 Elements of game-based learning

In each of the individual studies, I saw the potential of DGBL for learning, engagement and (to a smaller extent) motivation to learn. But what elements of the digital games contributed to these outcomes? Each of the five studies provided some clues about the important elements of DGBL for engagement, motivation to learn and (perceived) learning outcomes. In this section, I examine which elements of the five studies that foster motivation to learn and (perceived) learning outcomes are found in more than one of each study. Some elements are internal, such as the element of *competition*, *cooperation/collaboration* (used interchangeably here), *usability*, an *authentic context* and *feedback*, and others are external such as the *role of the teacher* and the *ability of students*.

2.1.1 Competition

The definition of games presented in the introduction to this dissertation included the internal element of competition: 'organized play, involving one or more players, with goals, constraints, rules, interaction, challenges, pay-offs and their consequences, and aspects of competition (with another player or oneself). A narrative, story or fantasy elements are involved and the game should provide enjoyment and pleasure' (p. 2). The five studies herein showed that the element of competition plays a role in engagement and sometimes in motivation to learn. Study 1 (review) showed that competition was important for engagement, and in Study 5 (interviews with teachers), the teachers mentioned competition as an important element for engagement and for motivation to learn. Additionally, some teachers in this study (Study 5) mentioned that when competition was not present, the students missed it and looked for ways to compete. Habgood (2007) also mentioned that students look for ways to compete in the absence of competition in the game. He added that this is mostly in the beginning of the game, when students have similar game scores (Habgood, 2007), which might relate to the idea that challenges should be achievable.

Study 5 (interviews with teachers) also showed that, from a teachers' perspective, competition was more important in playing games than in creating games. The results of my studies regarding the role of competition in motivation to learn seem to be inconclusive. Teachers mentioned competition as an important element for motivation to learn, but in the game No Credit, Game Over, the competitive element of students watching other students' scores did not affect their motivation to learn.

Existing literature contains extensive discussions on the role of competition. Vandercruysse et al. (2013) and Boyle et al. (2016) stated that research on competition in games is inconclusive regarding the effects on learning outcomes and motivation. Boyle et al. (2016) found mixed support for whether competition contributed to learning. Cagiltay, Ozcelik, and Oczelik (2015) hypothesised that it might matter who students are competing against. Vandercruysse et al. (2013) had their students compete against a virtual character and found that competition was not significantly related to student's learning gains and only partly related to students' motivation. By contrast, in their study in which students competed against each other, Cagiltay et al. (2015) found competition to be positively related to motivation and post-test scores on learning database concepts. Whether competition contributes to learning also seems depend on whether the competition is between individuals or teams. In their meta-analysis, Clark et al. (2016) 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. Thus, competition could be considered positive when it is between groups of students rather than individuals. Our studies echoed this finding; however, in the studies described in this dissertation, competition was not mentioned in these studies as an important element for learning. Nevertheless, in the game Frequency 1550, competition does play a role in learning. The results of playing this game are not only described in this dissertation, but also in Admiraal, Huizenga, Akkerman and Ten Dam (2011), who showed that the more students were engaged in group competition while playing the game Frequency 1550, the more they learned about the medieval history of Amsterdam.

2.1.2 Cooperation/collaboration

As mentioned in the above discussion about competition, teachers can have students work together while playing or creating games. In creating games using the platform 7scenes (Study 4), the students mentioned that they liked the collaborative element. In the other two field studies (Studies 2 and 3), this collaborative element was not explicitly studied. The study of Trespalacios, Chamberlin, and Gallagher (2011) showed that middle school students prefer to play multiplayer games for several reasons (in order of importance): being able to play with friends, collaborating to reach the goal, competing and because it provides more challenging situations.

My field research for this dissertation showed that teachers or designers of the game deliberately had students cooperate. For example, Frequency 1550 and NCGO are designed to have students collaborate while playing the game, and teachers in the interviews (Study 5) mentioned deliberately having their students cooperate and that they considered collaborative skills as a learning outcome. The teachers of 7scenes (Study 4) wanted students to work together to create games so that the students would have to explicate their thoughts. Van der Meij, Albers and Leemkuil (2011) mentioned articulation and argumentation in a study on collaboration; however, while students did not learn from collaborating during gameplay, they did learn from discussing their answers on the test together.

In Study 1, I found that the studies of Ke (Ke & Grabowski, 2007; Ke 2008a, 2008c) considered cooperative learning an important element that contributes to motivation for math through DGLB. Students in a cooperative game-playing condition were more motivated for math than students in a competitive or individualistic game-playing condition. Wouters et al.'s (2013) meta-analysis also showed that playing games in a group was the most effective condition for learning. They stated that this might be because some learning activities such as the articulation of knowledge are not automatically addressed by learning games and that playing in a group might be an effective way to foster these additional learning activities (Wouters et al., 2013). As could be seen in Van der Meij et al.'s (2011) study, collaborating during gameplay does not always invoke learning. We agree with Wouters et al. (2013) that more research is needed on the guidelines for cooperation and to understand the most effective group size.

2.1.3 Authentic context

In the studies in this dissertation, several aspects relate to an authentic context for learning; that is, students are either performing authentic tasks or studying in the real world, an authentic environment. The pedagogical approach that situates learning tasks in the context of real-world situations, providing opportunities for learning by encountering the same problem-solving challenges as in daily life, is called authentic learning (Herrington, Reeves, & Oliver, 2014). Examples of students doing tasks in the real world are Frequency 1550 (Study 2) and NCGO (Study 3). Students learned about medieval Amsterdam (Study 2) while walking through the authentic city centre with historic buildings, and they learned about debt (Study 3) by visiting organisations that play a role when someone is in debt. Study 3 faced students with a problem they could encounter in daily life and is in line with what Herrington et al. (2014) called authentic learning.. The designers of the game NCGO chose to have students visit real organisations in the game with the aim of lowering the threshold to enter these organisations if needed (when in debt) later in life. Learning in an authentic context in the sense of an authentic environment, as we saw with Frequency 1550 and NCGO, was made possible by the portability of mobile location-based games and their possibility to add an extra layer to the environment by connecting assignments to the players' location in an authentic environment (Avouris & Yiannoutsou, 2012; Wake, 2014). This link with the environment seemed to be missing in many of the games students created in the study about creating games (Study 4). The students created games that could have been played without the element of portability and context sensitivity and hence did not use the strength of learning with mobile location-based games. This might be one reason students failed to learn much, but more research is needed to see if this is a suitable explanation.

The review (Study 1) showed that in game making, authorship and ownership of the game, involvement in real research and development and making games for a particular group were important characteristics for engagement. These game characteristics make creating games a more positive experience than regular school assignments; students feel they are doing something authentic because the game they create will be played by other students. Prater (2016) showed in her dissertation that creating a game for a real audience made many students feel like an actual game designer or programmer. In Study 4 on creating games, the aspect of authorship and ownership was important. Students appreciated the creative aspect of the game because they were able to decide on the subject, what assignments to create and where to place them on the map as they would in real life, without consulting the teacher.

The teachers mentioned the importance of an authentic context, such as starting their own company, with regard to motivation to learn (Study 5) because students started to realise the value of the theory in practice. Therefore, by playing the game, students realised that what they had learned in school was meaningful if they wanted to start their own companies. They learned this without the real-life risks of having a company (learning in a safe environment).

