Change of Learning Environment Using Game Production – Theory, Methods and Practice

Lars Reng, Lise Busk Kofoed[(⊠)], and Henrik Schoenau-Fog

Department of Architecture, Design and Mediatechnology,
Aalborg University, Aalborg, Denmark
{lre,lk,hsf}@create.aau.dk

Abstract. Game Based Learning has proven to have many possibilities for supporting better learning outcomes, when using educational or commercial games in the classroom. However, there is also a great potential in using game development as a motivator in other kinds of learning scenarios. This study will focus on cases in which development of games did change the learning environments into production units where students or employees were producing games as part of the learning process. The cases indicate that the motivation as well as the learning curve became very high. The pedagogical theories and methods are based on Problem Based Learning (PBL), but are developed further by combining PBL with a production-oriented/design based approach. We illustrate the potential of using game production as a learning environment with investigation of three game productions. We can conclude that using game production is a powerful pedagogic tool for establishing learning, motivation and engagement.

Keywords: Purposeful game development · Problem based learning
Change of learning environment · Design based learning
Integrating theory & practice

1 Introduction

Development of learning is a very important part of today's agenda for learning institutions and for private companies. This calls for new teaching strategies to establish new teaching and learning possibilities in companies, in higher education as well as in primary schools. For all, the teaching strategies have to be focused on specific knowledge as part of the learning goals for the future, but also to establish motivation and engagement. Furthermore, the skills of collaboration, creativity and innovation have been stressed as some of the most important 21st century skills together with critical thinking which count for both companies and educational institutions [1].

Using games as learning tools have been studied for several years [2, 3, 4], and the learning outcomes are often reported to be rather successful [5, 6, 7]. Designs with narrative role-play based learning goals is an interactive approach to learning that involves the participants in collaborative, creative problem solving in a meaningful context, which can be implemented with non or varying degrees of technology [8].

This study will focus on cases where the learning environments are transformed into different kind of game production units where employees or students are producing games with a purpose as part of the learning process. In this paper, we present the pedagogical theories and methods which are based on Problem Based Learning (PBL) as used at Aalborg University, Denmark [9], but are developed further combining PBL with a design based approach. We illustrate the potentials of using such purposive game productions as a learning environment with investigation of three cases of game productions, which involved 54 employees from a process company producing a non-digital problem-solving game, 25 students from Aalborg University, Media Technology Bachelor study producing a purposeful digital game, and 7 teachers plus 55 pupils from a public school also producing purposeful digital games. The cases are described and analyzed and the main results indicate that all participants who worked on the game production was very motivated and engaged and acquired several new technical, social and analytical skills and competences. Furthermore, the results also indicate that the university students as well as the employees also increased their knowledge of production of and skills in project management. The findings illustrate great potentials in changing the learning environment and using production oriented activities, such as game development in all kind of learning scenarios. We conclude that using purposive game production is a powerful pedagogic tool for establishing motivation and engagement, and thereby foundation for learning.

2 Pedagogical Approach

In order to heighten learners' engagement and motivation in getting new knowledge we have experienced that learning through simulated praxis offer a highly efficient approach to working with subjects of high complexity [8]. Producing games make it possible to simplify, categorize and structure the relevant factors in a way that creates clarity and strategic outlook. This function as a map where the scaling helps eliminate the noise and call attention to the essential factors [10]. Furthermore, fabricating their own games is a powerful approach to learning that involves learners in a collective and creative problem solving processes [8, 5]. The pedagogical theories and didactic methods are based on Problem Based Learning and project organized teamwork (PBL) as used at Aalborg University, Denmark [9], but are developed further combining PBL with a production-oriented or design based approach [11]. According to theories of Problem Based Learning and situated learning, design based learning creates contextualized and authentic learning as design tasks which force students to work in an environment which demands are close to real life skills and domain knowledge when practiced in project work [12]. Developing knowledge and skills required in such situations are in addition more transferrable to future situations [13]. Design-based learning using 'enactivism', which is a framework that argues that a close connection between affordance of a learning environment and a learner's capacity of action is implicit in the PBL learning process, and a close connection between affordance of a learning environment, and a learner's capacity of action and perception in knowledge development [14] seems to fit to our pedagogical approach. In the case of a fabrication of a non-digital game the learners were employees working in a company, and it was

