Motivating Factors and Tangential Learning for Knowledge Acquisition in Educational Games

Peter Mozelius[1], Andreas Fagerström[2] and Max Söderquist[2]
[1]Department of Computer and Systems Sciences, Mid Sweden University, Sweden
[2]Department of Computer and Systems Sciences, Stockholm University, Sweden
mozelius@dsv.su.se

Abstract: Game-based learning has been a strong emerging trend in the 21st century, but several research studies on game-based learning reports that the educational potential of games has not been fully realised. Many educational games do not combine learning outcomes with entertaining gameplay. At the same time as there is a tendency to digitise and personalise education by the use of digital games, there still exists a lack of knowledge about efficient educational game design. To identify design factors that are important for players' learning motivation this study has analysed three popular entertainment games that were selected for their educational values.

The aim of the study is to explore, analyse and discuss, if and how motivating factors and intrinsic integration of knowledge in educational games might be related to players' perceived knowledge acquisition. Test players with experience of the selected digital games were recruited from online gaming forums where a questionnaire also was used to collect data. Lepper's and Malone's set of heuristics for intrinsic motivation in interactive learning environments were used in a combination with Habgood's and Ainsworth's theory of intrinsic integration to examine the relationship between these factors in the educational games. Beside the direct acquisition of knowledge from gaming there was also an analysis of the concept of tangential learning.

Results from a t-test showed that tangential learning was significantly more important for two of the tested games. Correlation analysis revealed several relationships between factors, where intrinsic integration was pointed out as particularly interesting for knowledge acquisition and tangential learning. Results showed weak or no relationships for Lepper and Malone factors, but with some tendencies for control, imagination and competition.

Keywords: Educational games, Intrinsic integration, Tangential learning, Game-based learning, Learning motivation

1. Introduction and Aim

There is a long tradition of using games in educational contexts and in the 1980s Game-based learning (GBL) began as a research topic (Habgood & Ainsworth, 2011). Educational games differ from traditional education in the sense that a game explicitly requires that the learner/gamer is active (Gee, 2003; Portnow, 2008). This can promote active learning instead of the traditional view of students as mere passive knowledge consumers. GBL has a potential to provide active learning instead of students as passive knowledge consumers (Gee, 2003). However, despite the hype of GBL in the 21st century, educational games do not seem to have reached their full potential to engage learners (Gunter, Kenny & Vick, 2008; Brusse, Neijens & Smit, 2010; Sigurdardottir, 2012).

One possible explanation to the failure might be that educational games do not have a gameplay that motivates gamers to play and learn. Papert (1998) has described the worst GBL artefacts as Shavian reversals, when games are inheriting the worst properties from both its parents in the creation of a boring e-book instead of a learning stimulating game (Wiklund, & Mozelius, 2013). Researchers' advice is to design games more as platforms for autonomous learning than e-books and to integrate content in gameplay and game mechanics (Habgood & Ainsworth, 2011).

Another branch of GBL is to instead use Commercial Off-The-Shelf (COTS) games for learning purposes (Charsky, 2008; Wiklund, & Mozelius, 2013). According to Van Eck (2006) COTS games are suitable for educational contexts since they are affordable and well-designed by professional game developers. On the other hand COTS games need a thorough analysis before they can be integrated in curricula and course syllabi since part of the content can have a fictive nature (Van Eck, 2006).

In a study by Charsky (2010) it is reported that both the academia and the industry have a demand for serious and educational games that can provide something more than just entertainment. An identified problem is the

Reference this paper as: Mozelius P, Fagerström A and Söderquist M, "Motivating Factors and Tangential Learning for Knowledge Acquisition in Educational Games" *The Electronic Journal of e-Learning Volume 15 Issue 4 2017*, (pp343-354) available online at www.ejel.org

lack of a thorough design framework (Charsky, 2010). Recommendations are that such a framework should be grounded in research on a combination of COTS and educational games, inspired by earlier work on motivational model for game construction by Lepper and Malone (1987) and Gee (2003). The aim of the study is to explore and discuss if and how motivating factors, intrinsic integration of knowledge and tangential learning in educational games might be related to students' perceived acquisition of knowledge.

1.1 Problem

The problem that this study have tried to address is that many educational games have failed with the intended combination to be entertaining and educational at the same time. A problem that has been identified to have its roots in the fact that the games do not meet the players goals and that they, in a classroom setting, are not efficient enough to replace traditional teaching methods and neither entertaining enough to attract learners (Kerawalla & Crook, 2005). In the increasingly digitised society today, it seems like a waste of resources to not use the identified motivating effect and learning potential of digital games (Gros, 2007; Prensky & Prensky, 2007; Mozelius, 2014).

