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Digital game-based learning: Towards an experiential gaming model

Kristian Kiili*

Tampere University of Technology, Pori, Pohjoisranta 11, P.O. Box 300, FIN-28101 Pori, Finland

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Abstract

Online games satisfy the basic requirements of learning environments and can provide engaging learning experiences for students. However, a model that successfully integrates educational theory and game design aspects do not exist. Thus, in this paper an experiential gaming model that is based on experiential learning theory, flow theory and game design is presented. The model stresses the importance of providing the player with immediate feedback, clear goals and challenges that are matched to his/her skill level. The flow theory is used as a framework to facilitate positive user experience in order to maximize the impact of educational games. Especially, the factors that contribute to flow experience are discussed. The experiential gaming model can be used to design and analyse educational computer games. However, the model works only as a link between educational theory and game design and does not provide the means to a whole game design project.

Keywords: Educational games; Flow; Experiential learning; Game design

1. Introduction

One of the challenges of designing Web-based learning materials is that of engaging students. Hosting a Web-based course should not just be about providing information but also about facilitating students' experiences. Unfortunately, it seems that the Web is used mainly as an information distribution channel

* Tel.: +358 2 627 2951.
E-mail address: kristian.kiili@tut.fi.

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that neglects the needs of students. To achieve students' attention, new ways to utilize computers must be found. The use of technology alone does not motivate students that have lived in the midst of technology all their lives. Thus, learning situations and methods that engage learners must be created. One approach is to introduce online computer games in education. Computer games may create a new learning culture that corresponds better with students' habits and interests (Prensky, 2001).

Generally, games satisfy the basic requirements of learning environments identified by Norman (1993) and can provide an engaging environment for learning. Traditionally, games are equated with having fun. However, the fun factor is not the magic bullet in educational game design. The promise of educational games is to engage and motivate players through direct experiences with the game world. Games should provide possibilities for reflectively exploring phenomena, testing hypotheses and constructing objects. Unfortunately, games have been used in education primarily as tools for supporting the practice of factual information. The nature of action-based drill and practice games may lead to behaviour, where players tend to try actions with no reflection on outcomes. In such games players may simply keep on experimenting with actions until their scores improve. However, such behaviour, based only on trial and error, does not enhance learning.

This paper emphasizes the need for integration of educational theories and game design to be able to design meaningful and engaging educational games. The main purpose of this paper is to present an experiential gaming model that stresses the importance of designing and balancing challenges in order to generate an optimal learning experience for players. The flow theory presented by Csikszentmihalyi (1975) is used as a framework for facilitating positive user experience of the players. The focus is not on the precise moments of the flow experience itself, but on the factors contributing to the flow experience in order to maximize the impact of educational games.

2. Flow and game-based learning

Games are designed to generate a positive affect in players and are most successful and engaging when they facilitate the flow experience. Csikszentmihalyi (1975) introduced the flow state through the study of people involved in activities such as rock climbing, chess and dance. Flow describes a state of complete absorption or engagement in an activity and refers to the optimal experience (Csikszentmihalyi, 1991). During optimal experience, a person is in a psychological state where he or she is so involved with the goal driven activity that nothing else seems to matter. Past research has shown that the flow state has positive impact on learning (Webster, Trevino, & Ryan, 1993) and should be taken into account when designing digital learning materials including games.

The original flow activities, such as rock climbing, diverge from activities performed with computers. Finneran and Zhang (2003) have argued that activity performed in computer-mediated environments needs to be broken down into the main task and the artifact used to accomplish the activity. Artifact is a broad term that covers both tools and toys. It is apparent that the mastering of complex artifacts can not be taken for granted. Furthermore, Finneran and Zhang (2003) have proposed a person-artifact-task (PAT) model that conceptualizes the major components of a person working on a computer-related activity. According to the model, the likelihood of experience flow is dependent on the interplay between the person, the task and the artifact. The main contribution of the PAT model to the flow theory is to provide a means to consider what really influences experiencing flow: the task itself, the use of artifacts or individual differences.

