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Published in:
International Journal of Learning

Publication date:
2010

Document Version
Publisher's PDF, also known as Version of record

THE INTERNATIONAL
JOURNAL of LEARNING

Volume 17, Number 10

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www.Learning-Journal.com

THE INTERNATIONAL JOURNAL OF LEARNING
http://www.Learning-Journal.com

First published in 2011 in Champaign, Illinois, USA by Common Ground Publishing LLC
www.CommonGroundPublishing.com.

ISSN: 1447-9494
Publisher Site: http://www.Learning-Journal.com

THE INTERNATIONAL JOURNAL OF LEARNING is peer-reviewed, supported by rigorous processes of criterion-referenced article ranking and qualitative commentary, ensuring that only intellectual work of the greatest substance and highest significance is published.

Typeset in Common Ground Markup Language using CGCreator multichannel typesetting system
http://www.commongroundpublishing.com/software/

Designing an Educational Game: Design Principles from a Holistic Perspective

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Abstract: When designing games with learning purposes used in a classroom, there often occur problems about the lack of learning content or the lack of game contents. Other disadvantages of existing educational games are the difficulty to provide a continual balance between the challenge and the pupils' skill to control and solve the given task. In this paper we suggest three different perspectives that need to be communicated across in order to design a useful educational game: teachers, pupils and game designers. It is our intention with this paper to suggest some design principles for educational games, and to integrate teachers, pupils and game designers needs and requirements. To set up these design principles for educational games we have used a holistic perspective. This means that the design principles must be seen in coherence within the social and physical environment. The design principles relate to the world in which the game is going to be used. This involves integration of thinking, feelings, perceiving, behaving, culture and context from game designers, teachers and pupils. The most important point in developing design principles for educational games may be that good games engage both pupils and teachers, and the interplay between game play, pupils and teachers creates some dynamic learning opportunities.

Keywords: Educational Game, Design Principles, State School

Introduction

SINCE THE EARLY 1960s, when the first computer game was developed, we have seen the technology and development of computer games evolve. Generation after generation, people have become more familiar with the use of computer technology, some more than others. The majority of children born since the 1990s have grown up with consoles, handheld consoles and PCs. The computer technology has become a part of the children's existence and they have a natural approach to the use of computers (Prensky, 2001a). Prensky (2001b) defines these children as the digital natives; children born into the time of digital technology. Additionally, when children play computer games, they absorb themselves into the game world with an intensity and enthusiasm that any teacher would envy (Prensky, 2001; Egenfeldt-Nielsen & Smith, 2004). Some computer games have an effect of absorbing and entertaining children for several hours. For that reason game designers have tried to design computer games for educational purposes (Prensky, 2003). However, it has shown not to be a straightforward assignment to produce successful educational games (Purdy, 2007; Annetta, 2008; Baek, 2008; Robertson and Howells (2008). The majority of educational games typically consist of simple applications, for instance multiple-choice applications, that do not have the engaging or committing entertaining elements as some computer games possess (Jessen, 2007).

The International Journal of Learning
Volume 17, Number 10, 2011, http://www.Learning-Journal.com, ISSN 1447-9494

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In a broad definition, the term educational games is commonly used for computer games with an educational purpose, which is computer games used for other purposes than only pure entertainment (Purdy, 2007). Game designers have become conscious of how pupils are motivated to learn and the entertaining elements from games are in focus. It is not just a question having pupils play a computer game; it is about taking advantage of the medium as a learning tool, by letting the pupil investigate and form hypotheses while experiencing a new unknown world. When the pupils investigate on their own, it corresponds more to how we learn in practise than the traditional learning with blackboards and books (Jessen, 2007; Annetta, 2008).

