INDEX

Introduction

This compilation includes research work that has been carried out in the field of Serious Games. Indeed, *Serious Games are known for many years and their advantage is to offer the possibility to learn individually in a holistic context.*

Playing enables citizens, employees, students e.g. to develop creatively problem solutions and to get a holistic view. At the same time the team competencies could be improved through simulation of various and changing conditions. People enjoy the individuality of solving the given tasks, the creativity. Through Serious Games content and methodologies are trained. The participants just have to be enabled to carry out, to play the games. By playing they increase their competences by getting individual skills and knowledge. Depending on the content of the game the participants are lead towards innovative and sustainable solutions. Serious Games belong to the media ecology of the 21st century doubtlessly and they support and improve unexpected learning processes. Serious Games do not have to be digital computer based educational tools; many non-digital easily applicable Serious Games exist as well which do not use any digital equipment.

Nevertheless, it is not quite usual to apply Serious Games within different contexts. The first part of this compilation deals with the application and implementation of Serious Games in Industry. Companies often need support to increase the competencies of their employees to remain competitive. Nevertheless, Serious Games in industry are not applied as often as reasonable. This chapter gives an overview on some applied and applicable games and the authors' experiences with the implementation of these games in industry. The second part shows the discussions concerning the development of Serious Games for different target groups and different educational purposes. At a last section of the compilation covers the field of Higher Education. Even in university classes the application and implementation of Serious Games is unusual.

Once more, I want to thank all authors for their valuable contributions!

Editor: Dr. Gabriele Hoeborn

Senior Researcher, University of Wuppertal

Acknowledgement

"But when I searched, I found no work so meritorious as the discovery and development of the arts and inventions that tend to civilise the life of man."

- **Francis Bacon**

My biggest appreciation has to go to my research and support team and in particular to Maike and Jennifer who are closely involved in these compilations. They made our work possible and they helped sustain our focus and our determination to continue searching on Serious Games and organizing this workshop.

Gabriele Hoeborn

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Serious Games and Industry

An Application Framework for Serious Games Integration in Companies

Aida Azadegan[1], Johann c.k.h. Riedel[1], Jannicke Baalsrud Hauge[2]

[1] *Nottingham University Business School, Nottingham, UK*
aida.azadegan@nottingham.ac.uk
johann.riedel@nottingham.ac.uk

[2] *University of Bremen, Bremen, Germany*
baa@biba.uni-bremen.de

Abstract

Serious Games are games that educate, train and inform using entertainment principles and creativity. Serious Games have provided a body of literature related to the potential for their application in different fields such as government, education and healthcare. However, less investigation has been focused on the integration of Serious Games in companies. The authors have developed a classification framework to help understand the different ways serious games can be used in companies. In order to achieve this aim, cases of serious games were identified from experts, conferences, events, developer companies and the Gala Network. These cases were reviewed to identify serious games relevant to business and management. From these, cases were collected of serious games application/use in companies. These were then classified according to the types of use in the classification framework. The identified ways serious games can be used in companies were: in corporate training, for change management, through viral diffusion and Gamification. A case example of each type of use is then presented in the paper.

Finally, future work towards the refinement of the framework that can add to theory building for research in the use and integration of serious games in companies is discussed.

Keywords

Serious Games, Integration in Companies, Integration Classification Framework, Gamification.

1 Introduction

Serious Games are 'more than fun'. A brief survey of the literature reveals that serious games are (digital) games used for purposes other than mere entertainment. Serious games have more than just story, art, and software. Zyda (2005) gives a formal definition of Serious Games: "Serious game: a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives."

In Serious Games, Game-based methods and concepts, as well as game technology, are combined with other ICT technologies to produce engaging learning tools. These have been applied to a broad spectrum of application domains ranging from training, simulation and education to sports, healthcare, corporate, government or any other socially relevant topics or business areas (Göbel et al, 2010).

Serious Games are an innovation that uses IT-based techniques, to create more dynamic companies. Serious Games introduce different types of applications in corporate settings. Examples of this could be teaching employees to solve problems in a non-traditional way using trial and error or by developing marketable business skills. Beck and Wade (2004) show that compared to non-gamers, employees who train with video games are good at "multi-tasking, good at making decisions and evaluating risks, flexible in the face of change and inclined to treat setbacks as chances to try again (cited in: Crandall and Sidak, 2006).

In this paper we are seeking to understand the requirements for Serious Games for use in business and industry. This work is being carried out as part of the GaLA - "Games and Learning Alliance", Network of Excellence on Serious Games. The GaLA Network is partially funded by the European Commission. It aims to cohere and integrate the research and development on Serious Games in Europe, to make a step change impact on Serious Games innovation. As a part of this, the network will elaborate methodologies for a non-intrusive integration of Serious Games in companies. Second, the network will examine the requirements of companies for Serious Games and identify and describe best practice use

cases. The integration should cover implementation guidelines, best practices, examples, assessment criteria and integration tools, as well as successful evaluation methods. This paper is an initial contribution to this.

2 Background

Scholars from a variety of disciplines have studied different perspectives of innovation and referred to innovation as a complex construct. At the corporate level, researchers have generally defined "innovation" as the development (generation) and/or use (adoption) of new ideas or behaviours (Damanpour and Wischnevsky 2006; Walker 2008; Zaltman, Duncan, and Holbek 1973). Organizations produce and introduce innovation for their own use or for use in other organizations. The generation of innovation is a process and the outcome is new to the corporate community (Damanpour and Wischnevsky 2006).

Serious Games can be defined as an IT based framework and a serious business that improves training, efficiency, and productivity in a variety of industries. Serious Games design and development has progressed towards becoming a high-technology industry (Crandall and Sidak, 2006). IT based frameworks and techniques, such as Serious Games, need to be integrated in companies, however, integration is a complex and challenging process (OnlineEduca, 2011). Success stories exist about integration of IT Frameworks into corporate settings. In addition to generally positive economic benefits, advantages such as convenience, standardized delivery, self-paced learning, and variety of available content, have made IT-based technology a high priority for many corporations (Strother, 2002).

Going back through the history of using Serious Games in Business and Management, Cohen and Rhenman (1961) described the most interesting characteristics of Serious Games application in Business and Management. These characteristics are summed up below:

1) the privileged contexts of delivery, which means mostly in Higher Education (e.g. Business Schools, Corporate Universities and Academic Institutes) or consultancy; 2) the relevance of situations represented so that players can identify themselves in realistic contexts close to their own experience; 3) the consequent engagement that brings 4) an effective learning experience.

During the 1950's it was the American Management Association that first used a management game for training purposes in the business domain in

1956 (Cohen and Rhenman, 1961). This exclusive scope lasted for long time and, as far as business and management is concerned this use is still valid nowadays.

The evolution and the use of Serious Games in Business and Management continued through the decades. Their evolution moved from a "rigid", "highly structured" approach where "the task of the players is restricted to choosing from among a limited number of prescribed alternatives, [where] the whole model of the environment has been put into mathematical form [so that] a computer can handle all situations which arise during the whole course of the game, and a feeling of realism is gained through the 'objectivity' of the machine" (Cohen and Rhenman, 1961).

Serious Games' development has continued, some recent examples are the use of Serious Games in the US Army - in 2002 they released the online, free-of-charge, America's Army (Alhadeff, 2007). The business school, Insead, designed several Serious Games for use in companies and with executives: in 2000 they released the EIS and the Eagle Racing simulation games addressing change management and collaboration respectively (see www.calt.insead.edu/eis/, www.eagleracing.net).

Hence, there is a long tradition of the use of Serious Games for corporate training. In this paper we are trying to understand in what alternative ways Serious Games have been, and can be, used in companies. We introduce a classification framework that helps to organize the knowledge and understanding towards the integration of Serious Games in corporate settings.

3 Methodology

The research presented in this paper is part of ongoing research to identify and describe integration methodologies for serious games in companies. A first step in this process is to identify the different ways in which serious games can be used in companies and to develop a classification of these ways. This will help to build theory about how companies can use serious games and how they can be integrated into companies.

To identify Serious Games, which have been used in companies, a case collection process was launched. This sought to identify Serious Games, which were relevant to their use in business and management, and to identify case studies of their application in companies. The Serious Games cases were collected from different sources described below:

1) Consultation with colleagues from the GaLA network: Case studies were collected from, and discussed with, GaLA network partners during regular meetings and during meetings of the two special interest groups - SIG 3.1 Business and Management and SIG 3.2 Engineering and Manufacturing.

2) Reviewing the last five years of the proceedings of the International Federation for Information Processing (IFIP) Working Group 5.7 SIG Workshop on Experimental Interactive Learning in Industrial Management: The papers published in the SIG proceedings for the years 2007-2011 were reviewed (Thoben et al 2007, Riedel et al 2008, Schonsleben 2009, Taisch 2010, Smeds 2011).

3) From consulting experts attending a recent industry event on Gamification (Games for Brands, London, 27th October 2011): cases of Gamification were collected by attending the presentations of the speakers who were representing Game companies active in game design and development, as well as through discussions with the experts at the event.

4) Reviewing case studies online: By doing a Google search for Serious Games developer companies and looking for case studies of serious games focusing on business, management and those used in companies.

The result of the case collection process is shown in table 1.

Table 1. Summary of Serious Games/Case Studies Identified

Collection Source	**Number of Serious Games/ Cases**	**Number of SGs/ Cases in Business and Management**	**Number of SGs used in Companies**
GaLA Network Colleagues	74	52	22
Recent IFIP SIG Proceedings	44	23	8
Games for Brands event	40	3	3
Online case studies	98	26	26
Total	**256**	**101**	**59**

In total, 256 cases of serious games were reviewed and from these the number of cases that were relevant to business, management, and industry was 101. The cases of application of serious games in companies were 59. Of the 256 Serious Games identified 39% were relevant to business and management; the others were relevant to education, health, etc. However, only a small number of actual applications in industry were identified – 23% of all Serious Games identified.

Analyzing the identified cases we concluded that there are only a few ways that serious games can be used in companies. A framework was then developed to classify the different ways in which serious games can be used in companies. All 59 of the Serious Games cases used in companies were classified. This framework is the first step to understanding how serious games can be used in companies. The framework forms the first element of theory needed for research. Theory building from case study research is particularly appropriate because theory building does not rely upon previous literature or prior empirical evidence (Eisenhardt, 1989). This framework is described in detail in the next section.

4 Serious Games Integration in Companies – A Classification Framework

The use of Serious Games for training and intervention has a long tradition in companies. However, as the technology of education, training and Serious Games improves new possibilities emerge. The way in which Serious Games can be used in companies needs to be understood in order to know the requirements for Serious Games and how best Serious Games can be used. New methods have emerged recently. From our experience in Serious Games, our awareness of developing trends and the case analysis above, a classification framework of how Serious Games can be used in companies was drawn up. Serious Games can be integrated into companies in four main ways (See figure 1 below):

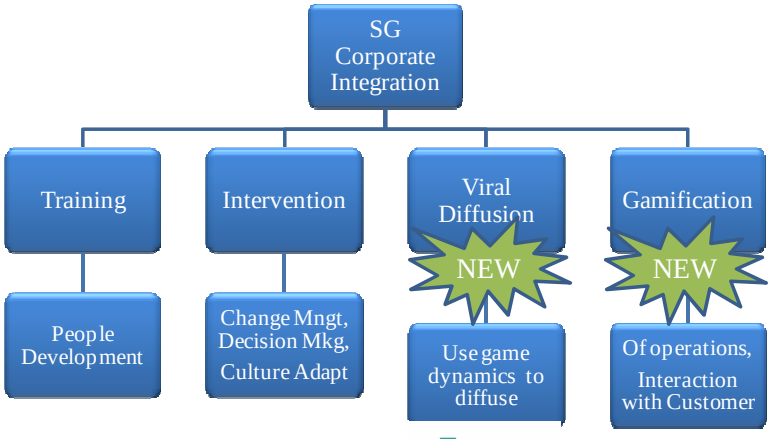

Figure 1: Classification Framework for Serious Games Integration in Companies

These four ways are described below:

1) Corporate Training

Games-based learning is gaining credibility and popularity for corporate training. As more and more people play computer-based games for

entertainment, corporate employees have come to engage easily with game metaphors and interfaces. Facilitated discussion during the game can solidify the information. Discussion also builds buy-in for the corporate objectives the training supports. Employees enjoy the interactivity, and most people will select “playing a game” as the preferred learning model when given a choice. In addition, according to result of research on Serious Games performed within the GaLA network, the effectiveness of knowledge transfer to the job makes serious games a good investment for the company.

As an example, INNOV8, developed by IBM, is a simulator of business activity using interactive 3-D, which helps teach key aspects of managing business processes and facilitates communication between business managers and IT staff of a company. This type of game, although fun, is based on realistic events and processes. The game was taken very seriously and has proved to be an effective method in training initial, continuing and accelerated development of new skills of employees.

2) Active Company Intervention

Within the tradition of change management, interventions in companies (typically by consultants) have been used to improve the company. Serious games have also been used as interventions in companies. The aim of these interventions is not to train people, but rather to help transform the people and the company. Classic examples of this approach are LEGO® Serious Play™, a facilitated workshop, where participants are asked different questions in relation to an ongoing project, task or strategy (Lund et al, 2011) and the SimLab™ method (Smeds and Poyry-Lassila, 2011).

3) Viral Diffusion

Similar to viral marketing, the viral diffusion of games in corporate environment happens through strategies such as social networks, word of mouth and other techniques. Games integrated through viral diffusion happen outside the formal structure and training processes of companies – the Serious Games are simply made available to all the relevant staff and marketing campaigns, or tournaments organised, to encourage playing of the game. This strategy for integration is new and has been enabled by employees having desktop computers and especially recently by mobile phone gaming.

4) Gamification

Finally, Gamification (also known as "funware") has emerged in the last couple of years. It is the use of game design techniques and mechanics to solve problems and engage audiences. Typically Gamification applies to non-game applications, particularly consumer-oriented web and mobile sites, in order to encourage people to adopt the applications (Zickermann and Lunder, 2010). It also strives to encourage users to engage in desired behaviors in connection with the applications. Gamification works by making technology more engaging, and by encouraging desired behaviors, taking advantage of humans' psychological predisposition to engage in gaming (Radoff, 2011). The technique can encourage people to perform chores that they ordinarily consider boring, such as completing surveys, shopping, or reading web sites. Gamificiation can be leveraged by companies as a sophisticated marketing technique, wherein customers are engaged in games, while simultaneously being exposed to the company – this can either be in a passive way similar to advertising or more sophisticatedly by engaging customers in a game which encourages their consumption of the company's products/services – eg. a mobile phone treasure hunt, etc. (Cook, 2010).

4.1 Integration Case Studies

Descriptions of the case studies used in the development of the framework are provided below. The cases are from Working Environment Service, Novo-Nordisk Pharmaceuticals, ABN Amro Bank, and Siemens' Plantville. Each case study corresponds to one of the four integration categories described in the classification framework above.

4.1.1 Working Environment Service – A Case of Corporate Training

The Working Environment Service serves as a national centre of working environment knowledge in Denmark. The organization obtains and communicates knowledge about the working environment from companies, projects and research based knowledge. The Working Environment Information Centre wanted to create an online experience, where public employees could learn about the constructive, individual approach to managing stress. The goal was to teach the player how to identify different types of stress and different ways to manage it, as well as showing ways to reduce stress in their everyday work.

The solution consists of a 2D Flash role-playing game, where the player can choose between different working environments, such as offices, hospitals and schools. In the game, the player encounters different problems and

situations that can potentially create unhealthy long-term levels of stress. Depending on the players' decisions, the stress-barometer goes up or down Serious Games Interactive (2011).

4.1.2 Novo-Nordisk – A Case of Active Company Intervention

Danish healthcare company Novo Nordisk operates in many countries and knows a great deal about the challenges and opportunities that go along with moving into new markets. Novo Nordisk had reached the decision to invest over $US200 million in the construction of a second facility in Brazil that would be 2-3 times the size of the existing one. This was a big challenge for the company. The company had to formulate a basic strategy for the Danish project leaders that would be spending 2-3 years abroad with their families to oversee the construction of the facility. Furthermore, there was a need to bring these managers together as a team – both on a professional and personal level.

Novo Nordisk decided to involve LEGO® Serious Play ™. The directors had heard about the way LEGO® Serious Play ™ process naturally allows group members to seek and identify important problems and then allow for free expression of problem-solving ideas – and they were willing to experiment. A two-day LEGO® Serious Play ™ Real Time Strategy session, which even included dialogue with existing Brazilian management, allowed the team to do decision-making and reach consensus on a concrete overall strategy for the construction of the new facility. Through LEGO® Serious Play ™, team members were able to identify problem areas that they had not previously seen – including some practical concerns about how their families would adjust to living abroad LEGO® Serious Play ™ (2011).

4.1.3 ABN Amro Bank – A Case of Viral Diffusion

This case presents the application of a serious game to educate and teach each employee on how they can translate core company values to everyday service. The company is an all-round bank servicing retail with private and commercial banking clients. Although the company is strongly represented in the Netherlands, the private banking company offices and services are also internationally established in 13 countries and territories. According to the latest annual report the company employs 26000 FTEs worldwide.

The serious games project was aimed at learning employees of the private banking network (up to €1 million sales) how to deal with the core values of the company in everyday life as an employee. For this project one of the

three company core values was selected (the core value "Trusted") and used as a basis for the game. "These core values can become a container concept so easily, we wanted to bring the concept closer to the employee. What does it mean for me?". The serious game was developed in cooperation with an external serious game developer and after a successful launch has already been followed by two other serious games.

4.1.4 Siemens Plantville – A Case of Gamification

Plantville™ is a new online gaming platform that simulates the experience of being a plant manager. Players are faced with the challenge of maintaining the operation of their plant while trying to improve the productivity, efficiency, sustainability and overall health of their facility. "We also hope Plantville will generate excitement in the areas of math, science and technology while inspiring a new generation of plant managers and engineers." said Daryl Dulaney, president and CEO, Siemens (Krampe, 2011). Using Plantville, Siemens aims to engage customers, employees, prospects, students and the general public while driving awareness of Siemens technologies and brand - it is essentially a gamified advertising technique. The game enables players to improve the health of their plants by learning about and applying industrial and infrastructure products and solutions from Siemens. Gamers will be measured on a number of Key Performance Indicators (KPIs), including safety, on time delivery, quality, energy management and employee satisfaction.

Throughout the game, players will be able to interact with Pete the Plant Manager, whose plant has just won the "Plant of the Year" award. Pete shares his best practices throughout the game to help players achieve outstanding results in plant performance. He will use webisodes, the Plantville Café, Puzzlers, and Facebook, LinkedIn and Twitter accounts to dialogue with gamers, provide hints to playing the game, and host a leader board for contestants.

