

The Design Principles for Flow Experience in Educational Games

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Abstract— Educational games have to be well designed to incorporate learner engagement, an integral component of educational effectiveness. One foundation of designing educational engagement is flow theory. This article presents a flow framework that describes the building blocks of flow experience that can be used to design appealing and effective educational games for formal and informal learning contexts. The framework provides the principles for good educational game design, based upon associative, cognitive and situative learning theories, including engagement and pedagogic elements with a focus upon feedback and flow principles. Furthermore, the paper clarifies the relation between the flow experience and immersion. We tested the flow framework in the RealGame case study, which revealed that the RealGame business simulation game was well designed and effective at engaging students. We found that the university 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, but a rewarding experience and feedback dimensions also scored highly by the students. Overall, the results indicate that flow framework is a useful tool in studying game-based learning experiences.

Keywords: *Game-based learning, serious games, technology enhanced learning, game mechanics, experience design*

I. INTRODUCTION

The ultimate aim of game design is to create appealing experiences to players. Thus, games can be seen only as artefacts or a cultural form that arouse meaningful immersive experiences [1, 2]. According to Dewey [3] experience can be described as a continuous interaction between human beings and their environment. Dewey states that the experience is a result of interplay between the present situation and 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. The subjective experiences of players as they play games are at the heart of explanations of engagement in games and a range of constructs: flow [5, 6], immersion [7], presence [8] and arousal, which have overlapping but also distinctive characteristics. These constructs have been proposed to explain the often positive experiences that game-players have, presenting a huge challenge for learning game designers in terms of translating the benefits of entertainment games into educational game contexts: how can we create games that

please as many players as possible and are still educationally effective?

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 the case of learning games, the learning objective element needs to be included, which makes the design even more challenging. As Quinn [9] argued, learning-games have to be designed properly to incorporate engagement that integrates with educational effectiveness – the challenge is to find a balance between game-play and learning objectives. In fact, the designer's task is to balance all the five elements mentioned above in order to create appealing experiences. One foundation to design engagement is flow theory [5, 10]. Flow experience goes beyond the basic game elements because it provides a universal model of enjoyment. According to [11], preliminary research suggests that game-playing experience is consistent with the dimensions of the flow experience.

The aim of this article is to propose a model for designing flow experience from the designer's perspective. The design principles of engagement [6] provide a starting point for this work. In order to be able to understand the background of the factors that contribute to flow experience, the elements that constitute user experience are first distinguished. After that the building blocks of flow experience are described. Finally, the usefulness of flow as a game design framework is considered in relation to an educational game played by university students: RealGame.

While work on existing learning theories is well developed, in recent work, three areas of learning theory have been outlined for e-learning: associative (more task-centred approaches to learning), cognitive which rely upon constructivist approaches to learning and situative (more socially-based learning)[12]. In game-based learning we have the opportunity to explore the use of all of these models.

II. USER EXPERIENCE

Design activity has been embraced in an attempt to 'design the user experience'. There has been some effort in creating models of user experience [e.g. 13, 14, 15, 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-theorised, which presents problems for replicating good design and developing improving standards of design.

User experience is often paralleled with usability [e.g. 18], although it does not consider the deeper principles of experience design or consider the emotional side of product use enough. In general, user experience is focused on the interactions between people and products, and the experience that results in certain context of use. User experience should be considered from physical, sensual, cognitive, emotional, and aesthetic perspectives [14].

Generally, 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. This criticism has ensued from the approach that defines usability from a product-oriented viewpoint, suggesting that usability can be designed into a product. Such an approach considers usability as being ease of use but does not commit to usefulness of the product and quality of use. Thus, a more user-oriented and performance-oriented definition is needed. In fact, [20] used the following definition (ISO 9241-11) that takes these aspects into account: *‘The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use.’* This broad definition of usability enables a shift of focus from features of products also to characteristics and feelings of users. In this paper usability or playability in game context is considered as being one factor among others that affects user experience. Figure 1 shows the authors’ macro-level conception about user experience from an individualistic point of view. The dimensions are not meant to be understood as overlapping but parallel.