In computer-mediated flow studies the following stages related to flow are distinguished: flow antecedents, flow experience and flow consequences (Chen, Wigand, & Nilan, 1999; Hoffman & Novak, 1996). There has been some debate on which factors referring to flow belong in each stage. Following is a summary of relevant factors in each stage. The antecedents of flow include focused attention, (Hoffman & Novak, 1996), a clear set of goals, immediate and appropriate feedback (Chen et al., 1999), potential control (Finneran & Zhang, 2003), a perception of challenges that are matched to the person's skills (Chen et al., 1999), playfulness (Webster et al., 1993), speed and ease of use (Skadberg & Kimmel, 2004). The flow experience itself comprises a merging of action and awareness, concentration, a sense of control over activity (Chen et al., 1999), time distortion, and telepresence (Finneran & Zhang, 2003). The flow experience leads to increased learning (Skadberg & Kimmel, 2004), increased exploratory behaviour (Webster et al., 1993), positive effect, an acceptance of information technology (Ghani, 1991), and perceived behavioral control. In Fig. 1 a framework of flow in computer-mediated environments is presented. The framework comprises the factors of each stage of flow and the components of the PAT model. The antecedents, speed and ease of use (Skadberg & Kimmel, 2004), are combined as a usability factor in the framework.

All three components, person, task and artifact, should be taken into account when designing educational games. Generally, the aim of an educational game is to provide students with challenges related to the main task so that flow experience is possible. When both the task and the use of the artifact are complex, then the artifact and the task may detract from the user's attention (Pearce & Howard, 2004). Bad usability decreases the likelihood of experiencing task based flow because the player has to sacrifice attention and other cognitive resources to inappropriate activity. Because the information processing capacity of working memory is limited (Miller, 1956), all possible resources should be available for relevant information processing rather than for the usage of the artifacts. In an ideal situation artifacts are transparent and allow the player to focus on the higher order tasks.

A user's prior knowledge and experiences affect how the user experiences and perceives the game world. If the system can offer the learner such challenges that are in correspondence with his or her skills, the possibility of experiencing flow is higher. In Fig. 2 the relationship between skills and challenges is presented.

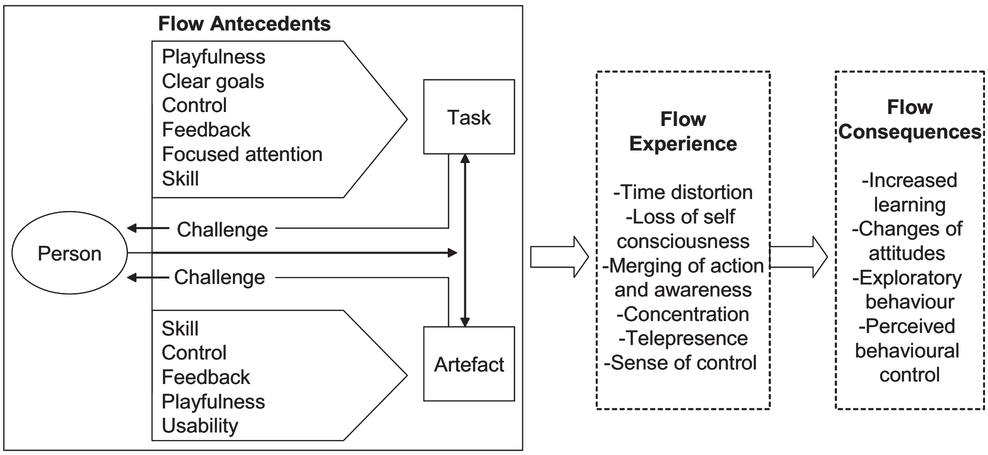

Fig. 1. Framework of flow in computer-mediated environments.

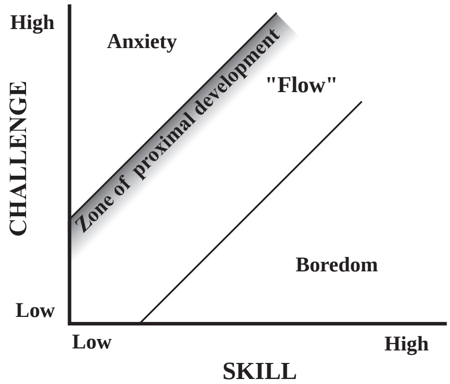

Fig. 2. Three channel model of flow (adopted from Csikszentmihalyi, 1975).

It is important that the challenge that a player faces in the game world is closely matched to the skill level of the player. If the challenge is significantly greater than player's skill level, he or she may feel anxiety. In contrast, if the challenge is significantly lower than player's skill level, the player may feel bored. Basically, the flow channel can be extended by providing some guidance to the player or by providing the possibility of solving problems with the help of other players. Thus, I have added the zone of proximal development into the model (Vygotsky, 1962). In order to keep a player in a flow state game designers should ensure that while a player's skill level increases the challenges also should become more difficult.