In Plantville, players can select which of the three virtual plants they would like to manage first: – a bottling plant, a vitamin plant or a plant that builds trains. At the start of the game, each type of plant is faced with different challenges. The players must identify the challenges facing their plant and implement solutions to improve the plant's KPIs. Gamers will compete with one another on a number of levels, including plant-to-plant and on specific KPIs. Pete's leader board will keep track of which players are performing the best on each of the levels. Plantville also uses brain teasers called Pete's Puzzlers that test a gamer's problem solving abilities. Also a fun and

educational platform called Plantville café is used to offer periodic online chat sessions with Pete on topics like process control, energy efficiency, industrial networking and more.

5 Conclusion and Future Work

The work described in this paper is ongoing research on the integration of Serious Games in companies carried out within the GaLA Serious Games network. We briefly reviewed the tradition of the use of Serious Games in Business and Management going back to the 1950s. We focused on the ways Serious Games can be integrated in the companies and elaborated on the possible new ways for incorporating Serious Games in companies.

The authors developed a classification framework to help understand the different ways serious games can be used in companies. Cases of serious games were identified from experts, conferences, events and the GaLA Network. These cases were reviewed to identify serious games relevant to business and management. From these, cases were collected of serious games application/use in companies, which were classified according to the types of use in the integration framework. The identified ways serious games can be used in companies were: in corporate training, for change management/intervention, through viral diffusion and Gamification. A case study of each type of use was presented. The integration framework introduced in this paper helps to build the basis for knowledge and theory development of the use and adoption of Serious Games by companies.

Future work should focus on refining and validating the integration framework by carrying out in-depth case studies of Serious Games adoption in companies. Documenting more case studies can help make a stronger justification of the framework. Work can focus on understanding the barriers, gains and benefits of serious games, and then to investigate how to improve the benefits, and overcome the barriers towards, the use of the Serious Games in companies.

The Framework introduced in this paper helps us to build up understanding the Serious Games integration more effectively and defines the basis for future research in the field. There is a need to carry out in-depth case studies of the implementation of Serious Games within companies for each of the identified ways of integration introduced by the framework.

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Increasing the link between co-creation and exploration phase in the Living Lab process by using games

Matthias Kalverkamp[1], Jannicke Baalsrud Hauge[1]

[1]*Bremer Institut für Produktion und Logistik GmbH,*
{kvp,baa}@biba.uni-bremen.de

Abstract

Innovation is a key to the competitiveness of the European Industry, and the importance of developing new and innovative services fulfilling the requirements of a customer increase. This has led to new approaches for co-creative design like the concept of Living Labs.

Ideation is considered as the first and very important stage of the innovation process. It can be observed that there are several similarities between the ideation process and constructivism (learning through experiencing). A method used for education based upon this paradigm is Serious Games (SG). Ideation is oriented towards the discovery of ideas. Games can be considered to do the same.

This paper describes the approach, the advantages and challenges of how to ensure the use of game results from co-creation processes for further development steps in a service creation process. Further, the validation approach of the first implementation is described.

Keywords

Living Labs, innovation, serious games

Introduction

The competitiveness of the European industry is depending on its ability to innovate and to develop services fulfilling the requirements of customers. The current highly dynamical, customer driven market with short time-to-market has led to new approaches within the service and product development processes that include the potential customers in the design

process (Sanders & Stappers, 2008). One approach for co-creative design is the Living Lab (LL) concept. In a LL, users are participating in the development and improvement of new products and services. Users are co-creating, exploring, experimenting and evaluating products or services and related tools and technologies in a LL during various iterations. In such a development process ideas are needed to proceed, either to identify an initial solution or for improving a former one. The development of ideas is a time-consuming process with an uncertain outcome (Rothwell, 1994). Thus, in order to increase the efficiency of this process, there is need for tools that support. One tool which can support idea generation is Serious Games (SG). While Games can provide a safe environment for experiences, their utilization implicate some disadvantages as well; e.g. ensuring that game results are used and transferred outside of the game is a tough task. By better integration of a SG into the LL's co-creation phase and connecting it with a toolkit used in the following LL phases, it is expected that game results can be used more effectively.

Background

A Living Lab (LL) is a real life open-innovation ecosystem strongly user-centred that is used for co-creative design (Følstad, 2008). Professional and explicitly non-professional stakeholders interested in service development and improvement participate in such LLs. Enterprises (or any other organization) can place specific technology or complete products/services in this environment intending to receive multi-perspective feedback. In a LL, users are participating in the development and improvement of new products and services. Users are co-creating, exploring, experimenting and evaluating products or services and related tools and technologies in a LL during various iterations; each of which covers the before mentioned four phases. In such a development process ideas are needed to proceed, either to identify an initial solution or for improving a former one (Pallot, 2011).

Ideation is considered as the first stage of the innovation process and is oriented towards the discovery of ideas. It is a time consuming process, and only a few ideas will ever reach the stage of product or services (Rothwell, 1994). Hence there is a need for supporting tools and methods. Analyzing methods used for ideation and how this process is carried out with paradigms used for education, it can be observed that there are several similarities between the ideation process and constructivism (learning through experiencing). Ideation is oriented towards the discovery of ideas.

SGs that are based upon the principle of constructivism can be considered to do the same. They are designed to engage and motivate (Hesmer, 2007).

SGs provide an environment where "trial and error" logics make is possible to experience the outcomes of mistakes without facing them in real life (Garris et al, 2002). They let the participants experience and learn in a safe environment, but in such a way that the gained skills and knowledge can be transferred to the real world. SG can be used for fostering innovation (Hesmer, 2007; Angehrn, 2005) Innov8 from IBM (IBM, 2011) is such a game, but so far they are hardly integrated in the real development process.

Participant Needs: Connecting SG and LL

Participants of the LL are integrated as well in the very first development process steps, like the discovery of service ideas, idea generation and the service development itself. SG is used for ideation, but the main focus is on the approach of idea development, and not on the integration in a real environment. This leads to a gap between the ideas discovered in a gaming environment and the product development process, often leading to a mis-match. Therefore, we are looking at how the results of a game can be conserved and transferred into the real world or further virtual surroundings, since such extraction and transfer of game results from ideation games could heavily improve the use of games in ideation processes. Furthermore, implementing the concept of SG into a LL could not only help to improve the transfer of game results but concurrently provide an environment where results are validated before professionally used in real world environments.

Gaming scenarios are usually used as a separate tool or in addition to other tools when they are part of an overall development approach. The idea of a LL is an iterative cycle throughout which a product or service is co-created and further developed. When using SGs to support the co-creation phase of a LL it is essential that the game results find their way into the exploration phase of the LL; in other words, the SG and its results have to become part of the LL and should not run "alongside". Therefore, ideas and concepts developed in the SG are passed on to LL participants for further discussion, feedback collection and to be (physically) implemented in the service idea starting with the exploration phase. In order to improve the link between a SG and previous or following process steps of a LL, the simple (manual) passing on of game results should became a direct connection.

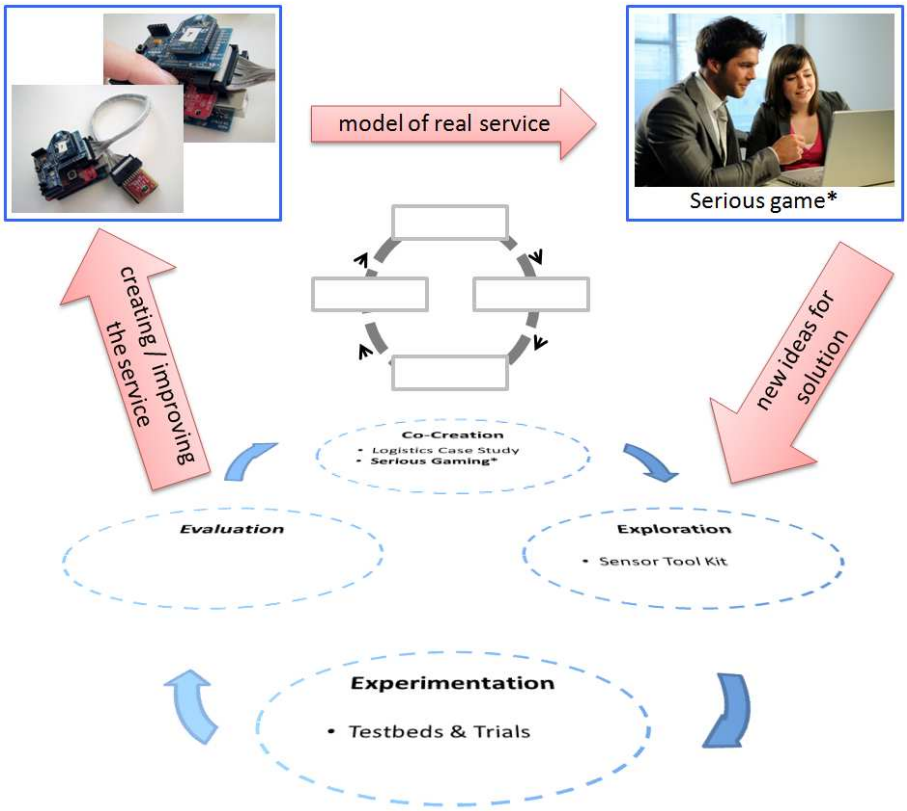

Figure 2: Integration of the Serious Game and the Toolkit (Logistics Use Case)

Through the LL phases exploration and experimentation new knowledge about the product or service is gained by the participants. Feedback and service/product data could then be fed into the SG again and such improve the co-creation phase in next LL iterations. Consequently, the co-creation (and gaming) process doesn't start with a totally new scenario or with the same scenario as in the previous gaming session, but would be enriched and adjusted based on the results of the previous LL iteration. Hereby the continuously improvement of the idea is supported by real data.

As an example for a prototypic implementation of such connection approach of SG into a LL, a LL for service development in intra-logistics is provided. In this LL a SG is used for idea generation. Figure 2 illustrates the approach on how to integrate and connect the SG and the LL; this is especially focussing on the case wherein this connection is tested. The learning cycle of Kolb (Kolb, 1984) (in the middle) illustrates that its learning styles are partly included in this approach. The individual purpose of a game determines which learning styles are used within the game. Nevertheless, due to the LL's iterative structure the potential to cover all phases rises. Before presenting the prototypic implementation, advantages and disadvantages of such approach are discussed.

Advantages and disadvantages

The utilization of SG provides some advantages, especially when dealing with non-experts in certain areas: Participants of a LL are neither meant to be experts for the particular field of the product/service which is developed, nor experts for ideation. Thus there is an additional need for a SG to provide a guided process for idea generation. Besides the guided process, SGs provide another advantage; it's their ability to provide an "equal environment for participation" which is not based on player's individual experience. Even thought the potential impact of non-experts might be lower and a mutual understanding could be missing (Kijkuit and van den Ende, 2007).

Furthermore, SGs provide a safe environment for idea generation. Additionally, implemented into the co-creation of a LL, the game results are not directly used in a professional real world environment but instead are validated throughout the following exploration. This provides the potential to reduce risks of non-fully developed services.

Nevertheless, disadvantages of using SGs have to be taken into account as well. The mentioned advantage of having a save environment can also be a risk: when developed solutions from the game would not meet e.g. safety requirements of real world environments. This risk can increase by the use of non-experts in the development process. Also the ability to think outside the box might change since it depends on the number of participants- this is fairly small in games compared to LL

Finally, SG are often unique development, and thus quite costly. This might not compensate potential advantages of their usage.

One important question is therefore, if the advantages of connecting the co-creation (SG) and exploration (toolkit) phases of a LL makes up for the disadvantages.

Prototypic implementation: A Logistics Use Case

In order to test the hypothesis, a small gaming scenario on intra-logistics has been developed. The focus in this use case is on developing a service for safety and security in intra-logistics by co-creation. The goal was to support ideation by developing a theoretical (virtual) service solution in the gaming environment and then transferring it into the exploration phase of the LL for further analysis.

When moving to the exploration phase of the LL, participants get introduced to an Arduino based sensor toolkit and a graphic user interface (GUI). With this toolkit the participants are enabled to build modular their beforehand virtually created service. In the given case the potential is seen to better connect the game with following (or previous) LL process steps. By using an Arduino toolkit with a GUI in the exploration phase, the game and the toolkit are consecutive used tools both on a digital basis.

Scenario development

The gaming scenario is facilitated, process based and comprises 11 steps carried out accordingly to the ideation process as described in Rothwell (Rothwell, 1994). In our case it is designed for 5 players and is build upon the be.mog engine (Duin, 2009). The gaming process starts with process step 1 wherein resource lists and available hardware are checked. At the same time, risk situations in intra logistics are elaborated (process step 2) and ranked (step 3) afterwards. Only the highest ranked risk situation is used in following process steps. With the identification of involved objects (process step 4) and determining their statuses (process step 5) the design of the future system starts. In a parallel session, the measurable statuses of the objects are derived while available resources are checked and matched with these measurable statuses (process steps 6 and 7). In process stet 8 the 'logic for risk" is phrased; i.e. the question "how the risk situation can be monitored and indicated by observing the environment with sensors" is answered.

The game proceeds with the decision how the risk situations should be displayed and in how much detail (process step 9). A solutions with less detail are e.g. 'Traffic light symbols'; more detailed visualisations are e.g. additional information in percentage or specific numbers. Finally, during the following step 10 the hardware which is needed for the service solution is selected due to budget constraints. The gaming process ends with a collection of comments and feedback.

During the whole gaming process events can be triggered. Within this gaming scenario they are mainly used to provide additional information for idea creation or to support the roles and their intentions.

Arduino toolkit: Transfer of game results

After actually playing the game, LL participants use the game results in the exploration phase by manually transferring them into the toolkit. First, the sensors (hardware) are connected to microcontrollers and afterwards

connected to a PC; this process is managed through the GUI. So far, this is almost a 'plug and play' process. Within the GUI, for each microcontroller the corresponding sensor(s) have to be selected from a drop-down menu. Thus, the toolkit knows how to communicate with the sensors. After connecting all relevant sensors with the GUI, the risk logic is defined. A risk logic is configured by choosing the according sensors from those which have been connected before and defining manually threshold values and limits. Certain settings can be chosen to adjust the risk logic properly.

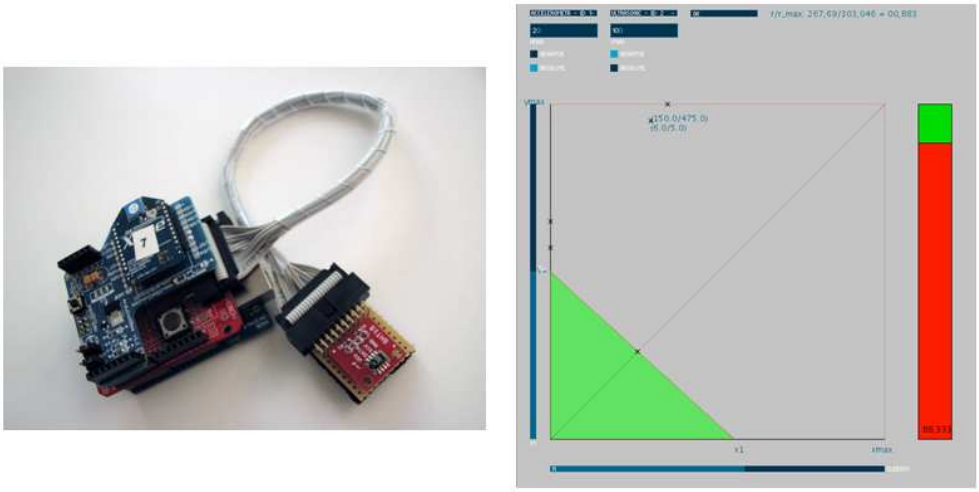

Figure 3: Sensors/Microcontrollers (left) and risk logic configuration window (right)

Preliminary Findings

The utilization of the SG in the logistics use case illustrates how the ideas generated in the gaming environment are transferred from the Co-Creation into the Exploration phase of the LL.

From a first testing and prototypical implementation of this approach, some preliminary findings could be derived. As the developed SG requires five users, which equals the number of different roles in the game, the co-creation and the following exploration phases where performed with five participants. This small number of participants limits the LL results as well as the findings from this analysis.

First experiments in this particular case indicated that a mixed group of non-experts and experts could improve the service discovery and ideation process, rather a group without expert users. This assumption was supported by a later game play and further exploration workshops and will be treated in more detail in another work.

Furthermore, both the mentioned advantages and disadvantages of providing a safe environment were recognisable. Still, the LL provides an important benefit; due to the validation of the service idea in the exploration phase, not considered safety and/or security issues can be identified before testing them in a real environment.

Additionally, the connection between the co-creation and exploration phase, respectively the SG and the Arduino toolkit, strongly indicated that such link would smoothen the transfer between the phases. Moreover, incrementally ideation would probably improve; especially if such link could also be established between experimentation/evaluation and the co-creation phase (next LL iteration). By this means the LL cycle would be closed with the SG fully integrated.

Interface between Game and Toolkit

Within this specific LL in combination with the described SG the potential of connecting the game stronger into the LL process is seen. By linking the game directly with the process and the Arduino toolkit rather than indirectly by manually transferring the game results, the game becomes not "just another tool" but a permanent feature for the LL. Such connection is in need of an interface which has the ability to communicate directly between the SG and the toolkit GUI, respectively the database. Furthermore, based on the quality of the connection some requirements have to be met. As a consequence thereof, the game itself would become more restricted in some of its process steps.

Table 1: Levels of Connection between SG and Arduino toolkit

Quality of connection	**Requirements**	**Consequences**
Basic: selected sensors are communicated between SG and the toolkit	Selection of sensors in SG based on a list equally to the list of sensors used for the drop-down/GUI.	No "free text" boxes but pre-defined lists
Medium: risk logic is pre-configured in the GUI/toolkit	Selected measured values and the expression of risk logics done in a manner which is machine-readable	Kind of values pre-defined Risk logic express in terms of related sensors
Advanced: changed service setting (toolkit) can be fed back into the game scenario	Game scenario adjusts itself by pre-selecting used sensors and/or changed risk logics	

Table 1 shows three levels describing the quality of connection between the SG and the Arduino toolkit/GUI, for each quality level the technical requirements for either the game and/or the toolkit are mentioned and the consequence for the game are listed. The mayor change through this approach would be the reduction of free-text boxes; this affects, besides the basic connection level, as well the other levels. Further, this challenges the potential to miss ideas which cannot be express properly, either by the provided data or by the participants. In order to estimate to what extend this limit would decrease the potential of this approach, further validation is needed.