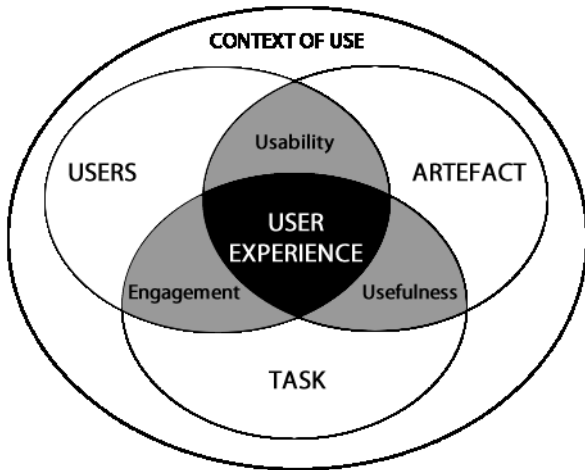


Figure 1. The elements of the user experience

User experience consists of three main elements: users, an artefact and a task. User experience emerges from the interplay between these elements in certain context of use. The Context of use is the actual conditions under which a given artefact is normally used. The characteristics of users, such as emotions, values and prior experience, determine how users perceive an artefact and the task at hand. Usability of an artefact is

determined in the interaction between users and an 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 [21]. Design of an artefact should support a shift from a cognitive artefact-interaction to a fluent one in order to guarantee enough cognitive resources for relevant information processing. Such a shift often means that the use of an artefact is effortless and easily learned [15].

However, not all playing should be effortless. In fact, a learning task should impose a germane cognitive load [22] that is required for knowledge construction. If the task is engaging, the user is willing to use more effort to accomplish the task. Skinner and Belmont’s [23] definition of engagement in 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 summarise, good usability, a useful artefact and an engaging task (challenges that the game provides) create prerequisites for a good educational experience. However, it is noteworthy that designers cannot design the subjective experience; only the context from which the experience arouses may be designed. In addition, task-centred learning is just part of the overall literature on learning theory, and relates more usually to training rather than education. In education, constructivist approaches are more usually adopted and these require cognition and affect [e.g. 12]. But most recently with the emergence of game-based learning, more opportunities for social and peer-focused learning are emerging [24].

Understanding meaningful and familiar activities as well as personal and situational interests [25] can maximize engagement and usability of a game-based intervention. Game contents should be varied according to players’ characteristics. Thus, a key challenge for designers is to get the correct balance between entertainment and fulfilling specified cognitive outcomes. The approach we have adopted in our previous development work has been a participatory design method, involving close inter-working of the designers with the user groups to ensure better uptake of the game within the chosen audience. This method is based upon work in multimedia design that was pioneered in Scandinavia [26]. This approach has become even more deeply deployed in the Roma Nova game, which seeks to iterate game design with students 11-15 years old over a five-year period [27].

III. BUILDING BLOCKS OF FLOW EXPERIENCE

The flow theory provides a meaningful framework to embody new qualities of experience that are relevant for educational purposes. Flow describes a state of complete absorption or engagement 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. Work from leading psychologists such as Csikszentmihalyi place greater emphasis upon enjoyment and pleasure in their work rather than focusing upon mental illness and diseases. Csikszentmihalyi's theory subsequently has been applied in several different domains including, for example sports, human-computer interactions, games and education. But in the area of games it has particular value, as it maps so well against the process of immersion experienced by players during game-play [27]. The aim of learning game design is to create so interesting an experience that it holds player's

attention as long and as intensely as possible. Imagine your previous gaming experience when a game totally captured your attention, when the time seemed to fly, when you didn't have any intrusive thoughts during playing and it felt so rewarding that you wanted to experience it again and again – can you still experience the feeling of flow? Next the ingredients that can be used to create such engaging experiences are defined. The elements of flow can be divided into three groups: Flow antecedents, flow state and flow consequences (see Fig. 2).

