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Flow framework for analyzing the quality of educational games ☆

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ABSTRACT

The challenge of educational game design is to develop solutions that appeal to as many players as possible, but are still educationally effective. One foundation for analyzing and designing educational engagement is the flow theory. This article presents a flow framework that describes the dimensions of flow experience that can be used to analyze the quality of educational games. The framework also provides design-support for producing good educational games, because it can be used to reveal ways to optimize learning effects and user experience. However, the framework only works as a link between educational theory and game design, which is useful for game analysis but does not provide the means for a complete game design. To evaluate the elements included in the proposed framework, we analyzed university student's experiences in participating in a business simulation game. We found that the students' flow experience in the game was high and the findings indicated that sense of control, clear goals and challenge-skill dimensions of flow scored the highest. Overall, the results indicate that the flow framework is a useful tool to aid the analysis of game-based learning experiences.

1. Introduction

The purpose of games is to create appealing and compelling experiences to players. Thus, games can be seen as artefacts or a cultural form that arouse meaningful immersive experiences [1,2]. According to Dewey [3] experience is a result of interplay between the present situation and our prior experiences. More recently, neuroscientists such as Gerard Edelman have explained learning as building upon existing mental 'maps' [4]. Consequently, players do not have identical playing experiences, but each player's experience is totally unique. Thus, the analysis of the subjective playing experience is crucial part of the game design process. The enjoyment level that an educational game offers is a key factor in determining whether the player will be engaged in the gameplay and achieve the objectives of the game. Thus, the ability to quantify the playing experience is important goal for both industry and academia.

In general, we need a reliable way to measure the overall engagement level of games and to pinpoint specific areas of the experience that should be improved. Several constructs have been proposed to describe playing experience, but definitional agreement has not been achieved. The most common concepts that have been linked to playing experience are flow [5,6], immersion [7], presence [8], involvement, and arousal, which have overlapping but also distinctive characteristics. According to Procci et al. [9] the concept of flow is one of the most popular constructs to describe the playing experience. Flow describes a state of complete absorption in an activity and refers to the optimal experience [5,10]. During the 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. An activity that produces such experiences is so pleasant that the person may be willing to do something for its own sake, without being concerned with what he will get out of his action. Csikszentmihalyi's [5,10] flow theory subsequently has been applied in several different domains including, for example sports, art, work, human–computer interactions, games and education. In fact, according to [11] preliminary research suggests that game-playing experience is consistent with the dimensions of the flow experience.

The basic elements that comprise every game are: mechanics, story, aesthetics and technology. These are all essential and none of the elements is more important than the others [1]. In educational games the learning objective is also involved, which makes the game design more challenging. Educational games have to be designed properly to incorporate engagement that integrates with educational effectiveness. While work on existing learning theories is well developed, in recent work, three areas of learning theory

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have been outlined for game-based learning: associative (more task-centered approaches to learning), cognitive which rely upon constructivist approaches to learning and situative (more socially-based learning) [12]. These learning approaches create a theoretical foundation for our current work.

The aim of this article is to propose a flow framework that facilitates the analysis educational games and provides design-support for game developers. The design principles of engagement [6] provide a starting point for this work. The paper starts with a background section that discusses the elements that constitute user experience and the pedagogical theories that frame the desired learning process and experience. The following section describes the proposed flow framework. Finally, in order to evaluate the usefulness and the relevance of the flow framework, its attributes and potential to indicate success of a game design, the analysis of students' experience with an educational business simulation game, RealGame, is reported.

2. Background

2.1. User experience

There have been some efforts in creating models of user experience [e.g. 13–16]. In particular there is a need for designers of educational artefacts to understand how users interact with different types of artefacts and how this interaction affects users' educational experiences. While some work in simulation design [e.g. 17] has explored this, the need to consider this from an educational gaming perspective is relatively under-theorized, which presents problems for replicating good design and developing improving standards of design.

The user experience is often paralleled with usability [e.g. 18], although the user experience does not consider enough the deeper principles of experience design or the emotional side of product use. It is obvious that user experience approach extends usability techniques [19] that aim more at the removal of obstacles from technical perspective than at providing engaging and rewarding experiences for users. In this paper usability or playability in a game context is considered as being only one factor among others that affects user experience. This view is in line with Forlizzi and Battarbee [14] who have argued that user experience should be considered also from physical, sensual, cognitive, emotional, and aesthetic perspectives.

Fig. 1 shows the authors' macro-level conception about user experience. The aesthetical, emotional and sensual aspects are not distinguished in macro-level. However, in micro-level they are seen as integral parts of game artifact that affect user experience.

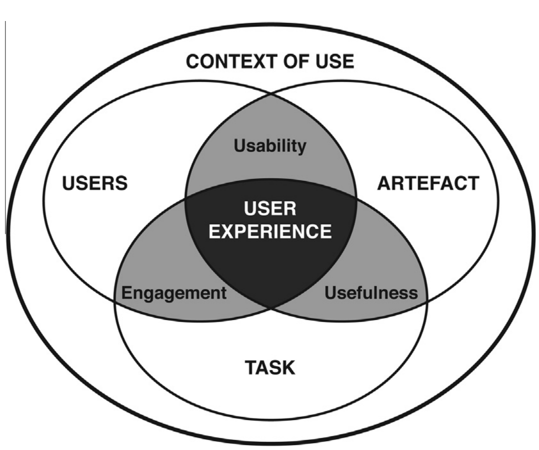

Fig. 1. The macro-level elements of the user experience.

The user experience consists of three main elements: users, an artefact and a task. The user experience emerges from the interplay between these elements in a certain context of use. This context of use is the actual condition under which a given artefact is normally used. The characteristics of the users, such as emotions, values and prior experience, determine how users perceive an artefact and the task at hand. We want to note that we understand the task concept broadly and thus it also refers to the goals of the user related to a certain activity. The usability of an artefact is determined base on the interaction between the users and the artefact. Usefulness refers to the design of an artefact containing the right functions required for users to perform their tasks efficiently and to accomplish their goals easily and efficiently [20].