When designing a computer game with learning purposes, there often occur problems about the lack of learning content or the lack of game contents. Kickmeier-Rust et al. (2007) stated that many existing educational games failed, when it came to competing with commercial computer games. Existing educational games are missing the link between the game play and the learning; either it is a simple application, where the learning is dominant and elements from a game play are applied to the application (such as multiple choices applications), or one have tried unsuccessfully to add some learning to the digital game (Kickmeier-Rust et al., 2007). Other disadvantages of existing educational games are the difficulty to provide a continual balance between the challenge and the pupils' skill to control and solve the given task. The pupils (both male and female) enjoy computer games, and the games which pupils prefer go along with an appropriate level of challenge, and multiple levels, so that they can make progress (McFarlane, Sparrowhawk and Heald, 2002). Teachers often ask sceptical questions and believe that violence, aggression, social isolation are the consequences of playing computer games (Prensky, 2003; Squire, 2003; Zyda, 2005; Poulsen, 2008). Furthermore, some teachers do not see the advantage of learning through technology. Some teachers have developed a culture where technology, such as computer games, is not a part of the culture and believe that games are only used for entertainment. Moreover, when the culture is challenged the teachers feel insecure, because they may not be used to handling such technology (Sprague, 2004; Prensky, 2007). Furthermore it is often difficult for the designers to hold a national curriculum (Kickmeier-Rust et al., 2007), and go in dialogue with teachers (Sprague, 2004).

This suggests that there are three different perspectives that need to be communicated across in order to design a useful educational game: teachers, pupils and designers. It is our intention with this paper to suggest some design principles for educational games, and to integrate teachers, pupils and designers needs and requirements.

Related Work

In Denmark, Egenfeldt-Nielsen (2005) made a survey upon the extent of use of educational games in the classrooms and the teachers' perceptions of computer games. The survey was a quantitative questionnaire distributed on the internet for teachers at different state schools in Denmark. The average age of the teachers was 45.5 years old. They had different backgrounds but in general they all had limited experience with computer games. Only 43 teachers from the Danish educational system participated in the survey, despite the fact that the survey was distributed to 150 schools often containing 20-40 teachers at each school. The same problem occurred in the survey conducted by Becker & Jacobsen (2005). As Becker and Jacobsen (2005) stated, it may not be the most optimal solution to make an online

questionnaire. When conducting a survey online there may be a risk that teachers with minor or no technical skills will not answer the questionnaire. Consequently, most of the teachers who responded to the questionnaire could be those who were most familiar with computer technology and those who already used games for educational purposes. A paper version or, even better, an interview scenario would have avoided any assumptions concerning the use of computer technology.

The survey conducted by Egenfeldt-Nielsen (2005) showed that there were both positive and negative statements of the teachers' perception of computer games. The primary positive statements were the motivation when playing computer game, alternative presentation, greater interest from the pupils' view, better learning atmosphere, peer collaboration and student autonomy (Egenfeldt-Nielsen (2005). The negative statements of the teachers' perception of the use of educational games in classrooms were mainly the quality of the titles of the games and lack of knowledge of computer games. Other problems mentioned by the teachers were access to computers, technical barriers, the problem of covering the curriculum, learning to play game, and more preparation (Egenfeldt-Nielsen, 2005).

The survey done by Becker and Jacobsen (2005) indicated that the primary barriers were the missing access to trail educational games, the support and skills to get started and the time that the teachers use to understand a game and prepare it for a class (Becker and Jacobsen, 2005). Most teachers did not know where or how to find the games, if the games were good enough for the given class or how to incorporate them in a class. Some teachers had a sceptical view of games and answered that the more the game "sounded" like a game, the less the teachers wanted to try using it (Becker and Jacobsen, 2005), which was the same observation that Egenfeldt-Nielsen did in his survey (Egenfeldt-Nielsen, 2005).