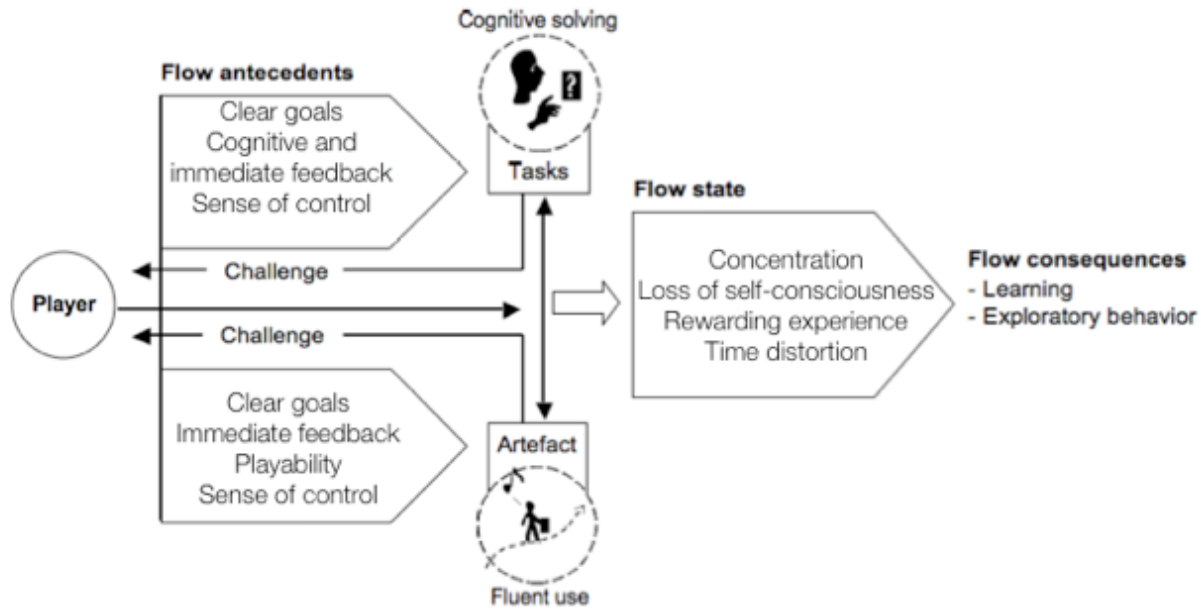


Figure 2. The flow framework

A. Description of Flow Antecedents

The flow antecedents are factors that contribute to the flow state and should be considered in educational game design. Most of the antecedents presented in Figure 2 are consistent with the original flow dimensions [5]. However, playability is a new one. All the antecedents are shortly described below.

When 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. 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 framework, the feedback dimension is divided into immediate feedback and cognitive feedback [28]. The immediate feedback keeps the player focused. If the player has to wait long before he can realise 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 is included because 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 [29] 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 modelling 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-centred design [30]. In previous work, the authors have proposed a new feedback model that include the type, content, format and frequency of feedback to be given in-game and extra-game [30]. 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 [31] a player's avatar's gestures illustrate the certainty of its knowledge (Fig. 3). 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 (Fig. 4).



Figure 3. Example of cognitive feedback in AnimalClass game



Figure 4. Cognitive feedback through virtual agents in Roma Nova

The playability antecedent is included to replace Csikszentmihalyi's action-awareness merging dimension, which is problematic in the learning game context. This replacement is reasonable, 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 should be spontaneous and automatic, but the educational content related to a player's tasks should be consciously processed and reflected.

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 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 [32], 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 of the user interface design of games is

to support the shift from cognitive interaction to fluent interaction. 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.