3. Gameplay and learning

It is important to pay attention to the factors that contribute to flow when designing educational games. However, also the importance of gameplay and relevant educational theories has to be considered in order to base the experiential gaming model presented in next section. The following is a short overview of gameplay and educational theory related to digital game-based learning.

3.1. Gameplay

Gameplay is the core of the game and its significance should not be underestimated. Although there have been attempts to define gameplay, no universally accepted definition exists. Game designers Rollings and Adams (2003) have defined gameplay as one or more causally linked series of challenges in a simulated environment. In fact, gameplay also includes the actions that the players can take to meet challenges. According to Costkyan (2002) good gameplay keeps a player motivated and engaged throughout an entire game. Ambitions to design engaging educational games have probably often failed because educational aspects have displaced gameplay. Underestimation of gameplay can be seen also in the market of entertainment games. Often the technology-driven games that have neglected gameplay, while concentrating on technological achievements, disappear from the market quite quickly. Thus, in educational game design both dimensions, educational goals and gameplay, should be balanced in order to achieve a meaningful entity. Rollings and Adams (2003) have distinguished several types of challenges that can be applied to educational games.

3.2. Players as problem solvers and explorers

Generally, games provide a meaningful environment for problem-based learning. The ability to solve problems is one of the most important features of human skills (Holyoak, 1991). Thus, one goal of education is to groom students to encounter novel situations (Bruer, 1993). Problem solving can be regarded as striving toward a goal which is not immediately attainable. Games provide a meaningful framework for offering problems to students. In fact, a game itself is a big problem that is composed of smaller causally linked problems. The nature of challenges that constitute the problem can vary greatly. Generally, a problem can be anything that somehow restricts a player's progress in the game world.

The problems can be classified into well-structured or ill-structured problems (Hong, 1998). Well-structured problems have definitive answers. In contrast, ill-structured problems normally encountered in real life have unclear goals and incomplete information relating to the problems. The best solutions to ill-structured problems depend on the priorities underlying the situation. Papert (1993) has stressed that ill-structured problems are more meaningful for the problem solver than well-structured problems because they offer more opportunities for a problem solver to use different problem solving strategies. Educators have tried to develop learning environments that support problem solving in complex life-like situations (Suomala, 1999). In fact, games provide a means to offer possibilities to students to set personal goals, to actively handle and gather information, and monitor and evaluate problem solving processes.

Problem solving can be associated with discovery learning. Learning environments such as games allow students to discover new rules and ideas rather than memorizing the material that others have presented. For example, simulation games offer possibilities to students to interact with the game by exploring and manipulating objects in order to test their hypotheses. Thus, while experiencing the game world, students become active participants in the learning processes and their motivation may shift from extrinsic to intrinsic rewards (Bruner, 1961).

3.3. Experiential learning

Experiential learning theory has long inspired the designers of digital learning environments (Lainema, 2003). Experiential learning builds upon the work of Piaget, Lewin, and Dewey (Nielsen-Englyst, 2003). Experiential learning theory consists of several models that stress the importance of direct experience and reflective observation. Kolb's (1984) experiential learning model that consists of four stages is the central work in the field of experiential learning. According to the model learning begins with a concrete experience followed by collection of data and reflective observations about that experience. In the abstract conceptualization stage a learner makes generalizations, draws conclusions, and forms hypotheses about the experience. In the final stage, the learner tests these hypotheses and ideas through active experimentation in new circumstances. Generally, the model stresses the continuous nature of learning and the appropriate feedback which provides the basis for a continuous process of goal-directed action.

The ideology of experiential learning provides a fruitful basis for integration of gameplay and pedagogy. In fact, Gredler (1996) has categorized simulations and learning games for experiential training. For example, business games are based on experiential learning theory (Isaacs & Senge, 1992; Lainema, 2003; Nielsen-Englyst, 2003). In the next section, an experiential gaming model is presented.