Future Work and Conclusion

It was shown that a link between the SG and the toolkit would improve transferability and therefore the incremental service development intended by a LL approach. Further assessment would be necessary to prove the potential of the described approach. This is additionally needed due to the small sample of participants and will go along with next gaming sessions.

For the implementation of such a link, an interface is needed which would be able to communicate between the two applications. Therefore the SG would need some adaption; as well the toolkit might change in order to realise the inter-connectivity.

Based on discussed preliminary findings, a connection between a SG and e.g. a sensor toolkit seems to be a promising approach. When dovetailing a SG such way into a LL, its potential usage would improve heavily. Still, this needs further evaluation and a strong consideration of the expected gaming outcomes as well as the goal of the individual LL.

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A serious game approach for learning lean product development

Endris Kerga[1], Marco Taisch[2], Monica Rossi[3], Sergio Terzi[4]

[1,2,3]*Politecnico di Milano, Department of Economics, Management and Industrial Engineering, Milano, Italy*
endris.kerga@mail.polimi.it, *marco.taisch@polimi.it*, *monica.rossi@polimi.it*

[4]*University of Bergamo, Department of Industrial Engineering, Dalmine (BG), Italy*
sergio.terzi@unibg.it

Abstract

Industrial capabilities to come up with new products are critically depend on how design knowledge is captured, represented/documented, used and reused. Thereby, product innovation and product development (PD) performances are enhanced upon leveraging on product and process knowledge. Lean PD enable companies to spent their efforts on value creation activities. Among the different lean PD elements, Set-Based Concurrent Engineering (SBCE) process is pronounced to foster innovation and avoid design and process risks. SBCE is a unique approach to develop a new product. In SBCE, designers explore alternative sub-system design solutions using proven knowledge, effectively communicate about solutions within different functional teams, and progressively converge into an optimal design solution as more knowledge is gained in a process.

This paper presets a SBCE serious game developed to bring a hand on experience to designers on how to apply SBCE in practice. Further, the paper discusses the learning outcomes achieved taking a company case in Italy. The results indicate that the game is effective to foster the declarative, procedural and strategic knowledge of players about SBCE process.

Keywords

Lean product development, Set-based concurrent engineering, knowledge based product development, Serious game

1. Introduction

Set Based Concurrent Engineering (SBCE) is a central element of lean thinking in product development (PD). It is a new PD process approach that revolutionize the way product concepts are generated and selected [1] [2]. In a traditional practice, a single concept is selected as early as possible assuming that it will be feasible. However, PD is characterized by uncertainties due to changes in customer requirements, manufacturability issues, sub-system configurations and so on. Thus, often PD project suffers from design reworks due to the so called 'false positive feasibility', where project teams assume a concept is feasible, but will learn later in the development process that it is not [3]. Toyota uses SBCE approach to tackle such a problem by effectively utilizing product knowledge (lesson learned) to generate alternative design concepts. Unless a concept is proven to be infeasible, designers won't eliminate it from a 'trade-space'. Moreover, in SBCE process, feasibilities of design sets are realized through integration events rather than gates reviews as in a traditional practice. The unique feature in SBCE process is that communication is based on proven data. Negotiation within multiple teams is facilitated by a pull event where teams can visualize risk and opportunities using tradeoff and limit curves. Finally, PD teams converge into an optimal design taking rough objective criteria (such as cost, quality and time), so as the process will continue to detail design stages.

However, the extant literature present SBCE process as a set of principles and the evidences for its merits are based on anecdotal evidences. These left both academic and practical gaps that need further investigations[4]. First, a learning method to execute SBCE process need to be provided so as to introduce and bring a hand-on experience to practitioners. Second, SBCE's advantages, limitations and implementation barriers should be investigated from practical point of view. Third, a methodological guideline should be provided on how to implement a SBCE process. Answering the above gaps helps to increase the awareness and adoption of SBCE process across industries.

The main purposes of this paper are to answer the first two gaps and provide suggestions to answer the third gap. Based on the SBCE principles [1] and [2], a computer based serious game (SG) has been developed. Moreover, it is validated in one case company to investigate the learning

outcomes of the game as well as to collect feedback from the case if SBCE process can be a practical approach to design a new product. The company designs innovative humidification and control systems in the HVAC/R market (www.carel.com). Mechanical, Electrical Software designers, and project managers who have different years of experiences have participated in the game.

2. Introduction of SBCE Game

To design the SBCE learning tool a serious game approach is used. In general, the application of games with the aim of education and learning is defined as "Serious games" [5]. In SG, players assume different roles and involved in simple and complicated decision making processes, which makes it attractive for SBCE process where alternative design exploration and convergence involve multiple viewpoints. Moreover, SG creates a safe and entertaining environment, so that players from the industry freely experiments SBCE process without interfering the actual PD process.

In the game, players have to design a simplified Airplane structure as shown in Figure-1. The Airplane has four sub-systems to be designed (body, wing, cockpit and tail). The game is divided into two stages: first stage, where players design an Airplane for a given list of customer requirements without following a SBCE process; second stage, where players are provided with the necessary instruments to execute SBCE process. The instruments will help players to explore alternative design concepts, communicate about alternative solutions within a team, and converge into an optimal one.

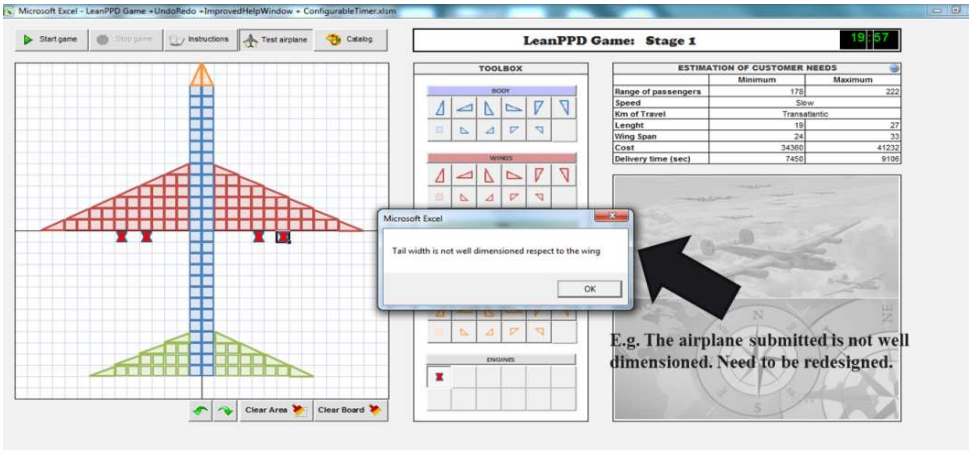

Figure 1: SBCE game interface (Stage one)

Once players completed a prototype design in the first stage, they should submit it to "testing department" to check for stability, flying conditions

and dimensional configurations. If it fails, the prototype should be redesigned. Redesigning has penalty costs. If the prototype passes the testing constraints, players will be given the breakdown of their performances in terms of quality, time and cost. Moreover, an aggregate measure called 'Lean Score' is provided for players by taking the sum variance of the customer requirements with the players performances. Before starting the second stage, a facilitator will introduce players with the SBCE process. In the second stage, players do the same as is the first stage; however, this time players will follow a structured SBCE process with its associated instruments to support player, see Figure 2. Finally, a comparison of performances will be presented to players to compare the two stages in terms of total development cost, time and quality (quality is defined as the deviation of players performance with customer requirements e.g. speed of the airplane). The second stage follows the following stepwise phases:

- **Knowledge test:** at beginning of the game "the chief engineer (CE)" questions about the aeronautics knowledge of players in the form of multiple choice questions. This equips players to have the right previous knowledge before designing an airplane. Moreover, the CE guides players to understand better the customer requirements.

- **Front loading process:** at this phase, player will be provided with Airplane models which are already in a knowledge library. This help players to compare what have already been designed by other designers before, so as not to waste time creating from scratch.

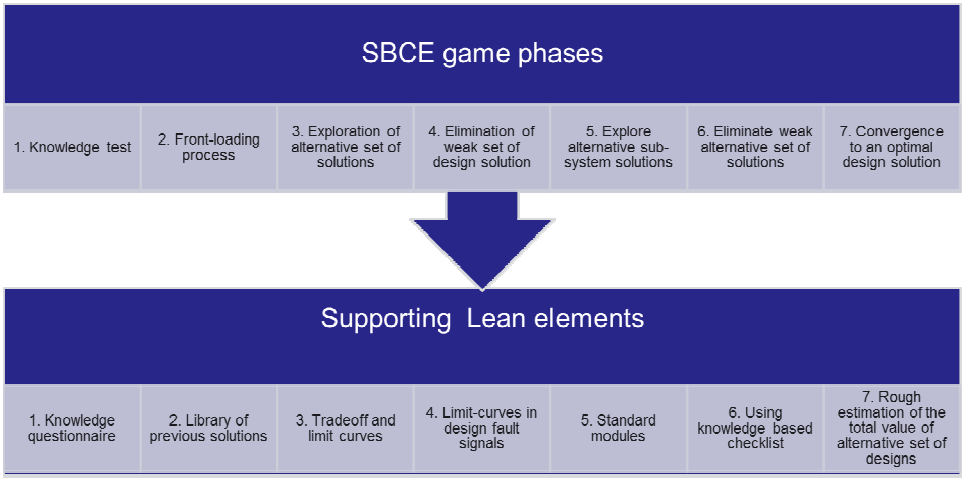

Figure 2: SBCE game: Stage two sub-phases

- **Explore alternative set of solutions:** at this phase, players will be supported by “tradeoff-curves” to explore alternative sub-system solutions and able to ingrate customer requirements into an Airplane design parameters. This phase is the be-ginning of a SBCE process in the game.

- **Elimination of weak solutions:** players at this phase can eliminate airplane’s sub-system solutions that are proved to be infeasible. Here, players supported by the so called “limit-curves” that show the feasibilities of the design alternatives early in the PD process.

- **Explore alternative solutions:** the above phases help players to come up with feasible bodies and wings. For each alternative body and wing solutions players can use standard cockpits and tails to prototype alternative airplanes

- **Eliminate weak alternative Airplane solutions:** at this phase, players have alternative Airplane solutions which should be evaluated against pre-prepared knowledge from “testing department” in the form of checklist. This checklist uses to classify full Airplane design solutions as “safe” and “risky”.

- **Convergence to optimal solution:** once alternative feasible airplanes are found, cross functional information from manufacturing, assembly, and supplier will be visible in a real time basis to estimate the cost and development time of each air-plane solutions. Moreover, visual charts are provided to show a rough estimation of the aggregate “Lean score” values of each designs to support decision making.

Finally, the detail performance comparison of the two stages will appear for discussion among participants in the game, as shown in Figure 3.

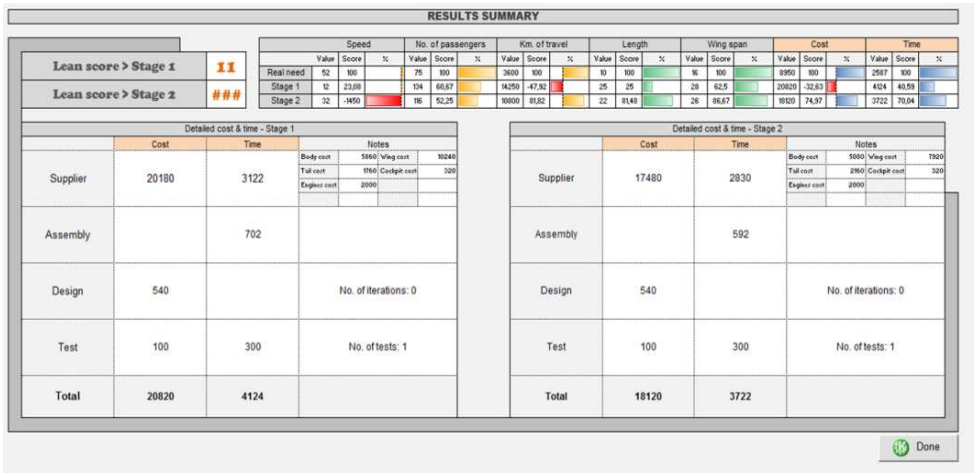

Figure 3: Comparison of a player performance in the two stages

3. Evaluation framework for learning outcomes

The comparison of performances between the two stages as shown Figure 3 can be taken as a validation mechanism to roughly estimate the advantages of SBCE process (second stage) over the traditional process (first stage). However, the main purpose is not to measure the performance leverages of SBCE process using the game. Because, the game is a simplified version of the reality and cannot capture the real complexities of a PD that make a SBCE approach more advantageous (Such as product complexity, innovativeness of the product, team size and so on). Therefore, in this paper, it is aimed at measuring the effectiveness of the game to translate the SBCE principles and its associated supporting elements. Given that, it is also aimed at measuring how practitioners have perceived the potential of SBCE process and its elements in improving PD performances.

Garris et.al. identified three level of knowledge aspects in order to measure the effectiveness of a SG [6]:

- **Declarative knowledge**: the first of three aspects of learning is the learning of facts or increasing one's knowledge about a subject. Frequently, SGs concern a specific problem or real world situation and are developed from a certain theoretical background. In serious games, one of the learning objectives is to increase the domain understanding of players. In this paper, the understanding of the SBCE theory and its supporting elements by players are parts of the declarative learning outcomes.

- **Procedural knowledge:** this aspect refers to the learning of procedures, and also to the understanding of patterns of processes

and behavior. In the SBCE game, procedural knowledge is related to players ability to associate the specific elements of SBCE process and the benefits of using them to support decision making.

- **Strategic knowledge:** the third learning aspect is that of increasing intellectual ability. Within gaming this aspect has been explained as implementing knowledge from the game in new (real-world) situations. Gaming can also contribute to developing reflective competences. Within complex systems as in PD, it is not only refers to implementing what is taught in the theory but also observing behavior and adapting to new situations. In SBCE game, several complexities have been simplified but adequate complexities are also added to keep players engaged. Since existing literature do not provide sufficient methodological approaches or guidelines to apply SBCE, reflecting on the possibilities of applying the full or part of the SBCE process using the game has been paramount.

  Based on the above framework, a structured questionnaire based on Liker scale has been prepared to measure the learning outcomes of the game. After playing the game with 36 designers (Mechanical, Electrical and Software) and project leaders of the Carel company, player were asked to evaluate the declarative, procedural and strategic learning aspects of the game. The players have working experience ranging from 4-15 years and age from 25-50 years.

4. Results and discussion

In general, the game has increased the level of awareness of players as shown in Figure 4. Players understand the usage of tradeoff and limit curves to generalize knowledge, and their application in order to explore alternative designs. Communication among teams in SBCE process takes different form than a traditional point based approach, where designers have only one conceptual solution to communicate about. In traditional design approach, information and design flow sequentially from one function to another in a 'back and forth' fashion. In SBCE process, different functions pull together their conceptual solutions and check sub-system compatibilities. In the game, players were provided with simple check-list to support communication and negotiation among teams. Though, player understand how to use this communication mechanism, some doubts are exhibited about the importance of using such a mechanism. This is due to the simplicity of the Airplane

to be designed, but in a real PD problem the complexity grows as more functions have to communicate about the alternative set of solutions.

Figure 5 shows the perceived advantages of following a SBCE process from practitioners perspective. The theoretical advantages of SBCE seems to be confirmed by the practitioners. Most of the designers played the game agreed that the most significant perceived advantages of SBCE are 'facilitate learning about design solutions' and 'avoid design risks'. Using knowledge from past designs and exploration of alternative designs enable the PD teams to brainstorm about set of solutions rather than one alternative. Moreover, frontloading the PD process minimize the probability of 'false positive feasibility' to occur.

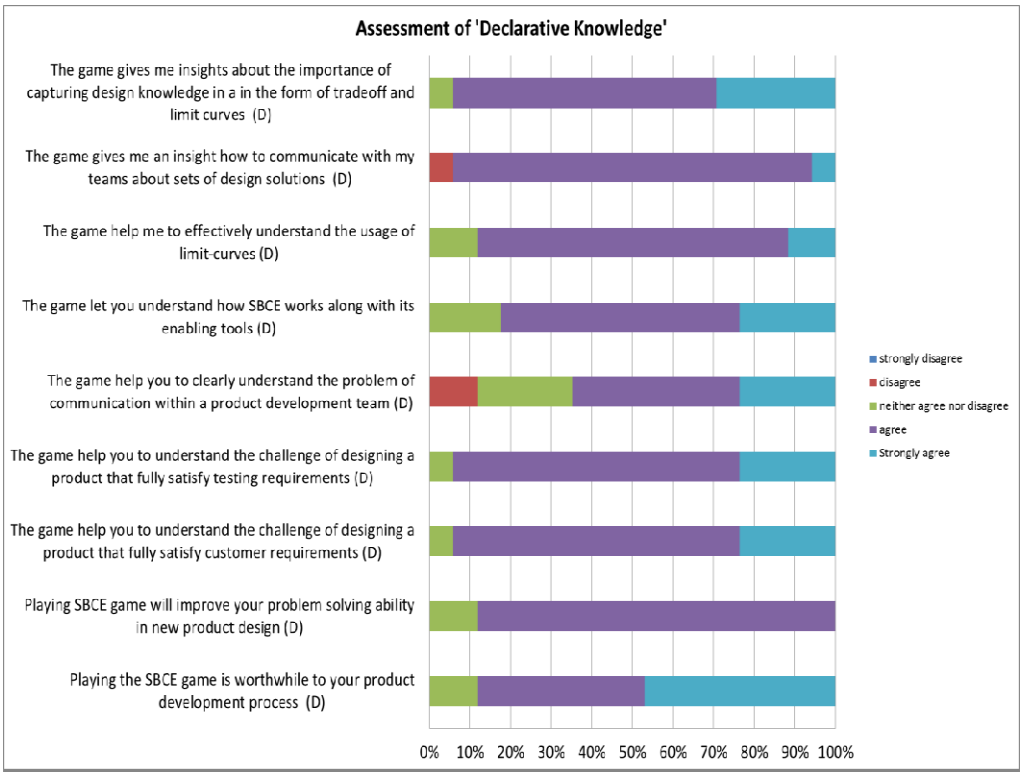

Figure 4: Assessment of learning outcome of declarative knowledge (N=36)