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 experience are represented on the axes of the model (Fig. 4). The letter P represents a person playing for example snooker. At the beginning (P1), the player has only a 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).

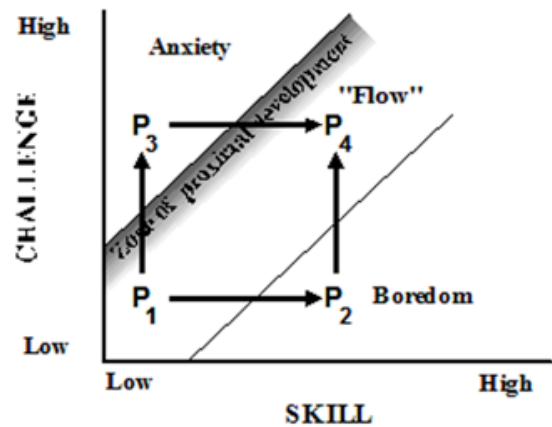


Figure 5. The extended three-channel model of flow (Modified from [33])

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 centred approaches to learning in-game. Thus, Vygotsky's 'zone of proximal development' [34] is added to the original model. 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 model also

acknowledges the importance of situative – or social learning [35].

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 stable 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 them.

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 research has shown that for example sports behaviour modelling is challenging and several games have received negative feedback related to unrealistic non-player character behaviour. Furthermore, in some multiplayer games it is relatively easy to guess when one is playing against AI and when one is playing against a human-controlled player. The construction of human-like behaviour in games is challenging and requires methods far beyond scripted interactions [36, 37]. 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 [38].

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 they know that they cannot ever reach such skill level, but still the illusion, a dream of it, lives and motivates the players to work hard towards their goals and dreams.

B. Description of Flow State

According to [33], 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. Because flow-inducing activities require complete concentration of attention on the task at hand, there are no

cognitive recourses left over for irrelevant information. Thus, self seems to disappear from awareness during flow. In other words, in flow there is no room for self-scrutiny [10]. 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, [39] 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]. It is noteworthy that 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.

C. Flow and Immersion

Immersion as a phenomenon resembles flow experience and these phenomena are often confused. Next we try to make a distinction between these phenomena in order to avoid possible interpretation problems that readers may face.

Immersion can be defined as a sensation of being surrounded by a completely other reality taking over all of our attention [40]. Reference [40] has divided immersion into three components: sensory, challenge-based and imaginative immersion. Sensory immersion is related to the audiovisual execution of games. Amazing graphics and powerful sounds easily overpower sensory information coming from the real world, shifting a player's attention entirely on the game world and its stimuli. On the other hand, challenge-based immersion concentrates on interaction between the game and the player. It corresponds to Csikszentmihalyi's [10] challenge-skill dimension while it assumes that the feeling of immersion is most powerful when the player can achieve a balance between challenges and abilities. The last component, imaginative immersion enables the player to become absorbed with the stories and the game world, or to identify himself with game characters. Generally, imaginative immersion reflects the possibility of using imagination and enjoying the fantasy of the game.

Although, immersion externally is quite a similar state to flow, it differs from flow in how it captivates a player. In flow a player directs all attention to a certain goal directed activity, whereas immersion means becoming physically or virtually a part of the experience itself. In short, the voluntary direction of attention to relevant content, which is an essential prerequisite for learning, makes the flow theory more interesting from an educational designer's point of view than the immersion based

models. However, this does not mean that immersion is considered as an unwanted state, but more like a lower level expression of flow experience, including several important aspects to be considered during game design. Nevertheless, when trying to immerse players we should keep in mind the cognitive constraints of human memory. Thus, the designers should consider for example Mayer's and Moreno's [41] multimedia learning principles when balancing the aesthetics of the games. The meaning of balancing should not be ignored, because too rich game environments tend to arouse incidental processing that may overload a player's mind and disturb learning.