2.1.4 Usability

Aspects of games such as quick progress, ease of use, amount of technological problems and the reading of instructions can be captured under the name usability, which is a term used in the software industry referring to delivering a user experience with as few unnecessary interruptions or challenges as possible (Latinen, 2015). The review (Study 1) showed that quick progress in the game and easiness of the game are important for engagement. Study 1 also showed that engagement is negatively influenced by technological problems and by having to read instructions; these are also reasons teachers mentioned for disengagement (Study 5). In Frequency 1550, students located in the headquarters were more engaged than those in the city, which is likely because they had fewer technological problems, or because they had to spend less time waiting and they had many different tasks and more overview over the tasks in the game. All these aspects might have contributed to this higher engagement.

2.1.5 Feedback

Many definitions of games include the element of feedback. It is also implicitly included in our definition under ‘pay-offs and their consequences’, which provide players with feedback about their actions. The teachers stated in their interviews (Study 5) that direct feedback from the game helped students realise the consequences of their actions and thus contributed to learning. The role of feedback is also mentioned in the review study (Study 1) and in other review studies such as that by Jabbar and Felicia (2015), which mentioned scaffolding as an important element for gameplay and learning and that 'feedback and many forms of support tools are inherent to DGBL, as users are on their own and need support to achieve their goals' (Jabbar & Felicia, 2015, p. 766). Wouters and Van Oostendorp (2013) also mentioned in their meta-analysis that feedback improved learning. Johnson, Baily, and Van Buskirk (2017) also reviewed the role of feedback on learning. They originally set out to research the role of feedback on learning *and* motivation; however, they were unable to find enough empirical evidence about how feedback affects motivation and thus focused solely on learning. Overall, process (explanatory) feedback tended to be more beneficial than outcome (corrective) feedback. Johnson et al. (2017) also looked at modality (visual or auditory), timing (immediate or delayed) and adaptation to individual differences. However, the results were inconclusive because the studies in the review had widely varied domains and types of games and there were limited studies available, but there was a trend towards immediate feedback. Johnson et al. (2017) advocated a value-added approach to understand the relationship between feedback and learner characteristics and advised that future research should focus on long-term retention and transfer.

Feedback can also be provided by the game itself, as in Frequency 1550 (Study 2) where students knew instantly whether their answers were right or wrong, but it can also be provided by the teacher. The next section examines the role of the teacher.

2.1.6 The role of the teacher

External elements also influence learning, motivation to learn and engagement. The review (Study 1) and interviews with teachers (Study 5) on their practice-based perceptions of the effects of games showed an important role of the teacher in DGBL, for learning outcomes and engagement. Teachers facilitate and coach students, give feedback, teach skills that are necessary to play the game and guide conversations. The importance of the teacher's role could be observed in our study on creating games (Study 4). In Frequency 1550 and NCGO (Studies 2 and 3, respectively), the game master assumed the role of the teacher as a facilitator of student reflection. The importance of the role of the teacher (or someone taking this role, such as a game master) is addressed in many other studies as well (e.g. Gabriel, 2016; Hämälainen & Oksanen, 2014; Marklund & Taylor, 2016; Owston et al., 2009; Prater, 2016). In his dissertation, Wood (2011) concluded that participants gain little in cognitive ability outcomes without the guidance of a teacher providing reflection and collaboration (Wood, 2011, p. 177). Marklund's (2013) dissertation also pointed out the important role of the teacher. The teacher should connect the gameplay to the subject matter, encourage reflections and direct the debriefing sessions. This is an important requirement of the teachers because games do not always automatically teach players what they need to learn for school; thus, teachers can help guide the learning process of students towards the intended specific educational goals.

2.1.7 *Ability of students*

A student characteristic that was mentioned several times in all five studies was the student's ability. The role of ability was mentioned mostly for learning; however, the results regarding what that role exactly are inconsistent. In our review (Study 1), Banerjee, Cole, Duflo, and Linden (2007) showed that the learning of the weaker students improved the most, whereas Greenhill et al. (2008) claimed that the moderate students learned the most. Additionally, in our study using Frequency 1550, the students with a higher educational level learned the most, even though the intention of the game was to provide an effective tool mainly for students from a lower educational level. However, when looking specifically at the students' history of ability, those with an initial low level gained the most in knowledge.

2.2 Concluding remarks

The five studies have shown that using games in education can be beneficial for learning, engagement and, to a lesser extent, motivation to learn. The overall research question was 'How do digital games contribute to learning, engagement and motivation to learn?' Using games in the lessons can be a way of fitting into students' personal worlds by using new media and peer interaction. Game play can make students more willing to put effort into what they have to do for school and help them to learn. The five studies presented in this dissertation show that several internal and external game elements might contribute to the benefits of games for learning, engagement and motivation to learn: competition, collaboration, an authentic context, usability, feedback, the role of the teacher and ability of the student. More research is needed to find out how these elements exactly influence learning, engagement and motivation to learn and interact with each other.

3. REFLECTIONS ON MY RESEARCH APPROACH IN THE EVOLVING FIELD OF DGBL AND FUTURE DIRECTIONS

In this section, I discuss the strengths and limitations of the study in light of the developing field of DGBL-research and provide future research suggestions.

3.1 Combination of methods and perspectives

This dissertation used quantitative and qualitative methods. Each method has its advantages and disadvantages, and using several methods helps to obtain a clear picture of the field. The quantitative data were obtained through objective test scores, questionnaire scores on perceptions and some data from the game (e.g. scores), while the qualitative data were obtained by interviewing teachers and students. As these studies were short-term studies without any follow-ups, future DGBL research should conduct longitudinal and follow-up studies (recommended by All et al., 2016) to examine the long-term effects of DGBL and rule out that the possibility of novelty effects (temporary effects due to something new being introduced, which wear off once the novel intervention is no longer novel). Additionally, the tests should be designed to match what the students learn via DGBL because traditional tests might not always capture what is being learned.

As well as combining methods, we studied DGBL from several perspectives: the perspectives of teachers and students, and students playing and creating games. The perspective of the game designer would also have been worth investigating (for instance looking at what the designer intended to bring about by creating the game) and might be a direction for future research.

3.2 The growing field of DGBL research

Because the field of DGBL is a rapidly growing field, this might raise questions about whether the results of my research are still valid, especially because my review relates to research published in 1999–2009. However, looking at more recent research, for instance the reviews of Clark et al. (2016), Jabbar and Felicia (2015) and Wouters et al. (2013), the research results on engagement, motivation for learning and learning resemble those found in this review. While the results remain somewhat ambiguous, overall, the use of games can be beneficial for learning, engagement and, to a lesser extent, motivation to learn. Boyle et al. (2016) updated Connolly, Boyle, MacArthur, Hainey, & Boyle's (2012) review about the positive impacts and outcomes of computer games. The updated review shows that little has changed regarding whether games positively influence learning and behavioural outcomes. They also found that games are still used mostly to support knowledge acquisition. However, there were some changes in the field. Progress has been made in understanding how specific game features such as competition engage players and support learning, and the understanding of features that make games more engaging has progressed in the sense that more precise definitions of constructs such as flow and engagement have been proposed and measures have been developed to differentiate more between these constructs (Boyle et al., 2016).

When I look back at my review and other reviews that have appeared in the meantime, the strength of my method of reviewing lies in systematically checking the minimum quality of the studies included and looking at the groundedness of the conclusions, which I did to include new research not published in peer reviewed journals and to subject all articles (peer reviewed or not) to the same analysis. Even in peer reviewed journals, some of the conclusions were not grounded in the design or results of the studies. I think it is important when writing reviews to scrutinise articles for groundedness and to not only look at conclusions, even when only using peer reviewed articles.