Despite the strong interest among researchers as well as among consumers and learners it seems that the educational games that are designed and developed today do not grab the target audience's attention. One factor that partly can explain the absence of success might be that many educational games do not reach the same standards of graphics and game mechanics as players of COTS games are used to (Kerawalla & Crook, 2005). A theory on how educational games can be designed to stimulate motivation can be found in Lepper & Malone's (1986) taxonomy of intrinsic motivations for learning and ideas on intrinsic integration have been described by Habgood & Ainsworth (2011). However, despite several research studies on the design of educational games (Gee, 2003; Dickey, 2007, Brusse et al, 2010; Tang & Hanneghan, 2014), there still seems to be a gap between theories and ideas in research, and the actual implementation and construction of educational games.

1.2 Aim of the study

This study has explored the relationship between learners' perceived acquisition of knowledge in educational games, and the concepts of intrinsic integration and tangential learning. The study was based on three games that all are described in detail under 'Selected games' in the method chapter. Furthermore, the study aims to analyse how theories and design ideas from research may be applied in actual game construction. This is also a type of study that earlier have been asked for by game researcers (Belanich et al., 2004). Hopefully, the outcomes of the study should be of use for researchers and game designers interested in motivation factors, intrinsic integration and tangential learning.

1.3 Research question

How might motivating factors and intrinsic integration of knowledge in educational games have an impact on learner's perceived acquisition of knowledge?

2. Extended background

Game-based learning has great potential to give many people a chance to learn new things on their own terms. Today this potential is not fully realised, mainly because many games used in education is of poor quality, both in terms of entertainment and education. It is an endeavour to digitise and personalise education by using computer games but at the same time it is problematic to not have any guidelines for educational game design. By examining popular entertainment games this study seeks to identify and understand which factors are important for players' learning motivation

2.1 Extrinsic and intrinsic motivation

Motivation can be divided into two main parts, extrinsic and intrinsic motivation (Cameron et al., 2005). Extrinsically motivated activities are activities where a person can achieve rewards or try to avoid punishment. These sticks and carrots are not directly related to the activities and examples of carrots in educational contexts are grades, certificates and diplomas (Mozelius, 2014). In digital games extrinsic motivation can be implemented by achievements and badges (Filsecker & Hickey, 2014).

Intrinsic motivation can be compared with gaming for gaming's sake or learning for the sake of learning (Mozelius, 2014). Intrinsically motivated learners tend to be more aware of inconsistencies, complexities, and unexpected possibilities (Kapp, 2012). A model that breaks down intrinsic motivation into two levels with seven components is Frank Lepper's and Thomas Malone's taxonomy of intrinsic motivation (Malone & Lepper, 1987). The levels and the components in the taxonomy of intrinsic motivation are:

The personal level

- **Challenge** in terms of goals, uncertain outcomes and performance feedback
- **Curiosity** in terms of sensory and cognitive inquisitiveness
- **Control** in terms of contingency, choice and power
- **Fantasy** with emotional and cognitive aspects interwoven

The interpersonal level

o **Cooperation** in terms of players working together to achieve goals
o **Competition** where players compete against each other to achieve goals
o **Recognition** in terms of making achievements available for others

(Malone & Lepper, 1987)

Dickey (2007) used the Lepper and Malone taxonomy in a study to analyse intrinsic motivation aspects of the online game *World of Warcraft.*

2.2 Intrinsic integration

An important factor for motivation in the design of educational games could be what Habgood & Ainsworth (2011) call *intrinsic integration*. Their claim is that the pedagogic or didactic quality of learning games is depending on how well learning content is integrated and interwoven in the gameplay. The problem might be that many educational games today separate the joyful gaming from breaks with mandatory 'learning exercises' to open up the next game level (Habgood & Ainsworth, 2011). An example of this is when the gamer should solve mathematical exercises by shooting at tiles to enter the right solution. Shooting at tiles is a game mechanic without any relevant alignment to the educational theme of solving mathematical problems.

Habgood & Ainsworth are not the only researchers advocating intrinsic integration, there exist several other studies conducted in the last decades that have emphasised the importance of integrating learning content with game mechanics and narration (Kafai, 1995; Ke, 2008; Klopfer et al, 2009; Ke, 2016). Furthermore, it has been pointed out that the extent to which content engagement is intrinsic to the main gameplay will influence gamers' learning (Richards et al, 2013). However, there is no guarantee that the intrinsic design of 'learning-play integration' in the core gameplay necessarily develops any knowledge (Ke, 2016).