IV. CASE STUDY ON REALGAME

The objective of this case study is to consider the usefulness of flow framework (Fig. 2) in studying flow experience in educational games. A collaborative business simulation game called Realgame [42] was used as a test bed.

A. 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.

B. 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 continuous (clock-driven) nature that reflects realistic time-dependent decision-making in the business world. Such continuous processing presents authentic tasks rather than abstract instructions.

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. Figure 6 shows some of the decision-making areas and windows of the game.

Figure 6. Example view of RealGame business simulation game interface.

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.

C. Procedure

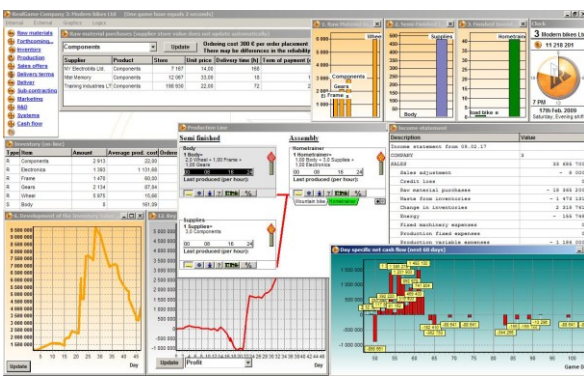
As 129 students enrolled the course, it was decided to have five exercise groups. Thus, each of these five groups played the simulation game twice. Before the sessions, the students were given a simulation introduction document and a short pre-assignment. In the introductory first simulation session,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

D. Measures

The data related to flow was gathered with a 9-item questionnaire developed by the authors (see [http...](http://...)). 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 [e.g. 6, 43]. 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.

E. 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 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.

TABLE I. MEANS AND STANDARD DEVIATIONS OF FLOW DIMENSIONS (N = 98)

Flow dimension	<i>M</i>	<i>SD</i>
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
Rewardin 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

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. However, the results also revealed that radical, dominant behaviour such as railroading does not support flow because it disturbs the progression of the decision-making and gaming in general. Thus, the educational game designers should use such game elements or instructional strategies that do not provide possibilities for too dominative behaviour to take place in game environments.

V. CONCLUSION

In this paper we have presented the Flow Framework for Game-Based Learning. This flow framework presents the design principles for developing engaging game elements that take account of associative, cognitive and situative learning approaches.

It is important to notice that the flow experience usually occurs when a person's body or mind is stretched to its limits in a voluntary effort. Thus, educational games should stretch a player's mind to its limits in his effort to overcome worthwhile challenges. This nature of flow supports the premise of using flow as a design approach in learning games. However, maybe the most important final result of flow is that flow inducing learning activities are not done with the expectation of some future benefit, but simply because the playing of an educational game itself is the reward. This type of attitude supports the ideology of life-long learning and is a priceless goal in education.

Although the elements of flow experience were distinguished in this paper, we dot not provide the magic formula that works in every game-based learning situation. While we are advancing closer towards developing an effective educational game design model and have elements of it already, the range of different learning conditions, contexts and learner groups present real challenges. Future research work will aim to integrate the Flow Framework with the cognitive feedback model, and test both within formal learning conditions. At present, educational designers need to mix and match the proposed principles in line with user group requirements using the participatory design methodology to maximize the efficacy of their learning games.