4. Experiential gaming model

There is a need to form a model that can be used in designing and analysing educational games. Amory and Seagram (2003) have tried to integrate educational theory and game design aspects but the models that they have presented are too superficial and do not take gameplay and flow theory into account. In this section, an experiential gaming model (Fig. 3) is presented. The main purpose of the model is to link gameplay with experiential learning in order to facilitate flow experience. The model describes learning as a cyclic process through direct experience in the game world. Both constructivist (Phillips, 1995) and pragmatist (Kivinen & Ristelä, 2003) views of learning are adopted. The model stresses that activity that is necessary for learning is not merely cognitive but also behavioural. Thus, learning is defined as a construction of cognitive structures through action or practice in the game world. The model is not concerned with the role of social interaction in learning.

The experiential gaming model consists of an ideation loop, an experience loop and a challenge bank. The operational principle of the model can be derived from the human blood-vascular system. The challenges based on educational objectives form the heart of the model. The task of the heart is to sustain the motivation and engagement of the player by pumping appropriate challenges to him or her. To overcome the challenges, a player generates solutions in the ideation loop reflecting lesser circulation. Generation of solutions is divided into a preinvative idea generation (Finke, Ward, & Smith, 1992) and idea generation. Preinvative idea generation refers to primary creativity (Maslow, 1963) and can be described as an unstructured and chaotic phase resembling the play of children. According to Finke et al. (1992) the generation of preinvative structures may be successfully undertaken without considering the constraints of the system and hopefully lead to innovative solutions. After the preinvative phase a player further develops solutions by considering the constraints and available resources of the game world. The ideation process is most fruitful if it is performed in groups.

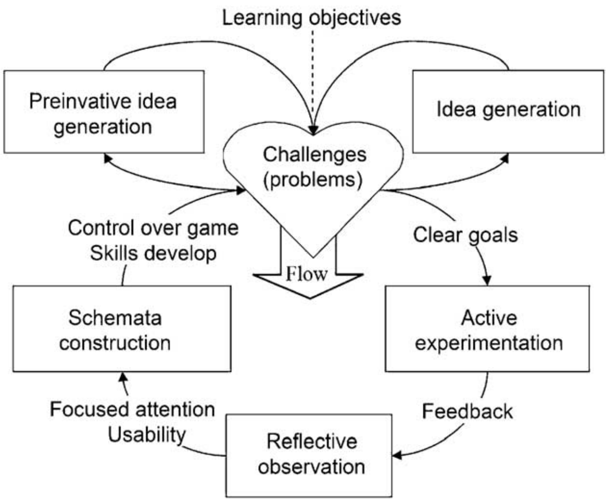

Fig. 3. Experiential gaming model.

After the ideation phase the player tests solutions in the experience loop reflecting greater circulation and observes the outcomes of actions. Game should be usable and provide clear goals and appropriate feedback to the player in order to facilitate flow experience. Additionally, according to Hoffman and Novak (1996), focused attention is an important factor that contributes to the flow experience. The reflective observation of the feedback may lead to the construction of schemata and enable the discovery of new and better solutions to the problems. In online learning environments reflection has been facilitated for example with conversation tools, intelligent tutorials (Seale & Cann, 2000) and computer-based tutors (Aleven & Koedinger, 2002) that can be utilized also in educational games. While testing solutions a player's skill level increases and he or she may achieve control over the game and the subject matter. If the performance of the player is based on only one particular solution, the gaming strengthens only those schemata that are related to this solution. As a result of one-sided activity in the game world the heart may become exhausted, leading to a reduction in the player's motivation in the long run. From a creative problem solving and comprehensive learning point of view it is important that the player endeavours to test different kind of solutions in order to expand knowledge on the subject matter. Generally, the task of the ideation loop is to cleanse the experience loop of old solutions by feeding it with fresh creative solutions to be tested and reflected.

From a motivation and learning point of view, the operation of the heart is essential. The heart should provide a player with challenges that are matched to his or her skill level in order to increase the likelihood of experience flow. Additionally, the tempo of challenges should be balanced with the player's characteristics. The trick of the games is to keep the player in a flow state by increasing the skill level of the game while the skill level of the player increases. However, it is impossible to predict how quickly a player's skills develop while gaming which makes the designing of games hard. On solution is to develop games that adapt to a player's behaviour. For example, Ketamo (2002) developed an adaptive geometry game that observes a player's behaviour in order to provide the player with appropriate problems. The evaluation results of the game showed that particularly players whose knowledge level of geometry was low benefited from adaptation. However, there are some aspects that should be considered when designing adaptive games. First of all, adaptation should be transparent to the player in order to ensure that the player does not change his or her normal behaviour in the game world. For example, if the player notices that the game becomes easier if she performs worse than he or she is capable of performing, the game has failed to provide meaningful challenges to the player. Secondly, adaptation should not change the user interface of the game. If the conceptual model of the game changes as a result of adaptation it may lead to usability problems. In summary, bad usability, inappropriate challenges and objects that break the harmony in the game world decrease the likelihood of experience flow.