According to Jacob Habgood (2005) two basic guidelines for the implementation of intrinsic integration in games are to:

1. Include the learning content in the parts of the game that are the most fun to play without interrupting the flow experience.
2. Integrate the learning content in the game world and in the player's interaction with it, to provide an external representation of the learning material that should be explored through the game mechanics.

2.3 Tangential learning

Educational games may not necessarily have to teach topics directly. In a video by Floyd and Portnow (2008) and in an article by Portnow and Floyd (2008), the concept of tangential learning is suggested as an alternative or complementary way for games to stimulate learning. The basic idea of the term is that a game should introduce a theme, a technique or a concept to inspire learners to further self-studies. Instead of direct teaching and learning a game should engage and stimulate learning by putting abstract knowledge in an attractive and engaging context.

Squire, DeVane & Durga (2008) explored the existence and potential of tangential learning in a study where lower secondary school students played Civilization III during a year. Civilization is a history game with a relatively high degree of realism where the player can follow a civilization from its beginning to present time

(Squire, 2005). Participants could be described as low and average performing students with low commitment to traditional History classes. By playing Civilization they started to seek information outside school and outside the actual gaming. During the year there was also an improvement in the formal subject grades (Squire, DeVane & Durga, 2008).

Several studies indicate that games have enormous potential to encourage tangential learning (Portnow & Floyd, 2008; Porcino et al, 2014; Rath, 2015), but there are also several identified obstacles. As highlighted by Robert Rath (2015) some problems to address are the lack of learning structures, online misinformation and players who are poor at source criticism. His method to handle these issues is an 'explanatory criticism' that should provide vetted information in a didactic structure that gives the learner a ground to start his or her own learning (Rath, 2015).

3. Methods for data collection and analysis

To understand what makes some educational games more successful in terms of transferring knowledge to the player than others, a questionnaire was distributed via online fora to the players of a number of educational entertainment games. The games were chosen because they contained a significant amount of information relevant for educational contexts, and that they have players active online in Internet fora.

The purpose of the questionnaire was to collect data about how players perceive the game and measure how much the players learned from playing the game. Data was collected and used to measure how well the motivating factors described by Lepper and Malone (1987), and Habgood and Ainsworth (2011) correspond to the user's perceived increase of knowledge.

3.1 Method of analysis

In order to determine whether the results obtained from the survey are statistically significant two methods are used, a T-test to determine differences between the results and a Pearson correlation analysis to determine the correlation between pairs of values.

The mean of the results are first analysed game by game. According to Denscombe (2010), the use of a median value be more suitable when working with ordinal data, where average values are more affected by outliers in the results. The problem with using the median value is that it allows little mathematical analysis.

There is a small risk that some extreme values affect the results when working with mean values, although in this case the number of respondents were so high that even very extreme values would have little impact. In order to better determine whether the mean values are actually saying something, the standard deviation of the results needs to be obtained. Mean values and standard deviations of the results were compared to see if some variables are significant.

By comparing values from the different games it can be determined if one is more successful at mediating knowledge than another. The independent variables that affect motivation and integrated knowledge can then be examined to see if any other variable is particularly strong in the game(s) that seems to be better at mediating knowledge. It will also be examined whether any of the factors that are prominent in the game has a weaker presence in the other games, and would therefore be able to explain a reduced perceived amount of learning for the respondents.

3.2 Selected games

Kerbal Space Program
Kerbal Space Program is a game developed by the *Studio Squad*, where the goal is to build spacecrafts, send them into orbit and visit moons and other planets. The game features a realistic physics engine and can simulate the physical laws that exist in our solar system (Hall, 2014). The company Teacher Gaming has made a modified version of Kerbal Space Program under the name *KerbalEdu*, a light version of the original game developed specifically for learning in classroom settings (Teacher Gaming, 2015).

NASA recognised the game's ability to spread interest in space research, and in 2013 went into a collaboration with Squad to develop an addition to the game where asteroids can be captured and placed in orbit, a project that NASA plans to perform in 2025 (The Guardian, 2015). Kerbal Space Program won the 2014 Game

Developers Choice Awards, appointed by the players as the year's games in the category Audience Awards (Game Developers Choice Award, 2015).