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REFERENCES

- [1] Schell, J. (2008). *The art of game design: a book of lenses*. Burlington, MA: Morgan Kaufmann Publishers.
- [2] de Freitas, S. & Neumann, T. (2009). The use of 'exploratory learning' for supporting immersive learning in virtual environments. *Computers and Education*, 52(2): 343-352.
- [3] Dewey, J. *Experience and Education*. Simon and Schuster, New York (1938/1997)
- [4] Edelman, G. (1994). *Bright Air, Brilliant Fire: On the Matter of the Mind*. Basic Books: 3-16.
- [5] Csikszentmihalyi, M. *Beyond boredom and anxiety*. Jossey-Bass, San Francisco (1975).
- [6] Kiili, K. & Lainema, T. Foundation for Measuring Engagement in Educational Games. *Journal of Interactive Learning Research*, 19 (3), (2008) 469-488.
- [7] Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., & Walton, A., (2008). Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies*, 66(9), 641-661.
- [8] Wirth, W., Hartmann, T., Bocking, S., Vorderer, P., Klimmt, C., Schramm, H., Saari, T., Laarni, J., Ravaja, N., Gouveia, F. R., Biocca, F., Sacau, A., Jäncke, L., Baumgartner, T., & Jäncke, P. (2007). A process model of the formation of spatial presence experiences. *Media Psychology*, 9, 493-525.
- [9] Quinn, C. *Engaging learning: Designing e-learning simulation games*. Pfeiffer, San Francisco (2005)
- [10] Csikszentmihalyi, M. *Flow: The Psychology of Optimal Experience*. Harper Perennial, New York (1991).
- [11] Weibel, D. Wissmath, B., Habegger, S., Steiner, Y. & Groner, R. (2008). Playing online games against computer- vs. human-controlled opponents: Effects on presence, flow, and enjoyment. *Computers in Human Behavior* 24 (2008) 2274–2291.
- [12] de Freitas, S. & Jameson, J. (2012) *e-Learning Reader*, London & New York: Continuum Press.
- [13] Buxton, B. *Sketching User Experiences: Getting the Design Right and the Right Design*. Morgan Kaufmann Publishers, Redmond, Washington (2007)
- [14] Forlizzi, J. & Battarbee, K. Understanding experience in interactive systems. *Proceedings of DIS 2004*. Cambridge, MA, 2004, 261-268.
- [15] Forlizzi, J. & Ford, S. The Building Blocks of Experience: An Early Framework for Interaction Designers. *Proceedings of the DIS 2000 seminar*. Communications of the ACM, 2000, 419-423.
- [16] Garret, J.J. *The elements of user experience: User-centered design for the Web*. New Riders Publishing, USA (2003).
- [17] Barton, K. & McKellar, P. (2011) From Master to Games Master: Managing Disequilibrium and Scaffolding in Simulation-Based Learning. In S.de Freitas & P. Maharg (Eds) *Digital Games and Learning*. London: Continuum Press: 226-251.
- [18] Nielsen, J. (1993). *Usability Engineering*. San Diego, London & San Francisco: Academic Press.
- [19] Lew, P., Olsina, L. & Zhang, L. (2010). Quality, quality in use, actual usability and user experience as key drivers for web application evaluation. *LNCS*, 6189, 218-232.
- [20] Bevan, N. & Macleod, M. Usability measurement in context. *Behaviour and Information Technology*, 13, (1994) 132-145.
- [21] McGrenere, J. & Ho, W. Affordances: Clarifying and evolving a concept. *Proceedings of Graphics Interface 2000*, Montreal, 2000.
- [22] Sweller, J., Van Merriënboer, J., & Paas, F. (1998). "Cognitive architecture and instructional design". *Educational Psychology Review* 10: 251–296.
- [23] Skinner, E.A. & Belmont, M.J. (1993). Motivation in the classroom: Reciprocal effects of teacher behaviour and student engagement across the school year. *Journal of Educational Psychology*, 85, 571-581.
- [24] de Freitas, S. & Liarokapis, F. (2011) *Serious Games: A New Paradigm for Education? In Serious Games and Edutainment Applications*, Ma, M. et al. (eds.), 9-23, Springer: UK.