If the task is engaging, the user is willing to use more effort in accomplish the task. Skinner and Belmont's [21] definition of engagement in the educational context can be applied to user experience. According to them, engagement refers to the intensity and emotional quality of a user's involvement in initiating and carrying out activities. Engaged users show sustained behavioural and cognitive involvement in activities accompanied by a positive emotional tone. To summarize, good usability, a useful artefact and an engaging task (challenges that the game provides) create prerequisites for a good educational experience. However, we want to emphasize that designers cannot design the subjective experience; only the context from which the experience arouses may be designed.

2.2. Constructivism and cognitive load theory

Wu et al. [22] in their recent study found that until 2009 the majority of published studies on game-based learning were not based on any specific learning theory – in their study only 91 of 567 studies based their investigations on a learning theory. They also found that the development of learning theory orientations has prompted more studies to focus on constructivism and humanism (i.e. experiential learning, which has had a central role in simulation game research; see Lainema [23]) than on behaviorism and cognitivism. A look at the very recent research on game-based learning (especially in research that takes place in the discipline of education) reveals a plethora of game studies that base their argumentation on constructivism. For example, constructivism has recently been referred to when studying learning in virtual worlds [24,25], business simulation games [23,26,27], primary schools and elementary education [28,29], educational game development [30], and debriefing of game learning [31].

In fact, for example Mayer [32] has argued that constructivism has become the dominant view of how people learn. The underlying premise of constructivism is that learning is a process in which learners are active sense makers who seek to construct coherent and organized knowledge [3,32,33]. This means that in games learning occurs when the players' active exploration (i.e. exploring the game world and testing discovered solutions to game's problems) makes them develop a knowledge representation of their experience or discover an inconsistency between their current knowledge representation and their experience. Attributed to view of social constructivism, learning usually occurs within a social context in which interactions between other people will activate collaborative exploration, articulation, reflection, and hence assimilation or accommodation for improved knowledge representations [34,35]. However, according to Kirschner et al. [36] constructivism is too often implemented using minimal guidance approach that wrongly assumes that people learn best in an unguided or minimally guided environment – the recent instructional design research has clearly shown that guidance support learning.

In order to be able to understand how can we support active knowledge construction process in games we have to consider the structure of human cognitive architecture. Any instructional process that ignores the human cognitive architecture is not likely to be effective [36]. The cognitive load theory provides a foundation to consider learner characteristics from the cognitive perspective. In general, the purpose of the cognitive load theory is to bridge the gap between information structures presented in the learning materials and human cognitive architecture so that learners can use their working memory more efficiently [37]. Human cognitive architecture is based on models of human memory that is usually divided to sensory memory, working memory and long-term memory from which working memory and long-term memory are most important for educational game designers. When designing educational games we should consider the constraints of human cognition and design the gameplay according to target group's skills, characteristics and prior knowledge.

In terms of cognitive load theory free exploration of highly complex game environment and bad instructional design may generate too heavy cognitive load that can hinder learning. Sweller et al. [38] 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 by 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 content. If the learning content 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. From learning point of view 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 [39] 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 [40]. Unused working memory capacity should be used by optimizing the germane cognitive load, by stimulating the player to process the provided content more deeply. According to Kirschner [41] 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 and playing behavior.

3. Flow framework for educational games

This section describes the proposed flow framework for educational games (see Fig. 2). The elements of flow can be divided into two groups: Flow antecedents (the grey star in Fig. 2) and the Flow state. The flow antecedents (described in more in detail in Section 3.1) are factors that contribute to the flow state and thus should be considered in educational game design. The dimensions of flow state (described more in detail in Section 3.2) are more abstract and they in a way describe the feelings of flow experience. The white triangles that surround the star describe meaningful factors that affect the design of the learning experience and game-based learning artefacts. In the model the order of antecedents is not relevant and they not purposely bind to factors surrounding them. Finally on the planes of the pentagon are illustrated five mind lenses (described more in detail in Section 3.3). (1) The sensing mind, (2) the processing mind, (3) the integrating mind, (4) the relating mind, and (5) the transferring mind lenses provide means to consider game elements systematically from the learning and interaction perspectives and relates flow dimensions to learning processes. Theoretically the mind lenses are founded on principles of cognitive load theory [41], multimedia learning theory [32] and constructivism [42]. The educational foundation of the framework and focus points of the mind lenses are based on the constructivism and cognitive load theory as discussed in Section 2.2.

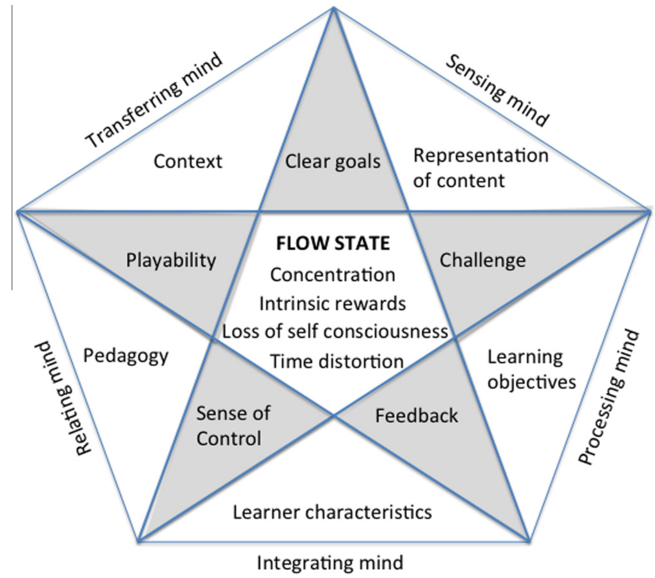

Fig. 2. Flow framework for educational games.