important for their motivation that they would be able to understand a learning process to see and understand how to change their own and others knowledge, skills and competences. Therefore, we have added a simplistic learning model based on Kolb's experiential learning cycle [15], Schön's theories about the reflective practitioner [16] and Cowan's reflection loops [17] with emphasis on meta-learning processes, shared visions and common mental models [18]. To deal with motivation we have used Kellers' ARCS model for motivational design and performance, which is based on a synthesis of motivational concepts and characteristics within three conceptual categories: attention, confidence and satisfaction [29, 20]. These categories are integrated in the design of the game, where the learners' attention is directed towards the interaction, the problem analyses, the problem-solving activities and implementation strategies, which has relevance through the simulations which occur in the game process. In the cases of the digital games, the development of purposeful games has been examined as a 'powerful learning environment' to stimulate active, autonomous learning via rich contexts and authentic tasks of compositions and construction [21]. Purposeful educational game production, that requires content application, can be applied as a micro world where designers or learners get to explore, represent and test their domain knowledge and skills for integrating them into the game [22], so we find that design based learning in general and computer game development in particular is well connected to PBL and project work. According to self-determination theory there are three basic cognitive needs that are universally applicable: the need for competence, autonomy and relatedness which is related to two main types of motivation: extrinsic and intrinsic motivation. Intrinsic motivation refers to those actions that students engage in as they are inherently interesting and enjoyable, while extrinsic motivation refers to individuals engaging in actions because they lead to separable outcomes (e.g. rewards) [23].

In order to fully integrate the value for students/employees in a learning situation it is important that the learning environment support the teaching to satisfy the learners need for autonomy [25]. To get a sense of relatedness it is important to be encouraged and valued by significant others (teachers, peers etc.) [24]. Construction of the learning process to suit the individual learner is embedded in the process of learning (here making the game), where the teacher/facilitator support the different stages of game-construction to the group of learners in a need-and/or desire-driven instruction so the outcome is tailoring of new knowledge and experience [24]. (See Fig. 1) Summing up, non-digital as well as digital game production can be based on the concept of PBL and
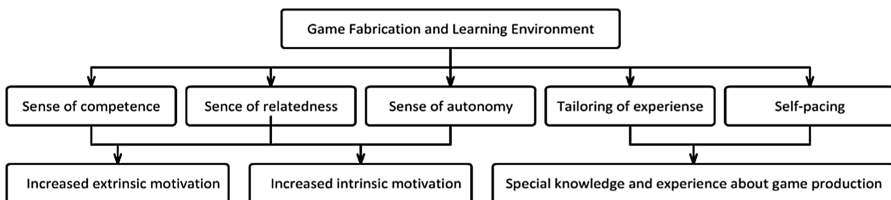

Fig. 1. The pedagogical elements in the fabrication of games and learning in a virtual production environment. (Inspired by Abeysekera and Dawson [24])

project work with a production-oriented/design based strategy, combined with a focus on motivation and engagement.

3   Method

The cases are from three different studies of game productions. The pedagogical approach has been the same with minor additions related to the specific case situation and the aim of the game. We have used action research [26] combined with an exploratory case-study approach [27] in combination with the descriptive, mixed-method case study [28, 29] to investigate the learning/teaching processes in each case.

This study explored the process of learning by design within the context of game development, project management and production. In particular, we addressed the following research questions in all three cases:

1. Did participating in a production of game development enhance motivation towards further learning?
2. How did the different aspects of the process of game production give knowledge and understanding of the different problems connected to each game production?
3. How did the game production strengthen confidence in own competence?