3.3 Moving beyond effects

Much research focuses on the effects of DGBL, which was important when little data was available on the effects and empirical studies on DGBL were needed. The effects of DBL were also something I focused on when starting this dissertation project. As the body of research on DGBL is growing, I suggest looking not only at the effects, but also at the process of using the game and examining what happens when students play or create games to establish why certain effects occur. All, Castellar and Van Looy (2016) recommended evaluating the process of the game intervention itself, using a naturalistic design with observational data collection for determining what makes a DGBL intervention effective. Evaluating the process of the game intervention aims at understanding the underlying mechanisms that might contribute to the effects that were found. I also emphasise the importance of collecting process data. For example, in Study 4, I observed teachers and students in their process of creating games for learning to see what they did. While the questionnaire data in this study showed that students did not perceive to have learned, observations of the students and the games they created showed that this might be because the game creation assignments were not related to their learning content. Nevertheless, the students had fruitful discussions in the process of creating games, which their teachers interpreted as student learning. It might be that the students' definition of learning is more limited than that of the teachers. I recommend that future research focuses not only on the effects of gaming, but also includes data collection on the process of gaming to establish what students and teachers do and think while a game is being played or created. By doing so, researchers can look beyond whether games work, and look at how they work, why they work, for what content, in what context and for whom.

4. PRACTICAL IMPLICATIONS

In this section, I discuss the practical implications of the results of the research in this dissertation. I address implications for teacher preparation and what should be done to facilitate game use in curricular contexts.

4.1 Teacher preparation

The use of games in secondary education is lagging behind the interest in games. This research highlighted the importance of the teacher in DGBL because they need to decide what games they can use practically (e.g. whether it fits in the schedule and whether the infrastructure is appropriate) and educationally (e.g. what goals need to be reached, whether it fits in the curriculum), they need to guide the gaming process and help with more technical questions (Marklund & Taylor, 2016). Teachers need to match technology, pedagogy and content knowledge (Koehler & Mishra, 2008; Mishra & Foster, 2007, 2009). The European Schoolnet report on how digital games are used in schools (Felicia, 2009) mentioned that the majority of teachers willing to incorporate games lack the knowledge and skills to do this successfully. Teachers do not feel prepared for using games in education (Verheul & Koops, 2013), which teachers in our interviews also mentioned. This problem is broader than the use of games: teachers do not feel prepared to effectively use ICT in their classroom (Tondeur, Pareja Roblin, Van Braak, Voogt, & Prestridge, 2016); therefore, it is expected that they will have problems effectively using games in the classroom. An important practical implication is that teacher education should prepare student teachers for using ICT and teaching with games and educate teachers how to match technology, pedagogy and content knowledge. The pedagogical use of ICT is not modelled enough for pre-service teachers. Therefore, prospective teachers need good role models to use ICT and games in education (Martinovic & Zhang, 2012; Tondeur, Van Braak, Voogt, Fisser, & Ottenbreit-Leftwich, 2012). Prospective teachers need to know how to use games in education and understand the characteristics of effective games. They also need to know how to find good games, which is a problem (Van Eck, 2015). In subject teaching, prospective teachers should be taught how to find good games for the subject, how to create games that fit their curriculum (Vallet et al., 2014) or alter existing games, either by changing the game or by adding information to the game. When finding and creating good games, teachers should carefully consider the elements that are present in a game, such as competition and authentic context, and check whether these elements contribute to engagement, motivation to learn and (perceived) outcomes.

Prospective teachers should be taught what the demands for game-based learning are, how to decide if using a game the best tool for their learning objectives and learners, what game to choose and whether the infrastructure is sufficient. They should then plan their didactic approach, communicate about the use of game and reflect on their role in DGBL. Prospective teachers should also have the opportunity to practice drafting lessons around digital games, using games in an authentic setting and receiving feedback on these actions (Gabriel, 2016; Tondeur et al., 2012).

4.2 Game use in curricular contexts

As mentioned earlier in this thesis, digital games are not always suitable for use in curricular contexts. Wake (2013) concluded in his dissertation that technology 'should align with existing technological practices and institutional constraints to be successful' (Wake, 2013, p. 105). Several things can be done to stimulate the use of games in the curriculum, and game designers should consider the curricular context and the goals that need to be reached when creating educational games for secondary education.

For teachers, there are also ways to facilitate the use of games in a curricular context. Often games take more time than the lessons that are dedicated for a certain subject. By working in an interdisciplinary manner, teachers can create time for playing games beyond the scheduled hours of the teachers' subject. As most games address more than one subject, they offer opportunities to learn beyond a specific subject. Therefore, if games are not used to teach one specific subject, but to teach more thematically, teachers will be able to create more opportunities to use games. Another opportunity to deal with the restrictions of class hours is having students play (partly) at home and use class time for debriefing sessions.

5. FINAL REMARKS

This dissertation has shown that DGBL has the potential for improving (perceived) learning outcomes, engagement and (to a lesser extent) motivation for learning. For learning and engagement, the results were more positive than for motivation for learning. Many elements play a role in DGBL: competition, collaboration, an authentic context, usability, feedback, the role of the teacher and ability of the student. Mobile location based-games enable on-site learning and can make it possible to place the learning in and authentic environment. While it was difficult to locate teachers who currently use games in the classroom, there is much to be gained by preparing teachers to incorporate games into their teaching. However, considerable research is still needed to investigate the conditions in which games work best for whom and how student activities relate to the benefits of game. So: to the next level of DGBL-research.

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SAMENVATTING

DIGITAL GAME-BASED LEARNING IN HET VOORTGEZET ONDERWIJS

Games zijn toegankelijk geworden voor het grote publiek en de potentie van digitale games voor educatie heeft de aandacht getrokken van zowel leraren als onderzoekers. Een decennium geleden waren de verwachtingen in het onderwijs hoog als het gaat om de inzet van games voor motivatie en leren. Gedegen onderzoek om deze verwachtingen te onderbouwen ontbrak grotendeels (Mishra & Foster, 2007). Gezien de verwachtingen van de waarde van het gebruik van spellen voor onderwijsdoeleinden was ik geïnteresseerd in de potentie van digital game-based learning (DGBL) met betrekking tot betrokkenheid van leerlingen, hun motivatie om te leren en het (waargenomen) leren. Mijn hoofdvraag luidt: Hoe dragen digitale games bij aan leren, de betrokkenheid van leerlingen en hun motivatie om te leren? Ik voerde vijf onderzoeken uit met als doel bij te dragen aan inzichten over de mogelijkheden van DGBL in het voortgezet onderwijs.

1. SAMENVATTING VAN DE BEVINDINGEN

In deze paragraaf vat ik de belangrijkste bevindingen van de vijf studies van deze dissertatie samen. De onderzoeksvragen voor deze vijf studies waren:

1) Wat zijn de effecten van DGBL op de betrokkenheid van leerlingen bij de game, de motivatie voor het onderwerp en de leerresultaten die in de onderzoeksliteratuur worden beschreven?
2) Wat zijn de motivatie- en leereffecten van DGBL?
3) Verklaren de game activiteiten van leerlingen verschillen in de motivatie om te leren, de waargenomen leerresultaten en hun game prestaties?
4) Hoe gebruiken leraren het maken van games door leerlingen en beïnvloedt het maken van games de motivatie van leerlingen en de waargenomen leerresultaten?
5) Wat zijn de percepties van leraren over de waarde van digitale games met betrekking tot de betrokkenheid van leerlingen bij de games, hun motivatie om te leren en hun leerresultaten?