3.1. Description of flow antecedents

All the flow antecedents except playability see (Fig. 2) are consistent with the original flow dimensions [5]. Next the antecedents are described and discussed in terms of educational game design.

When the player's goals are clear he can more easily stay focused on the learning tasks. It is good practice to provide a clear main goal in the beginning of the game. Furthermore, the main goal should be divided into sub-goals and provide them at an appropriate pace in order to create feelings of success. If the goals seem too challenging, the probability of experiencing flow is low. Furthermore, the goals should be related to the learning objectives of the game. If the learning objectives are discrete from gameplay, the game may fail to produce educationally effective experiences.

The main purpose of the feedback is to inform the player about his performance and progression toward the goals, to monitor progress of the learner by the tutor, and to create a feedback loop between the game and the level achieved. In the proposed model, the feedback dimension is divided into immediate feedback and cognitive feedback [43]. The immediate feedback keeps the player focused. If the player has to wait long before he can realize what effect his action caused, he will become distracted and loose the focus on the task. Additionally, the delayed feedback may create interpretation problems and in the worst-case even lead to misconceptions and negative learning transfer. The cognitive feedback relates to the cognitive problem solving – it provides the account for learning and cognitive immersion. The cognitive feedback aims to stimulate the player to reflect on his experiences and tested solutions in order to further develop his mental models [44] and playing strategies. In other words, it focuses player's attention on information that is relevant for learning objectives. However, the main issue within game-based experiences has been that feedback models are often generalized rather than personalized even though the technology would allow the modeling of user performance and user characteristics.

Previous research has demonstrated how feedback can be used in a more sophisticated way to personalize the game experience and to create more user-centered design [45]. In their previous work, the authors have proposed a new feedback model that includes the type, content, format and frequency of feedback to be given in-game and extra-game [45]. For example, feedback can be given to the learner via scaffolded learning in the use of an in-game avatar. For example, in AnimalClass games [46] a player's avatar's gestures illustrate the certainty of its knowledge. Based on the agent's gestures, a player can figure out what his agent knows and what he should do next. In Roma Nova a similar approach is adopted where virtual agents present the learner with information about ancient Rome and provide missions and quests. Bellotti et al. introduce the Experience Engine [47], an ad-hoc artificial intelligence engine designed to deliver tasks in order to optimize each player's experience and meeting teacher's defined educational goals.

The playability antecedent is included to replace Csikszentmihalyi's action-awareness merging dimension, which is problematic in the learning game context. This was done, because according to Csikszentmihalyi, all flow inducing activities become spontaneous and automatic, which is not desirable from a learning point of view. In contrast, the principles of experiential and constructive learning approaches give emphasis to the point that learning is an active and conscious knowledge-construction process. It is noteworthy that reflection is not always a conscious action by a player. However, only when a player consciously processes his experiences can he make active and aware decisions about his playing strategies and thereby form a constructive hypothesis to test. Thus, a distinction between activities related to learning and controlling the game should be made. This means that controlling the game (input controls; e.g. controlling the character with mouse) should be spontaneous and automatic, but the educational content related to a player's tasks should be consciously processed and reflected. However, this is not always the case; sometimes learning to control a game can be a main task or use of challenging user interfaces can positively affect on cognitive abilities (e.g. attention, mastery). This is true for games that would require devices or interfacing instruments to be utilized as part of the gameplay (e.g. using a haptic instrument to play virtual snooker or to control an airplane, to virtually touch virtual objects [48] and using Wii control to emulate physiotherapy).

Generally, the aim of a learning game is to provide students with challenges that are balanced with their skill level. Furthermore, challenges should be related to the main task so that the flow experience is possible. When both the task and the use of the artefact are complex, then the artefact and the task may detract from the player's attention. In fact, bad playability decreases the likelihood of experiencing task-based flow because the player has to sacrifice attention and other cognitive resources to the inappropriate activity. Because the information processing capacity of working memory is limited [49], all possible resources should be available for relevant information processing (the main task) rather than for the use of the game controls. Thus, the aim is to balance the complexity of the main task as well as the control needed to complete the tasks. Generally, the aim of the user interface design of games is to support the shift from cognitive interaction to fluent interaction, which in some cases will require come practice to acquire fluency. In an ideal situation, the controls of the game are transparent and allow the player to focus on higher order cognition rather than solely upon tasks. However, designers should ensure that they do not over simplify the gameplay in the way that players can only superficially rush through the game without deeper processing of the game content.

The challenge dimension can be explained with the three-channel model of flow [5,10]. Challenges and skills that are theoretically the most important dimensions of flow are represented on the axes of the model (Fig. 3). The letter P represents a person playing, for example, snooker. At the beginning (P1), the player has only little knowledge about snooker and can only perform basic shots. However, the player enjoys the activity (is occasionally in flow) because he feels that the difficulty is just right for his rudimentary skills. While training his basic shots, the player's skills are bound to improve, and he will feel bored (P2) performing such shots. Or he might notice that playing against an opponent is still too hard and he will realize that there are much greater challenges than performing basic shots individually. His poor performance may cause feelings of anxiety (P3).

Boredom and anxiety are negative experiences that motivate the player to strive for the flow state. If the player is bored (P2), he has to increase the challenge he is facing. The player can set a more difficult goal that matches his skills. For example, he could play against an appropriate opponent that he can barely win against in order to get back to the flow state (P4). In contrast, if the player feels anxiety (P3), he must increase his skills in order to get back to the flow state (P4). The player could, for example, develop his playing strategy and train to perform safety shots. In general, it can be said that flow emerges in the space between anxiety and boredom. The flow channel can be extended by providing some guidance to the player, or by providing the possibility of solving problems collaboratively. The need to adopt constructivist as well as associative learning is reflected in this need for cognitive as well as task-centered approaches to learning in-game. Thus, Vygotsky's 'zone of proximal development' [35] is added to the original model. The zone of proximal development refers to the difference between what a learner can do without help and what he or she can do with help. For example, in the snooker case, the player could ask for help from more proficient players to help him to develop his cue technique and playing strategy. The extended model also acknowledges the importance of situative – or social learning [51].

