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Affective patterns in serious games

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HIGHLIGHTS

- Paper discusses affective serious games that combine learning, gaming and emotions.
- A novel framework for the creation and evaluation of serious affective games.
- A novel approach is based on merging various design patterns.

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ABSTRACT

We discuss affective serious games that combine learning, gaming and emotions. We describe a novel framework for the creation and evaluation of serious affective games. Our approach is based on merging pertinent design patterns in order to recognize educational claims, educational assessment, best game design practices, as well as models and solutions of affective computing. Björk's and Holopainen's game design patterns have been enhanced by Evidence Centered Design components and affective components. A serious game has been designed and created to demonstrate how to outline a complex game system in a communicative way, and show methods to trace how theoretically-driven design decisions influence learning outcomes and impacts. We emphasize the importance of patterns in game design. Design patterns are an advantageous and convenient way of outlining complex game systems. Design patterns also provide favorable language of communication between multidisciplinary teams working on serious games.

1. Introduction

Video game industry is one of the fastest growing and dynamic forces in the IT market. An important part of the total production is generated by small companies and independent creators — it is mainly due to widely available free (or cheap) tools for game creation (i.e. engines and design patterns) and online digital distribution platforms. This is the source of innovative applications of video games.

By the end of the previous century, video games have become one of the most popular entertainment media around the world. For the last twenty years, there has been a significant increase in the interest about video games called **serious games**. This oxymoron is usually associated with the context of the popular book by Abt [1]. Abt referred to games in general, but nowadays this term is rather pertinent to video games designed or used for purposes other than mere entertainment [2,3]. Recent review and meta-analysis papers about the literature on serious games can be found in [4–12]. The use of serious games is prevalent in education.

Game design patterns are helpful to address and solve design problems. Actually, their power lies in communication. The knowledge about gameplay can be expressed using design patterns by designers, gamers and domain experts. It can be applied for analysis and evaluation of existing games or recombined into new game projects. In this paper, we would like to present the framework for combining three elements: *games, learning and emotions*. We believe that the combined components provide the synergy force that allows for better solutions for serious games. To achieve that, we will benefit from best practices in game design, educational assessment techniques and affective computing knowledge and methods. Our goal is to provide uniform, systematic, pattern-based tool for creation and evaluation of **affective serious games**.

Our idea is briefly shown in Fig. 1. We want to combine knowledge from affective computing, serious games and game design in order to refine new type of design patterns for affective serious games.

GAMES–LEARNING *synergy and Serious Games.* The mechanisms of interactions in video games are particularly effective in engaging

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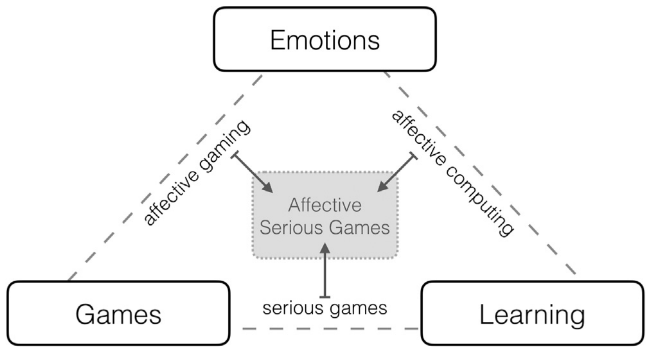

Fig. 1. *Affective Serious Games* triangle of relations. Our framework aims in synergy between elements depicted.

the user's attention, motivating or simply enhancing the attractiveness of standard information exchange modes. In game systems, the player is prone to the state of perception called immersion [13] and susceptible to the state of mind called flow [14]. Game systems may include rich interpersonal interactions. They may also be equipped with various controllers and monitoring devices, which enables players to use nature-based interfaces. Real time data on player's actions and behaviors and their biofeedback can be collected, so that the system can respond immediately. Many game attributes are those aspects of games which support or enrich learning. As the studies show, learners are increasingly challenged with problems regarding high-level (meta-) cognition — functions such as declarative knowledge (understanding one's own abilities), procedural knowledge (perception of the difficulty of the task) or conditional knowledge (using strategies to gain information and learn). The question of how to fuse gaming and learning, or how to blend fun and education, is exploited in literature in the main as the issue of serious games or edutainment.

EMOTIONS–LEARNING *synergy and Affective Computing.* Cognitive scientists and other experts prove that emotions significantly affect perception, rational thinking, memorizing, decision making, and learning as well [15]. Motivation, engagement, interest, excitement, confusion, boredom are examples of affective states that influence learning. In real world, a good teacher recognizes positive and negative affective states of a student, and reacts appropriately to the circumstances. Affect recognition is rarely based on verbal communication between the teacher and the student. Instead, it relies on nonverbal information: usually tone of voice, facial expressions, gestures. Moreover, reactions of the teacher may be also based on nonverbal or even subconscious communication. Therefore, one can assert that a good teacher, being now the agent in virtual world, should have the ability to recognize, understand, and simulate affective states. This is in brief the paradigm of Emotional Artificial Intelligence or Affective Computing. One of the used tools is the data-collecting interface monitoring player's actions and engaging biofeedback.

EMOTIONS–GAMES *synergy and Affective Gaming.* Video games are regarded as the most promising and challenging applications of Affective Computing research [15]. It is self-explanatory, as emotions have always been the "Holy Grail" of games. Their success depends on evoking emotional reactions in players. Game designers dream that their games will evoke complex emotions. There is a huge literature pool establishing practical knowledge and design patterns on how to evoke emotions in games with narratives, avatars, rewards, rules, user interfaces, interactivity and multi-player options.