Crusader Kings

Crusader Kings II, is a grand strategy game developed by *Paradox Interactive*. It allows the player to experience and control large parts of the Mid Ages in Europe, the game has been described as one of the more historically accurate in the genre (The Public Medievalists, 2014). The game has a large player base and has influenced players to seek further knowledge about the events that occur in the game.

Civilization

Civilization is a series of grand strategy games developed by *Firaxis Games*, where the player gets to control a civilization from its beginnings to modern times. The games possess a high degree of realism, which makes it possible to acquire knowledge about historical events (Battersby 2010). Furthermore, Civilization games have a so-called Civilopedia containing information about the civilizations that the player can control. An idea of including Civilopedias is that players should be able to gain real world knowledge and thus make them more involved in the game.

3.3 The survey

Slightly different surveys were sent out depending on the game, where the game's main theme is represented by either one of three subjects: history, astrophysics or politics. The word game in brackets will be replaced with the name of the game being examined. The questions are designed by the study authors to measure the variables studied: *knowledge acquisition, tangential learning, intrinsic integration* and *the Lepper and Malone factors*. Each issue also has an associated, optional input field for comments, where additional comments can be collected to more clearly describe the respondent's opinions.

- The first four questions are census questions regarding age, gender and education
- The first three Likert-scale questions deal with prior knowledge
    - The question regarding prior knowledge of the subject is to verify that past knowledge or previous interest is not affecting acquired knowledge since previous knowledge is an underlying variable that can affect the outcome.

I knew a lot about (history/astrophysics/politics) before I started playing (game).

- The question regarding gained knowledge measures how much the respondent experience that they have learned from playing the game. Perceived acquired knowledge is one of the dependent variables and is believed to be affected by the motivational factors.

I have learned a lot about (history/astrophysics/politics) from playing (game).

- The question regarding having sought knowledge on their own outside the game is to measure the occurrence of tangential learning. Tangential learning is the second dependent variable, and is believed to be affected by the motivational factors

I've felt motivated to seek out additional information about (history/astrophysics/politics), either outside or in the game, when it was not necessary for completing goals in the game.

- The fourth Likert-scale question examines how well the respondents feel that knowledge is integrated into the gameplay. This question is based on Habgood and Ainsworths (2011) study which showed that a high degree of knowledge integration facilitates learning.

I feel that information about (history/astrophysics/politics) is very well integrated within the game mechanics of (game).

- The last seven questions of the questionnaire explores the respondent's perception of the game in regards to Lepper's and Malone's (1987) heuristics: challenge, curiosity, control, imagination and cooperation, competition and recognition.

I would describe (game) as challenging in regards to finishing goals and progressing.

The amount (or lack of) information available to me in game was enough to keep me curious.

When playing (game) I feel in control of choosing my own strategies and controlling the mechanics of the game.

I have felt immersed in (game), in that I can either relate to the characters or feel like I'm a part of the game.

I rely on cooperation with other people, either in or outside the game, to understand the game better and finish goals.

I compete with other players of (game), in measuring our in game accomplishments.

Receiving recognition from other players of (game) is important for my motivation to continue playing.

4. Results

The questionnaire had a total of 635 respondents (N = 632), where players of Kerbal Space Software accounted for 442 of the responses, Crusader Kings accounted for 145 of responses and Civilization constituted 45 of the answers. The average age of the respondents overall was 21 years, and evenly distributed between games with the average age of Kerbal Space Program players being 21 years, Crusader Kings 22 years and Civilization 21 years.

Table 1: Respondents' average age

	Respondents	Respondents %	Average age	Standard deviaton
Kerbal Space Program	442	70%	20.94	7.17
Crusader Kings	145	23%	22.47	7.55
Civilization	45	7%	21.45	8.85
total	632	100%	21.33	7.37

The respondents were mostly male, a small number of females and even fewer people that would not disclose their gender or identified as intergender participated.

Table 2: Gender distribution

	Male	Female	Intergender	Unspecified
Kerbal Space Program	97%	1%	1%	1%
Crusader Kings	93%	4%	0%	3%
Civilization	91%	7%	0%	2%
total	96%	2%	0,5%	1.5%

Table 3 illustrates the respondents' level of education, which is close to equal for all games with a majority of respondents without any experience of higher education.