1.1 Onderzoek 1: Review van digital game-based learning literatuur

In de in *hoofdstuk twee* beschreven studie werd een decennium (1999-2009) aan empirisch onderzoek over leren en motivatie-effecten van digital game-based learning onderzocht. Voor deze systematische review van de literatuur werden 46 studies geselecteerd. Van deze studies analyseerde ik de claims van auteurs over de betrokkenheid met het spelen van de game, motivatie voor de inhoud van de game en het schoolvak, het leren van feitelijke kennis en cognitieve en metacognitieve vaardigheden. Van de 93 claims in deze studies waren er 81 gegrond in de onderzoeksopzet, de analyse en de resultaten. Over het algemeen zijn de claims dat digital game-based learning betrokkenheid oproept bewezen: leerlingen zijn inderdaad betrokken bij het gebruik van games. De resultaten met betrekking tot motivatie zijn minder duidelijk: games lijken leerlingen te motiveren voor de inhoud van het schoolvak, maar niet meer dan andere manieren van leren. Claims over het leren zijn doorgaans positief, maar wanneer DGBL werd vergeleken met andere educatieve interventies, leerden leerlingen alleen meer feitelijke kennis. Leerlingen ontwikkelden niet altijd meer cognitieve vaardigheden en in één geval zelfs minder. Voor metacognitieve vaardigheden gold dat leerlingen metacognitieve vaardigheden ontwikkelden, maar niet meer dan de controlegroep. Concluderend kan worden gezegd: games spreken leerlingen aan, zijn motiverend en maken leren mogelijk, maar in vergelijking met andere vormen van educatieve interventies zijn de effecten alleen groter voor betrokkenheid en het leren van feitelijke kennis.

1.2 Onderzoek 2: De game Frequency 1550

In *hoofdstuk drie* werden de effecten van het spelen van een mobiele geschiedenis game, genaamd Frequency 1550, onderzocht. De betrokkenheid van de leerlingen bij de game, hun kennis van geschiedenis en motivatie voor geschiedenis in het algemeen en het onderwerp Middeleeuwen in het bijzonder, werden onderzocht. Een quasi-experimenteel design werd gebruikt om leerlingen die de mobiele geschiedenis game Frequency 1550 speelden te vergelijken met leerlingen die reguliere lessen op projectbasis volgden. 458 leerlingen waren betrokken bij de studie: 232 in de experimentele groep en 226 in de controlegroep. De resultaten toonden aan dat leerlingen die de game speelden betrokken waren en significant meer kennis vergaarden over Amsterdam in de Middeleeuwen dan leerlingen die regulier onderwijs op projectbasis volgden. Er werden geen significante verschillen gevonden tussen de twee groepen met betrekking tot motivatie voor geschiedenis of de Middeleeuwen. Concluderend leidde de game Frequency 1550 niet tot meer motivatie bij de leerlingen voor geschiedenis of de Middeleeuwen, maar waren de leerlingen die de game speelden wel betrokken en leerden ze meer over geschiedenis dan leerlingen in regulier onderwijs op projectbasis. De activiteiten van leerlingen tijdens het spelen van de games kunnen dit mogelijk verklaren.

1.3 Onderzoek 3: De game No Credit, Game Over

Onderzoek naar de relatie tussen wat leerlingen doen tijdens het spelen van een game en de resultaten van het spelen van een game is schaars. In de studie die in *hoofdstuk vier* wordt beschreven, worden daarom de game activiteiten van leerlingen tijdens het spelen van de game No Credit, Game Over (NCGO) gerelateerd aan hun motivatie voor leren, waargenomen leerresultaten en prestaties in de game om te beoordelen of de verschillen in deze resultaten verklaard kunnen worden door de game activiteiten van de leerlingen. In NCGO gebruikten leerlingen tablets om virtuele informatie met betrekking tot schulden te combineren met het doen van opdrachten in de stad. Informatie werd verzameld van 181 leerlingen die de game speelden en vragenlijsten invulden met betrekking tot hun game activiteiten, motivatie voor leren en leerresultaten. Een deel van de variabelen werd op individueel niveau gemeten, terwijl andere variabelen op groepsniveau werden gemeten (omdat leerlingen een tablet deelden). De resultaten lieten zien dat vier game activiteiten gerelateerd zijn aan motivatie voor leren, waargenomen leerresultaten en team game prestaties. Het gaat om de volgende activiteiten: inleven in het personage tijdens de game, iets anders doen dan de game, het bezoeken van organisaties en het kijken naar de route. Iets anders doen dan de game en inleven in het personage hadden een negatief effect op motivatie; inleven in het personage had daarnaast ook een negatief effect op waargenomen leren. De activiteiten ‘bezoeken van organisaties’ en ‘kijken naar de route’ hadden een positief effect op team game prestaties. Nader onderzoek is nodig om de effecten te kunnen verklaren.

1.4 Onderzoek 4: Maken van games

Het gebruik van games om betrokkenheid te genereren, motivatie te bevorderen en leerresultaten te verhogen kan naast het spelen van games ook bereikt worden door het maken van games. Dit laatste is mogelijk zelfs succesvoller aangezien leerlingen actief hun eigen kennis moeten gebruiken en toepassen in een nieuwe situatie om een game voor anderen te maken. Ik onderzocht de manier waarop leraren het ontwerpen van games door leerlingen in hun onderwijspraktijk gebruikten en of het maken van games invloed had op de motivatie van leerlingen tijdens de les en op wat er volgens de leerlingen geleerd werd. Dit onderzoek wordt beschreven in *hoofdstuk 5*. Twee leraren uit het voortgezet onderwijs werkten gedurende 12-14 lessen met een platform om digitale spellen te maken. 74 leerlingen (tweedeklassers) maakten en speelden educatieve mobiele locatie games. Leerlingen werkten samen in kleine groepen van twee tot vier leerlingen. Leerlingen rapporteerden dat ze leerden hoe ze een game konden ontwikkelen en dat ze plezier ervoeren in het maken van de game. Het maken van de game leek hun waargenomen leren van vakgerelateerde kennis of motivatie om te leren echter niet te verbeteren. Leerlingen die hun eigen game in kleine groepen maakten gaven aan meer geleerd te hebben en meer gemotiveerd zijn om te leren dan leerlingen die samenwerkten aan het ontwerp van een game met de hele klas.. De leerlingen hadden mogelijk meer begeleiding nodig van hun leraren om baat te hebben bij het maken van games, aangezien ze problemen leken te hebben met het verbinden van de games met het onderwerp.

1.5 Onderzoek 5: Percepties van leraren

De perceptie van leraren over het nut van digitale games is mogelijk een reden voor de beperkte toepassing van digitale games in het onderwijs. De studie in *hoofdstuk zes* focuste op de percepties van docenten. Ik interviewde leraren die digitale games in hun lessen gebruikten over hun percepties met betrekking tot de betrokkenheid van leerlingen bij de games, hun motivatie voor leren en hun leerresultaten. Semigestructureerde interviews werden gehouden met 43 leraren in het voortgezet onderwijs. In het algemeen rapporteerden bijna alle leraren dat bij het gebruik van games in de les leerlingen betrokken waren bij games; de leerlingen waren bereid tijd te investeren in het spelen en maken van games. De meeste leraren gaven ook aan dat digital game-based learning het leren van leerlingen bij verschillende vakken beïnvloedde. Wat de leerlingen leerden, verschilde volgens hun docenten; het maken van games was meestal verbonden aan programmeren, terwijl het spelen van games voor een grote verscheidenheid aan doelen gebruikt werd, zoals inzicht verwerven in economische processen en causaliteit. Een kleiner aantal leraren observeerde positieve effecten met betrekking tot motivatie voor leren. Dit werd vaker benoemd bij het spelen dan bij het maken van games. Competitie leek een positieve rol te spelen tijdens het spelen van games.

Deze dissertatie poogde inzicht te verschaffen in de manier waarop digitale games bijdragen aan (waargenomen) leren, betrokkenheid van leerlingen bij het spelen of maken van games en motivatie om te leren. Uit de bevindingen van de vijf studies lijkt het beeld te zijn dat digital game-based learning bevorderlijk is voor het leren van leerlingen. Leerlingen zijn betrokken bij het spelen en maken van games. Resultaten over motivatie om te leren zijn tegenstrijdiger. In de volgende paragrafen bespreek ik mijn reflecties op de resultaten en op methodologische zaken, in combinatie met enkele suggesties voor toekomstig DGBL-onderzoek.