Becker (2007) designed a course for teaching teachers how to use games for educational purposes. The course was designed to teach teachers about advantages and disadvantages of educational games, and how to use games in their teaching. The assignment for the teachers was to analyse and think of how to integrate a game in their own teaching. During the course, Becker (2007) let the teachers play the games themselves; the teachers needed to get familiar with how computer games work in action. If they should make use of computer games in classroom, then they need to play the game themselves before letting the pupils play (Becker, 2007). An evaluation of the course showed that the teachers were surprised of computer games' ability to be used in education. However, the majority of the participating teachers realized a lack of curriculum in the games and lack of some contextual design principles (Becker, 2007).

Methods

To set up some design principles for educational games we have used a holistic perspective. This means that the design principles must be seen in coherence within the social and physical environment. The design principles relate to the world in which the game is going to be used. This involves integration of thinking, feelings, perceiving, behaving, culture and context from both teachers and pupils. The most important point in developing design principles for educational games may be that good games engage both pupils and teachers, and the interplay between game play, pupils and teachers creates some dynamic learning opportunities. The holistic perspective is to emphasize that learning is situated not only within the game but also around it. This is also what Gee (2003) calls internal and external design grammars.

Educational games simulate identities, experiences, contexts, and social relationships in designed spaces (Gee, 2003).

Gee (2003) presents five theoretical qualities of interest concerning computer games, which can be useful in a school context to facilitate learning in a more engaging way. The five qualities are: semiotic domains, learning and identity, situated meaning and learning, telling and doing and cultural models. With inspiration from these five qualities we designed qualitative interviews with teachers, pupils and designers. We have used purposeful sampling (Koerber and McMichael, 2008) to find the right participants to interview. This means that we have been looking for participants who possess certain traits or qualities regarding educational games, e.g. participants having experience using an educational game. We also wanted to interview more than one participant from each group (teachers, designers and pupils) to get a wider variety of perspectives.

The approach to the interviews was performed by a semi-structured interview guide (Kvale and Brinkmann, 2009), which covers an everyday conversation with a structured starting point, but structured by different themes. The list of questions was used as a guideline. We made sure that all the themes were covered by the end of the interview. We have used the content analysis (Patton, 1987) to label and structure our data. It turned out to be a good method in this study, because it was a rather fast method for organizing and simplifying the complexity of the data into some meaningful themes. All the mentioned names are not the people's real names in order to protect their identity.

Interview with Teachers

Some of the barriers for incorporating games in classrooms are lack of technical skills, no experience with computer games in general and uninformed knowledge of the advantages of games. In this study we find it sufficient to collect empirical data only from teachers having experience with using educational games in classrooms. The Avedøre School (just outside Copenhagen) has many years of experience with using educational games in the classroom. We contacted Brenda, who teaches biology, and uses educational games. The other interviewed teacher was Ellen, a librarian at a school in Odense, in a so called "Combilibrary", which is an integrated public and school library. Ellen has about eight years of experience with helping teachers incorporating computer games into the classroom. The semi-structured interview guide with the interviewed teachers had these themes: using educational games in classrooms, pro and cons of the preparation and teaching with an educational game, and the teachers perspective of the design of an educational game.

Interview with Game Designers

We also interviewed two game designers, Nigel and Dan. They both have great experiences developing educational games. They have previously worked together. Nigel is creative director and founder of a company within educational games, and Dan is a programmer, dealing with interactive media.

Both the interviews with teachers and designers were performed as In-Depth Interviews (Gubrium & Holstein, 2001). We wanted some deep information and knowledge, which could not be obtained in a survey, because we sought experiences, perspectives, values and decisions regarding design principles within educational games. The themes for the game

designers interview guide was: earlier experiences when designing educational games and pro and con of an educational game from a designers perspective.

Interview with Pupils

The interview with pupils was performed as a group interview (Kvale and Brinkmann, 2009) at Thomas´ School in Skovlunde (nearby Copenhagen). The school is a private Christian school with many years of experience using different educational games. The focus group consist of: Martin, Peter, Carla and Anna. They were all from the 6th grade, and were used with approval from both the school and their parents.