Table 3: Respondent's education level

	Secondary school	Upper Secondary school	Tertiary education	University Degree	Postgraduate studies	Postgraduate Degree
Kerbal S P	31%	17%	29%	14%	4%	6%
Crusader K	19%	14%	28%	21%	9%	8%
Civilization	31%	22%	27%	16%	5%	6%
total	28%	17%	27%	16%	5%	6%

Table 4 shows the educational orientation of the respondents who have post-secondary education. The respondents are mostly technically oriented in their education, with some significant numbers in social sciences and humanities as well.

Table 4: Respondent's educational orientation

	Natural Sciences	Technical	Medicine	Social Sciences	Humanities
Kerbal S P	20%	62%	3%	7%	7%
Crusader K	9%	44%	4%	23%	20%
Civilization	8%	42%	0%	23%	27%
total	17%	56%	3%	12%	12%

Respondents perceived knowledge before playing differed between the games, where players of Kerbal Space Program showed a mean value of 2.5, while players of Crusader Kings and Civilization produced a mean value around 4.

4.1 Knowledge acquisition and Tangential learning

Mean knowledge acquisition shows that respondents feel they have acquired new knowledge from playing games, where Kerbal Space Program show a mean value of 5.29, Crusader Kings got a mean of 4.75 and Civilization 4.24. Regarding tangential learning players of Kerbal Space Program answered about the same as for the acquisition of knowledge, but players of Crusader Kings and Civilization valued tangential learning higher than acquisition of knowledge directly from the games with mean values of 5.31 and 4.87.

Table 5 shows the mean value and standard deviation of the respondent's prior knowledge, knowledge acquisition, and the degree of tangential learning

Table 5: Respondent's prior knowledge, knowledge acquisition and tangential learning

	Prior Knowledge	std.dev.	Knowledge acquisition	std.dev,	Tangential learning	std.dev.
Kerbal S P	2.53	1.38	5.29	1.01	5.25	1.11
Crusader K	4.02	1.35	4.75	1.2	5.31	1.02
Civilization	4.16	1.53	4.24	1.32	4.87	1.32
total	2.99	1.53	5.09	1.13	5.24	1.11

4.2 Summary of answers

Table 6 shows the mean value and standard deviation of the respondents' answers to the questions regarding prior knowledge, increase of knowledge, tangential learning, integration of knowledge in the game, challenge, curiosity, control, fantasy, cooperation, competition and recognition.

Table 6: Mean values for motivating factors, prior knowledge and knowledge acquisition.

	Mean value	Standard deviation
Prior knowledge	2.99	1.53
Knowledge acquisition	5.09	1.18
Tangential learning	5.24	1.11
Intrinsic integration	4.57	1.13
Challenge	4.93	1.09
Curiosity	4.88	1.11
Control	5.20	0.92

	Mean value	Standard deviation
Fantasy	4.4	1.38
Cooperation	3.53	1.6
Competition	2.54	1.64
Recognition	2.12	1.4

5. Analysis

A t-test was performed to investigate whether there was any difference between how much respondents learned from the games directly and how much they learned through tangential learning via other sources. For Kerbal Space Program there was no significant difference with a p-value of .4255. For Crusader Kings tangential learning was significantly greater than acquisition of knowledge from within the game, where p <0.0001. For Civilization tangential learning was also significantly greater, where p = 0.0067. For all the games combined tangential learning was significantly higher than direct knowledge acquisition, where p = 0.0038.

Table 7: Mean values for direct knowledge acquisition and tangential learning, and significance from the t-test of the difference between the two.

	Knowledge acquisition	Tangential Learning	Significance
Kerbal	5.29	5.25	0.4255
Crusader	4.75	5.32	<0.0001**
Civilization	4.24	4.87	0.0067**
total	5.09	5.24	0.0038**

**Significance at 0.05 (two - tailed)*
*** Significance at 0.01 (two - tailed)*

5.1 Correlation analysis

To investigate the relationship between the factors examined in the questionnaire a Pearson correlation analysis was performed for each combination of two values. Due to the high number of respondents there was a risk that even weak correlations yielded significant results. Therefore the analysis only treats correlations of around 0.3 or above and -0.3 and below as significant.

Prior knowledge showed low or non-significant correlations with other factors. A weak positive correlation was found between prior knowledge and direct knowledge acquisition for Civilization (r = 0.35), which could indicate that more knowledge leads to improved knowledge acquisition. However, this tendency was not found for the other games, which despite low r-values or insignificant results rather indicated a negative relationship where more prior knowledge would lead to less knowledge acquisition.