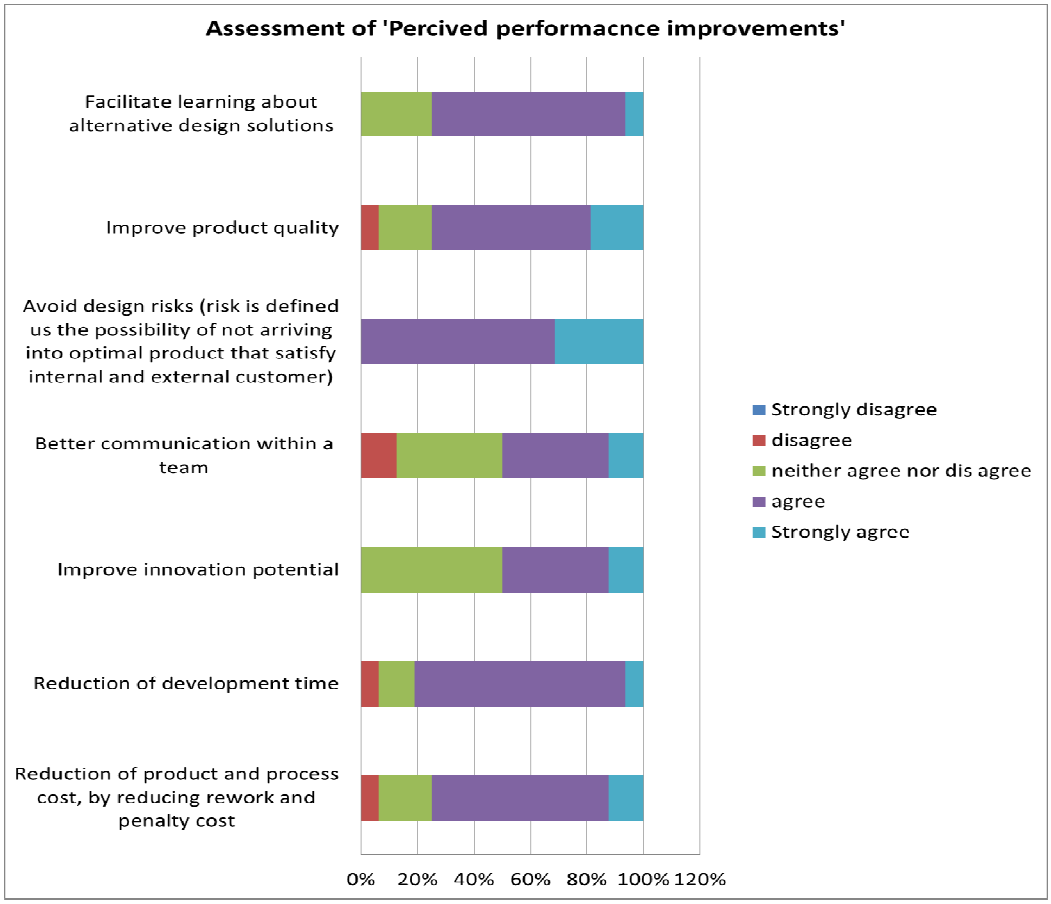

Figure 5: 'Perceived performance' improvements of SBCE process

The players perceived also that SBCE reduce the development time and cost as shown in Figure 5. However, such claims cannot be guaranteed if teams are not able to identify when to stop exploring and start converging [7].

Among the main difficulties that have been mentioned to implement SBCE process is the generation of 'limit-curves 'as shown in Figure 6 and 7. Limit curves are fundamental to apply SBCE process. They are curves that generalize knowledge of sub-system designs. Designers can show the 'risky' and 'safer' design regions using such curves. However, companies in the current practice don't use such curves to document, represent and share lesson learned or knowledge. Therefore, the main challenge will be to build the necessary competences to capture, represent and share past (static) and current (dynamic) knowledge gained through experimentation.

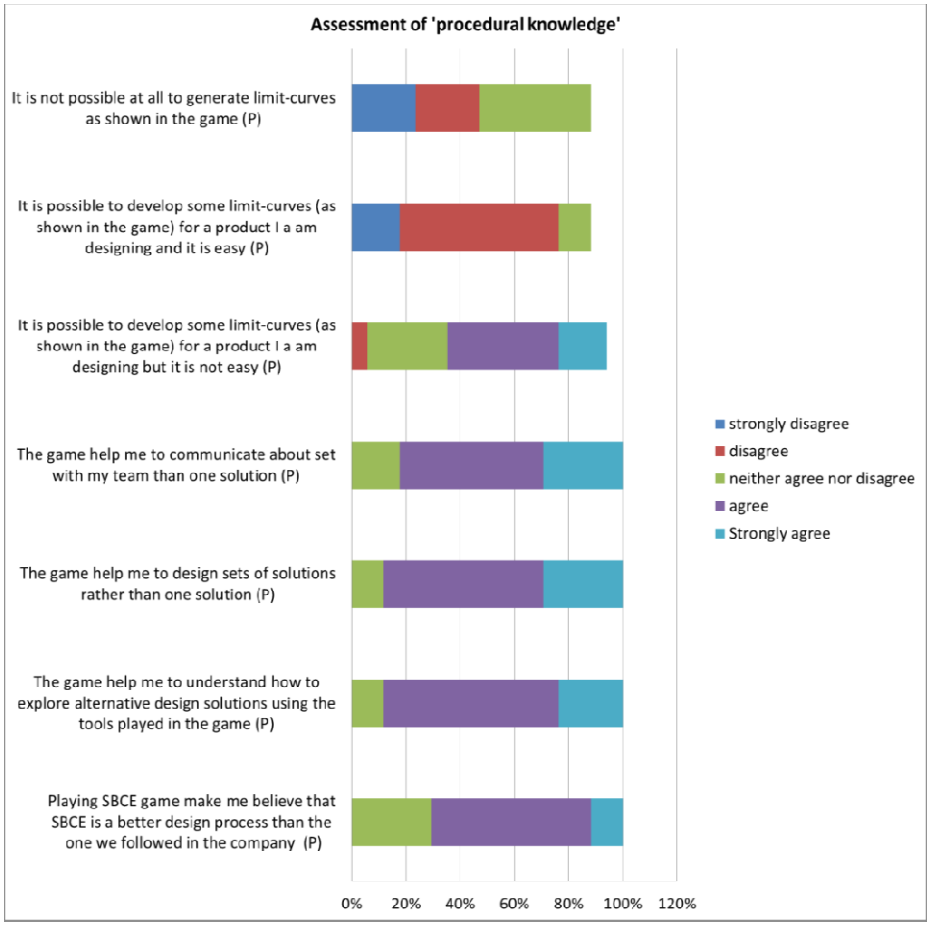

Figure 6: Assessment of learning outcome of procedural knowledge (N=36)

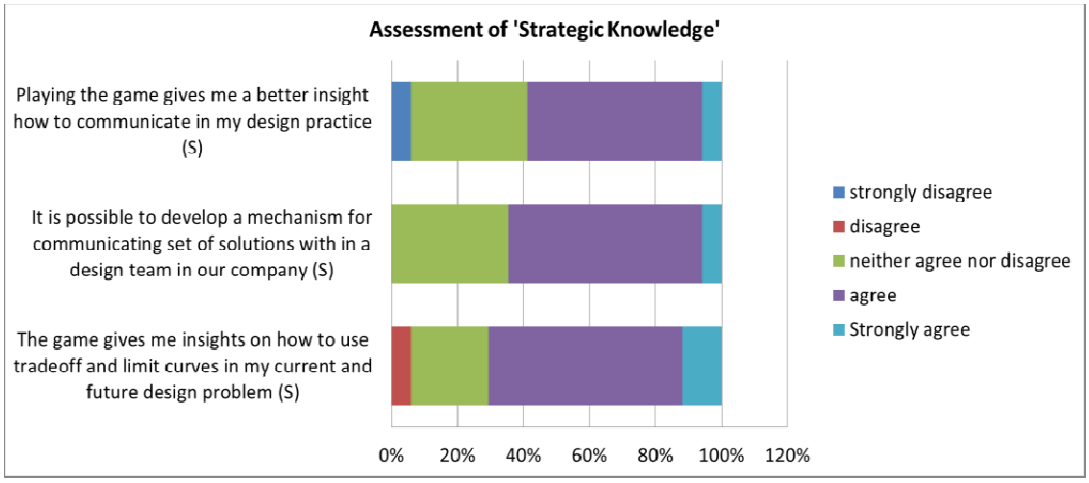

Figure 7: Assessment of learning outcome of strategic knowledge (N=36)

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Serious Games:

Developement and Experiences

Systems Snapshot – A Serious Game for Increasing Understanding of Organizational Models, Leadership and Communication in Increasingly Complex Systems

Harri Paananen[1], Riitta Smeds[2]

[1]*Aalto University, School of Science, SimLab*
harri.paananen@aalto.fi

[2]*Aalto University, School of Science, SimLab*
riitta.smeds@aalto.fi

Abstract

Systems Snapshot is a serious game developed for increasing understanding of complex organizational models, in this case the matrix organization model, leadership, and communication in complex systems. It is played out as a live-action role-play (LARP). The learning with System Snapshot includes elements of both experiential co-creation of practice, as well as innovative co-creation of knowledge. The element of empathizing, by simultaneously acting as oneself and the character one is role- playing, strengthens the collaborative knowledge creation process. Systems Snapshot is highly modifiable, and can be adapted for highlighting various different topics including leadership, organizational change, organizational models and communication.

Keywords

Serious Game, Complexity, Systems Theory, Live Action Role Play, Practice Co-creation, Knowledge Co-Creation

Theoretical Background

Inspiration

The roots of this gaming model are in two separate theoretical fields. On one hand it is inspired by complexity theory. Complexity is defined by Battram (1999) as ”the condition of the universe which is integrated and yet too rich and varied for us to understand in simple common mechanistic or linear ways”. In an increasingly complex world, members of organizations need to be aware of the rapidly changing nature of their surroundings and lose any illusions they might have about the usefulness of fixed process and organization descriptions. Processes in organizations are by no means closed systems. There is simply so much information, interaction and inputs involved that micromanagement becomes harmful and it is prudent to consider leading through goals and guidelines. The game seeks to highlight this through various challenging and surprising inputs and problems, which participants have no clear-cut instructions for.

On the other hand the game has undertones stemming from systems theory and systems intelligence. Hämäläinen and Saarinen (2008) define systems intelligence as “an ability to connect with the complex interconnected feedback mechanisms and pattern structures of the environment from the point of view of what works”. Especially in large organizations, members of organizations need to be aware of their own part in, and influence on, the various systems they interact with. Every action leads to reactions and changes in the systems, and one needs to understand the implication of those changes. The game illustrates the need for systems intelligent behavior by giving the group of participants a wide range of largely interdependent roles to play inside and close to the hypothetical organization that is at the center of the game.

Theory of Gaming

The gaming system used in Systems Snapshot is live-action role playing (LARP). LARPs are non-scripted multiplayer games, where participants play role characters and interact with other role-played characters in a fictional setting represented by the real world. Forms of LARPs derive directly or indirectly from pen-and-paper role-playing games, and combine narrative fiction with gaming mechanics, which mediate the outcomes inside the gaming world. LARPs, unlike their close relative improvisation theater, do not include an external audience but only participants and Game Masters (GM), who are responsible for organizing and running the

game. LARPs are a new medium, but they do not necessarily require any ICT support and cannot be seen as a technological innovation, but as an artistic and aesthetic innovation instead. (Konzak, 2007)

LARPs in various forms have been utilized in education and corporate training for decades, but there has been little academic research conducted on the subject matter. As a pedagogic method, LARPs can be defined as a part of drama education, and more specifically participatory theater. It is very similar to process drama, with the exception of including gaming mechanics and a much more prepared structure. Pedagogic LARPs offer two significant benefits for learning: 1. a participant in a LARP gains knowledge of the game context and creates **subjective meanings for this knowledge** through playing the game and interacting with the game world, and 2. the participant learns, thorough aesthetic doubling i.e. simultaneously existing as both oneself and the character one is role-playing, to **empathize** with a perspective different from his/her own through living out a role during gameplay. Unlike recreational LARPs, pedagogic LARPs include work that is done before and after the actual gaming event, such as reading introductory material, and reflection and conceptualization based on the game. (Pitkänen, 2008)

According to Harder (2007), LARPs are an excellent way of organizing teaching since they fit the 21st century requirements for quality education so well: instead of memorizing facts, educational LARPs are about helping participants "internalize knowledge, skills and competencies", a complex task which requires the cooperation of participants. Furthermore, Henriksen (2004) states that role-play, if properly used, "seems relevant in order to reflect on the complexity of social or humanistic practice, and thus has potential for facilitating learning processes within these fields".

According to Harviainen (2007), LAR's are exemplifications of highly complex or even chaotic systems, and thus provide an excellent platform for increasing understanding of organization models, leadership and communication in complex systems.

Systems Snapshot was developed to be played with people from a real company. The LARP approach was chosen specifically to provide participants with subjective, emotional experiences on the complex subject matter at hand, and to promote systems intelligent behavior in the participants through empathizing with an organizational role unfamiliar to one's own. By participating in the game, players cross knowledge boundaries and gain a subjective experience of the challenges of the matrix

organization model, thus creating a powerful overall learning outcome. On the other hand, players act out roles differing from their own real-life work roles and by so doing learn to empathize with other, dissimilar agents within their matrix organizations.

Theories of Co-creating Practice and Knowledge

The Systems Snapshot LARP creates for the Game Company a "Community of Practice" (Wenger 1998; Smeds and Alvesalo 2003) where the players together create the practices through working together, and experience the complexities and challenges of working in a matrix structure. The game artefacts: the organization chart, the role descriptions, the game structure and rules, act as mediators in the experiential co-creation of the practices and the practice-based knowledge. These artefacts are the "boundary objects" around which the collaborative practices of the Game Company Community emerge (Wenger 1998).

The joint game experience however also triggers many ideas how to improve the organizational structure and processes. After the game itself, these ideas can be further used as input for innovative knowledge co-creation. The same artefacts that were used in the game for the co-creation of practice can after the game experience mediate new knowledge co-creation, and new "boundary objects" can be developed (e.g. Star 1989, Carlile 2002, Levina 2005, Smeds et al. 2006). The players of the Systems Snapshot that first acted and created the "Community of Practice" can in the debriefing phases become an "Innovative Knowledge Community" (Hakkarainen 2009) that collaboratively develops the organizational structure, processes and management of the Game Company – and potentially also of the real company (Smeds at al. 2011).

During the System Snapshot game, the Game Masters stay in the background, and interfere with the game as little as possible. In the beginning of the game, they first give to the players the game instructions and materials, and during the game they provide the inputs and guidance. However, after the game, in the later debriefing phases of the System Snapshot session, the importance of facilitation for knowledge co-creation grows.

The Systems Snapshot serves double co-creation goals:

1) In the game, the participants **co-create experientially, by acting out their roles, the working practices** in a complex Game Company. They

share experiential knowledge and create shared understanding about the practical challenges of working in the matrix organization. They also get ideas for improvement.

2) After the game, the participants reflect together on their experiential learning, share their ideas and continue with innovative and purposeful **knowledge co-creation, to improve the organization's structure, processes and management**.

The Game

In the Systems Snapshot LARP participants manufacture concrete products for clients played by other participants, simultaneously striving towards **personal and organizational goals**, according to company and role-specific background material they have received at the beginning of the game. Participants are encouraged to pick roles as far as possible from their own work role to increase their understanding how others are affected by decisions made within a complex system. Throughout the game, two Game Masters provide **inputs**, keep **time**, give **instructions** if needed, and manage **communications and travel** within the organization.

There are no ICT-requirements to the game; only a projector and a pair of portable computer speakers are needed.

There is no way to "win" the game. Participants can merely try to play out their role as well as they can. The lessons of the need to "let go" instead of control, to set goals, delegate and communicate proactively, are driven home by way of **inputs** into the game environment: a **rush order** of prototype products from the client, a request for **stress leave** coming from an employee at another office, etc. These inputs force the participants to think ahead and consider the bigger picture behind their immediate organizational surroundings.

In the beginning of the game, participants are likely to concentrate on their own "box" in the organization chart and tackle sudden **emergencies** with attempts at control and micromanagement, but transpiring events will soon force them out. The aim is that this experience of **failing due to efforts at control and micromanagement** will, unlike all the lectures the participants have probably heard on the subject matter, cause a personal understanding of the importance of **leading through goals, delegating and communicating proactively**.

The game itself is divided into four (+1) separate phases:

The briefing session (15 min): The Game Masters explain to the participants the objectives of the game, the communication methods used in the game, the various roles (17-22) available, and the organizational structure and guidelines of the Game Company.

The simulation (45-75 min): The participants will act out their assigned roles in any manner they feel best reflects the instructions they have received. There is much room for independent action within the given organizational framework, as the game structure merely provides a starting point for the interaction and the Game Masters only provide some additional, surprising inputs on the way. The end result of the simulation is open, and largely up to the participants.

The reflection (5-20min): Experiences of the participants are discussed with the whole group. The Game Masters facilitate the discussion, focusing the attention to differing experiences from different viewpoints within/near the organization, as well as to different reactions to the various inputs given in the game.

The conceptualization (15-30min): The participants are divided into four **heterogeneous teams** so that the members represent different types of roles played out in the simulation. Each of the teams discusses the events of the **simulation from a different perspective** (e.g. customer relationships, communication, trust etc.) and lists challenges and best practices related to their theme. If there is time, the teams can rotate between different themes, commenting and adding on the material written by previous groups. In the end, each group presents the findings on their themes to the whole group, and the Game Masters facilitate the joint discussion and creation of knowledge.

(Transfer of the learning to own organization): After the conceptualization, the discussion can go on to transfer the new understanding and knowledge to the real world organization. This requires facilitation, and new boundary objects that relate to the real company's processes. One idea to be tested out in the future could be to combine

Systems Snapshot with a company-specific developmental process simulation (e.g. Smeds et al. 2006).

The Use and Results of the Game

Systems Snapshot has been originally developed at Dazzle Oy, a Helsinki-based training, consulting and innovation company who describe themselves as “an experimentation laboratory for new ways of working”. The game has been utilized for management training modules in global corporations operating in the engineering and chemical industries. The first author of this paper worked at Dazzle from 2010 to 2012, and utilized this version of the game in international management training modules in Europe, Asia and North-America.

This version of Systems Snapshot, played in the matrix context, has been run 26 times since 2008 and has included over 500 participants. In addition to the matrix context, the gaming model has been applied to various other contexts including leadership communication, adopting a new operational model, team building, and preparation for organizational change. Results from the matrix game have been generally very positive, with many participants naming it their favorite portion of the week-long training modules they were participating in.

The conceptualization phase seemed especially fruitful. Each participant group co-created many pages worth of best practices to deal with the challenges they faced during the game. Some of the most common suggestions for improving operations in the matrix organization included

Implementing a new, coaching style leadership model to ease delegating and autonomous decision making.