4   The Three Cases

4.1   Case 1: Crossing the Borders – a Game in a Change Process

Case 1 is an example from a larger technological and organizational change in a mid-sized Danish processing company. A characteristic of the organization is that there is a very distinct division between the employees in the production and those per-forming the administrative and management functions which cause a major problem because a lack of communication between the departments and no understanding or common knowledge of each department's problems. During several workshops using the PBL approach the employees themselves identified problems about delaying of test results, missing information, no sufficient planning and IT-problems [30]. A two hours' pre-workshop was organized where representatives from three departments (which has the problems); production, IT and Laboratory should analyze the problems, and they found a distinct lack of communication and almost no common knowledge about the different departments. Representatives from each department then set up the following questions: Where are the borders to other departments? Which departments do we have to be in close contact with? What important information and knowledge are needed from the different departments so they understand our need and we understand their need? What do each department expect from the other department and what are the departments able to deliver according the common goals? During a co-creating design process those questions were transformed into a non-digital game, where a process during the 3 departments were designed as a problem-solving game e.g. the process of a sample from production has to go through the Lab and IT and feed-back should be

given back to production. Very motivated employees from the three departments played the game, and they should interact when they could see a problem. Each problem was projected on a screen. Playing the game was an eye-opener for all participants. They suddenly recognized why it sometimes was problematic e.g. to get some test results very fast from one department. Another department also found that they had to be much more specific when they asked for information if it should be useful for the planning task. And one department realized that they did not know which support they actually could get from the IT-department.

After this game, each department started to formulate projects to solve the problems they had met during the game. They did their project work according to the previous learned PBL method, and quite fast they had solutions to be tested and implemented in their daily work. It was projects about an improved planning system for the production process and the planning department, projects about how to share knowledge and information between three departments etc. One project was about efficiency at the laboratory which had always got complaints. All departments wanted their tests to be prioritized highest. When different departments worked together on a solution they developed a priority system and recommended that an extra laboratory assistant was absolutely necessary. The management agreed with the project proposals, and they were all implemented. Making and playing the game was successful and the employees all felt very motivated and found they had gained not only new knowledge and experience but also a feeling of competence in relation to understand and being able to contribute to the change process, and later the game was played and modified several times by the employees them self [30].

4.2 Case 2: Purposive Game Production – Experiment for University Students

All technical programs at Aalborg University are based on Problem Based Learning. Each semester is divided between courses (15 ECTS) and problem based project work (15 ECTS). The idea behind the purposive game production was mainly motivated by three major issues: Students at the end of their Media Technology bachelor education seem to have a growing concern about the skills and abilities they have learned would fit the needs and requirements of the industry. Another issue was that the students did not feel they had enough time to focus on a single skill/discipline in order to truly understand what was required to fully master it. The third major issue was a general lack of motivation [4]. In order to create a format that would allow the teacher full control of the production, giving the students an experience as close to that of being in a company, and still staying within the requirements and rules of the current study plan, and a very limited time frame; the format chosen is illustrated in Fig. 3. The students would have their semester split in two. First a three-month period where the students would be part of the virtual company for the purposive game production. Second a one month academic project where the students would work in smaller PBL project-groups, and use their product of the game production to develop and investigate an academic problem within the theme of their semester. 20 students were accepted for the experiment. Each of the 20 roles for the production was carefully decided upon based on industry practice, the students' previous experience, and the short timeframe of the

production. It was decided to use SCRUM method to manage and control projects [31]. Most SCRUM models function with a project owner role being part of the company, but not part of the development team. The project owner set the requirements for the product. By giving these roles to the teachers, there would be full control over the production, but the daily management tasks should be done by the students. All students were allowed to apply for the positions they felt most passionate about. The number of students who accepted the terms was 20, and the distribution of roles was also almost as desired.

The most important requirements for the game were:

- The game must be a meaningful, purposive game, build with the purpose to enhance teaching of a real, critical, and important topic in public schools (kids age 13–16). The students chose to work with the theme "Global Warming".
- The game had to be 100% factual valid, and true to the latest research in the field.
- The game must give the young people an experience that would facilitate a fact-based discussion about the topic and its possible solutions in the classroom.
- The game had to meet a professional quality that would allow the students to use it when applying for a future job.