A weak positive correlation was found between knowledge acquisition and tangential learning (r = 0.38). This correlation implies a beneficial effect between learning from a game and seeking additional knowledge from outside the game. While it does not show which of the two affects the other, it does suggest that tangential learning should not be dismissed when discussing the educational potential of a game. A medium strong correlation was found between knowledge acquisition and intrinsic integration (r = 0.43) with the strongest relationship being for Civilization (0.58), which supports Habgood and Ainsworths (2011) theory that knowledge must be integrated into the game's mechanics to effectively be taught. For Lepper and Malone's factors for intrinsic motivation a few weak positive correlations were found. A weak correlation between knowledge acquisition and control (r = 0.26) was found. In Kerbal Space Program and Crusader Kings a weak correlation was found between knowledge acquisition and imagination (r = 0.27, r = 0.28), and for Crusader Kings there was also a weak correlation between knowledge acquisition and competition (r = 0.29). This indicates that the player's sense of immersion and control is important for learning. Competition may be important for some games depending on how competitive they are. Crusader Kings showed such a relationship while Kerbal Space Program, which lacks built-in elements of competition between players, does not show such a correlation.

Table 8: Correlations between knowledge acquisition and the studied factors.

Corr w/ Knowledge Acquisition	Total	Kerbal	Crusader	Civilization
Prior knowledge	-0.16879**	-0.0805	-0.10005	0.34623*
Tangential	0.37878**	0.43151**	0.25255**	0.38391**
Integration	0.42654**	0.37694**	0.37625**	0.5827**
Challenge	0.21766**	0.16042**	0.16638*	0.2659
Curiosity	0.1716**	0.15175**	0.22092**	0.22076
Control	0.25911**	0.23944**	0.20213*	0.18868
Fantasy	0.19503**	0.26718**	0.27706**	0.1191
Cooperation	0.13566**	0.1551**	0.14496	0.10325
Competition	0.15301**	0.13481**	0.28585**	0.02116
Recognition	0.16802**	0.10809*	0.19423*	0.23018

** Significance at 0.05.*
*** Significance at 0.01.*

Tangential learning showed overall fewer associations with the different factors than the direct acquisition of knowledge. Intrinsic integration showed a weaker positive correlation with tangential learning (r = 0.24) than for direct acquisition of knowledge (r = 0.38). A weak to medium strong correlation was found between tangential learning and curiosity for Crusader Kings (r = 0.33) and Civilization (r = 0.52), suggesting that the more curious a player, the more they are motivated to seek out additional knowledge on their own. Civilization also had a weak positive correlation between tangential learning and cooperation (r = 0.33).

Table 9: Correlations between tangential learning and the studied factors.

Corr w/ tangential	Total	Kerbal	Crusader	Civilization
Prior knowledge	0.01258	-0.02421	0.09647	0.28494
Integration	0.24164**	0.26185**	0.22488*	0.13163
Challenge	0.07872*	0.07071	0.0387	0.2802
Curiosity	0.022148**	0.15067*	0.33337**	0.51835*
Control	0.18932**	0.21446**	0.17708*	0.09867
Fantasy	0.17113**	0.20801**	0.08413	0.04967
Cooperation	0.21318**	0.23648**	0.11794	0.33167*
Competition	0.13803*	0.14592*	0.11835	0.27608
Recognition	0.06709	0.06218	0.03613	0.20279*

** Significance at 0.05.*
*** Significance at 0.01.*

6. Conclusion

Results showed that tangential learning accounts for a substantial part of knowledge learned for the observed games. The concept of inspiring players to effectively seek out knowledge and teach themselves is an exciting notion, and it may be a piece of the puzzle that's been missing in educational game development. If tangential learning is proven as a viable means of education it may shift the role of educational games from being merely instructional to be more motivating and inspirational.

The most obvious, and expected finding, is that intrinsic integration of learning content seems to be a crucial design factor. This can also, like in the study by Habgood and Ainsworth (2011), be aligned to educational games potential to stimulate tangential learning. In two of the three tested games respondents perceived that they learnt more by tangential learning than by direct learning and a design idea worth further exploration is to construct games that includes a model or a module for further self-studies. An interesting example of this are the built-in encyclopaedias in the Civilization games where gamers can dig deeper for knowledge about historical events in the gameplay.

In games where knowledge has been successfully integrated, the game mechanics can serve as platforms for trying out and experimenting with ideas that have been acquired outside of the game. Imagine learning about avionics and how wing designs affect speed and manoeuvrability, or reading historical descriptions of the British longbow and how it changed the way battles were fought, and imagine having a tool to try out and experiment with those concepts, seeing how they play out and how changes made by the player effects the outcome.