2. CONCLUSIES EN REFLECTIES OP RESULTATEN

2.1 Onderdelen van game-based learning

In elk van de individuele studies zag ik de potentie van digital game-based learning voor leren, betrokkenheid en motivatie om te leren. Maar welke onderdelen van digitale games droegen bij aan deze resultaten? De vijf uitgevoerde studies leverden een aantal aanwijzingen voor belangrijke onderdelen van digital game-based learning ten aanzien van betrokkenheid, motivatie om te leren en (waargenomen) leerresultaten. In deze paragraaf breng ik de vijf onderzoeken samen en reflecteer ik op de onderdelen die in meer dan één studie genoemd zijn als bevorderend voor de betrokkenheid, motivatie om te leren en (waargenomen) leerresultaten. Deze onderdelen zijn *competitie*, *samenwerking*, *bruikbaarheid*, een *authentieke context, feedback,* de *rol van de leraar* en *het niveau van leerlingen*.

2.1.1 Competitie

Competitie wordt genoemd in mijn definitie van games: “georganiseerd spel, met één of meer spelers, met doelen, beperkingen, regels, interactie, uitdagingen, beloningen en hun consequenties en onderdelen van competitie (met een andere speler of met zichzelf). Een verhaal, vertelling of fantasie-elementen worden gebruikt en de game zou plezier en genot moeten bieden” (p. 2). Mijn studies toonden aan dat het onderdeel competitie een rol speelt in de betrokkenheid en soms in de motivatie om te leren. De reviewstudie liet zien dat competitie belangrijk was voor betrokkenheid. In studie 5 (interviews met leraren) noemden leraren competitie een belangrijk onderdeel voor zowel betrokkenheid als motivatie om te leren. Deze studie liet ook vanuit het perspectief van de leraar zien dat competitie belangrijker was in het spelen van games dan in het maken van games. De resultaten van mijn studies met betrekking tot de rol van competitie in motivatie om te leren zijn niet eenduidig, aangezien ik bij de game No Credit, Game Over zag dat het competitieve element van leerlingen die de scores van andere leerlingen bekeken hun motivatie om te leren niet beïnvloedde.

Er bestaat veel discussie in de literatuur over de rol van competitie. Vandercruysse et al. (2013) en Boyle et al. (2016) stellen dat onderzoek naar competitie in games onduidelijk is met betrekking tot de effecten op leerresultaten en motivatie. Een meta-analyse van Clark, Tanner-Smith en Killingsworth (2015) vond dat de effecten van digitale games op leerresultaten groter waren bij single-player games zonder competitie en bij games met samenwerkende team-competitie dan bij single-player games met competitie. Het is dus mogelijk dat competitie een positieve factor is wanneer het niet gaat om competitie tussen individuele leerlingen, maar om competitie tussen groepen leerlingen. De laatstgenoemde vorm van competitie was vaak aanwezig in onze studies.

2.1.2 Samenwerking

Zoals eerder vermeld in het bespreken van competitie kunnen leraren leerlingen laten samenwerken bij het spelen of maken van games. Bij het maken van games met het platform 7scenes (studie 4) rapporteerden leerlingen dat ze het element van samenwerking leuk vonden. In de andere twee veldstudies (studies 2 en 3) werd dit niet expliciet onderzocht. De studie van Trespalacios, Chamberlin en Gallagher (2011) toonde aan dat *middle-school* leerlingen liever multiplayer games spelen. Ze verkiezen dit om meerdere redenen (in volgorde van belangrijkheid): met vrienden kunnen spelen, samenwerken om het doel te bereiken, te concurreren en omdat het meer uitdagende situaties biedt.

In al mijn veldonderzoek in deze dissertatie lieten leraren of ontwerpers van de game de leerlingen bewust samenwerken. In mijn reviewstudie gaven de onderzoeken van Ke (Ke & Grabowski, 2007; Ke, 2008a; Ke, 2008c) aan dat samenwerkend leren een belangrijk onderdeel is dat bijdraagt aan de motivatie voor wiskunde door middel van DGBL. Leerlingen in een samenwerkende game conditie waren meer gemotiveerd voor wiskunde dan leerlingen in een competitieve of individualistische game conditie. De meta-analyse van Wouters, Van Nimwegen, Van Oostendorp en Van der Spek (2013) toonde eveneens aan dat het spelen van games in een groep de meest effectieve conditie voor leren was. Ze gaven als mogelijke redenen dat een deel van de leeractiviteiten zoals het expliciteren van kennis niet automatisch plaats vindt tijdens het leren met games en dat het spelen in een groep een effectieve manier zou kunnen zijn om deze extra leeractiviteiten te bevorderen. Van der Meij et al.

(2011) laten echter zien dat samenwerken tijdens het spelen van games het leren niet altijd bevordert. Ik ben het met Wouters et al. (2013) eens dat meer onderzoek naar richtlijnen voor samenwerking en het begrijpen van de meest effectieve groepsgrootte nodig is.

2.1.3 Authentieke context

In de onderzoeken in deze dissertatie worden meerdere aspecten genoemd die te maken hebben met een authentieke context voor leren. Deze authentieke context kan bestaan uit het uitvoeren van authentieke taken door leerlingen en/of dat leerlingen opdrachten te laten doen in de echte wereld. De didactische benadering die leeropdrachten in de context van situaties in de echte wereld plaatst en mogelijkheden voor leren biedt door het tegenkomen van dezelfde uitdagingen met betrekking tot probleemoplossing als in het dagelijkse leven, wordt authentiek leren genoemd (Herrington, Reeves, & Oliver, 2014). Voorbeelden van leerlingen die taken in de echte wereld uitvoeren zijn Frequency 1550 (studie 2) en NCGO (studie 3). Leerlingen leerden over Amsterdam in de Middeleeuwen (studie 2) terwijl ze door het authentieke stadscentrum met historische gebouwen liepen. En leerlingen leerden over schuld (studie 3) door organisaties te bezoeken die een rol spelen wanneer iemand schulden heeft. De link met de omgeving leek te ontbreken in veel van de games die de leerlingen maakten in de studie over het maken van games (studie 4). De leerlingen maakten games die ook gespeeld hadden kunnen worden als er geen sprake was van mobiele devices en contextgevoeligheid en maakten daardoor geen gebruik van de kracht van leren van mobiele games op basis van locatie. Dit is mogelijk een van de redenen waarom leerlingen niet veel leerden. Meer onderzoek is nodig om vast te stellen of dit inderdaad een verklaring is.

Voor betrokken zijn bij het spelen of maken van een game werd in de reviewstudie (studie 1) aangetoond dat het auteurschap en eigendom van de game belangrijke kenmerken zijn in het maken van games. Ook het meewerken aan onderzoek en ontwikkeling en het maken van games voor een bepaalde groep is van belang. Prater (2016) geeft aan dat het maken van een game voor een echt publiek veel leerlingen het gevoel geeft dat ze een game designer of programmeur zijn. In studie 4 over het maken van games leek het onderdeel auteurschap en eigendom belangrijk te zijn. Leerlingen waardeerden het creatieve aspect van de game zeer, evenals de mogelijkheid om zelf beslissingen te nemen over het onderwerp, de opdrachten en waar ze deze konden plaatsen op de kaart, zoals ze dit in het echte leven zouden doen. Ze namen hun eigen beslissingen; de leraar besliste niet voor ze.