Caused by the short timeframe a simplified timetable with only a few of the traditional phases of a game production was given to the students. As the students were in an unfamiliar situation compared to their traditional semester projects, it was decided to keep a fairly high amount of regularly spaced deadlines to ensure that mismanaged activities were detected early. (See Fig. 2).
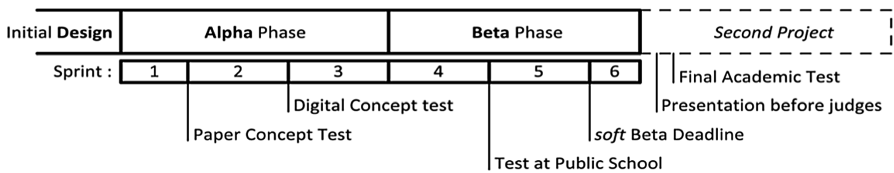

Fig. 2. The purposive game production time table for Media Technology students.

The production facilities were organized in a large group room at Aalborg University's campus where the purposive game production team members organized their own area and divided it into sections based on their roles – e.g. programmers, 3D designers, 2D designers and production management. A group of seven game company CEOs came to judge the quality of the final product. It can be concluded that the group organized project-work does have the flexibility and framework for establishing a learning/teaching environment which could enhance students' motivation for further studies and at the same time gain knowledge and experience within aspects of game production and management of larger productions. This approach can supports students' different interests within the different semesters study-regulations as well as it can give experiences very close to a real production situation. The main findings of surveys, observations and interviews were that students learned more than the learning

goals in the study regulation, and that the game-based learning strategy seems rather efficient and demanding for the students [5]. Students experienced a lot of frustration due to the overwhelming challenge of managing a team of 20+ team-members, causing them to truly understand the importance of good project management. They also experienced that sufficient communication, planning and coordination of the game production as a whole as well as the team production is very important, and that they had to be better equipped regarding those aspects. These reflections might be the best starting point for new learning processes – which furthermore was emphasized by the fact, that members of the jury committee offered jobs to some of the students.

In summary, it can be concluded that the new learning environment together with the elements in the pedagogical model have given students increased motivation and self-confidence (see Fig. 1) not only to continue their study the next semester, but they also had shown that they were able to obtain their goals. Furthermore, they improved their special knowledge and experience about game production [5].

4.3   Case 3: Game Production in a Danish Public School – the Teachers' Challenges

The lack of motivation among pupils in secondary schools is a big problem in many Danish public schools. At the same time, there is a political pressure on the public schools that there should be more focus on math and natural science, hoping to motivate more students to get interested in technical areas and to continue their education either in college or in training schools. A general question is then how a game production activity can be developed as a teaching and learning tool in a Public School. A team of teachers from a smaller public school embraced one of the most challenging new game based learning methods, and wanted to implement it on their 9th grade pupils [5]. Their latest evaluation of their 8th grade pupils had shown a low level of motivation and ability to continue their education [32]. None of the teaching staff had any experience with game development. Making a purposeful game production is one of the most demanding teaching activities for a teacher [4]. Therefore a prof. game developer should educate the teachers in game development based on the professional Game Engine 'Unity'. A few weeks before the start of the pupils' project the teachers had agreed on a challenging project. They would like the pupils to create a game that would give the player a realistic experience of being a refugee. With all the current news of European countries daily closing new borders and changing their rules on immigration, they were asking if it would be possible to create a game that could teach the pupils how it would be for a refugee from Syria or Libya to make it all the way to Denmark. The idea was very interesting, but 'Purposive Game Productions' is a challenge even for experienced teachers and pupils [33]. We agreed to assist the teachers building the framework for this challenging production. In this activity, our focus was on the process of making the game as we see the biggest learning potentials in the production of a game - not in playing them - for the teachers as well as for the pupils. We investigated how the team of teachers developed and planned how to organize their teaching and get their pupils started to make the game. The teachers' overall idea of the game was based on the question about how refugees came to Denmark, and the process confirmed that teachers who are using purposive game