The relationship shown between intrinsic integration and tangential learning further strengthens this. More research is needed testing the extent of tangential learning in games that either only motivates the player to learn more and games that require the player to gain knowledge to complete the game. An idea for future research is to implement and test this more specific in learning games on computer science where authors have the required domain knowledge. This should follow the recommendation from Portnow & Floyd (2008), to enable learning but to keep entertainment as the main goal of the games. Domain knowledge is important to not violate the concept of that players transcending from the game to the related content, should be introduced with quality content to ensure a sufficient knowledge acquirement (Portnow & Floyd, 2008).

7. Future work

What would be an interesting continuation is to test the games in a real educational setting and to compare students more formal mandatory gaming with voluntary gaming. In such a study students' learning outcomes should be measured by pre- and post-testing.

The concept of tangential learning is still relatively new and warrants more research in exploring the concept and its relationship to direct knowledge acquisition in educational games. It would be interesting exploring if different types of knowledge and skills favour one method over the other. A deeper understanding of the relationship between intrinsic integration and tangential learning would also be interesting, mainly, if games that require knowledge from the player to become better at the game affects tangential learning, or if the power of tangential learning merely stems from the players growing interest in the subject.

This study will also be included as a part of the ResearchGate *project 'Learning to Program by Playing Learning Games'* where authors will try to apply the concepts of intrinsic integration and tangential learning in the field of programming education. For ResearchGate members the project can be accessed via:
https://www.researchgate.net/project/Learning-to-Program-by-Playing-Learning-Games

To implement the concepts in game-based learning environments takes time and requires resources. One of the authors are currently part of a large scale project application where these ideas could be part of a three year collaboration between five universities with experience and expertise in the field of game-based learning for programming education.

References

Battersby, J. (2010). Intrinsic Learning in Games: Literature Review. *Research Methods*, June, 4, 1-5.

Belanich, J., Sibley, D. E., & Orvis, K. L. (2004). *Instructional characteristics and motivational features of a PC-based game* (No. ARI-RR-1822). Army Research Inst for the Behavioral and Social Sciences Alexandria, VA.

Brusse, E.D.A., Neijens, P.C., & Smit, E.G. (2010) Talking to Deaf Ears? Two Routes to Narrative Persuasion in Entertainment Education, In proceedings of *International Conference on Future Imperatives of Communication and Information for Development and Social Change*, Bangkok

Cameron, J., Pierce, W. D., Banko, K. M., & Gear, A. (2005). Achievement-Based Rewards and Intrinsic Motivation: A Test of Cognitive Mediators. *Journal of Educational Psychology*, 97(4), 641.

Charsky, D. (2010). From edutainment to serious games: A change in the use of game characteristics. *Games and culture*.

Deci, E. L., & Ryan, R. M. (2011). Self-determination theory. *Handbook of theories of social psychology*, 1, 416-433.

Denscombe, M. (2010). The good research guide: For small-scale social research projects: For small-scale social research projects. Berkshire: McGraw-Hill International.

Dickey, M. D. (2007). Game design and learning: A conjectural analysis of how massively multiple online role-playing games (MMORPGs) foster intrinsic motivation. *Educational Technology Research and Development*, 55(3), 253-273.

Floyd, D. and Portnow, J. (Writer) (2008) Video Games and Learning [Online} (Accessed 12/05/2016) from: http://www.youtube.com/watch?v=rN0qRKjfX3s

Game developers choice awards (2015). 14th annual game developers choice award. (Accessed 30/04/2016) from: http://gamechoiceawards.com/archive/gdca_14th.html#

Gee, J. P. (2003). What video games have to teach us about learning and literacy, *Computers in Entertainment (CIE)*, 1(1), 20-20.

Gros, B. (2007). Digital games in education: The design of games-based learning environments. *Journal of research on technology in education, 40(1)*, 23-38.

Gunter, G. A., Kenny, R. F., & Vick, E. H. (2008). Taking educational games seriously: using the
RETAIN model to design endogenous fantasy into standalone educational games. Educational
Technology Research and Development, 56(5-6), 511-537.

Habgood, J. (2005). Zombie Division: intrinsic integration in digital learning games. *Cognitive Science Research Paper-University of Sussex CSRP, 576*, 45.

Habgood, M. J. & Ainsworth, S. E. (2011). Motivating children to learn effectively: Exploring the value of intrinsic integration in educational games. *The Journal of the Learning Sciences*, 20(2), 169-206.