The interview with the pupils from the Thomas´ School took place as group interviews to insure they felt more comfortable, relaxed and engaged in the group setting. The group setting is also important for minimizing the power differential between the researcher and the pupils. As Gubrium and Holstein notice (2001) there is also less chance for a researcher to impose adult interpretations and language on the pupils if they are interviewed collectively. It was important that the pupils did not associate the interviewer as a teacher, and thereby assuming that questions only had one correct answer. We were also aware of adjusting the questions so they were more at the same level as the pupils – not having long and complicated questions. It was also important that the interview took place in their normal environment – at the state school, so they felt secure, and could also reference by pointing at specific objects in the environment. For instances some of the pupils pointed at some computers, where they sometimes played computer games.

Findings

Motivation and Quality

In the Danish preschool, educational games are most frequently used in the introductory period. In 4th-6th grade the use of educational games decreases to about 50%, and in 7th-9th grade to hardly any use. The reason for the decrease in the use in the elder grades is that it is difficult to find educational games for the elder pupils. According to the teacher Brenda, an educational game has to both motivate the pupil and deliver a high quality of learning, but games such as these are very difficult to find. Brenda suggests that an educational game be divided in 5 to7 levels of difficulties. This is to reach the majority of the pupils' abilities. There is perhaps one problem with the level of divisions. The multiple levels puts the individual pupil in a situation where he or she has to judge his or hers own level of competence. Moreover, the pupil must be aware of his or her own level when the educational game has been played. Instead of choosing a level, we believe that the game should contain different depths of learning. Thus, all the pupils will learn from the educational game; poor pupils will perceive the superficial knowledge, and the competent pupils will submerge in the depth of the game and perceive the underlying knowledge.

By asking Brenda what she thought of the idea having a mixture of game elements and learning content, she responded:

> *"It would benefit the game if it is similar to what they play at home. The logic of the game is essential for their motivation". (Brenda, teacher).*

That is to say, the pupils find the game more logical if they can compare it with something they are familiar with from their everyday life. It is therefore important to design the educational game with as much game content as possible without compromising the learning content. Motivating the pupils is one of the requirements for teachers to use educational games in the classrooms. Furthermore, the educational game as well needs to be easily understood by the teachers. Brenda states that an educational game in her opinion is accessible when it is installed and straightforward when loading and starting it, and when the starting menu is well-arranged e.g. a list with an explanation of the choices that can bring one further in the educational game. In addition, the educational game should have a continual increase in the difficulty level and all the pupils should be actively participate. Brenda also suggests that an educational game should have a well-arranged overview in the start:

> *"Making an overview of the content of the educational game will ease the general view for the teachers and motivate them to continue to explore the possibilities of the educational game. It is also important to design something that is familiar to the teachers". (Brenda, teacher).*

We will attempt to design a product that consists of an overview that will seem familiar to most teachers. Concerning the control of a game, there are often tutorials available in the game option. However, this is not the most accessible approach when learning how to control a game. Dan comments that game designers have improved the use of tutorials. A classic tutorial often gives the player a lot of information at one time, while leading the player through a level that is not an integrated part of the game. Instead the designers have started making the tutorials as a part of the game narrative.

Brenda recommends that all the pupils be actively involved in the educational game. Often there is only one computer for two or three pupils, which implies that the educational game needs to be designed so one pupil is not just leaning back in the chair while the other one is working. In traditional class discussions it is often the teacher who does the talking; only a few pupils participate in the discussion:

> *"Computers are not for group work, where we are more than one pupil on the same computer. It is really irritating. So you can just lean back and fall asleep, while others work on the computer. That is not fun". (Martin, Pupil, 6th grade).*

The game designer's solution to Martin´s quote is to place dilemmas in the educational game. Niels give an example from Little Big Planet, where the players have to co-operate in order to complete the level. The pupils need to be put in a situation where they are actively wondering and discussing what to do to get further in the game.