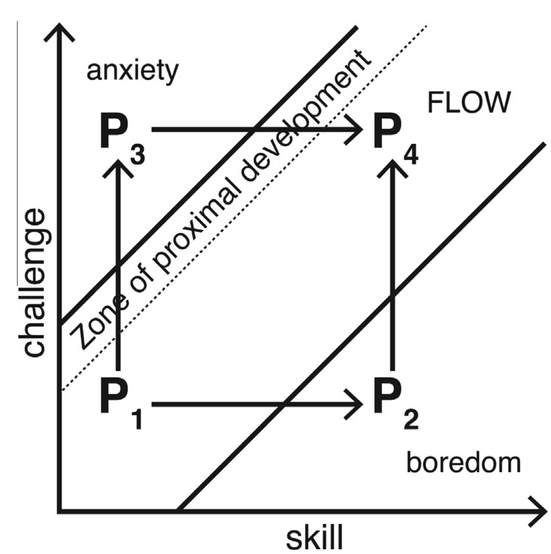

Fig. 3. The extended three-channel model of flow (Modified from [50]).

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The model shows that flow is a linear channel where both P1 and P4 represent situations where the player is in the flow state. Although both situations are equally enjoyable, P4 is more complex because the challenges involved and skills required are greater. Neither situations P1 or P4 are permanent states because every now and then the player tends to either feel boredom or anxiety, which motivates him to strive for the flow state in order to feel enjoyment again. In conclusion, this dynamic feature explains why flow activities lead to growth and discovery. From the point of view of learning activities, the three-channel model of flow has an important role in that it represents how the process of flow might develop through a single activity. The challenge of the game design 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 in order to maximize the impact of playing. The way how different people perceive challenges makes the balancing of challenge level difficult. Some people seem to prefer very challenging task although they may perform badly in a game. On the other hand some people prefer easy challenges and expect to perform well in a game. Thus, in many studies the reliability of challenge-skill dimension is usually quite low.

In many competitive games the behaviour of opponents affects the challenge level of the game. In general, opponents can be either human-controlled or computer-controlled. The construction of human-like behaviour in games is challenging and requires methods far beyond scripted interactions [52,53]. The previous research results indicate that the type of the opponent influences significantly the playing experiences. For example, [11] showed that users who played against a human-controlled opponent reported more experiences of enjoyment and flow. Thus, the challenge of game design is to create believable human-like behaviour for non-player characters that can adapt to player's skill level and that way facilitates flow experiences [54].

Sense of control clearly relates to the challenge-skill balance dimension. Csikszentmihalyi [10] has stated that sense of control refers to possibility rather than to actuality of the control. It can be said that a person senses when he can develop sufficient skills to reduce the margin of error close to zero, which makes the experience enjoyable. For example, a trainee snooker player can train hard and dream about perfect skills. However, unconsciously he knows that he cannot ever reach such a skill level, but still the illusion, a dream of it, lives and motivates the player to work hard towards his goals and dreams.

3.2. Description of flow state

According to [50], whenever people reflect on their flow experiences, they mention some, and often all, of the following characteristics: concentration, time distortion, rewarding experience and loss of self-consciousness. During a flow experience, such as during game-play, a person is totally focused on the activity and is able to forget all unpleasant things. However, during important activities such as learning, it is hard to stop thinking how others evaluate us. When a player can ignore what others think of him or her, the player has lost self-consciousness. The problem is that the criticism that the player may face turns his attention away from the actual task and turns too much to self, which does not facilitate the performance and playing experience. Self seems to disappear from awareness during flow – in flow there is no room for self-scrutiny [10] and thus the player is not worried about others' opinions (e.g. players, teachers, etc.). Here the self refers to the self-esteem and thus loss of self-consciousness does not limit reflective thinking processes. According to Csikszentmihalyi [10] during the flow experience the sense of time tends to bear little relation to the passage of time as measured by the absolute convention of a clock. Time seems to either pass really fast or the seconds may feel like minutes. Rewarding experience refers to an activity that is done, not with the expectation of some future benefit, but simply because the doing itself is interesting and fun.

For example, [55] have stated that sports can offer such rewarding experiences that one does it for no other reason than to be part of it. Furthermore, they argue that a sport setting is structured to enhance flow. Although winning is important in sports, flow does not depend on the final outcomes of an activity, and offers athletes something more than just a successful outcome. The playing of games is convergent with sports. In fact, an optimal experience usually occurs when a person's body or mind is stretched to its limits in a voluntary effort to accomplish something difficult and worthwhile [10]. Such experiences are not necessarily pleasant when they occur, but they still produce enjoyment. However, no matter whether the experience is pleasant or not, flow works as a hook that engages players and gets them to play games again and again.

3.3. Description of mind lenses

The essential processes for active learning are: selecting relevant material, processing selected material, integrating selected material with prior knowledge, sharing own understanding with others e.g. [39] and the ability to transfer the learned knowledge and skills into new situations. When playing serious games learners are challenged to extract relevant information from a game world, interpret provided feedback, select corresponding parts of information and integrate all of these elements to coherent representation and at the same time track the state of the game, decide right actions to carry out, and possibly communicate with other players. This requires a lot from the player, because the game world changes during playing, important information may be presented only a while, and thus it needs to be kept actively in working memory in order to integrate it to earlier presented information and relate it to one's actions and prior knowledge. Such demands may easily impose high cognitive load in learners cognitive system and hinder effective learning and playing. Thus, the flow framework distinguishes five mind lenses that provide means to systematically and reflectively consider game elements from the learning and interaction perspectives without neglecting the flow principles.