Increasing awareness of organizational structure, decision-making authority, roles and responsibilities in order to make cross-functional cooperation smoother.

Limiting the number of overlapping roles for an individual to avoid bottlenecks and careless decisions due to work overload.

Furthermore, many participants through all of the game events reported, especially in the reflection phase, that playing the game from an unfamiliar role was an eye-opening experience. A common comment was that participants had simply not even thought about what, for example, a conflict situation can look like from the “other side of the table”. These

results show that the gaming model does indeed support empathizing through aesthetic doubling.

The System Snapshot thus supports a learning cycle from co-creating and experiencing complex and challenging practices, to intentional, innovative knowledge co-creation to improve these practices. The learning process can be mapped upon the four phases of the organizational knowledge creation spiral (Nonaka and Takeuchi 1995): 1) the participants socialize and share tacit knowledge via acting together in the simulation, 2) they convert this tacit knowledge into externalized, explicit knowledge in the collaborative reflection phase, 3) they further combine this explicit knowledge and co-create new knowledge in the conceptualization teams and in the facilitated joint discussion, and finally 4) they can take a step towards internalizing the new knowledge into their own work and organization, in facilitated company-specific workshops, such as process simulations.

The special "empathizing" feature of the System Snapshot LARP, the simultaneous acting as oneself and the character one is role- playing (aesthetic doubling) seems to strengthen the collaborative knowledge creation process throughout the phases of the System Snapshot game. It brings into the gaming experience the important emotional backing that has been shown to strengthen learning outcomes.

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Supporting on-line training of engineers in the wind energy sector by using games

Jannicke Baalsrud Hauge[1], Rosa Garcia-Sanchez[1]

[1]*Bremer Institut für Produktion und Logistik GmbH,*
{baa,gar}@biba.uni-bremen.de

Abstract

The growing consumption of limited reserves of fossil fuels and their impact to the environment have raised global interest in renewable energy. Proper knowledge of renewable energy is lacking in many levels of society. It has been observed that a considerable amount of work has been done for developing technologies so that we can use the renewable energy more efficiently. However, the educational sector seems to be slower in offering educational and vocational training courses that can fulfill the need well educated employees arising in the renewable energy industry. However, during the last decade this is slightly changing and both on-site and on-line training courses are offered. These are often very theoretical, and in this article we will look at an approach that will give the participants a possibility to apply the theoretical knowledge. In this article we will discuss the approach using Serious Games for on-line training as well as the first results and the boundaries we have experienced.

Keywords

Wind energy sector, professional education, serious games

Introduction

Wind power has been used as energy source for long time. In ancient time, wind energy was used to pump water and since the Middle Age, windmills were used in Europe to grind corn. However, for several centuries, the use of this unstable energy supplier diminished as non-renewable energy sources like coal covered the increasing need of energy supply. Today, due to better technologies and materials as well as due to the fact that we already know that some non-renewable energy supplies will not last for many more decades, we see a change within the EU towards renewable energies. Some European countries have been supporting the construction of wind parks and bio-gas plants for decades, but due to the new Renewable Energy Directive (2009/28/EC) there is also a high growth within this sector in countries like Spain, Italy and United Kingdom (REN21, 2011). This directive states that at least 20% of final energy consumption by 2020 needs to be supplied by renewable energies. In order to reach this target there is a need to invest more in renewable energy power plants. However, there will only be a return on investment, if the companies that invest and build these plants do have access to well skilled employees, both for planning and construction as well for maintenance.

The needs of wind energy sector

In analysis of the market development of two of the leading countries within the Wind Energy sector, it can be observed that Spain experienced a fast development of the field in the last 10 years. In 2001 Spain had installed capacity of 3337 MW (Council, 2010) and in 2011 this had increased to 21674 MW 2011 (Association, 2012). Currently the installed capacity is more than 6 times the installed capacity in 2001. In Germany, the production increased from 8754 MW (Council, 2010) in 2001 to 29060MW (Association, 2012) in 2011. If we look at the increase of jobs within this sector, it can be stated that the European job market “there were around 192,000 people in the EU employed directly or indirectly by the wind energy industry“ in 2009 (ewea, 2009), but “According to EWEA’s latest statistics, the wind energy sector will create some 250,000 new jobs in Europe in the next decade, thus it is expected that the overall number of jobs in this sector will be 280,000 by 2015 and 450,000 by 2020”(ewea 2009). Based on these numbers it appears obvious that there is an increased need for people with education or vocational training within this field. Despite the Bologna process, the educational and vocational training

sector is still subject to national processes and it takes time from discovering the needs to implementing suitable courses as a part of secondary and tertiary education since the development of curricula is a time consuming process. Also the implementation new courses or changing of existing needs organisational preparation. This is still in progress in the wind energy sector. Consequently, it can be stated that there is a need for training programmes (ewea, 2009) within this area. Such programmes both formal on-line and on-site training will guarantee the access to well skilled labour force.

Requirements on employees in the wind energy sector

Wind power plants have been in operation in Europe for more than 20 years. These wind mills require maintain techniques and practises. Thus, there is a need of qualified engineers and technicians carrying out these tasks, additional to those needed for the construction. Wind power plants are often in rural areas or off-shore and consequently the requirements for maintenance are different to those for construction. This puts new requirements on the education of engineers and professionals which need a more practical education (eliceo.com, 2012) comprising topics on production, installation, operation and maintenance from a technical point of view. Additionally, the wind energy industry is a globalised sector and the employees are operating in several countries. Wind mills are often built in Germany, Denmark, UK or Spain and transported to the country where the wind power plant is based and built. This internationalisation makes it indispensable for wind energy professionals to acquire additional knowledge on European and national legislation. In order to have the ability to work in a multicultural environment they also need cooperation, flexibility, adaptability and team spirit skills.

Both aspects, technical and managerial are essential when working in an expanding and global market as wind energy. These requirements on specialise education are eye-catching and reflect the need of vocational training on the field to meet the demand of the industry sector.

State of the art on wind energy education and vocational training

Countries like Germany and Spain have discovered the need of the wind energy sector and implemented course both at secondary as well as tertiary

level. The table below lists different courses and programs available at the moment and shows the progress that has been made during the last decade.

Course	Topic	Institution Country	Tertiary/ Secondary (T/S) Vocation (Y/N)	Target group
Curso Técnico en Energía Eólica	Management on Wind energy	Escuela Europea de Dirección y Empresa (Spain)	S Y	Technical students
Técnico en Energías Renovables	Basic knowledge on Renewable Energies	Estudioline (Spain)	S Y	Technical students
Experto/Especialista Universitario en Energía Eólica	Fundamentals and technology on Wind Energy	UNED: Escuela Técnica Superior de Ingeniería Industrial (Spain)	T Y	Technical students
Técnico en Energía eólica	Fundamentals, technology and management on Wind Energy	Colegio Oficial de Ingenieros Técnicos Forestales (Spain)	S Y	Technical students
Curso online energía eólica	Fundamentals and technology on Wind energy	Universidad Católica de Ávila (Spain)	S Y	Technical students
Physics and Engineering Physics, BSc/ MSc	Specialized on Wind Energy	Carl von Ossietzky Universität (Germany)	T N	Bachelor and Master of Science students
Técnico en Energías Renovables	Fundamentals of renewable energy	Fomento Profesional (Spain)	S Y	Technical students
Postgraduate programme renewable energy	Fundamentals of renewable energy	Carl von Ossietzky Universität (Germany)	T Y	Scientist and engineers
European Master in Renewable energy	Fundamentals in renewable energy technology	Different Universities in Europe	T Y	Technical students
Techniker/in - Windenergietechnik	Fundamentals, technology and management on Wind Energy	Bundes Agentur für Arbeit (Germany)	S Y	Technical students
Master of Science Wind Engineering	Interdisciplinary course involving mechanical engineering, electrical engineering, the energy industry and environmental technology	Different Universities in Germany	T N	Graduate Students
Postgraduate courses on wind energy	High quality education in important wind energy topics.	CE Wind	S Y	Engineers
State approved wind energy technician	Technical wind turbines knowledge	Flensburg College of Design and Technology (Germany)	S Y	Technical students

Offshore Sicherheits- und Rettungstraining	Training personnel for service, maintenance and repair of wind turbines.	BZEE (Germany)	S Y	Professionals working on wind energy
Rotorblattreparaturen	Training personnel for maintenance and repair of rotor blades.	BZEE (Germany)	S Y	Professionals working on wind energy
Servicetechniker für windenergieanlagen	Fundamentals and technical knowledge on wind energy	BZEE (Germany)	S Y	Technical students
Maritime Technologien	Development, design and operation of wind turbines in onshore and offshore areas	Hochschule Bremerhaven (Germany)	S(Bachelor) N	University students
Windenergietechnik	Understand the techniques of the complex system "wind turbine" with all its facets.	Hochschule Bremerhaven (Germany)	T(master) Y	Technical students
Process Engineering and Energy Technology	Technique of material and energy transformation with environment friendly processes	Hochschule Bremerhaven (Germany)	T N	University students
Training and Qualification on Wind energy	Fundamentals and technical knowledge	Deutsche WindGuard Knowledge GmbH (Germany)	S Y	Graduate engineers and technical students
Offshore Sicherheits- und Notfalltraining	Training on technical service for wind energy		S Y	Technical students and professionals
Maschinenbau, MSc Bauingenieurwesen, MSc Elektrotechnik, MSc	Specialize in the area of wind energy	Leibniz Universität Hannover (Germany)	T N	University students
Systems Engineering	Specialize in the area of wind energy	Universität Bremen (Gremany)	T N	University students
Technology of Offshore Wind Energy Course	Wind turbine, electrical and offshore engineering aspects	TU Delft (Nederland)	S Y	Professionals

Figure 4: Examples of available courses and programs

This overview shows that there is a main focus on rather theoretical topics, but as mentioned above, there is a need for practical skills. In an interview a Professor of Mechanics of ETSII (UNED) Spain says that maintenance is mainly on the rotor blades and on the electromechanical system of the windmill. (RTVE , 2012), and looking at the courses mentioned above, it seems that only a few cover this topic. A second observation is that the Germans do have a broader offer on courses. There are mainly two reasons for this- firstly, wind power plants have been longer in operation in Germany than in Spain, secondly, the Germany has a very well developed professional education, also offering a specific professional education on wind energy (BAA, 2012). Consequently, many German companies are

aiming at expanding abroad, and many German professionals are assigned to work abroad. These employees do have a high level of professional skills, but not always aware of different working conditions, legislative and cooperation issues that are important in order to succeed abroad. Even though some of these topics can be thought in on-line courses, it is very difficult to mediate more practical and collaborative skills by lectures. In such case, the use of experiential learning methods like serious games has been proven to be very efficient (Windhoff, 2001). Serious games offer a risk free training environment and have been used for mediate skills on complex systems for several decades in the military education (Hays, Singer, 1989). Since the 1950's there is an increased use of games also for civil purposes (Wolfe, Crookal, 1998), mostly for teaching purposes. In the area of logistics, serious games have been developed for mediating skills on insulated problems like the bullwhip effect, on understanding the supply chain as such or for improving the collaboration among employees working in supply or production network.

Requirements on the game

The examples above are only a few examples but it illustrates the large variety of applications. We have therefore looked at possibilities for letting employees experience the new working environment in a safe environment by using games. The intention of the game is that the user can either use it before or during his mission.

The analysis of the educational offer above shows both a need for technical and managerial topics. These need different approaches, and in a first step we are looking on how Serious Games can support the managerial topics and inter-organisational collaboration. Based upon the gap analysis the following requirements on the game were defined:

- Exemplified learning by experience,
- Training of soft and management skills
- Acquisition of background knowledge, including EU and national regulations
- Gaming in a realistic environment,
- Anticipation of the mode of action, the potential and the boundaries of enterprise collaboration,

- Playing different scenarios

The target group is often involved in different types of collaboration and in different countries, thus they have to perform differently. Therefore, the game will offer different scenarios reflecting the working environment. Thus we have chosen a single-user concept, based upon an engine with authoring tool ensuring both the opportunity to play alone as well as allowing fast reconfiguration if it needs to be adapted. This tool is called SPIKO. It was developed in a German national project and has been in use for educational purposes since 2005.

Gaming Concept

Each game session contains n phases with variable number of sequences with adjustable parameters in order to reflect different situations.

The model foresees that there will be some five different "stages". Stages are fields which the player can choose and in which he will get information of the situation, decisions possibilities, background information, the characteristics of the roles as well as the set of parameter chosen, previous sequences of the events etc.

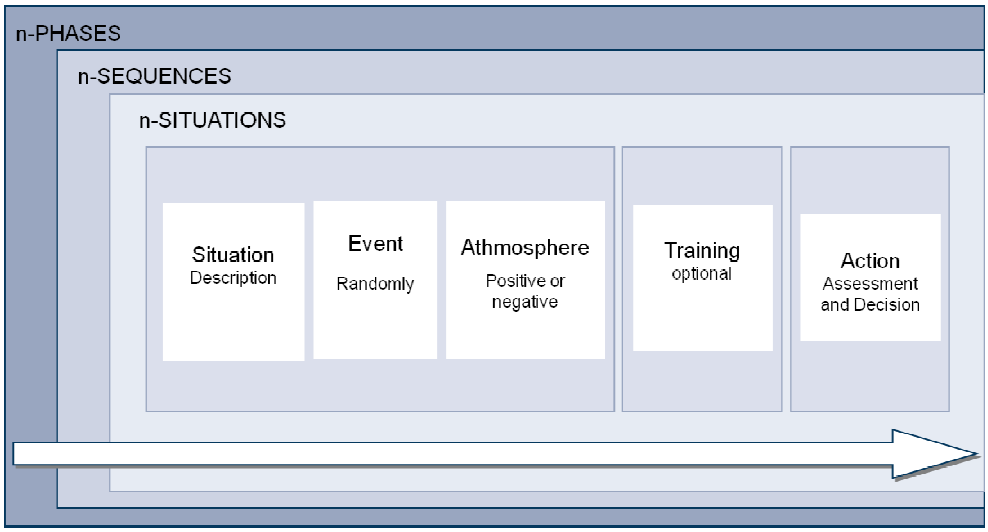

Figure 5: Concept

A player is supposed to play through one case, which always will last from the first idea of cooperation until the concrete operation of a sequence of the considered business process. When the player takes a wrong decision or undertakes fatal actions, the game will end abruptly. The learning effect will

be achieved by the player's experience of the consequences of his decision and acting.

Each level consists of many different variable elements which all influence the path of the game. The player may choose a role, he can change some characteristic parameters, and he will influence the game with his decisions. External events and computer generated interrupts will also influence the game as well. It is a complex gaming logic behind these factors, which will give the player reasonable reaction on his decision, behaviour and performance as well as new events, so that the learning impact will be high.

Implementation of a first scenario

The different gaming scenarios are still under development, but a prototypical scenario has been implemented. This first scenario on the wind energy sector is a generic one for collaboration between different countries in the European framework. The starting point is that a German company is likely to get a contract on the construction of an off-shore wind park in Spain. This is a large task, and it is a question on whether they can carry out this task alone or if collaboration is more favourable. In a first step, they will send a senior engineer to look at the environment and to check the opportunities as well as to identify the barriers. The player plays the role of this senior engineer. During the game, he will play experience all phases in the life cycle of a wind park. The areas in which the players will face problems are related to EU legislation, communication, cooperation and culture. He starts with looking at different cooperation forms, and for each phase he has to take decisions and to assess the situation. He is also confronted with legal aspects, since this is a defined need within the sector. He will phase events and he will need to take action in order to fulfil his mission. The system provides him feedback and gives him an impression on how the atmosphere in the potential cooperation is. He will also get question on technical topics, but these are limited, since we are more focussing on the management part. At the end, he needs to deal with the maintenance issue.

This scenario has been implemented as a prototype and tested by four players. The first results showed that the player gain insights on legal aspects as well as on specific challenges in the wind energy sector, but it also showed that there need to be some improvements.

Conclusion

There is a need of qualifying more employees to fulfil the need of the wind energy sector, both from a technical as well as managerial perspective. This sector is highly international and the employees need to adapt to different working environments. This requires not only very good technical knowledge and practical skills, but also a high degree of cultural and co operational competence. It is difficult to mediate this in on-line courses, since the employee need to experience it. In this article we have showed how serious games can be used for this purpose. The testing showed that the participants gained insight, but it also showed a clear need on improving the part on legislation, since this topic is difficult to understand. For the technical learning, it will be more recommendable other type of game that bring more simulation possibilities for a practical learning on the maintenance and construction of power wind plants. However, the sample so far is too small, so during the next months the game will be tested with a larger group in order to verify the results.

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SMEs and Innovation - support by Serious Games and External Providers

Maike Riesenbeck, Gabriele Hoeborn, Jennifer Bredtmann

University of Wuppertal, Department of Engineering, IZ 3

m.riesenbeck@uni-wuppertal.de

ghoeborn@uni-wuppertal.de

bredtmann@uni-wuppertal.de

Abstract

The creation of innovation includes the use of the potential of an enterprise and of its employees. The potential of an employee cannot easily be measured. The abilities and knowledge has to be gathered, including formal and informal parts. Based on this data and according to the potential of the company specific further training, lifelong learning has to be offered to increase and develop the employees' potential.

Keywords

Serious Games, innovation, external provider, networks, SMEs.

Introduction

Nowadays the pressure of being competitive means the pressure of being innovative. Even in times of financial and economical crises the importance of innovation increases in all sectors.

The most established definition which is used in the European Union is that an innovation is a new or significantly improved product (good or service) introduced to the market or the introduction within an enterprise of a new or significantly improved process. Innovations are based on the results of new technological developments, new combinations of existing technology or the utilization of other knowledge acquired by the enterprise (EUROSTAT 2009). Innovation in the EU Glossary means although:

> "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relation. The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new (or significantly improved) to the firm (EU Glossary 2012)".

According to Zimmermann and Niefert (2009) Small and Medium-sized Enterprises (SMEs) show a significant smaller participation in innovation activities than large companies. To keep one's competiveness includes being innovative, therefore, companies needs to work on their innovation abilities.

Big companies easily recruit well-educated and specialized employees and as well they can easily offer a specific further training. SMEs do not have this possibility, the necessary funding is missing on the one hand. And on the other hand the flexibility of releasing employees from work to participate in further training is available to a limited extent. Thus, they need new methods and approaches to implement further training into their every day work life to enhance their competitiveness.

All over Europe SMEs are quite important to keep the economy running, most of the employees, 66,7% in Europe-27 in 2009, are working in such kinds of enterprises. Table 1 offers data concerning the number of employees, the added value, and the labour productivity related to the size of the companies. This data underlines the importance of supporting SMEs to be innovative and enhance their competitiveness.