development as a teaching tool are confronted with big challenges which are connected to all phases of the coordination, planning, implementation and continuation of the teaching and learning (see Fig. 3). The process identified several challenges:
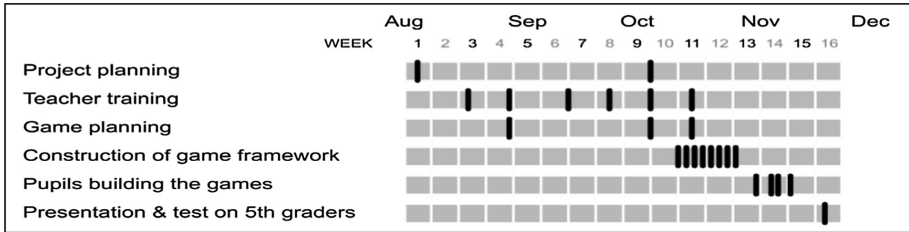
	Aug			Sep			Oct			Nov			Dec	
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

Figure content:

Project planning
Teacher training
Game planning
Construction of game framework
Pupils building the games
Presentation & test on 5th graders

Fig. 3. Timetable of the project

1. The teachers had to be introduced to game development (incl. programming) which was part of working with the game engine; Unity. This was done with a series of six intense workshops of four hours. The goal was that the teachers would remember enough to help the pupils in their game development phases.
2. The teacher's daily time schedule made it very difficult to find a common time for planning. So, it was decided that it should be after school hours.
3. It was difficult to get all teachers to meet at the same time because of other tasks.

Four months was a long process for the teachers, and there seem to be some level of fatigue among almost all teachers.

At the day of presentation, 14 games were demonstrated - each dealing with a different country. The classroom was organized so the name of each country was hanging on a sign above each game. The plan was that you could walk from one country to another and experience the different problems the refugees meet during their escape.

All games except one did function, and all groups had made their own game development and graphics. The young game developers were very enthusiastic about their game and tried "to sell" their product. In general, they were proud of the results, even some groups said they could have done better if they have had more time. They liked to show their game and explain how they have made it. The teachers found that the main part of the pupils was rather motivated during the process, but some of the students had difficulties. About 10% had difficulties keeping focus and concentration, so a full day may be too much, because they are not used to work like that. It was also difficult to keep them in their groups for so long, but teachers reported that some groups were much more active than they used to be, and especially the girls became very motivated and determined. The teachers agreed that most of the students had learned a lot besides programming and game-development: geography, Danish, culture subjects and especially collection of data as well as working in a group being part of a large project with 14 groups. A big surprise for the teachers was that the game activity was so time-and resource consuming. It was difficult to make a proper schedule for planning and implementation [33]. The teachers would like to develop the use of games as a

teaching strategy, but they would need to have more knowledge and skills using Unity, and they need more time and experience about using games so they would be able to analyze what the students had learned. The teachers also reflected that their pedagogical strategy should be very clear; the learning objectives and the tool to "measure" the students' learning process as well as the learning outcome. The head of the school had also followed the production, and was very surprised to see the great improvement in the students focus and well-structured work.

5   Conclusion

The main reason for using purposive game development as a teaching method is that learners are forced to be focused, and cannot proceed without fully understanding in depth the material they are trying to model into a game, as well as every detail of the essential information to use. Furthermore, to end with a successful game production, they have to decide how to best model the knowledge into an enjoyable game for the users/players. Combined with the fact that most people find this type of challenge highly motivating, they very often turn from extrinsic motivation into a series of intrinsic motivational goals that drive them way beyond solving the minimum requirements of their project. It can be concluded that learning through game production does have the flexibility and framework for establishing a learning/teaching environment which can enhance learners' motivation and engagement and provide the necessary qualifications aimed for. The pedagogical approach including Problem Based Learning using project work has been very useful when planning and implementing the games. All the involved persons, employee, students, teachers and pupils got valuable experiences and knowledge related to the specific topics in the different games they constructed.

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