Teacher Guide

Educational games are often accompanied by a teacher guide, describing how the game works and how the pupils can learn from it. In some cases, the teacher guide is so comprehensive and complicated that it will take the teacher more time to familiarize them with it than the time the pupils spent on it. The teachers prefer a guide that can tell them step by step how to understand and control the educational game. A common reflection from all the

interviews was about the teachers' culture and authority towards the pupils. Educational games may be difficult for teachers to master completely, which often results in a lack of use of the educational games. Nonetheless, it is not a necessity to master a game 100%, in contrast to literature where the teacher would read the material several times before giving a lesson. The challenge is change the teacher culture and the authority that exists between the teacher and the pupil. It is important to know that games are a medium that cannot always be mastered completely, and because of the progression of digital media it may happen that a pupil knows more than the teacher.

"Computer games are quite another media, and must be understood in another context. We must get used to drawing on the students competences". (Ellen, Liberian and teacher).
"It is also really bad when the teacher just messes things up, because they do not know how the computer works or what is going on in the game. But sometimes we also help our teacher. Especially Martin helps our teacher with computer stuff, but we also call Martin little nerd ((laughing)). (Anne, pupil, 6 th Grade).

In the classroom the teacher has an authority in the form of his or her knowledge of the given subject and the ability to communicate the knowledge. The authority disappears to a certain extent when entering a computer room, where many of the pupils are at least as good as the teachers at playing the games. In addition to this it can be difficult to control the learning that the teacher has intended and the teachers are afraid that the pupils do not perceive the knowledge. Nonetheless, it is not only the responsibility towards the pupils but the parents of the pupils as well. Brenda tells:

"You really have to be careful about what kind of games you choose. When the pupils are coming home from school, their parents ask them – so what have you been doing in school today", and the children respond "We have been playing computer games". That's why it is really important to know the purpose of why the pupils are playing computer games, and explain that to both pupils and parents". (Brenda, teacher).

Brenda refers to the pupils' parents when she talks about incorporating educational games into the classroom. When playing an educational game the pupil has, to a considerable extend, influence over which assignments he or she wants to accomplish. The pupil has the possibility to construct his or her own learning, and that is what is important when playing an educational game. Ellen expresses how to look at the learning process:

"We are making learning to the pupil's project and not the teacher's project" (Ellen, Liberian and teacher).

Despite the fact that several educational games have been produced, it seems there is always a missing element in the educational game; the design of the educational game has either been focused on the pupil's motivation, the designers' limitations or the teachers' needs for a high level of learning while the motivation from game play have been lacking. By examining the different perspectives from a holistic approach we can now arrange some design principles that fulfil the different needs.

Design Principles

Through our investigation on the problem field, related work and the performed interviews with teachers, pupils and game designers, the factors for why the teachers are not using computer games sufficiently in their lessons has become evident. Furthermore we have realized the importance of the educational and didactic aspects of a game when achieving an optimal learning through the positive elements from computer games. This is a benefit for pupils' learning abilities, but can also be a great advantage when an educational game is designed to be more accessible for teachers with no experience in computer technology.

With a holistic approach of the achieved empirical data, we have designed some principles for educational games. The table lists the disadvantages (attitudes/concerns about educational games/improvements) of existing educational games, from the teachers, game designers, and pupil's perspective and from information gathered from related work, followed by our design principles and a short description of the reason and importance of the principles.

Table 1: Attitudes/Concerns and Design Principles

Attitudes/Concerns about Educational Games	Design Principles	Description
Problem of covering the curriculum.	The goals of the game are specified and fulfilled by the curriculum standards. There must be some kind of record of what the pupils has been doing during a session of gaming. The games have short play duration, various levels, and content that is in agreement with the pupil's skills. Where help is needed, or important information is conveyed through text, it is vital that the reading age of the text matches the target age of the players. Pupils need to be able to get to the right bit of the game without elaborate set up or working through unrelated material. The ability to save and restart the game where the player left off is important.	It is important not only to know what that the pupils learn but also that they learn what is needed compared to the curriculum standard, when they play an educational game. Therefore an educational game needs to be designed with the right curriculum for the given target group, and give the teacher information about what can be taught. Furthermore the educational game should contain different levels of learning to comply with the different levels of intelligence in the class. To learn something new each time the educational game is played, it is an advantage that the pupil can save the game in order to make progress in learning about a given subject.