Het belang van een authentieke context met betrekking tot motivatie om te leren werd door leraren genoemd in de interviews (studie 5). Het werd bijvoorbeeld genoemd door leraren die gebruik maakten van een game waarin leerlingen hun eigen bedrijf begonnen. Leerlingen zagen de waarde van de theorie voor de praktijk: door het spelen van de game realiseerden leerlingen zich dat wat ze op school leerden betekenisvol is als je je eigen bedrijf begint. Ze leerden dit zonder de risico's van het hebben van een bedrijf in de echte wereld (leren in een veilige omgeving).

2.1.4 Bruikbaarheid

Snelle voortgang in de game, gebruiksgemak, afwezigheid van technologische problemen en het al dan niet hoeven lezen van instructies in het spel kunnen geschaard worden onder de noemer bruikbaarheid. Bruikbaarheid is een begrip uit de software industrie en betreft het bieden van een gebruikerservaring met weinig onnodige onderbrekingen of uitdagingen (Latinen, 2015). De reviewstudie (studie 1) liet zien dat snelle voortgang in de game en het gemak van de game belangrijk zijn voor de betrokkenheid. Het toonde ook aan dat betrokkenheid negatief wordt beïnvloed door technologische problemen en door het moeten lezen van instructies. Dit zijn volgens de geïnterviewde leraren eveneens de redenen voor de enkele gevallen van gebrekkige betrokkenheid die zij tijdens de interviews noemden (studie 5). In Frequency 1550 waren leerlingen op het hoofdkantoor meer betrokken dan degenen die in de stad opdrachten uitvoerden, waarschijnlijk deels omdat ze minder technologische problemen ervoeren, maar mogelijk ook omdat ze minder vaak hoefden te wachten en ze veel verschillende taken en meer overzicht hadden. Dit alles heeft mogelijk bijgedragen aan deze hogere mate van betrokkenheid.

2.1.5 Feedback

Het element feedback wordt in veel definities van games opgenomen. Het zit ook in onze definitie, niet expliciet, maar meer impliciet als ‘beloningen en hun consequenties’. Beloningen en hun consequenties voorzien de spelers van feedback op hun acties. Leraren stelden in hun interview (studie 5) dat directe feedback van de game de leerlingen hielp om de consequenties van hun acties te realiseren en dat het bijdroeg aan leren. De rol van feedback wordt ook in mijn review (studie 1) genoemd, evenals in andere reviews zoals die van Jabbar en Felicia (2015), Wouters en Oostendorp (2013) en Johnson, Baily en Van Buskirk (2017). Feedback wordt in deze reviews genoemd als een belangrijk onderdeel van leren. Feedback kan door de game zelf gegeven worden, zoals in Frequency 1550 (studie 2), waar leerlingen onmiddellijk wisten of hun antwoorden juist of fout waren, maar het kan ook door de leraar worden gegeven. In de volgende paragraaf gaan we dieper in op de rol van de leraar.

2.1.6 De rol van de leraar

Er zijn ook elementen buiten de game die leren, motivatie om te leren en betrokkenheid beïnvloeden. Mijn reviewstudie (studie 1) en interviewstudie (studie 5) met leraren over hun op de praktijk gebaseerde percepties van de effecten van games toonden een belangrijke rol van de leraar in digital game-based learning, voor leerresultaten en voor betrokkenheid. Leraren ondersteunen en coachen leerlingen, geven feedback, leren leerlingen vaardigheden die nodig zijn om de game te spelen en begeleiden gesprekken tussen de leerlingen onderling en tussen de leerlingen en de leraar. Het belang van de rol van de leraar kan worden geobserveerd in onze studie over het maken van games; de leerlingen waren al geholpen met de begeleiding van de docent, maar hadden om te leren waarschijnlijk nog meer begeleiding nodig gehad, sturing in het verbinden van de game met de omgeving en de lesinhoud (studie 4). In Frequency 1550 en NCGO (respectievelijk studies 2 en 3) had de game master de bovengenoemde rol van leraar van het faciliteren van reflectie van leerlingen. Het belang van de begeleidende rol van de leraar (of iemand die deze rol aanneemt, zoals een game master) wordt in veel andere studies besproken (bijv. Gabriel, 2016; Hämälainen & Oksanen, 2014; Marklund & Taylor, 2016; Prater, 2016). Een belangrijke conclusie in de dissertatie van Wood (2011) was dat deelnemers zonder de begeleiding van een leraar die reflectie en samenwerking bood weinig winst behaalden in resultaten op cognitief vermogen (Wood, 2011, p. 177). Marklund's (2013) dissertatie benoemt de belangrijke rol van de leraar als de persoon die de game play aan het onderwerp moet verbinden en reflecties moet opwekken en evaluatiesessies moet leiden. Dit is belangrijk voor leraren omdat games leerlingen niet altijd automatisch leren wat ze moeten leren voor school. Leraren kunnen leerlingen begeleiden in het proces richting de betreffende specifieke onderwijsdoelen.

2.1.7 Het niveau van leerlingen

In meerdere van mijn vijf onderzoeken komt het niveau van leerlingen naar voren als iets wat van belang is bij DGBL. Het niveau van de leerling werd vooral genoemd bij de leereffecten, maar de resultaten over wat de rol van het niveau hierbij precies is, zijn niet consistent. In onze review toonde de studie van Banerjee, Cole, Duflo en Linden, (2007) bijvoorbeeld dat de zwakkere leerlingen (qua leerprestaties) zich het sterkst verbeterden, terwijl in de studie van Greenhill, Pykett en Rudd (2008) de gemiddelde leerlingen (gemiddelde hoeveelheid voorkennis) het meeste leerden. In onze studie naar F1550 leerden de leerlingen met de hoogste onderwijsniveau het meest, terwijl de game bedoeld was als een mooie tool voor met name de leerlingen van een lager onderwijsniveau. Maar wanneer specifiek gekeken wordt naar de voorkennis van geschiedenis verbeterden de leerlingen met weinig voorkennis zich het meest.

2.2 Slotopmerkingen

De vijf studies hebben aangetoond dat het gebruik van games in het onderwijs bevorderlijk kan zijn voor leren, betrokkenheid bij de game en in mindere mate voor de motivatie om te leren. Mijn algemene onderzoeksvraag was: Hoe dragen digitale games bij aan leren, betrokkenheid en motivatie om te leren? Het gebruiken van games tijdens lessen kan een manier zijn om aan te sluiten bij de leefwereld van de leerling door het gebruik van nieuwe media en interactie met klasgenoten. Het kan leerlingen meer bereid maken om inspanning te leveren voor wat ze moeten doen op school en ze daarmee helpen om te leren. Kijkend naar de vijf studies laat mijn dissertatie zien dat er verschillende onderdelen binnen en buiten de game bestaan die mogelijk bijdragen aan het feit dat games bevorderlijk zijn voor leren, betrokkenheid en (in mindere mate) motivatie om te leren. Deze onderdelen zijn: competitie; samenwerking; een authentieke context; bruikbaarheid; feedback; de rol van de leraren en het niveau van leerlingen. Meer onderzoek is nodig om te bepalen hoe deze onderdelen leren, betrokkenheid en motivatie om te leren exact beïnvloeden en wat hun interactie is.

3. REFLECTIES OP DE ONDERZOEKSAANPAK EN TOEKOMSTIGE RICHTINGEN VOOR ONDERZOEK

In deze paragraaf bespreek ik de sterke punten en beperkingen van het onderzoek in het licht van het ontwikkelende terrein van DGBL-onderzoek en geef ik suggesties voor toekomstig onderzoek.