3.3.1. The lens of the sensing mind

The lens of the sensing mind relates to sensory memory. It emphasizes that humans cannot attend to all things at once, but have to select areas of interest from the world. In general, learner's prior knowledge affects how learner perceives the game world and what he or she selects to process consciously in working memory. Attention is used to focus our mental capacities of the sensory input so that the mind can successfully process the stimulus of interest [56]. For the design of game based learning interactions this means that we should ensure that the learner selects the most important content and elements (things that support the adoption of learning objectives) from the game for further processing in his working memory. The game designers should consider the use of audio-visual effects to grasp player's attention in crucial moments.

3.3.2. The lens of the processing mind

The lens of the processing mind addresses the limitations of human working memory that is responsible of processing selected information and retrieving existing knowledge from long-term memory. This lens emphasizes that the human working memory is very limited in both capacity and duration. According to Miller [49], we can deal with no more than seven elements of information at a time without overloading the information processing capacity and decreasing the effectiveness of processing. Thus, according to

Sweller et al. [38] any interactions between elements held in the working memory require working memory capacity, reducing the number of elements that can be dealt with simultaneously. When designing learning interactions we should remember that every game element has a cognitive price and they should be wisely used [57]. For example, Schrader and Bastiaens [58] found that the high-immersive gaming environment can lead to the strongest form of virtual presence but on the other hand can also decrease learning. This finding is consistent with multimedia learning theory arguing that multimedia presentations are more effective when irrelevant material is excluded e.g. [59]. Thus, the game designers should decide whether the extraneous elements engage players so much that it is reasonable to include them into the game or not. One further issue, which complicates considering the lens of the processing mind is that games usually provide a learning environment which is dynamic and complex (i.e. games create a process of activities and events linked to and dependent on each other) and in this respect are different from most other forms of teaching and learning. This dynamicity is clearly a thing that creates a challenge for the game designers as game design is not only about the content, the game elements and the way they are presented, but also their cause-effect relationships that stress the learner's working memory. Furthermore, the representation of the game elements should be optimized according to multimedia learning principles [39]. For example, the modality effect states that working memory capacity may be increased by the use of visual, auditory and haptic information processing channels simultaneously. In complex games haptic feedback could provide new ways to reduce extraneous cognitive load and that way release working memory resources to other senses. Furthermore, haptic interaction supports immersion while learners can experience the game more realistically and pervasively.

3.3.3. The lens of the integrating mind

The lens of the integrating mind emphasizes the meaning of long-term memory in human intellectual skills. According to the cognitive load theory the human intellectual ability relies on knowledge stored in long-term memory, because our working memory is incapable of highly complex interactions involving novel content. Thus, we should carefully consider the learner's' knowledge level when designing learning interactions – designs that require learners to engage in complex reasoning processes involving combinations of unfamiliar elements are likely to be deficient [38]. Integrating of selected information with existing knowledge involves building connections between relevant portions of prior knowledge and incoming information. The game designers should consider how to support the activation of knowledge in long-term memory in order to facilitate integration process. To summarize, according to this lens it is important to be aware of the characteristics of the target group and optimize the challenges and game content accordingly.

3.3.4. The lens of the relating mind

The lens of the relating mind addresses the meaning of sharing your learning experiences with others, which is central in the sociocultural view of constructivism. Duffy and Cunningham [60] claim that a primary way in which mental functions are altered by the mediation of language signs is that knowledge, and thereby learning, becomes a social, communicative, and discursive process, inexorably grounded in talk. These views connect the game learning elements – besides of being something to just interact with – to the social nature of game-based learning.

For a new player of any multiplayer game the process of starting as a novice and gradually becoming a more skillful player is almost exactly how Lave and Wenger [61] describe learning as legitimate peripheral participation. Peripheral participation means that a learner is always located in the social world, and changing locations and perspectives are part of actors' learning trajectories, developing identities, and forms of membership. Here peripherality is a positive term, suggesting an opening, a way of gaining access to sources for understanding through growing involvement. The learner is a newcomer who changes knowledge, skill, and discourse and at some point becomes an old-timer. This is a process of developing identity and the learner transforms into a member of a community of practice. This process is motivated by the growing use value of participation, and by the newcomers' desires to become more skilled and knowledgeable members of the community. The challenge of the game design 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 in order to maximize the impact of playing and support the development of a player. This process is something that can be quite clearly be seen in massive multiplayer games where a novice player gradually learns to become a better player and attains a better social status in the virtual game world. Social status, leaderboards and different forms of character development plays a crucial role in engaging users to playing and socializing.

What is said above does not mean that in the learning situation the players should be left working, communicating and collaborating alone. According to Hämäläinen and Oksanen [62] in authentic learning contexts totally free collaboration does not necessarily promote productive collaboration or high-level learning. Thus, players need support for collaboration that can be embedded into the game itself or provide teacher a possibility to facilitate players collaboration. For example, collaboration scripts are used to support collaborative learning [63]. The main idea of collaboration scripts is to improve collaboration through structuring interaction processes among players [62].

Ketamo and Kiili [57] have shown that breaks in game playing facilitate conceptual change in single player games. They argue that informal discussions about the game during breaks triggered players to reflect on their playing behavior and consider the content more deeply, which led to changes in thinking. This finding supports the idea of debriefing that has been found to be crucial part of game based learning interventions. Both the in game and external discussions relay on Vygotsky's [35] principles arguing that learning is best understood in light of others within an individual's world. In fact, the Zone of Proximal Development (ZPD) defined by Vygotsky [35] stresses that the assistance and scaffolding cues provided by the more capable persons may lead to learner's intellectual growth. To summarize, the purpose of relating mind lens is to trigger game designers to implement game elements that facilitate purposeful collaboration, sharing of knowledge and provides teachers possibilities to participate in game events.