	Number of enterprises	Persons employed	Value added	Apparent labour productivity
	(million)		(EUR 1 000 million)	(EUR 1 000 / person)
All enterprises	21.0	135.8	6 176	45.5
All SMEs	20.9	90.6	3 617	39.9
Micro	19.3	39.3	1 348	34.3
Small	1.4	27.9	1 147	41.2
Medium-sized	0.2	23.4	1 122	47.9
Large	0.0	45.2	2 559	56.6

	Number of enterprises	Persons employed	Value added	Apparent labour productivity
	Share in total (%)			Relative to total (%)
All enterprises	100.0	100.0	100.0	100.0
All SMEs	99.8	66.7	58.6	87.8
Micro	92.0	29.0	21.8	75.3
Small	6.7	20.5	18.6	90.5
Medium-sized	1.1	17.2	18.2	105.3
Large	0.2	33.3	41.4	124.5

Source: Eurostat (online data codes: sbs_sc_ind_r2, sbs_sc_con_r2, sbs_sc_dt_r2, sbs_sc_1b_se_r2)

Table 2: Enterprise size class analysis of key indicators, nonfinancial business economy, EU-27, 2008 (Eurostat, 2011 a)

The loose of competitiveness of SMEs would lead to an economical crisis. The most effective way to keep SMEs competitive is to support their innovation abilities. Additionally, any development of a company towards innovation could be positively recognized by the granting of credits. In the last years the rate of denial of credits for SMEs increases in the majority of the European countries, these denials lead to activity limitations up to becoming insolvent. For example in 2007 the success rate of credit requests in Germany was up to 85,3%, 2010 it decreases down to only 75,9%, comparable to Greece, in 2007 the success rate reaches 87,6 % and 3 years later only 59,6% (Eurostat, 2011 b). SMEs offering a well established and well founded further training will thereby show a well planned business concept at the same time.

This requires that SMEs need further training to generate innovation abilities and to keep their competitiveness. And Serious Games are an innovative methodology to practice further training and to create innovation which additionally underlines the innovative alignment of an enterprise and its business concept.

The question turned out how to generate these innovation abilities without the resources of large concerns. This paper will give a suggestion how the problem could be solved, and it will include the use of Serious Games.

Serious Games are universally usable, for all employees or just for management training. Of course a lot of games already exist and can be used, but additionally enterprises have the possibility to design these games individually with external providers. Most of the time any specific and individual solution is quite expensive, and, therefore not affordable for SMEs. But if the games and the costs could be shared with different enterprises, an affordable solution could be developed. So, there the possibility of further training together with employees of other enterprises can be created.

It is well-known, that SMEs build networks to help each other. These networks can be used and intensified by a mutual training and could help the enterprises to get more innovative without billions of Euros.

Related to Bredtmann a network is a union, an affiliation of enterprises on the principle basis of the equal righted co-operation to protect the market position of the involved enterprises, and to have mutual advantage with the aim to improve the situation (Bredtmann 2009). This definition includes the advantage of having well educated employees through mutual further training.

Design of Serious Games enhanced through external providers

Serious Games are computer based or non computer based applications which are providing knowledge and serious topics through gaming. They are based on the idea of learning during and through gaming easily. The focus of this methodology is gaming; priority is given to a gaming character not to teaching or providing knowledge. Sometimes the process of knowledge transfer is carried out on a secondary level, not even perceptible obviously.

Serious games include all aspects of education and teaching, training, and informing suitable for various users not depending on age, culture or personal background (Michael & Chen, 2006). The gaming priority of this methodology lead to high motivated and engaged user groups. Furthermore, creativity and new ways of thinking are developed and supported by the partly interactive design of serious games. Combined with the games, fun and knowledge a new learning style has been developed. Additionally, serious games do not just include educational aspects; they also support communicational aspects and simulation at the same time.

Serious Games are used for further training .The people who know the best what an enterprise needs for further training are the employers and employees of these enterprises. But they do not have the know-how to design a Serious Game for their companies.

So, it turned out obviously that a collaboration of providers of Serious Games and employers and employees would be an efficient way to design the best game.

Serious Games, obliviously they are games leading to an educational goal, can be computer based but they do not have to. As we know the use of information technology in SMEs is a little bit smaller than in big enterprises. Table 2 gives an overview on the use of computers related to company size.

Number of employees	Use of Computer in %	Use of internet in %
1-9	84	81
10-49	97	96
50-249	99	99
More than 250	100	100
Totally	85	82

Table 3 Destatis, 2011; German statistic

It should be discussed if the use of a computer based game should be chosen to raise the computer and digital media competencies of the employees at the same time. But the final decision is based on the requirements towards the game.

The external provider should be able to offer Serious Games and further training for a network group due to their mutual interests. At this time there do not exist any networks using the networks for further training. This is a research gap to develop a solution to be transferred and applied directly and practically. Some providers of Serious Games almost work together with the client and design the game as required on demand.

An example is Game Engineers, they develop Serious Games and Silver Games (Serious Games 50+). The development can be done with the client and his specific requirements and then they also conduct the training courses if necessary /www.game-engineers.com, 11.04.2012/.

Sometimes the development of a specific and individual Serious Game may be too expensive but some already existing Serious Games may be adaptable, like Q-Key 2. This board game is based on the DIN EN ISO 9000 for quality management and can be adapted on the customer wishes. The training is offered to a group of 5 to 10 employees, so that this is possible for SMEs to join it alone or with other employees from their network /www.qkey.de, 26.04.2012/.

Requirements on the network

SMEs often work in niches and do not have all production stages within their enterprises. Thereby networks emerge and can be used for more competitiveness towards the big companies.

Besides these common goals, a further training within a network offer communication and networking opportunities as well. Serious Games do not just increase the innovation potential of SME employees they also increase the interaction between the employees within a network. And this will lead to an increase of informal and maybe formal abilities as well strengthening the potential of the employees and the innovational potential of the enterprise at the same time.

If the network is used for further training some requirements have to be fulfilled. First of all it would be desirable when the different enterprises are located in the same area. This facilitates the further training with Serious Games and the further communication after finishing the training. Short distances between the participating partners additionally offer the possibility of several short training lessons dated on different days. This solution may be helpful concerning releasing employees from work, because SMEs and their work flow are often not very flexible toward this release.

The possibility of online training exists as well, but in this case the team spirit and the communication caused by it may not be developed or be lost.

Serious Games - Requirements and Offers

Using Serious Games for further training is not that popular, but the authors think that it could be a method for the future. Big companies have developed their own Serious Games for further training like flight simulation e.g.. Many of these games do not have open access they are just

for internal application. There are some games for lifelong learning or education but very few concerning further training of employees.

The Serious Game Award 2011 in Germany (nordmedia GmbH, 2011) shows what kinds of games are used at the moment and in which sector they are placed. The winner was a learning game for illiterates called "Winterfest", so it is a game for people having a 'weakness', a disease like the second-place finisher "Dr. Bonneys Zappelix Zaubert" a game of skill for ADHD-patients. Table 3 gives a small overview on existing Serious Games and their field of application.

Application	Game
educational game kids and young adults	• "ExperiMINTe", Zone 2 Connect GmbH • "Our Courts", Sandra Day O'Connor College of Law
sport and health	• "Brain Age", Touch Generations • "Dance Dance Revolution", Konami computer Entertainment Tokyo Inc.
language programs	• "phase 6″, phase 6 AG • "English Coach", Cornelsen
further training	• "Lufthansa Flugsimulation A380″, Thales • "British Gas Service", British Gas Service
recruiting	• "TechForce – Das Adventure-Spiel der Metall- und Elektro-Industrie", Zone 2 Connect GmbH • "L'Oréal Brandstorm", L'Oréal
simulation and business games	• "Business Success", PIXELearning • "Better Business Game", British Telcom

political events	• "Global Conflicts: Palestine", Serious Games Interactive • "Stop Disasters!", playerthree
consumer education	• "Fold it", Washington University • "Biogasanlage/ Biofermentation Viessmann", Zone 2 Connect GmbH
medicine/ psychology	• "Virtual Iraq", University of Southern California • "Packy & Marlon", Click Health "Magic Castle", Zentrum für Kinder- und Jugendpsychatrie der Universität Zürich

Table 3: Overview based on the website: seriousgames.de

Enterprises need individual training methods with personalized requirements respectively with a lot of parameters that can be changed. But they do not just need the games they also need training in how to use the games. So, the providers have to offer these trainings as well. Maintenance of the games by the providers may be an additional offer to assure best training conditions.

Traditionally, to start a new task, like to operate a new machine, usually is accompanied by instructions given by an instructor and a training period. But not all trainings can be organized that way due to different reasons. Therefore, Serious Games should be used.

A first case study on the requirements on Serious Games as a further training tool lead to the following demands by employers:

- Specific knowledge according to the alignment of the enterprise
- Language competence
- Communication competence
- Intercultural competence
- Applicability of the new competencies

- Further training should not disturb the work flow of the company
- Flexible time schedule of further training
- Flexible space schedule of further training
- Further training should lead to self-organized learning
- Further training should support enterprise and employees
- Further training should motivate the employees to make them remaining in the enterprise

The employees added:

- Further training should be motivating
- Further training should be interesting and inspirational
- Want to understand the sense, the goal of the further training

By considering the above mentioned requirements the use of Serious Games in further training can be increased. At the same time this allows the application of serious games for further training in SMEs and SME-networks.

Conclusion

This paper shows that the possibility of innovation for SMEs could be enhanced through Serious Games.

The idea to offer further training and lifelong learning through Serious Games in a network for SMEs ensures the company innovative potential.

The use of synergy effects through a network is the chance to offer further training for an SME and its employees. By using these synergy effects for training SMEs have a cost advantage and it can start an exchange of knowledge between the participating employees across company borders.

In between the market competition, and especially for SMEs, it is necessary to support and enlarge the employees' abilities and to start knowledge exchange. With the innovative methodology of Serious Games it is possible to develop individual and specific further trainings as well as training concepts which can be used in SME networks for further training.

By creating an SME network the requirements of employers and employees have to be considered. Without the compliance with the requirements the acceptance of further training and the Serious Games can be lost.

The investigation of compliance with the requirements for Serious Games in SME networks is a condition to design future further training modules.

There is still a lot of research to do, but at the current situation in Europe it is necessary to strengthen these enterprises. The depicted aspects were given under the reflection of the current situation they have to be demonstrated in the future.

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Serious Games and Higher Education

Developing a Methodology to Evaluate Motivation in Serious Game in Manufacturing Education

Borzoo Pourabdollahian, Marco Taisch

Politecnico di Milano, Department of Management, Economics and Industrial Engineering

borzoo.pourabdollahian@mail.polimi.it, marco.taisch@polimi.it

Abstract

Having multi-skilled engineers who can master the complexity associated to sustainable manufacturing emerging in the intensive competitive global market is a must for manufacturing companies. The current approaches to manufacturing education and training, both at university and industry, need to be revisited to improve the learning effectiveness of manufacturing engineers. An important factor in the learning effectiveness is the delivery mechanism and recently serious games are a promising suitable supplementary method to enhance the learning experience in engineering schools and industry. The research shows a common trait across all learning theories, which is the impact of a learner's motivation on the learning outcomes. A key characteristic of serious games, and consequently what make them attractive, is the level of engagement achieved. Therefore, serious games have the potential of providing a learning environment where individuals experience learning contents in a "fun" way, thereby achieving a higher level of motivation than using more traditional learning methods. Although there is a growing body of evidence of the correlation between the game mechanics that contribute to the learner's motivation, which subsequently increase their engagement and motivation, these serious game design considerations are not necessarily common to all learning domains. This paper presents a methodology in order to assess whether there are patterns that can be used in serious games within manufacturing education and to identify these game characteristics.

Keywords: *serious games, motivation, learning outcomes, manufacturing education*

Introduction

Nowadays, manufacturing companies are involved in an aggressive talent war in order to survive in the present competitive global market. Gone are the days where an engineer would be someone with mostly a mechanical engineering background, now in a knowledge based economy, an engineer is required to have a multi-disciplinary set of competences to deal with the increasing complexity of the manufacturing industry, including the so called “soft skills” (eg: negotiation, leadership, sense-making, etc). The predominant human resource strategy has been the recruitment of multi-disciplinary engineers and technicians with the necessary knowledge and expertise to tackle the complexity associated to new trends emerging in both manufacturing and engineering. However, these are in very short supply and the need to have human capital with multi-disciplinary skillset is compounded by the reduced time to competence that is imposed by the organizational need of agility and responsiveness to an ever changing market need. The traditional approaches to teaching and imparting knowledge are no longer sufficient, raising the challenge for new learning methods and tools to train young engineers about the most advanced production systems. Another alternative would be to educate the current workforce, to have the necessary competences, but the lack of effective delivery tools make the process unfeasible and otherwise too costly for a manufacturing company, in particular a Small Medium Enterprise (SME), to consider.

The advent of serious games brings the promise of a novel instructional method to manufacturing and engineering education. The use of serious games provides the opportunity of situated learning, where the learner is emerged in the actual context and therefore increasing the retention rate whilst improving the potential for transformation of the learner. Therefore, it is important to understand how to make serious games in manufacturing truly effective learning experiences.

An important dimension towards making serious games effective is making them engaging to keep the learner motivated. Consequently, it is important to identify and understand the motivational factors that strengthen

emotional engagement of learners. This knowledge can assist a serious game production team to employ them appropriately in the resulting game as a game mechanic, a user interface, game design, learning process, pedagogical content, measurement, etc.

There is a growing number of studies focusing on the learner's motivation in serious games. Garris and Driskell (2002) stated when some features of the game incorporated with educational aspects make a more enjoyable environment for learners. Parker and Lepper (1992) explained the learners prefer learning programs that included fantasy characteristics, which was a theme developed further by Asgari and Kaufman (2004) who discussed about fantasy and curiosity as two main elements in computer game motivation. However, it is uncertain if these motivational characteristics are equally relevant in serious games in the particular learning domain of manufacturing.

In this paper, we present a methodology for evaluating motivation in serious games within the particular domain of manufacturing education. We address the current challenges in manufacturing education, why alternate learning delivery mechanisms may need to be employed to achieve effective transformation of a new generation of engineers. The paper will discuss the role of motivation in designing a serious game and studies that have been carried out about serious game attributes. Finally, we conclude with a designed hypothesis and research questions for evaluating the effectiveness of serious games in manufacturing education and propose methodologies for answering the research questions are presented.

Why Serious Game in Manufacturing Education?

Manufacturing education plays an important role for training the new generation of knowledge-based engineers. The shortcomings of conventional teaching approaches are not sufficient in order to make competence engineers in shorter time frames, raising the demand for other alternatives to effective learning which also more efficient.

Serious games have being widely used in areas such as military, whom have been early adopters. However, the promises of serious games have extended the learning domains to health, business, and more recently to

manufacturing education. One of the foundational benefits of serious games is the unique opportunity for learners to experience learning and entertainment at the same time. Furthermore, being boring and complicated, engineering courses are usually criticized by students in engineering schools and decreasing the number of attendances in engineering courses is a critical problem for engineering schools (Coller and Scott, 2009). But, by application of serious games many serious concepts in manufacturing and engineering will be learnt in an enjoyable way (O' Sullivan et al., 2011). Therefore, it needs more studies in order to reveal how exactly serious games can improve the learning out come in manufacturing education in comparing with traditional methods such as classroom, role playing and case study.

In literature two main goals, primary and secondary, are identified for serious games in order to make them as useful learning methods (Connolly et al., 2011). In manufacturing domain, the critical intention is making an improvement in the acquired knowledge and skill by engineers. This is correspondence with the primary goal of serious game defined by improving knowledge or skill acquisition through playing. In the other hand, enhancing the learners and tutors' motivation is highlighted in the secondary goal which is currently a serious problem in manufacturing education.

In that case, serious games' objectives can be compatible with three types of learning outcomes identified in Bloom taxonomy. In this taxonomy, "Cognitive" domain includes acquired knowledge and skills and it is defined as an ability to remember facts and concepts. The second type is called "Affective", which encompasses the individual and environmental emotional factors influencing the learning process (e.g. motivation, attitude, etc). "Psychomotor" is the last type of learning outcomes that address learning outcome based on physical activities and communication facilities. Kraiger (1993) argues that learners achieve three kind of knowledge:

Declarative knowledge, which consists of answers to questions about "what is knowledge about?"

Procedural knowledge, which explains "how knowledge about?"

Tacit knowledge clarifies "which, when and why knowledge".

The Importance of Motivation in Manufacturing Education

Even if a learning program has been perfectly designed, it will fail if the learners do not have enough motivation to learn (Karoulis and Demetriadis, 1984).

Heckhausen defines motivation in the psychology area as diverse processes that a person chooses special behaviors and then applies them in order to achieve a specific result (Heckhausen, 1991). It is completely an uncertain process and many ungovernable variables can affect learners' motivation (Keller, 1987). The importance of motivation cannot be overstated by some, as in the case of Keller believing that motivation is the most crucial factor for designing a training program for employee learners (Keller, 1983). Also Bloom explains how the individuals' feelings can influence on learning outcomes and focus on the motivational components which include "willingness to respond", "satisfaction in responding", "positive react to a specific phenomenon" and "self-efficacy". He called this type of learning as "Affective learning" and described its relation with other types of learning, cognitive learning and psychomotor learning (Bloom, 1956).

In a practical view, lack of enough desire to learn among learners is a critical problem for engineering schools and industrial systems. Some studies have shown that the productivity of traditional learning activities based on "reading", "watching" and "discussing" is very low. In the fact, just 10% to 30% of the content is recalled by the learners (O' Sullivan et al., 2011). Lack of motivation may be considered as one of the factor that makes this low level of productivity and consequently students are forced to participate in a course only to pass the course. Chryssolouris indicates that engineering schools need suitable training program where learners are involved seriously in the learning program. He also emphasizes the importance of designing attractive and enjoyable learning process to train new generation of knowledge workers in industrial systems (Chryssolouris, 2007).

Serious games can also increase the learners' motivation by providing them with a safe environment where a learner may experiment and explore possibilities without the risk of real failure. Therefore, considering motivational elements in designing serious games for manufacturing education can increase the level of engagement among learners and then it influences on the level of acquired knowledge and skills. In the next section

we discuss how the motivational components are considered in the existing frameworks to evaluate and design serious games.