3.1 Combinatie van methodes en perspectieven

In deze dissertatie werden zowel kwalitatieve als kwantitatieve methoden gebruikt. Iedere methode heeft haar eigen voor- en nadelen en voor een goed beeld van het onderwerp is het gebruik van meerdere methoden aanbevolen. We gebruikten kwantitatieve data, zoals objectieve toetsresultaten, scores op vragenlijsten over percepties en data uit de game (de score), evenals kwalitatieve data middels het interviewen van leraren en leerlingen. Longitudinale studies of follow-up studies zijn niet in deze studie opgenomen en zijn nodig in toekomstig DGBL-onderzoek (ook aanbevolen door All et al., 2016). Longitudinale studies zijn nodig om meer te kunnen zeggen over de effecten van digital game-based learning op de lange termijn en om uit te sluiten dat de gevonden effecten mogelijk *novelty effecten* zijn (tijdelijke effecten vanwege iets nieuws dat wordt geïntroduceerd. Deze effecten verminderen zodra de nieuwe interventie niet meer zo nieuw is). Toetsen moeten mogelijk ook beter aansluiten bij wat leerlingen met DGBL kunnen leren. Het is mogelijk dat traditionele toetsen niet altijd dekken wat er geleerd wordt tijdens het leren met games.

Naast het combineren van methodes bestudeerde ik DGBL ook vanuit verschillende perspectieven: de perspectieven van leraren en leerlingen, evenals de perspectieven van leerlingen die games spelen en leerlingen die games maken. Het opnemen van het perspectief van de ontwerper kan ook interessant zijn (bijvoorbeeld het kijken naar wat de ontwerper beoogde te bewerkstelligen met het maken van de game) en is een mogelijke richting voor toekomstig onderzoek.

3.2 Het groeiende domein van digital game-based learning onderzoek

Zoals in de introductie werd gezegd is het veld van digital game-based learning een (snel) groeiend domein. Dit leidt mogelijk tot vragen over de validiteit van de resultaten van mijn onderzoek in het heden, met name de resultaten uit mijn review waarin ik onderzoek van 1999-2009 kritisch bekeek. Echter, kijkend naar recenter onderzoek, bijvoorbeeld naar de reviews van Clark et al. (2015), Jabbar en Felicia (2015) en Wouters et al. (2013), komen de resultaten over betrokkenheid, motivatie om te leren en het leren zelf overeen met de resultaten uit mijn review: de resultaten zijn enigszins tegenstrijdig, maar het algemene beeld was en is nog steeds dat het gebruik van games bevorderlijk kan zijn voor leren, evenals voor de betrokkenheid en in mindere mate voor de motivatie om te leren. Boyle et al. (2016) hebben de review van Connolly et al. uit 2012 over de positieve impact en resultaten van computer games geüpdatet. De geüpdatete review toont aan dat er inderdaad niet veel is veranderd met betrekking tot het bewijs over de al dan niet positieve invloed van games op leren en gedrag. Ze vonden tevens dat games nog steeds vooral worden gebruikt om het verwerven van kennis te ondersteunen. Er waren echter ook enkele veranderingen in dit gebied. Er is vooruitgang geboekt op het begrijpen van hoe specifieke kenmerken van een game, bijvoorbeeld competitie, spelers betrokken maken en leren ondersteunen. Daarnaast is meer bekend over het begrijpen van kenmerken die games boeiender maken, in de zin dat preciezere definities van constructen zoals flow en betrokkenheid zijn voorgesteld en er maten zijn ontwikkeld om meer te kunnen differentiëren tussen deze constructen (Boyle et al., 2016).

Terugkijkend naar mijn review en andere reviews die in de tussentijd zijn uitgevoerd, zit de kracht van mijn methode van reviewen in het systematisch checken van de minimum kwaliteit van de studies die werden meegenomen en naar de gegrondheid van de conclusies. Dit is gedaan omdat ik nieuw onderzoek dat niet in peer-reviewed journals was gepubliceerd wilde meenemen. Ik besloot daarom om alle artikelen (peer-reviewed of niet) aan dezelfde kwaliteitscheck te onderwerpen. Zelfs in peer-reviewed journals was een deel van de conclusies niet gegrond in de bevindingen van de studies. Ik denk dat het goed is om bij het uitvoeren van reviewstudies artikelen te blijven beoordelen op gegrondheid en niet alleen te kijken naar de conclusies, zelfs wanneer alleen peer-reviewed artikelen worden gebruikt.

3.3 Verder kijken dan effecten

Veel onderzoek is gericht op de effecten van digital game-based learning. Het kijken naar effecten was belangrijk toen data over effecten nog nauwelijks aanwezig waren en empirische studies over game-based learning nodig waren. Het was ook iets waar ik me op richtte bij de start van mijn dissertatieproject. Aangezien de hoeveelheid onderzoek over digital game-based learning groeit, stel ik voor niet alleen naar de effecten maar ook naar het proces van het gebruiken van de game te kijken. Dus om ook te kijken naar wat er gebeurt wanneer leerlingen games spelen of maken, wat leerlingen en docenten denken en doen. Dit geeft mogelijk inzicht in waarom bepaalde effecten plaatsvinden. All, et al. (2016) bevelen aan om effectstudies aan te vullen met de evaluatie van het proces van de game interventie, waarin een naturalistisch design met experimentele datacollectie wordt gebruikt om te bepalen wat een DGBL interventie effectief maakt. Het is gericht op het begrijpen van de onderliggende mechanismen die mogelijk bijdragen aan de gevonden effecten. Ik benadruk het belang van het verzamelen van procesdata en gebruikte ook procesdata in mijn studies. In mijn onderzoek naar leerlingen die games maakten (studie 4) observeerde ik bijvoorbeeld leraren en leerlingen in hun proces van het maken van games voor het leren. Dit deed ik om te zien wat de leraren en leerlingen deden tijdens dit proces. Data uit vragenlijsten in deze studie lieten zien dat leerlingen niet het idee hadden geleerd te hebben. Door mijn observaties van de leerlingen en het kijken naar de games die zij maakten, kon ik als mogelijk verklaring vinden dat de opdrachten die leerlingen maakten niet verbonden werden met de leerinhoud. Echter, ik kon - net als de leraren - observeren dat de leerlingen zinvolle discussies hadden tijdens het proces van het maken van games. Er waren discussies die de leerlingen zelf niet als leren zouden interpreteren, maar discussies die volgens hun leraren wel bijdroegen aan het leren door leerlingen. Het is mogelijk dat leerlingen een beperktere definitie van leren hebben dan leraren.

Mijn aanbeveling is dat meer onderzoek wordt verricht dat niet alleen gericht is op de effecten, maar dat ook datacollectie over het proces van gamen en wat leerlingen en leraren doen en denken tijdens het spelen en maken van games wordt meegenomen. Op deze manier kunnen onderzoekers verder kijken dan de vraag of games werken en analyseren hoe ze werken, waarom ze werken, voor welke inhoud, in welke context en voor wie.

4. PRAKTISCHE IMPLICATIES

In deze paragraaf bespreek ik de praktische implicaties van de resultaten van het onderzoek in deze dissertaties. Ik richt me op implicaties voor voorbereiding van leraren en wat moet gebeuren om gamegebruik in onderwijscontexten te faciliteren.