- [25] Renninger KA: Individual interest and its implications for understanding intrinsic motivation, In *Intrinsic and Extrinsic Motivation: The Search for Optimal Motivation and Performance 2000* (C Sansone & J M Harackiewicz, Eds.) Academic Press, San Diego, 373-404.
- [26] Schuler, D & Namioka, A. (1993) *Participatory Design: Principles and Practices*. New Jersey. Lawrence Erlbaum.
- [27] Dunwell, I., Hendrix, M., Arnab, S., Petridis, P., Protopsaltis, A., Pierr, A., Rosciano, M., and de Freitas, S. (2012) *Facilitating Intuitive-Guided Learning in a Serious Game through Integration with a Learning Content Management System*. *Journal of Computer Assisted Learning (JCAL)*.
- [28] Butler, D. L., & Winne, P. H. Feedback as Self-Regulated Learning: A theoretical synthesis. *Review of Educational Research*. 65, (1995) 245-281.
- [29] Merriënboer, J. J. G. & Kirschner, P. A. Ten steps to complex learning: A systematic approach to four-component instructional design.
- [30] Dunwell, I., de Freitas, S., Jarvis, S. (2011) *Four-dimensional consideration of feedback in serious games*. In *Digital Games and Learning*, de Freitas, S. and Maharg, P., Eds., Continuum Publishing: 42-62.
- [31] Ketamo, H. & Suominen, M. *Learning-by-Teaching in Educational Games*. In *proceedings of Ed-Media 2008*. 30.6.–4.7.2008, Vienna, Austria, 2954-2963.
- [32] Miller, G. The magical number seven, plus or minus two: some limits on our capacity for processing information. *Psychological Review*, 63, (1956) 81-97.
- [33] Kiili, K. *On Educational Game Design: Building Blocks of Flow Experience*. Publications of Tampere University of Technology, no. 571. Doctoral thesis, Tampere University of Technology, Finland (2005)
- [34] Vygotsky, L.S. (1962). *Thought and language*. Cambridge, MA: The M.I.T. Press.
- [35] Mayes, T. & de Freitas, S. (2007). Learning and e-Learning: The role of theory. In H. Beetham & R. Sharpe (eds) *Rethinking pedagogy in the digital age*. London. Routledge.
- [36] Amor, H.B., Murray, J. & Obst, O. (2006). Fast, Neat and Under Control: Arbitrating Between Steering Behaviors. In Rabin, S. (ed.) *AI Game Programming Wisdom 3*. Massachusetts: Charles River Media Inc., pp. 221-232.
- [37] Ketamo, H. Nurmi, C. & Kallama, K. (2011). *User Generated AI in Sports Education*. In *proceedings of ECGBL 2011*, October 2011, Athens, Greece, pp. 20-21.
- [38] Panzoli, D., Peters, C. Dunwell, I., Sanchez, S., Petridis, P., Protopsaltis, A., Scesa, V. & de Freitas, S. (2010). Levels of Interaction: A User-Guided Experience in Large-Scale Virtual Environments, *IEEE 2nd International Conference in Games and Virtual Worlds for Serious Applications (VS GAMES10)*, Braga, Portugal, March 26-27, IEEE, pp. 87-90
- [39] Jackson, S. & Csikszentmihalyi, M. (1999). *Flow in sports: the keys to optimal experiences and performances*. Champaign, IL: Human Kinetics.
- [40] Ermi, L. & Mäyrä, F.. Fundamental components of the gameplay experience: Analysing immersion. In S. de Castell & J. Jenson (Ed.), *Changing views: Worlds in play - selected papers of the 2005 Digital Games Research Association's Second International Conference*, (pp. 15-27). Vancouver: Digital Games Research Association & Simon Fraser University.
- [41] Mayer, R. E., & Moreno, R. Nine ways to reduce cognitive load in multimedia learning. *Educational Psychologist*, 38, (2003) 43–52. Lawrence Erlbaum Associates, London (2007)
- [42] Lainema, T. (2003). *Enhancing Organizational Business Process Perception – Experiences from Constructing and Applying a Dynamic Business Simulation Game*. Turku School of Economics, Series A-5:2003. On-line: http://info.tse.fi/julkaisut/vk/Ae5_2003.pdf
- [43] Kiili and Lainema 2007