3.3.5. The lens of the transferring mind

The purpose of transferring mind lens is to emphasize that game designers should consider ways to facilitate the transfer of learning in games in order to maximize the benefits. Transfer of learning (hereafter transfer) means the ability to apply knowledge or procedures learned in one context to new contexts. Transfer is usually divided into near and far transfers [64]. Near transfer refers to ability to apply learned knowledge and procedures in closely related settings. In contrast, far transfer refers both to the ability to use what was learned in one setting to a clearly different one as well as the ability to solve novel problems that share a common structure with the knowledge initially learned.

The research has indicated that transfer of knowledge and problem-solving skills into novel situations is rare especially when far transfer is considered [64]. For example, DeLeeuw and Mayer [65] found that adding game-like features to a computer-based learning activity caused students to pay attention to game details but did not motivate students – particularly men – to learn more deeply. However, the study utilized only some game like features such as competition and thus the results cannot be generalized to all kind of games. One of the main reasons for the inability of traditional teaching methods to facilitate the development of flexible and useful knowledge and skills is the lack of contextualizing or anchoring the content being learned [66]. In fact, the promise of serious games lays on assumption that in games learning can take place in authentic context [67]. An important question is in what fidelity we should model the real world context in games so that the transfer of learning is possible. Inadequate fidelity may result in unfulfilled learning outcomes as learners struggle to address the additional demands required to reflect on virtual experiences in the context of real-world events [68–70]. When considering the representation of the content we should also remember the constraints that limited capacity of working memory causes.

The taxonomy proposed by Barnett and Ceci [64] breaks transfer into content and context factors. The content factor considers what is transferred. It is important to consider learning objectives of the game because design of transfer may be expected to differ depending on whether one should learn a specific fact or more general principle. The aim of the context factor is to clarify the distinction between near and far transfer. The context factor is divided into several dimensions including knowledge domain, physical context, temporal context, functional context, social context, and modality. The consideration of these dimensions is important when trying to design an educational game that supports transfer.

According to Bereby-Meyer et al. [71] motivation plays an important role in transfer. The literature of achievement motivation goals makes a distinction between performance goals and mastery goals [72]. Performance goals refer to engagement in the task with the purpose of demonstrating one's competence. People directed by performance goals tend to avoid challenges because they perceive failure as indicating insufficient ability. In contrast, mastery goals refer to an engagement in the task with purpose of mastering skills and learning. Mastery goals tend to foster adaptive patterns of achievement characterized by challenge seeking, concentration on task and metacognitive activity as well as transfer [73]. Thus, from flow perspective game designers should structure the game in the way that it facilitates mastery goals. Especially, goal and feedback dimensions of flow can be used to direct the motivation to mastery goals. However, this does not mean that mastery of the game is necessary to experience flow, but the flow experience facilitates the achievement of intrinsically motivating mastery goals.

4. Case study on RealGame

The objective of this case study is to consider the usefulness of the flow framework (Fig. 2) in studying flow experience in educational games, which would link to whether the design facilitates the achievement of high level of flow. A collaborative business simulation game called RealGame [74] was used as a test bed. RealGame was selected to this study, because we wanted to study flow in a complex game environment that is not visually as attractive as common entertainment games. The analysis of flow experience using the proposed framework is a means to evaluate the proposed attributes included in the framework.

4.1. Participants

The participants of the study were students of Turku School of Economics, Finland ($N = 98$). The majority of the participants were younger than 25 and they participated this course on their 2nd or 3rd year of studies. The business simulation gaming sessions were part of the course Enterprise Systems, which is a course given by the department of Information Systems Science. The participants were mainly majoring in Accounting and Finance, Marketing, Management, Logistics, and Information Systems.

4.2. Description of the test bed

In RealGame business simulation game (http://www.realgame.fi) the problems and situations that the students face are designed to be very similar to those of real-life working contexts of business organization. The students are supposed to apply their schooled knowledge and skills in the gaming environment. An important characteristic of the simulation game is its clock-driven nature that reflects realistic time-dependent decision-making in the business world. Such continuous processing presents authentic tasks rather than abstract instructions. This means that the game is not turn-based like most of the business games, but it has an internal time, which proceeds at a certain defined speed. The game operator can change the clock speed during the game if he or she wants to. In terms of flow this means that the game operator can increase the game challenge and skills requirement through increasing the game clock speed while the skill level of the players increases and players are able to make decisions faster. The game operator can make decisions about the game speed adjustment according to players' performance analytics that the game provides. The game clock speed cannot be adjusted individually, which means that all players of the gaming session work under same time pressure.

The purpose of the used game scenario was to set a team of players in a position where they steer a manufacturing company called Modern Bikes Ltd (the second simulation session of the course). The imaginary Modern Bikes simulation company is situated in one of the Nordic countries and it produces Road bikes and Mountain bikes for three different market areas. The aim of using the simulation game was to give the participants a view of the different functions in a manufacturing organization and to illustrate how challenging it is to parameterize different automatic enterprise information systems functions, like the re-order point in the inventory, when the customer demand is not stable. Fig. 4 shows some of the decision-making areas and windows of the game.

The Modern Bikes model was played in a competitive format: the companies within each session competed against each other (common raw material resources and common customer markets). During the game teams made different kinds of decisions on different aspects dealing with the operational environment of the simulation company. This means that they manage the basic material flow, follow market reports, and try to react to competitor market actions, and so on. For example, teams can make decisions on terms of delivery, sales prices, terms of payment, marketing investments, and product development. Playing the simulation game is demanding as the teams also have to manage the whole supply chain process from suppliers to customers and the monetary process of the company. In terms of the extended three-channel model of flow, in RealGame the challenge level for the participants is adjusted by increasing or decreasing the simulation internal clock speed. This way the problem of anxiety or boredom is avoided, but managing this requires that the game operator is constantly in the picture.