4.1 Voorbereiding van leraren

Het gebruik van games in het voortgezet onderwijs loopt achter op de interesse in games. In mijn onderzoek zag ik dat de leraar belangrijk is in digital game-based learning. De leraar moet besluiten welke games gebruikt kunnen worden, door bijvoorbeeld te kijken of het binnen het rooster past, welke doelen bereikt moeten worden en of het binnen het onderwijsprogramma past. De leraar moet het gameproces educatief begeleiden en ook in staat zijn te helpen met meer technische vragen (Marklund & Taylor, 2016). Leraren voelen zich echter niet voorbereid om games in te zetten in de klas, bleek uit onze studie en dit wordt ook in andere studies gemeld (bijvoorbeeld Verheul & Koops, 2013). Dit probleem is breder dan het gebruik van games: leraren vinden dat ze niet voorbereid zijn om ICT in het algemeen effectief in hun klas te gebruiken (Tondeur, Pareja Roblin, Van Braak, Voogt, & Prestridge, 2016). Een belangrijke praktische implicatie is daarom dat het onderwijzen van leraren de leraren in opleiding zal helpen in de voorbereiding van het gebruik van ICT in het algemeen en het lesgeven met games in het bijzonder. Toekomstige leraren zouden onderwezen moeten worden over onder andere wat er nodig is om digital game-based learning in te zetten, hoe ze kunnen bepalen of het gebruik van een game de beste tool is voor hun leerdoelen en leerlingen, welke game ze moeten kiezen en welke infrastructuur hiervoor toereikend is. Ze zouden het opzetten van lessen rond digitale games moeten kunnen oefenen, evenals het gebruik van games in een authentieke setting en feedback op deze acties moeten krijgen (Gabriel, 2016; Tondeur, Van Braak, Voogt, Fisser, & Ottenbreit-Leftwich, 2012).

4.2 Het gebruik van games in onderwijscontexten

Games zijn niet altijd geschikt voor gebruik in onderwijscontexten. Wake (2013) concludeerde in zijn dissertatie dat technologie in lijn moet zijn met bestaande technologische praktijken en institutionele beperkingen om succesvol te zijn (Wake, 2013, p.105). Meerdere acties kunnen worden ondernomen om het gebruik van games in het onderwijsprogramma te stimuleren. Game ontwerpers zouden rekening moeten houden met de context van het onderwijsprogramma bij het maken van educatieve games. Ze zouden ook moeten kijken naar de doelen die in het voortgezet onderwijs bereikt moeten worden.

Voor leraren zijn er ook manieren om het gebruik van games in de onderwijscontext te faciliteren. Games nemen vaak meer tijd in beslag dan de lessen die voor een bepaald vak zijn toegewezen. Door interdisciplinair te werken kunnen leraren tijd maken om games te spelen buiten de geroosterde uren van het eigen vak. De meeste games betreffen meer dan één vak, dus de meeste games bieden mogelijkheden om meer te leren dan over één specifiek vak. Wanneer games niet worden ingezet om een specifiek vak te leren, maar om op een meer thematische manier les te geven, zal dit meer mogelijkheden maken om games te gebruiken in het onderwijs. Een andere mogelijkheid om met de beperkingen van lesuren om te gaan is door leerlingen (deels) thuis te laten spelen en de lestijd te gebruiken voor evaluatiesessies.

5. SLOTOPMERKINGEN

Deze dissertatie heeft laten zien dat digital game-based learning potentie heeft voor (waargenomen) leerresultaten, betrokkenheid en (in mindere mate) motivatie om te leren. Ik zag dat veel aspecten van games een rol spelen in digital game-based learning: competitie; samenwerking; een authentieke context; bruikbaarheid; feedback; de rol van de leraar en het niveau van de leerling. Mobiele locatie-gebaseerde games maken on-site leren mogelijk en faciliteren het leren in een authentieke omgeving. Het bleek moeilijk om leraren te vinden die gebruik maken van games. Er is veel winst te behalen door leraren voor te bereiden op het gebruik van games in de klas, maar er moet ook nog veel worden onderzocht met betrekking tot de condities waarin games het beste werken, voor wie en hoe activiteiten van leerlingen gerelateerd zijn aan de voordelen van games. Dus: op naar het volgende level van DGBL-onderzoek.

AUTHOR CONTRIBUTIONS

Papers in this dissertation and contributions of co-authors.

Chapter 2 is based on:
Huizenga, J., Admiraal, W., & Ten Dam, G. (2011). Claims of games: a decade of research on motivational and learning effects reviewed. *In Book of abstract and extended summaries* (pp. 2079-2080). Exeter, UK : University of Exeter.

Contributions:
Jantina Huizenga reviewed the literature, searched, collected and analyzed the data and drafted the various versions of the manuscript. The research team for this article further consisted of Wilfried Admiraal and Geert ten Dam, who together supervised Jantina Huizenga. The research team collaboratively conceptualized and designed the study. As a form of audit, the research team discussed all the steps in the process of analysis and its outcomes, and where necessary the primary data were rechecked. The supervisors contributed to the analysis and interpretation of the data, and reviewed and revised the manuscript.

Chapter 3 is based on:
Huizenga, J., Admiraal, W., Akkerman, S., & Ten Dam, G. (2009). Mobile game-based learning in secondary education: engagement, motivation and learning in a mobile city game. *Journal of Computer Assisted Learning, 25, 332-344.* doi: 10.1111/j.1365-2729.2009.00316.x

Contributions:
Jantina Huizenga reviewed the literature, collected and analyzed the data and drafted the various versions of the manuscript. The research team for this article further consisted of Wilfried Admiraal and Geert ten Dam, who together supervised Jantina Huizenga. The research team discussed the various steps of the research. The team collaboratively conceptualized and designed the study, deliberated about the data analysis and its outcomes. The supervisors audited the analysis and interpretation of the data and contributed to reviews and revisions of the manuscript. Sanne Akkerman contributed to reviews and revisions of the manuscript.

Chapter 4 is based on:
Huizenga, J.C., Admiraal, W.F., Ten Dam, G.T.M., & Voogt, J.M. (to be submitted) Mobile game-based learning and students' game activities.

Contributions:
Jantina Huizenga reviewed the literature, collected and analyzed the data and

drafted the various versions of the manuscript. The research team for this article further consisted of Wilfried Admiraal, Geert ten Dam and Joke Voogt, who together supervised Jantina Huizenga. The research team discussed the various steps of the research. The team collaboratively conceptualized and designed the study, deliberated about the data analysis and its outcomes. The supervisors audited the analysis and interpretation of the data and contributed to reviews and revisions of the manuscript.

Chapter 5 is based on:
Huizenga, J., Admiraal, W., & Ten Dam, G. (2011, October). Merging digital and urban play spaces: Learning by playing and creating location-based games in secondary education. In *Proceedings on the 5th European Conference on Games Based Learning* (p. 703). Academic Conferences International Limited.

Contributions:
Jantina Huizenga reviewed the literature, collected and analyzed the data and drafted the various versions of the manuscript. The research team for this article further consisted of Wilfried Admiraal and Geert ten Dam, who together supervised Jantina Huizenga. The research team discussed the various steps of the research. The team collaboratively conceptualized and designed the study, deliberated about the data analysis and its outcomes. The supervisors audited the analysis and interpretation of the data and contributed to reviews and revisions of the manuscript.

Chapter 6 is based on:
Huizenga, J.C.; Admiraal, W.F.; Voogt, J.M., & Ten Dam, G.T.M. (2017). Teacher perceptions of the value of game-based learning in secondary education. *Computers & Education, 110, 105-115.* https://doi.org/10.1016/j.compedu.2017.03.008

Contributions:
Jantina Huizenga reviewed the literature, collected and analyzed the data and drafted the various versions of the manuscript. The research team for this article further consisted of Wilfried Admiraal and Geert ten Dam, who together supervised Jantina Huizenga. The research team discussed the various steps of the research. The team collaboratively conceptualized and designed the study, deliberated about the data analysis and its outcomes. The supervisors audited the analysis and interpretation of the data and contributed to the first reviews and revisions of the manuscript. In later reviews and revisions Joke Voogt contributed as well and was added to the supervision team.