Evaluating the Role of Motivation in the Effectiveness of Serious Games

Attributes of Serious Games

The analysis of serious games to determine their characteristics that stimulate learners' motivation and engagement: challenge, competition, fantasy, rewards, and etc (Caillois, 1961; Grendler, 1996; Hays, 2005 and Smed, 2003). A number of prominent studies identify the attributes of serious game are shown in Table 1.

Study	Attributes
Van Staalduinen (2010)	Challenge, conflict, progress, control, interaction, location, representation, adaption, feedback, fantasy, goal, rules, mystery
Killi and Kristian (2005)	Challenge, goal, feedback, control, playability, gracefulness
Charsky (2010)	Competition, goals, rules, choice, challenge, fantasy
Garris et al. (2002)	Fantasy, rules, goals, sensory stimuli, challenge, mystery, control
Yussef (2010)	Attention, scaffolding, interaction, control, practice, feedback, rewards
Csikszentmihalyi (1992)	Challenge, absorption, goal, feedback, concentration, feedback
Karoulis and Demetriadis (2005)	Goal, fantasy, curiosity, feedback, rewards, choice, competition

Wilson et al (2008)	Challenge, conflict, control, fantasy, communication, mystery, representation, rules, sensory stimuli

Table 1: attribution of serious games

Evaluation Frameworks

Knowing the ability of serious game in order to motivate players is an important issue for both tutors and designers. Literature research identifies a number of evaluation frameworks, which study the effectiveness of serious games from different perspectives. Table 2 shows existing frameworks for evaluation the effectiveness of serious game by focusing on motivation

Study	Framework
de frietas and Oliver (2006)	Four Dimensional Framework
Amory (2006)	Game Object Model version 2
Kiili (2005)	Experiential Gaming Model
Egenfeldt – Nielsen, Simon (2003)	Learning environment, personal learning factor, learning outcome
Csikszentmihalyi (1990)	Two axes flow channel
Quinn (2005)	Engaging learning
Garris et al (2002)	Game Based Learning model
Charles (2009)	Engagement in learning
Hu (2008)	Eduventure Game Framework
Wouters et al (2007)	Learning outcomes taxonomy
Karoulis and Demetriadis (2005)	Motivational matrix
Malone and Lepper (1987)	Design Heuristic for Motivating Instructional Environment
Hays(2005)	Design framework for Instructional Games
Hainey (2010)	Game Based Learning

Table 2: Existing frameworks for serious game evaluation

Of particular interest are Game Based Learning model (Garis et al, 2002), Four Dimensional Framework (de Freitas and Oliver, 2006), Design Heuristic for Motivating Instructional Environment (Malone and Lepper, 1987) and finally Game Based Learning (Hainey 2010). It is based on these that we will derive the evaluation framework for assessing motivation in

serious games for manufacturing education. Consequently, we go in further detail with each one.

Game Based Learning model is a well-known framework to demonstrate how using games support learning outcomes (Garris et al., 2002). The model focuses on integration of instructional contents and game characteristics in the learning process in order to motivate the learners to repeat the game process (Pivec and Dziabenko, 2004). This repetition finally will lead to learning. They consider the model in three main phases, first is "Input" where it needs that instructional contents and game characteristics are completely blurred. In the "Process" phase learners react to the input through different feelings such engagement and fun. Then these judgments can change the learners' behavior and therefore, their concentration in learning task will be increased. Finally learning will be happened after completing this iteration process and receiving various feedbacks regarding learners' performance (Garris et al., 2002).

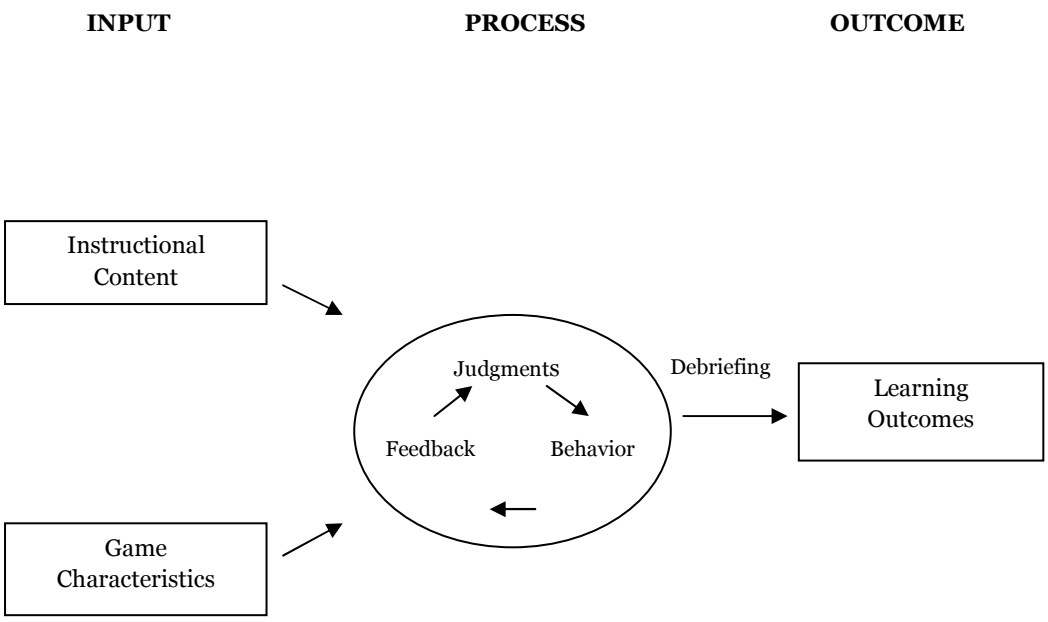

Figure 1: Game Based Learning model (Garris et al, 2002)

Four Dimensional Framework. de Freitas and Oliver (2006) develop it in order to evaluate the effectiveness of serious and simulation games by focusing on tutors' interest. They believe that current efforts are insufficient to assist teachers and instructors to assess the benefits of educational

games (de Freitas and Oliver, 2006). Tutors are usually thinking about the advantage and disadvantage of games when they want to select a game to teach. In this situation, they ask themselves: which game can support particular learning context? How much the chosen game can be useful?

Four Dimensional Framework is developed based on pedagogy approach that includes "Context", "Mode of representation", "Pedagogy" and "Learners specification". The first dimension is context that represents where the learning and game takes place. Historical, political and economic aspects are considered in macro level, also accessing to special resources and tools is considered in micro level in this aspect. This feature is able to support learners and putting them in the environment where they can overcome to various challenges. Besides, learners have different preferences in different levels; also they are in different ages with different backgrounds. These characteristics are considered in learners specifications. For example there are some evidences of significant benefits in using simulations games to achieve various skills (de Freitas, 2004). The level of immersion and fidelity in games and simulation is defined in the third attribute of this model and called "mode of representation". The distinction between the critical reflection process which happens outside the learning process and the level of immersion is emphasized by this attribute. The pedagogy represents the features of a game or simulation in order to increase the motivation of learners about the methods, models and theories employed to enhance the learning outcomes (E-Contents, E-Assessment, etc).

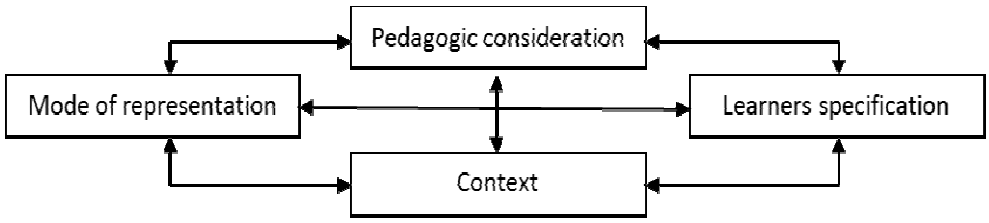

Figure 2: Four Dimensional Frameworks (de Freitas and Oliver, 2006)

These four dimensions have not to be considered separately and their impacts together need in order to measure the effectiveness of a serious game or simulation in a learning process (de Freitas and Oliver, 2006).

Game Based Learning. Hainey believes that previous efforts in this field have studied effectiveness of serious games in general and broad perspectives without generating enough amounts of particular ideas to evaluate and analysis the games and simulations. He also explains that there are insufficient links in the literature to help researchers to consider specific measurement, experimental designs and statistical techniques by seeing examples (Hainey, 2010).

He presents an evaluation model that includes six abstract categories as shown in Figure 3. "Learners' performance" represents the ability of serious games in improving the learning performance. Based on the Bloom taxonomy the knowledge performance can be categorizes as declarative, procedural and tacit knowledge (Kraiger, 1993). Learners and instructors' motivation means the ability of games to stimulate learners to play the game and to increase the level of interest among them. It also explores what motivates instructors to use serious games and simulations into their curricula. The third category is learners and instructors' perception and it represents the perception of learners about various parts of a game such perception of time, perception of reality and perception of complexity. Also perception of instructors whether game support learning context. Besides, learners and instructors' attitudes include different positive and negative elements in learners' and teachers mind that influence on serious games effectiveness. Learners' attitude towards learning contents and game characteristics such immediate feedbacks or rewards and also instructors' attitude about fitting the game into the particular curricula are two examples in this area. Kolb believes that learners prefer to acquire knowledge and skills in different way and different styles (Kolb, 1984). Hainey calls this feature as learners and instructors' preference such as: preference between learning by serious games and class room and if serious games, preference between board games and digital games. In addition, all factors in the game environment which can impact on learning effectiveness are considered in "GBL environment". Hainey defines five subcategories for GBL environment. They are virtual environment, usability, scaffolding, level of social presence and deployment (Hainey, 2010). Finally if playing game needs cooperation among players, collaboration will influence on effectiveness of serious game.

Moreover, he provides a number of advantages and disadvantage of educational game noted in the literature. Increasing the learners' motivation, providing a free risk environment, enhancing the learners' self-

esteem, flexibility and adaptability of the game, creating positive emotions and using computers as an acceptable tool for learning are identified as advantages of game based learning. In opposite, absence of empirical evidence in effectiveness of game-based learning is recognized as the main disadvantageous item. Moreover, generating aggressive behavior among players and high cost in running the educational games are determined as disadvantages in using game based learning (Hainey, 2010).

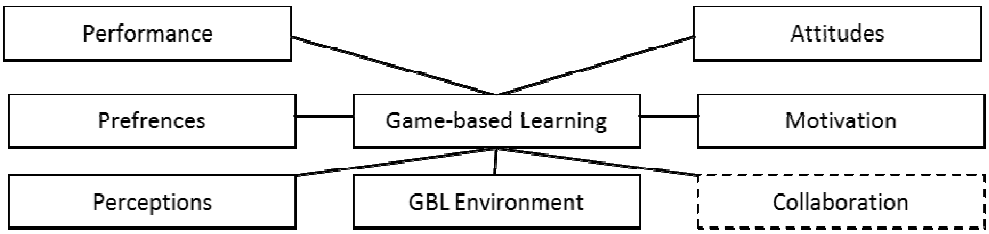

Figure 3: Game Based Learning evaluation framework (Hainey, 2010)

Design Heuristic for Motivating Instructional Environment is the last framework that is explained. Malone and Lepper (1987) present a framework for designing motivating instructional games which is shown in Table 3. Motivation in this framework is divided into "individual motivation" and "interpersonal motivation". The attributes of "individual motivation" are explained in the below.

Challenge: putting challenge in learning activities can make them enjoyable and increase the level of learners' motivation. Providing an unpredictable process to achieve a specific goal and immediate feedback of learners' performance during a game can enhance the learners' motivation.

Curiosity: it is the most direct individual motivation factors for learners (Berlyne, 1965). Giving incomplete information to players can strongly stimulate them to be involved in learning process. Considering the optimum level of gap between known and unknown information perceived by learners is a critical issues to maximize the motivation level.

Control: the ability of learners to affect the components in learning environment makes a sense of power among them. When students have the

feeling of power they spend more time and make more efforts in learning process in comparison when they have not (Cardova and Lapper, 1996).

Fantasy: something in the serious games which are not belonged to real life. It evokes mental images of physical or social situation which are not really present. It represents also the level of players' interest in two ways of endogenous/intrinsic fantasy and exogenous/extrinsic (Asgari and Kaufman, 2004).

The second type of motivation is "interpersonal motivation" which depends on other persons. In the following, cooperation/competition and recognition are introduced.

Cooperation and Competition: Malone and Leaper consider them as a common element because they are side by side in many cases. Considering cooperation and competition among learners in designing serious game can improve the learning outcomes by increasing the motivation.

Recognition: this aspect of motivation is defined with variety terms in learning theories, but as a general definition it focuses on learners' efforts appreciated by others. This appreciation will enhance the learners' motivation.

Individual Motivation	Challenge	Goals: 1. clear and fixed goal, 2. learners' ability to define goals
		Uncertain outcomes: 1. difficulty 2. different level of goals 3. mystery 4. chance
		Performance feedback: 1. frequent 2. clear 3. constructive 4. encouraging
		Self-Esteem: 1. providing feeling of competence 2. meaningful goal
	Curiosity	Sensory Curiosity
		Cognitive Curiosity
	Control	Contingency
		Choice
		Power
	Fantasy	Emotional aspects
		Cognitive aspects
		Endogeneity
Interpersonal Motivation	Cooperation/Competition	
	Recognition	

Table 3: Malone and Leaper framework

Developing a Methodology for Evaluating the Effectiveness of Serious Games

Given what we understand until know in terms of cognitive and affective learning outcomes and serious game attributes, we define the hypothesis and research questions. In this section also the proposed methodology for answering to each research question is identified.

Hypothesis: Learning outcome by using serious game in manufacturing education is higher than learning outcomes achieved by classroom.

Research Question 1: What is the difference in declarative knowledge achievement in manufacturing education between engineering students who use serious game and those who use class room method?

Research Question 2: Are existing evaluation frameworks for enhancing the learners' motivation applied in designing the serious games for manufacturing education?

In order to answer the first research question "experiment research methodology" will be used. By doing pre-test and post-test among an experimental group who learn by playing the game and a control group who learn in the class and then comparing the two groups results the difference in the declarative knowledge achievement will be identified. This technique by comparing the pre and post test scores indicates the difference level of declarative knowledge acquired in the target and control groups. It has been used in some studies on game based learning; for example, Ebner and Holzinger (2006), Sung (2006) and Hainey (2010).

Three steps will be done to answer the second research question. 1) By applying "Archival research methodology" existing papers, articles and efforts will be studied and analyzed and then the first draft of motivation taxonomy in manufacturing education will be introduces. 2) The survey/questionnaire methodology will be applied to measure the effectiveness of each motivation factors among engineering students in academic centers or engineers and technicians in industry for testing and developing the taxonomy. 3) The case studies methodology will be applied to test if the motivation factors based on the proposed taxonomy are considered in the serious games (LeanPD game, SBCE game , etc) designed for manufacturing education.

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Using Gaming Concepts in Management Education Classes: Finding the Conditions for Success

Prof. Alastair Nicholson and Dr. Steve New

Said Business School, Oxford University, Oxford, UK

Alastair.Nicholson@sbs.ox.ac.uk

Said Business School, Oxford University, Oxford, UK

Steve.New@sbs.ox.ac.uk

Abstract

Gaming and games ought to be ideal media for business education. The idea of a game suggests a set of players, or sub-teams of players, participating tactically, and under pressure, to reach a winning position. Business, with its multiple functions and external competitive pressures can be readily represented within a gaming context. Yet, to date, little general progress has been made in bridging these parallel worlds; this is certainly true of classic classroom of MBA learning contexts, where fifty-plus students typically have sessions lasting two to three hours. This paper will report some experience in defining some fully proven, workable examples and draw implications on the conditions for success in future game development.

Reproduction of a business learning experience in a gaming context requires the essentials of a 'table-top' game on a huge scale. We have found the use of a data projector in displaying the overall status of the unfolding game on a big screen is a frequently a major benefit. Similarly, participants' decisions, requests or other actions, when communicated through wireless keypads or handsets to a computer driving the game

presentation, allow real-time status to be displayed. Thus, as decisions are made, all, to influence the choices of actions, can view the unfolding situation. That the situation is reflected in real time lends immediacy and a sense of immersion. Therefore the use games or simulations, supported and enhanced by appropriate technologies, can transform a lecture theatre, normally a haven of student detachment, into an arena of student engagement.

Given this technical and spatial configuration, the substantial questions for a successful game are: how to select a business phenomenon that can be useful and relatively faithfully reproduced, how to scale down the scope of the issue in real practice and how to scale up the speed of the activity so that behaviours and tactics can be reproduced with realism. That realism requires multiple managers with mixtures of tasks facing uncertainty and the need to collaborate or compete. The successful development and execution of the gaming situation then depends on the learning pathway being exposed, the open end game being pursued as the outcome, and the facility to expose the implied policies rapidly. A game structure which allows for this learning progression, whilst facilitating ad-hoc tutor interventions and rapid changes in the participant's focus from 'head-down' game-player to 'head-up' student, is another important design consideration.

The paper will report on the experience we have gained over ten years and propose a development pathway to realise the potential of this kind of learning in management education that, we believe, is substantial.

Keywords

Gaming, management education, interactive learning

Section 1: The Gaming Opportunity

Gaming and games ought to be ideal media for business education. The idea of a game suggests a set of players, or sub-teams of players, participating tactically and under pressure to reach a winning position. Business, with its multiple functions and external competitive pressures can be readily represented within a gaming context. Yet, to date, little general progress has been made in bridging these parallel worlds. This is certainly true of classic MBA classroom learning contexts, where 50+ students typically have sessions lasting 2-3 hours.

Section 2: The Challenges of Introducing Games into Business Learning

What seems to be a great opportunity is not yet widely accepted. The challenges of introducing games into these business-learning contexts are substantial. We will site three sets of difficulties.

Firstly, any business game, whilst needing a diversity of both actions and implications must have a focus. The focus must fit within a relevant educational course and current syllabus. With that focus, the game should not look too precisely like a particular situation, as students will see it as a narrow experience and relevant only to that context. So the first skill in designing a business game is the reproduction of a business context which can evoke relevant experiences, yet is both general enough to lead on to wider learning, as well as precise enough to feel the reality of its context.

Secondly, the game must be simple enough in appearance and in practise, but complex enough to raise intricate questions. By simple, we mean that the game requires few instructions for students to grasp what is required of them, and straight-forward enough for teachers using the game to be in control of the circumstances. However as the game progresses by students playing the game and the learning takes place in a step-by-step way, complexity is acquired in the gaining of experience and through reflection in breaks between 'rounds' in the game, before continuing with the next 'round'.

Thirdly, a game needs to have a conclusion wider than the specific learning that gives opportunity for interpretation. The virtues of using gaming for education lie in the chance to bridge specific technical experience with behavioural, and indeed emotional experience.