4.3. Procedure

As 129 students enrolled the course, it was decided to have five exercise groups. Each of these five groups played the simulation game twice. Before the sessions, the students were given a simulation introduction document and a short pre-assignment. In the

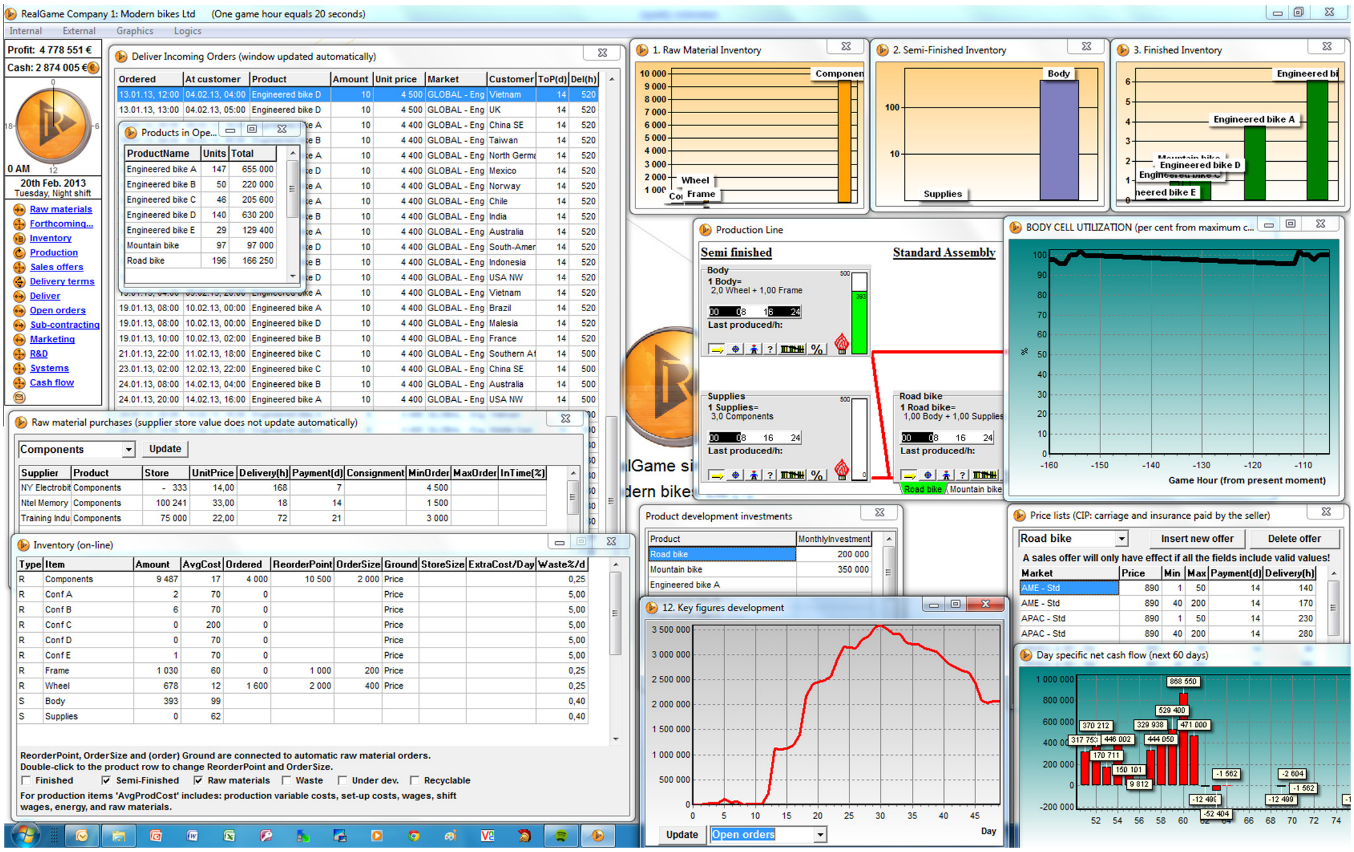

Fig. 4. Example view of RealGame business simulation game interface.

introductory first simulation session, the simulation game was less complex and the simulation clock ran more slowly than in the second session. The second session (Modern Bikes Ltd,) was organized two weeks after the introduction session. The participants were given basic information upon which to plan this new situation so that the increased simulation speed would not become uncontrolled during the second playing session.

Each of the sessions lasted approximately four hours. In each gaming session there were 6–8 companies competing against one another. The companies were steered by groups of two to four participants (the most common number being 3 students in 27 out of 32 groups). During the sessions the game was occasionally stopped and financial reports were run. The participants were given time to analyze the game process and to create plans for their future operations. Gradually during the sessions the clock speed was increased. At the end of the day the gaming part of the session was stopped and situation reports were run, and analysis and game debriefing performed.

Research data was gathered from the second simulation session. After the simulation session players were asked to fill in the questionnaires. 103 students participated the second gaming session and out of these, 98 returned a properly filled questionnaire.

4.4. Measures

The data related to flow was gathered with a 9-item questionnaire developed by the authors (see http://www.flowfactory.fi/research/flowscale.pdf). A 6-point Likert-type response format was used. The items included were derived from the GameFlow questionnaire [6]. The dimensions included were challenge, goal, feedback, playability, concentration, time distortion, rewarding experience, loss of self-consciousness, and sense of control. Each dimension was measured with a scenario-based item in order to avoid interpretation problems that have appeared in earlier studies. For example, the feedback dimension was operationalized as follows: "The game provided me such a feedback that I was aware how I was performing. I could really perceive the consequences of my actions." We also utilized the financial and performance results from the students managed companies (Turnover, Profit, average production costs etc.), indicating the groups' ability to manage their decision-making environment.