Hall, C. (2014, 27 January). To the Moon and Back: Kerbal Space Program. Polygon.com. (Accessed 28/04/2016) from: http://www.polygon.com/features/2014/1/27/5338438/kerbal-space-program

Kafai, Y. B., & Kafai, Y. B. (1995). *Minds in play: Computer game design as a context for children's learning.* Routledge.

Kapp, K. M. (2012). *The gamification of learning and instruction: game-based methods and strategies for training and education.* John Wiley & Sons.

Ke, F. (2008). Computer games application within alternative classroom goal structures: cognitive, metacognitive, and affective evaluation*. Educational Technology Research and Development, 56(5-6)*, 539-556.

Ke, F. (2016). Designing Intrinsic Integration of Learning and Gaming Actions in a 3D Architecture Game. *Handbook of Research on Serious Games for Educational Applications, 234*.

Kerawalla, L., & Crook, C. (2005). From promises to practices: The fate of educational software in the home. Technology, *Pedagogy and Education, 14(1)*, 107-125.

Klopfer, E., Osterweil, S., & Salen, K. (2009). Moving learning games forward. *Cambridge, MA: The Education Arcade.*

Malone, T. W., och Lepper, M. R. (1987). Making learning fun: A taxonomy of intrinsic motivations for learning. *Aptitude, learning, and instruction*, 3, 223-253.

Mozelius, P. (2014). Game Based Learning-a way to stimulate intrinsic motivation. In *Proceedings of the 9th International Conference on e-Learning ICEL* (pp. 272-279).

Papert, S. (1998). Does easy do it? Children, games, and learning. *Game Developer*, 5(6), 88.

Porcino, T. M., Strauss, E., & Clua, E. G. (2014, May). Hugo against dengue: a serious game to educate people about dengue fever prevention. In *Serious Games and Applications for Health (SeGAH), 2014 IEEE 3rd International Conference* on (pp. 1-5). IEEE.

Prensky, M., & Prensky, M. (2007). Digital game-based learning (Vol. 1). St. Paul, MN: Paragon house.

Portnow, J., & Floyd, D. (2008). The power of tangential learning. *Edge Online*.

Richards, J., Stebbins, L., & Moellering, K. (2013). Games for a digital age: K-12 market map and investment analysis. *In Joan Ganz Cooney Center at Sesame Workshop*, New York.

Rath, R. (2015). Game Criticism as Tangential Learning Facilitator: The Case of Critical Intel*. Journal of Games Criticism, 2(1),* 1-9.

Ryan, R. M., Rigby, C. S., & Przybylski, A. (2006). The motivational pull of video games: A self-determination theory approach. *Motivation and emotion, 30*(4), 344-360.

Sigurdardottir, H. (2012) Debating Matters in Digital Game-Based Learning, in Proceedings of the 6th European Conference on Games-Based Learning (ECGBL 2012), pp 471-477. Academic Publishing, Reading, UK.

Squire, K. (2005). Changing the game: What happens when video games enter the classroom. *Innovate: Journal of online education*, 1(6).

Squire, K. D., DeVane, B. & Durga, S. (2008). Designing centers of expertise for academic learning through video games. *Theory Into Practice*, 47(3), 240-251.

Tang, S., & Hanneghan, M. (2014). Designing educational games: a pedagogical approach. Gamification for Human Factors Integration: Social, Education, and Psychological Issues*: Social, Education, and Psychological Issues, 181*.

TeacherGaming (2015). (Accessed 29/04/2016) from: http://www.teachergaming.com/index.html#projects

The Guardian (2015). Minecraft in space: Why NASA is embracing Kerbal Space Program. (Accessed 29/04/2016) from: http://www.theguardian.com/technology/2014/may/22/kerbal-space-program-why-nasa-minecraft

The Public Medievalist. (2014). It’s what you do with it that counts: factual accuracy and mechanical accuracy in Crusader Kings II. (Accessed 30/04/2016) from:
http://www.publicmedievalist.com/ckii-houghton/

Van Eck, R., 2006. Digital game-based learning: It's not just the digital natives who are restless. *EDUCAUSE review*, 41(2), p.16.

Wiklund, M., & Mozelius, P. (2013). Learning Games or Learning Stimulating Games: An Indirect Approach to Learning Stimulating Effects from Off-the-Shelf Games. *International Journal of Digital Information and Wireless Communications (IJDIWC)*, 3(3), 290-300