Hard to find educational games that are both motivating and deliver a high quality of learning The pupils should recognise the game play	Contain a suitable balance between game play and learning. An educational game needs to be designed with as much game content as possible without compromising the learning content. Providing an accessible overview and integrate a high level of learning. To motivate the pupils, the game play needs to be recognizable; reminiscent of commercial games. The pupils can choose their own goals. The structure of the educational game should give the pupil the opportunity to explore the game world on their own and create their own path of knowledge. In this way it will be the pupils' project instead of the teachers.	Educational games should not be used just to have fun but to learn while having fun, investigate, and be motivated to learn. Therefore the educational game should have a balance between learning and game play in order for the pupil to be motivated to play the educational game while still learning. The pupils may be more motivated if they find the game more logical and similar to other games they play. When designing the educational game with a structure that lets the pupil investigate, it can give the pupil curiosity and motivation to play and learn the educational game.
The teachers have minor or no technical skills. Lack of knowledge about computer games in general. No support to get started. Pupils find it annoying when teachers do not know how the educational game works. The preparation before using an educational game takes too long time.	The overview of the educational game has to seem familiar to the teachers. Integrate the guidance in the game narrative and let the tutorial be a part of the game. Tutorials are useful when learning how to master a new educational game. The user interface is obvious and written instructions are not needed.	The teachers need to play the game themselves before presenting it for the pupils. By integrating the tutorials in the educational game, it may make the learning process easier for the teachers as well as for the pupils. If there is too much work for the teachers on learning how to use the educational game, they give up. The educational game needs to appear manageable when the teachers need to prepare it for a class.
Difficult to have group work on computers. All pupils should be active involved in the educational game.	Peer collaboration; place dilemmas into the game.	Most often, the pupils are sitting more than one at each computer. To avoid passive pupils, a suggestion is to design an educational game with dilemmas where the pupils can work together by discussing issues.

Quality of the game title.	The game title should describe the part of curriculum that is covered in the game.	This principle does not concern the design of an educational game. However, the reason for mentioning this principle is that the majority of the teachers thought that the more an educational game sounded like a game, the less they wanted to use it. Therefore it is important that the game title appeals to the teachers.

Conclusion

The different perspectives (from teachers, designers and pupils) to educational games are a mix of thinking, feelings, perceiving, behaving, culture and context. The different perspectives offer different things on different levels and can be used to set some design principles. There was a difference in how the interviewees directed the focused of their answers. The teachers' point of view was directed on the pupils' needs. This can be interpreted as the teachers' and the pupils' needs are in symbiosis; by fulfilling the pupils' requirements, the teachers' needs are fulfilled too. Yet, this does not mean that the teachers' needs are fulfilled, if the pupils' needs are considered, but that the teachers' needs often are met by fulfilling some of the pupils' demands for playing educational games. The teachers also make an effort in letting the pupils know how to use computer games in their teaching. But they also focused on the lack of information about using computer games among the teachers, and this is a problem that has to be solved. The game designers focused on the quality of the design, which was influenced by economy, politics, and special wishes from companies who arrange the order. They say that these three factors have a large influence of the result of the final product and therefore it is not always possible to develop an educational game after the original intentions. The pupils mostly focused on words "fun", "exploring" and "learning".

In our future work the principles will be implemented in a game design of an educational game, where the functionalism of the principles will be verified.

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My research focus is on the social use of different media in a learning context. The purpose of my research is to focus on the social use and take the everyday life in account. My background is from a sociological field, and I have previous done research in Interactive Television, mobile culture and attitudes towards robotic technologies.

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