Motivating factors and intrinsic integration of knowledge in educational games

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Abstract

Several studies indicate that the educational potential of games has not been fully realised, and a lot of games used in education do not live up to the duality of entertainment and educational outcomes. While there is an endeavour to digitise and personalise education by using computer games there is a lack of knowledge about what makes an educational game effective. By examining popular entertainment games this study seeks to identify which factors are important for players' learning motivation.

This study aims to explore and discuss if and how motivating factors and intrinsic integration of knowledge in educational games might be related to perceived acquisition of knowledge. Players of educational games were recruited from gaming forums and a questionnaire was used to collect data. The study used Lepper's and Malone's set of heuristics for intrinsic motivation in interactive learning environments and Habgood's and Ainsworth's theory of intrinsic integration to examine the relationship between these factors and the educational use of digital games. In addition to the direct acquisition of knowledge from gaming there was also an analysis of gamers' 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 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 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 and the intrinsic integration of knowledge in educational games might be related to 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

- **Cooperation** in terms of players working together to achieve goals
- **Competition** where players compete against each other to achieve goals
- **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.*

Intrinsic integration and Tangential learning

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.

On the other hand educational games do not necessarily have to teach topics directly. Portnow (2008) brings up and suggest the concept of *tangential learning*. The basic idea of the term is that a game could 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 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, but by playing Civilization they started to seek information outside school and outside the actual gaming and during the year there was also an improvement in the formal subject grades (Squire, DeVane & Durga, 2008)

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 used in education today and have a following of players active on 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. This data is 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.

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 T-test uses two sets of data, by comparing the average values and standard deviation it is determined whether there is a statistically significant difference between the two datasets. Significance is annotated with character p, which stands for probability. The value of p, a number between 0 and 1, shows the percentage probability that the differences in the two sets of values occurred by chance. The lower the p-value, the less the risk that a difference is just coincidence. A significance level set for the values to be considered significant. Often a significance level of 0.05 is set and is printed as $p < 0.05$, but the significance levels can also be set lower (Denscombe, 2010).

Correlation analysis does the opposite of what the t-test is doing. Instead of finding the differences between two sets of values a correlation analysis investigates whether there are connections between them. The correlation was visualised with a scatter-plot, a graph with one category along the x-axis and the second category along with the y-axis.

For each pair in the dataset, in this case a respondent with a value of knowledge acquisition (y-axis) and one of the factors for motivation (x axis), is a dot in the graph where the value of y meets the value of x. The correlation analysis takes all the dots for all pairs of data and examines whether there is a connection, which is annotated with a value of r. A relationship is printed with an R-value between 1 and -1, where 1 and -1 is a perfect connection and 0 is no correlation.

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.
    - 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.
    - 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

- 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.
- 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.

Environment

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 Middle 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.

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.

	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

Table 1. Respondents' average age

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.

	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 2. Gender distribution

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.

	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 3. Respondent's education level

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.

	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%

Table 4. Respondent's educational orientation

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

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

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.

	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
Fantasy	4,4	1,38
Cooperation	3,53	1,6
Competition	2,54	1,64
Recognition	2,12	1,4

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

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 $p = 0.0038$.

	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)*

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

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). The correlation suggests that the more a game teaches the more it motivates players to seek out additional knowledge on their own. 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.

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

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).

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

6. Conclusion

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 is the built-in encyclopaedias in the Civilization games where gamers can dig deeper for knowledge about historical events in the gameplay.

Furthermore, gamers want to be in control of the gaming as well as of the learning and the order of learning sequences. Lepper also mentions the importance of control and Malone (1987) and the idea that autonomy stimulates motivation is also a central idea in the Self-determination theory (Deci & Ryan, 2011). Self-determination is also found to have a positive impact on game enjoyment and gamers' intrinsic motivation (Ryan et al., 2006).

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.

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