5. On educational game design

The experiential gaming model can be used to design and analyse educational games. However, the model works only as a link between educational theory and game design and does not provide the means to a whole game design project. There are several issues that should be considered when designing educational games that are not included in the experiential gaming model. Although, in this paper, the importance of gameplay is stressed, attention has to be paid also to the creation of an engaging storyline, appropriate graphics and sounds, and game balance. If these aspects are neglected, good gameplay cannot save the game. The following is a short overview of these aspects and cognitive load in an educational game context.

5.1. Storytelling

The use of stories in games is a fundamental part of game design (Rollings & Adams, 2003). In fact, almost every game has some sort of story attached to it. Generally, the story integrates the challenges into a larger task or a problem (Seagram & Amory, 2004). The importance of the story to a game depends on the complexity of the game. Generally, the more complex the game is the more important the story tends to be (Rollings & Adams, 2003). At the least, the story is just a short paragraph that sets the background for the game. For example, in *Operation Splash*, the player takes the role of an undersea explorer who commands a submarine while maintaining the mechanical operations of submarine (Yuen, Toprac, Steele, & Reimer, 2004). The main goal of the player is to collect samples of sea life and bring them back to the station. Although, the story is simple, its' meaning in immersing and engaging the player is extremely important. In contrast, the role of the story can be educative. The game can be divided to interactive gameplay events and to the non-interactive story events where the game designer tells the player important things about subject matter without player having to do anything. The non-interactive elements are usually implemented as animations and should be designed according to design principles presented by Mayer (2001). In an ideal situation the player can apply the information provided by animations to interactive gameplay events.

5.2. Game balance

The main objective of balancing a game is to provide a game that is internally consistent and fair, without allowing players to exploit flaws to gain advantages, as well as to make sure that game is fun and engaging (Rollings & Adams, 2003). The goal is to interlock all the elements seamlessly to avoid dominant strategies that usually ruin a game. A dominant strategy can be defined as a strategy that surpasses all others by being the best one to choose under any circumstances (Rollings & Adams, 2003). Educational games, especially, should be balanced so that the main determining factor for the success of a player is the player's skill level. Although random events are possible, a better player should perform better in the long run. Normally games start out balanced and then get out of balance while players interact with the game. Traditionally, progress in a game is rewarded by positive feedback and rewards. In other words, the action of a player that is ahead in the game is made somehow easier. This tends to lead to a situation where "the rich get richer and the poor get poorer". Thus, it is important to ensure that such positive feedback loops have a reasonable response time delay before they kick in, in order to keep the game fun and engaging. However, the whole idea of the positive feedback loops is controversial with the goal of education. Although, good performance should be rewarded also the progress of not so good players should be somehow supported in order to ensure that they can catch up to better players and complete the game. One solution is to make the game adapt to a players' skill level as discussed above. In addition, challenges should be balanced so that the game's difficulty increases incrementally and dos not spike irregularly. If the challenge level decreases before the game is completed a player may lose interest in the game.

5.3. Optimizing cognitive load

It seems that the main problem of multimedia learning materials is that the working memory capacity of learners is often overloaded due to inappropriate ways of presentation (Kiili, 2004). Also in educational games the risk of overloading a player's working memory is high because traditionally games have consisted of rich multimedia elements. To overcome the limited capacity problem Mayer (2001) presented a cognitive theory of multimedia learning that assumes that working memory includes limited channels for both visual and auditory (verbal) processing. The limited capacity assumption refers to the cognitive load theory stressing that the working memory capacity limits the amount of information that can be processed in each channel at one time (Sweller, 1994; Tindall-Ford, Chandler, & Sweller, 1997).