A secondary group of challenges is to find simple ways of administering the game in action. Documentation and control over the activity should not encumber both the orchestration of the learning via the game by the teacher, and the rules of the game experienced by students. The teacher needs to be comfortable with the context, and the students need to know boundaries to their activities.

A further third set of challenges affect the teacher and the learning. The use of games for learning, particularly interactive games, may be fun, but the purpose is to enrich learning through experience in a deeper way than would be possible by learning from text books, from lectures or simply acquiring knowledge in a passive individual way.

Accepting these challenges as part of the reason behind the hesitation in introducing games to business education, leads on to opportunities for general principals of design to be identified from games that have proved successful. In the following sections we describe two types of gaming experience used within MBA education that may demonstrate some of the general principals in the design of games for business learning.

Section 3: Three Interactive Games and their Implications in Practice

In this section we will describe three interactive games that have proved to be successful in business education and that have been used extensively by varied teachers and appear to have properties for success. All have been developed over the last ten years, each starting with an educational goal, and normally being taught within distinct programmes on business courses.

The first of these games, called the Discovery Exercise, reproduces a small business environment in a lecture theatre setting. The business has four products, nine functions – sales, buying, in-bound logistics, etc. Each function has a defined role, and the working of the business requires products to be constructed from physical pieces, working through an operational system, running alongside an administrative system managing

the logistics and the activities. The game is controlled by the use of handsets (held by the various business functions) with radio contact to a PC displaying the status of the game on the classroom screen. The game thus has three common threads that run through any business institution – a physical system of movements, a support or infrastructure system and a control system that is aiming to guide the business towards results and performances.

The game is run effectively, with between fifteen and fifty participants and the progress of the game is driven by the series of actions taken in between individual runs of the game where discussion takes place about the way in which participants and groups, may cooperate in an improved way. The benefits of the game are that it reproduces many aspects of the working business environment as it involves discussion, recognition of difficulties, communication problems and debate about actions. As the structure of the game enables systematic changes over time, the learning from discussing improvements and selecting investments can be applied and used in the game. The outcome of the game is thus determined by the choices and actions the gaming participants and partners have taken.

The second game in this group of interactive games is the development of the historically well-known 'Beer Game' which demonstrates induced, and yet unnecessary, instabilities in supply chains. In this context, we have called the game Impulse. Again it uses electronic handsets for communication that permit the whole Beer Game experience (which in the original physical version can take an hour or even two hours to be completed for a single run) to be completed within half an hour. Furthermore, the data is automatically made available for participant discussion. This increased speed of execution allows for detailed interpretation of the behaviour in supply chains, and an opportunity for examining reconfiguration of the structure in the light of suggestions made by the participants and increasing variability in dealing with supply networks in practise.

Once again this scheme can be run with varied numbers and with changing parameters so that the linkage between teams can be developed in different ways. By allowing the initial teams to be individual practitioners facing difficulties of variation and reliability, in both supply and demand, the teams can then, after the first run, become participants in a network where the behaviour within the network, in turn, causes difficulties. Again this provides opportunities for both behavioural learning and logistics learning.

A third interactive game called 'Oligopoly' has been developed and used repeatedly within the economics courses at Said Business School. Here there are a number of teams and a number of industries, all representing companies within an oligopolistic, competitive context. The game allows the teams to choose their output levels within their industry, in a gambling context, in which they be lucky or not with their individual profitability depending on the behaviour of the other teams. Again a series of runs allows varied positions of collaboration, collusion and cheating to be undertaken by the various teams within an industry, which create difficulties in the outcomes of the various industry contexts in which the teams compete. The purpose of the game is to demonstrate the emergence of basic economic stabilisation under varied behavioural expectations.

These three interactive schemes required certain properties to be present for the educational gaming experience to work. These include:

- A rapid set-up of the classroom, especially with large numbers.
- The existence of an environment where a large screen can demonstrate the overall position of the game and the use of handsets to communicate with the laptop displaying the situation.
- The ability to have a run, to debate, to learn and to dispute and then repeat the process which enables both progressive and more complex learning to take place in an environment of varied behaviours and varied educational subjects.

Section 4: Moving Case Studies Towards a Gaming Environment

Business schools, notably Harvard Business School, introduced schemes of learning about management through the discussion of case study situations. This was introduced as an alternative to the direct delivery of knowledge by permitting a discovery and contextual process for investigating needs and ideas in management. The case study approach also provides a context for learning through educational gaming. There are often many functions and a pathway forward, certainly in a business case, where the work to be done and the management of the work to be done, pursues commercial outcomes. There are also many possible pathways forward. Thus a good case study description will in fact be a possible gaming situation for student teams to debate and represent alternative points of view.

Typically however, the case study tends to be given out, as a whole, in advance of class. It is then discussed, as a whole, and the end point is perceived before the start of a session. At the Said Business School we have experimented by breaking case studies into a series of learning points, then asking groups to represent different business functions and argue the case, for or against, particular actions in a dynamic manner.

A possible route for doing this is to break the case study into a series of A, B, C, D, E, sub-sets in which decisions are made on the way through the case in order to reach some conclusions. Data is withheld and subsets of data can be made available to students on request. They are thus able to think through, 'what is the information I need to get to the next stage'? Sometimes, that stage is not a winning position, but a state of understanding at which the next decision can be taken. The students engage in a selective way of choosing information from this larger variety and with their increasing intelligence on the case, and the emerging situation as it actually happens, they are able to compete on the effectiveness of their decisions and actions. This approach has been tried on several cases and has reproduced a sense of excitement, of risk and the sense of gaming, normally introduced using artificial data. It adds realism to many cases in the sense of the execution of the management tasks, and introduces the idea that a business is always a competitive situation - both internally and externally.

The Four Conclusions

The record of our investigation and experiences suggests there is much potential for the use of games and gaming in management education. The advent of new communication technologies has enabled parties in gaming to be present in a classroom, and to overcome the delays and administrative effort, which instead goes into debating progress as the game advances. Even though we have well defined contexts, and established rules in the game, we face the paradox of the fragility of games in effectiveness to represent a real situation, and in operating in relation to student behaviour in a way that leads to learning and not just merely to gaming.

The paper has highlighted some success criteria for the content and context of games based on these trials. Two kinds of developments have suggested

a pattern for effective delivery of a reproduction of the business context and for the case study engagement potential. The student approval from these examples has been appealing within our own, rather narrow context of business school courses. The key is to embody these learning opportunities within a gaming environment that can incorporate a combination of technical learning, commercial awareness, and above all human behaviour, within a single classroom experience. It is to be hoped that interactive gaming becomes a natural feature of management educational courses.

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Application of Serious Games to lower Gender and Cultural Barriers

Gabriele Hoeborn, Maike Riesenbeck, Jennifer Bredtmann

University of Wuppertal, Department of Engineering, IZ 3

ghoeborn@uni-wuppertal.de

m.riesenbeck@uni-wuppertal.de

bredtmann@uni-wuppertal.de

Abstract

The application and implementation of Serious Games aim on stimulating creativity, engagement and motivation of learners. Therefore, the use of digital and non digital educational games is related to positive effects. Nevertheless, the users of Serious Games are out of different target groups. To implement a successful offer for learners includes the compliance with the requirements of the stakeholders to ensure acceptance and appreciation. Therefore, the gender and culture specific requirements towards Serious Games have to be gathered through the different stakeholder groups. The evaluation of the requirements leads to a gender and cultural specific input for designing the Serious Games. Both parameters are crosscutting issues which strongly influence the process of designing and implementing Serious Games. The following paper offers an overview on our experiences with the application of serious games while teaching national and international engineering classes.

Keywords

Serious Games, gender and cultural barriers, engineering classes.

Introduction

Serious Games are computer based or non computer based applications which are providing knowledge and serious topics through playing. They are based on the idea of learning during and through applying the game easily. The focus of this methodology is playing; priority is given to a gaming character not to teaching or providing knowledge. Sometimes the process of knowledge transfer is carried out on a secondary level, not even perceptible obviously.

Serious Games include all aspects of education and teaching, training, and informing suitable for various users not depending on age, culture or personal background (Michael & Chen, 2006). The gaming priority of this methodology lead to high motivated and engaged user groups. Furthermore, creativity and new ways of thinking are developed and supported by the partly interactive design of Serious Games. Combined with the games, fun and knowledge a new learning style has been developed.

Additionally, Serious Games do not just include educational aspects; they also support communicational aspects and simulation at the same time.

Gender and Cultural Aspects

Serious Games are dealing with different topics. They are used to learn about process steps for example in the health sector, for employee trainings, recruitment and many other fields.

They offer an easy access through gaming to various and sometimes complex issues and topics. At the same time they include the potential to make aware of gender and cultural barriers and to reduce them. This is quite important due to the aspect that user groups do not only originate in different age groups; they can have as well a different cultural background.

User groups have different expectations and requirements on Serious Games and their application out of different cultural backgrounds e.g.. Acceptance of Serious Games can only be ensured through the compliance with these requirements. This acceptance is the condition to ensure the learning process. This compliance with the requirements by taking into

consideration the gender and cultural sensitive requirements is requested for the acceptance of Serious Games.

These requirements have to be considered to develop, implement and apply Serious Games. Cultural differences have been acquired especially through socialization. According to Hofstede (Hofstede, 1991) culture is defined as a 'software of the mind'. Due to the cultural differences a misunderstanding or non-understanding can occur. Potential for this mis- or non-understandings increases in groups with different cultures. Serious Games can ward off these misunderstandings.

In general and simplifying cultural barriers are determined by:

- language
- behavior and attitudes (verbal and non-verbal)
- different ways of thinking, awareness, interpreting, and understanding
- role and hierarchy behavior

These factors need to be considered by using Serious Games. The behavior towards each other and the way of solving problems vary due to cultural differences. All these aspects define the group identity and group atmosphere as well as the individual learning process. The awareness of these differences is the condition to counteract to these gender and cultural differences. The problem solving through Serious Games should lead to a development and support of abilities and competences without being (negatively) influenced by gender or cultural barriers.

The following section is based on experiences of the authors during the application of Serious Games, especially on "Lego Racers Championship" in different national and international contexts.

The Game

In 2009 two of the three authors got familiar with the Serious Game LEGO Racer Championship during the European Quality Conference (QMOD) and even played this in an international team.

It was introduced there by LEGO managers. Originally, it supported the goal to install a new quality management system at the LEGO company.

LEGO Racers Championship is a competition in which two or more groups carry out a LEGO car race.

During the explanation the game is illustrated by the game instructor (lecturer). Just the task of carrying out the race is explained, the learning goal is not mentioned at all. The instructors appoint the participants for the different groups and the group leader and handout the material which may be used.

The phase of the game itself consists of two phases. The time to carry out the entire game is limited. The first phase of the game is called the preparation phase and it is defined by building LEGO cars, choosing three cars to carry out the race and to build a helping construction (if required) by the given material.

The second phase begins when the group leader start the race. Only within the race, the teams can score points. During both phases, it is possible to buy information advices from the instructors. These advices valued at 500 points in the preparation phase and during the race 5.000 points. At the race itself, the maximum score that can be achieved is in the bull's eye of the racetrack 10,000 points.

In this game each decision, taken individually or by the group, has consequences and influence the outcome.

Nevertheless the main goal is not to win the championship. The focus of the game is competition. Just as a secondary level of the game the teamwork, role perception and problem solving skills are trained. The awareness of a group work and dealing in the group are the central elements. Strengthening of communication skills, decision making and teamwork skills are supported and the generating of creative approaches towards problem solving as well.

Here it is quoted the way it is used in class (Hoeborn et al., 2011):

„LEGO Racers Championship

As you may know, the LEGO racing team is the best in the world, but in order for the team to stay that way, they will need your help. The reason why the team is number one is that they have the most stable cars in the world. However, before the next race they will need three new cars and that is where you come in. Because of your expertise, The LEGO racing team has hired you to select the three new cars.

The game is divided into two phases:

- a **preparation phase** and
- an actual **race phase**

Preparation phase: chose the cars and prepare for race

Race phase: you attempt to score as many points as possible

Duration is 20 Minutes, including both phases, for example if you spend 12 minutes on preparation, you have 8 minutes left for the actual race and vice versa.

Preparation Phase

- The **track**: you have to start at the launch area and to reach the bull's eye (scoring the most points)
- The **preparation phase rules**:
    - select ***three cars***,

- you may use the ***given materials*** –scissors, cardboard, boxes e.g.- to build whatever construction you might like to help the cars hit the bull's eye

    - you are only allowed to ***build within the launch area***

    - you may ***change the construction at all time*** during

    this exercise

The team leader: ***I will choose the team leader*** when I am done explaining the rules.

Only the team leader can ***start*** scoring points process by clapping into his/her hands and saying ***'Go!'***

The Race

The **three cars** you have chosen must all be used in the race, and they **must take turns.**

The amount of points you score depends on where the **front wheels** of the car stop. Both wheels have to be inside the same ring.

You can **lose points**:

- If the car stops outside the bull's eye you will lose **1,000**

points.

- You will lose **5,000** points if you touch a car in motion.

- You will lose **5,000** points if you damage a car.

You have to administer your time! Total amount of 20 minutes!

Advice

- You can buy an advice from me at any time during the game.
- An advice in the preparation phase will cost you 500 points.
- An advice in the race phase will cost you 5,000 points."

These instructions are offered to the students via a power point presentation.

Application experience

The authors are using the described LEGO game since 2010 in various engineering classes, nationally and internationally. They have even met it themselves 2009 during a European conference and played it in an international team during the conference. The following chapter refers to the experiences, results and observations during many application of the LEGO game. It gives an overview on the authors' experiences with the application of this Serious Games while teaching national and international engineering classes.

Especially the cultural and gender-specific aspects in dealing with the problem-solving within the game are highlighted. In early 2012 the use of the games started to take place at a company's level which extends the experience and knowledge.

Application in engineering classes

The use and application of the game took place in the period 2010 - 2012 in various engineering classes; such as bachelor and master students of mechanical engineering, safety and security engineering and civil engineering. The group composition was very different: gender mixed groups as well as mono-educative groups, cultural and language mixed groups as well as quite homogeny groups. Table 1 offers an overview on the

group compositions. These groups and the applications of the LEGO game were the basis for our case studies.

Period	Engineering Class	Structure of Group
2010	Mechanical engineering	2 Mixed group - German
2010	Safety and security engineering	2 Mixed group - German
2010	Mechanical engineering	2 Mono-educative – women - German
2010	Mechanical engineering	2 Mixed group – Slovak
2011	Civil engineering	2 Mono-educative – women – German
2011	Mechanical engineering	2 Mixed group - German
2011	Safety and security engineering	2 Mixed group - German
2011	Mechanical engineering	2 Mono-educative – women - German
2012	Mechanical engineering	2 Mixed group - German

Table 1. Engineering Classes

General observations:

Competition: Regardless to the study level of the students - bachelor or master - and the different degree course of groups the students intended to get as many points as possible and to win the competition. This behavior appeared independently to cultural or gender background. The educational goal being on the secondary level is not directly visible; the students do even discuss 'teamwork and competition'.

Secondary level goal: At the level of bachelor degrees the second level goal is not recognized at all even when discussing the students' behavior and attitudes towards the game. The recognition of the underlying objective started at the level of master's students.

In general, the groups behaved very heterogeneously depending on their national backgrounds (German, Indian, Chinese, Slovak, Polish, and Pakistani) and their gender (Hoeborn et al., 2011)

Acceptance of team leader:

For female team leader it turned out to be difficult to gain acceptance in mixed groups. They succeeded partly according to cultural background and

individual behaviour. A general commitment to various roles within the team was not carried out in any of the groups. In female groups there was no role discussion but they acted as a team.

In Slovakia it turned out quite different and even difficult to play the game due to extremely different pedagogical ways of teaching (Hoeborn et al., 2011). It turned out that the students were not used to apply Serious Games or to carry out group work at all.

In general, there exist two different ways of performance: The leaders' decisions were not transferred by the group , self appointed (male) leaders appeared. Mostly the other students tried to smooth the situation by making additional suggestions to these of the self appointed male leaders. The second way was that the leaders' decisions were transferred and the groups reacted like a team, they discussed decisions as well (Hoeborn et al., 2011).

Advices: It turned out surprisingly that across all groups the offered advices of the game were not bought and used.

Application of the LEGO game in industry

In 2012 the application of the LEGO Game was firstly carried out on company level. The game was applied by two of the authors to a small and highly innovative company in Chile, which deals with the development of different plant substances. For the application of the game half a day was used. 12 senior employees of the company including two of the three business executives played the game. The teams were chosen in a way to get two balanced groups each including one of the executives. A balanced distribution of men and women were equally respected. As team leaders two reserved young female employees were chosen.

The observed results obviously did not differ from the behavior of the students.

Competition:

The two teams of the company were focused on competition and did not recognize directly the hidden target. Both groups focused on the first phase the preparation phase

Acceptance of team leader:

In one of the two groups the female team leader was accepted. They worked together as a team during the preparation phase and the whole game. In the other group everyone works for him- or herself. The female team leader was not accepted, the leadership did not succeed. In this group, the second phase of the game, the racing itself also started very late and with little time to get points.

Advices:

Both groups did not buy any advices during the game.

Secondary level objective:

The recognition of the hidden objective was given partly during the reflection of the game. Even some group members, of the group which lost the game, expressed their frustration of losing the game and did not recognized the secondary level objective at all. When the game and its objectives were discussed and reflected it turned out that most the participants did not get the hidden objectives at all. They did not recognize that teamwork was the task.

The replacement of the leadership role during the games turned daily normal hierarchy upside down and this was not totally accepted. The leadership role is not independent on the cultural and gender perspective.

During the reflection all participants realized the importance of common problem solving, performing as a team. All team members and their ideas are needed just a mutual work will lead to success.

Reflecting the team performance especially the two executives got the importance of improvement to build a team and perform as a team. Additionally they realized their gender unbalanced behavior. The company got the demand of team spirit and its weakness, they will work on.

Conclusion

The described experience in the application of Serious Games in different cultural areas leads to the perception that independently to gender and cultural context, the game itself and its first, obvious level of competition was in the focus of the participants. At a certain level of education, regardless of the origin, culture and gender, the second level of learning the underlying objective was perceived. Through all applications the common experience of team, the awareness of roles and team understanding were

the learning contents and their importance were underlined. Through this playful approach to deal with gender and cultural barriers is simplified. A reduction of existing barriers is possible with the support of the game. This process of reducing the gender and cultural barriers is important and needs to be investigated further on.

Nowadays serious games are common educational tools. Attention should be paid that through the application a development of a new learning process was started. The process to reduce gender and cultural barriers is connected to individual requirements towards the created learning process.

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