4.5. Results

Table 1 shows that the flow level experienced by the players was high ($M = 4.60$, SD = .63) and experiences were quite congruent. The reliability of the used flow questionnaire indicates that the flow dimensions are internally quite consistent ($\alpha = .78$). This result supports the findings of [10] who argued that whenever people reflect on their flow experiences, they often tend to mention all

Table 1
Means and standard deviations of flow dimensions ($N = 98$).

Flow dimension	*M*	SD
Challenge – skill balance	4.81	.98
Clear goals	4.95	.90
Feedback	4.40	1.13
Playability	4.18	1.27
Sense of control	5.14	.97
Rewarding experience	4.43	1.05
Concentration	4.46	1.10
Loss of self-consciousness	4.44	1.35
Time distortion	4.57	1.06
Flow experience (construct)	4.60	.62

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the nine flow dimensions. In general, high mean values of each dimension indicate that the game was well-designed and provided appropriate circumstances for experiencing flow. The feeling of control, clear goals, and challenge-skill balance dimensions scored the highest values.

The players had clear goals and they understood the aim of the game ($M = 4.95$, SD = .90). In the game players could define short-term goals for their company, which facilitates achieving of flow. Although the user interface of the game is complex and the playability dimension of flow scored lowest ($M = 4.18$, SD = 1.27) high sense of control was experienced ($M = 5.14$, SD = .97). This indicates that players felt that by practicing they can learn to master the simulation environment.

Although RealGame is not visually as rich as most commercial video games, it still produces very high experiences of flow. Plausible reasons for this are that the challenge in the simulation game is a meaningful one ($M = 4.81$, SD = .98). The participants showed high ownership on their achievements in their simulation game company. The meaningfulness of the task was probably one of the key characteristics in the simulations successful application. Furthermore, the varying clock speed of the simulation functioned as a tool with which to maintain good level of interest of the participants. Increment of the clock speed raised the challenge level and while the players learned to run their companies better and better, the challenge level was never too easy. In fact the players reported that they really liked the time pressure that increased clock speed created. This outcome shows clear support for the three-channel model of flow.

The flow construct had clear relations with game performance. The flow correlated with (1) Turnover ($r = .29$, $p = .004$; Turnover is the sales of the simulation company, and calculated automatically by the simulation application), (2) Profit ($r = .33$, $p = .001$; Profit = Turnover – different costs in the company; calculated automatically), and (3) Team's position within the game session according to the Profit figures ($r = .31$, $p = .002$). Furthermore, the analysis of user behaviour indicated that the ability to influence on game events contributes to the flow experience. For example, the reward dimension was related with the number of changes each team made in their sales offers ($r = .32$, $p = .001$) and the number of all team decisions and activities (like reports run and windows selected) made ($r = .28$, $p = .007$). These results seem to indicate that games, which require continuous situation scanning and decision-making, and include time-intensity, provide good possibilities for experiencing flow. Overall, it can be said that the ability to influence on game events as well as on other players is one of the major factors enhancing the flow experience.

In terms of mind lenses players seemed to struggle now and then in finding all relevant information to back up their decisions. However, this is actually a feature of the game that aims to simulate the complex decision making system. Thus, in this kind of game it is not reasonable to provide all information directly to players, but players have to know what information they need and find that information from the system. In fact, the game does not include any extraneous information and graphics, but only content that can be used in making decisions and controlling the game. From processing mind perspective the time intensity of the game can also be regarded as harmful for the learning, if the time pressure becomes the actual purpose. Tin fact, the observations of the training sessions revealed that without breaks in the simulation (clock stopped) and purposeful preceding planning assignments the participants would not be able to effectively consider how they are performing in the simulation and how they could boost their performance. The operator of the game have to ensure that players have enough time to reflectively process the feedback that the game provides as well as time to discuss about the game events and decisions as the relating mind lens suggests. Like the players gradually learn how to master their game company, the teacher also learns how to run the game sessions and facilitate learning outcomes. Without decent breaks the participants would satisfy in just playing the simulation game without necessarily having very high motivation in achieving good financial results, reflecting on their performance, and constructing new knowledge. The observations also showed that almost without exception the teams are extremely eagerly discussing their simulation company's challenges and decisions. This takes place under the time pressure and our assumption is that the time intensity of the environment leads to very high concentration in the decision-making and meaningfulness of the experience, which further enhances the teamwork. Thus, time intensity together with joint responsibility in the team facilitates flow and intensive peer learning. Finally, in this case we did not study the transfer of learning and the gathered data cannot be used to consider the transfer of learning lens of the flow framework.

5. Conclusions

In this paper we have presented the flow framework for analyzing and designing educational games. The framework describes the dimensions of flow experience that can be used to analyze the quality of educational games. The framework also provides design-support for producing good educational games, because it can be used to reveal ways to optimize learning effects and user experience. In order to support the integration of learning objectives the framework distinguishes five mind lenses that provide means to consider game elements systematically from the learning and interaction perspectives. However, the framework works only as a link between user experience, educational theory and game design and does not provide the means to a whole game design project. Nevertheless, the flow framework can be used to scrutinize game designs and reveal new ways to optimize learning effects and user experience.

Based on the proposed flow framework we studied the playing experiences of RealGame business simulation game. The results showed that the framework can be used to analyze the overall quality of the playing experience, but it does not provide detailed information about the shortages or highlights of the game. If the aim is to study reasons why the game fails to produce a good playing experience, the used flow scale needs to be extended with dimensions related to game mechanics and audio-visual implementation or complementary research methods has to be used. In general, the proposed framework has the potential to inform the design of new games as well as provide insights to redesign existing games based on the analysis of the attributes included in the framework. In the future we will concentrate on developing an extended playing experience scale that takes also the game mechanics, user interface solutions, audio-visual implementation, social aspects and the mind lenses into account. Furthermore, one of our future aims is to validate the framework in different game contexts.

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