In order to reduce extraneous cognitive load, the designers of educational multimedia or games should also consider the utilization of haptic feedback in learning materials. The use of haptic technology can simulate cutaneous and kinesthetic sensations so that games not only look but also feel (McGee, 2002). Haptics support immersion while learners can experience learning materials more realistically. Generally, the promise of multimedia learning lays on modality effect, assuming that working memory capacity may be increased by the use visual, auditory and haptic information processing channels simultaneously. It is important to notice that graphics and sounds entice the player but the gameplay keeps him or her there. Thus, the most challenging task of educational game design is to find a balance between attractive elements and educational objectives in order to optimize the possibility of players experiencing flow and then learn the relevant skills and information provided by the game.

Sweller, van Merrienboer, and Paas (1998) have identified three separate sources of cognitive load. Cognitive load may be affected by the intrinsic nature of the material (intrinsic cognitive load), the manner in which the material is presented (extraneous cognitive load), or the effort needed for the construction of schemata (germane cognitive load). Intrinsic cognitive load refers to the inherent nature of the task or the subject matter of the learning material. If the learning material consists of numerous elements that are related to one another, the intrinsic cognitive load is high. In contrast, if the material is simple, including only a few connections between elements, the intrinsic cognitive load is low. According to the cognitive load theory, instructional design cannot change the intrinsic cognitive load. Therefore, the most important aspects of the cognitive load theory for educational game designers are extraneous cognitive load and germane cognitive load.

Extraneous cognitive load is unnecessary cognitive load and is determined by the instructional design. If the game is poorly designed, the extraneous cognitive load is high because learners have to engage in irrelevant cognitive processing. Mayer (2001) has primarily examined different presentation formats in order to reduce the extraneous cognitive load of learning materials. However, the reduction of the extraneous cognitive load by an ideal instructional format does not guarantee that all free cognitive resources will be allocated to a deeper knowledge construction process (Bannert, 2002). Unused working memory capacity should be used by optimizing the germane cognitive load, by stimulating the player to process the problems provided more deeply. According to Kirschner (2002) the approach of encouraging learners to engage in appropriate cognitive processing can only work if the total cognitive load of instructional design is within working memory limits. If a learner's cognitive system is overloaded, it might impact negatively on learning. In summary, cognitive load should be optimized in games by cutting down irrelevant multimedia elements, applying modality effect, providing usable user interface and challenges that support knowledge construction.

6. Conclusions

The primary intention of this paper was to present an experiential gaming model that facilitates flow experience. The model stresses the importance of providing players with immediate feedback, clear goals and challenges that are matched to players' skill levels. It is apparent that flow experience cannot be guaranteed to players, but educational games that provide the possibility of experiencing flow certainly can be provided. The reward of flow is obvious: it has a positive impact on learning and players' attitudes. The experiential gaming model can be used to design and analyse educational games. However, the model works only as a link between educational theory and game design and does not provide a means for a whole game design project. Designers of educational games should also pay attention to the appearance of the game, an engaging storyline and appropriate game balance in order to involve players.

Although facilitating experiences of students is important, it is not an adequate approach for designing meaningful Web-based learning environments. Online instruction, including games, should also support creativity and involve critical thinking (MacDonald, Stodel, Farres, Breithaupt, & Gabriel, 2001). Garrison, Anderson, and Archer (2001) proposed a model of practical inquiry for detecting critical thinking in text-based online environments. The model of practical inquiry has several interests in common with an experiential gaming model. Both models include phases such as exploration of ideas, construction of meaning and active experimentation of solutions. A critical question in both models is the transition between the world shared and a world that is private. In online multiplayer games players can collaboratively solve and explore problems in a shared game world, but ultimately critical reflection occurs in a private world. The challenging task of educational game designers is to develop the sort of game worlds that support reflective thinking in the private world.

In the future, the experiential gaming model will be tested and further developed. Presently an online game where university students work in a production company as trainees is being hosted by the author. In the game, players are hired to produce the best possible learning material concerning usability while trying to increase their banking balances by selling components that they have produced to other players. An important feature of the game is a prodding system that helps a player to perform all the necessary actions within the time constraints. The system informs the player about deadlines, provides guides to relevant information, as well as feedback for the player. An experiential gaming model was used as a framework to design this IT-Emperor game. A demand-driven learning model (MacDonald et al., 2001) was also utilized in the design process. One other consideration in particular was consumer demand of authentic and industry-driven content. As a result, the content of the game reflects the problems and issues that may arise in a production company. In addition, a jury formed from members of different corporations was employed to give feedback to the players. The results of IT-Emperor will be reported in the near future. Flow antecedents in particular will be validated.

7. Uncited reference

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