GAMES–LEARNING–EMOTIONS *synergy and Affective Serious Games.* Our approach is to focus on game mechanics. Educational goals should be defined as claims in terms of knowledge, skills and abilities (KSA). We choose Evidence Center Design approach [16] to incorporate educational claims and educational assessment methods. The task model is defined using S. Björk's and J. Holopainen's patterns [13], modified according to affective computing principles [15]. It is actually the main advantage of using patterns: that different experts can communicate about various topics on the level of elementary interactions that translate directly into the mechanics implemented in the game engine. Additionally, patterns are a way to turn the static language of the description to the "verbal", relational game system, focused on the individual's actions. Moreover, some part of the work that a well-functioning team of highly experienced game industry specialists have performed (maybe more intuitively than deliberatively) can be now analyzed and reused as an example of best practices, a proven combination, or as a quick experimentation with a new solution. Björk and Holopainen have proposed a systematic framework that allows for a holistic approach to the design and evaluation process. Our goal is to extend this proposition to include affective elements that touch player's cognitive immersion, concentration and, indirectly, learning. Properly crafted affective models can also become units of evaluation with the appliance in the evidence-based assessment, as they translate into concrete tasks and scenarios without dismantling the whole construction.

2. Games, learning and emotions. Definitions and approaches

2.1. Games

It is troublesome to create a general definition of games, since this term is commonly used to convey a very wide range of diverse phenomena (from folk games to virtual reality). It is also used as a metaphor that expresses specific processes, which are not precisely games ("Game of Life", playing the stock market, etc.). Nevertheless, definitions are important — we need them to inform about core properties of intuitively understandable phenomena.

One of the first, modern, systematic approaches to studying games was that of Johann Huizinga. In his book "Homo Ludens" [17] he points out that play (and therefore — game) has a paramount role in establishing and negotiating cultural and social structures. "Play is older than culture (...) always presupposes human society". Philosopher also distinguished five properties of playful activity: it is free, separated from regular life (it is out of "ordinary"), it creates it is own order of rules and hierarchy that is supreme during the time of play, and it is connected with no profit per se (it is disinterested and undisguised).

Another important aspect of game definition comes in from of the work of Roger Caillios. "Man, Play and Games" [18] is the important 1961 book by that French sociologist. Theorist interprets main social structures as various forms of games emphasizing role of play in establishing those structures. Caillois refers to the concepts of Johan Huizinga and adds more elaborate interpretations of forms of play. He argues that the key factor in forming the playful activities is not solely a competition. He also notes the considerable difficulty in defining play, concluding that play is best described by six core characteristics: (1) It is non obligatory, free activity; (2) It is separates itself from everyday life – has its own, special time and space; (3) It is somewhat unpredictable, user's effort matter to the outcome; (4) It is not productive – which means it has no other purpose than play itself; (5) Its rules are in no regard to laws of everyday life. During play, rules of play overtake standards and codes of conduct; (6) It involves imagination, playact that requires some level of suspending the disbelief.

In his well-known paper [19] another author, Jesper Juul, proposed a new definition of game including core game features: (1) Games are rule-based activities; (2) Games have quantifiable outcomes (winning, losing, points etc.); (3) Some outcomes are valued by players as positive, some contrary, and it is important to participants; (4) Games require involvement and player's effort. They are not self-running mechanisms. They offer challenge, hence outcome is valued; (5) Games' consequences are not permanent in a fundamental way. Classical games can be played without heavy repercussions in real life.

One of the most interesting definitions of games comes from the philosopher Bernard Suits [20]: "Game-Playing as the Selection of Inefficient Means. Mindful of the ancient canon that the quest for knowledge obliges us to proceed from what is knowable to us to what is knowable in itself, I shall begin with the commonplace that playing games is different from working. Games, therefore, might be expected to be what work, in some salient respect, is not. Let me now baldly characterize work as "technical activity", by which I mean activity in which an agent (as rational worker) seeks to employ the most efficient available means for reaching a desired goal. Since games, too, evidently have goals, and since means are evidently employed for their attainment, the possibility suggests itself that games differ from technical activities in that the means employed in games are not the most efficient. Let us say, then, that games are goal-directed activities in which inefficient means are intentionally (or rationally) chosen. For example, in racing games one voluntarily goes all around the track in an effort to arrive at the finish line instead of "sensibly" cutting straight across the infield. (...) to play a game is to engage in activity directed toward bringing about a specific state of affairs, using only means permitted by specific rules, where the means permitted by the rules are more limited in scope than they would be in the absence of the rules, and where the sole reason for accepting such limitation is to make possible such activity".

2.2. Related works on learning, gaming and emotions

Games-based learning (GBL) or digital games-based learning (DGBL) investigate learning purposes of serious games (designed deliberately for education) and COTS (commercial-off-the-shelf games, primarily designed for entertainment) [4,21–24]. Prensky [25] defines DGBL as the usage of the entertaining power of digital games to serve an educational purpose. Intelligent Tutoring System (ITS) is a computer system that provides immediate and customized instruction or feedback to learners, usually without enrolling human teacher [26]. ITSs are examined for improvement by addressing the connections between affect, cognition, motivation, and learning [27–30]. The construction model to join ITS and multi-mode affective system is given in [31]. Intelligent Virtual Environments for Training (IVETs) combine two complex systems: Virtual Environments and Intelligent Tutoring Systems [29]. In artificial intelligence, embodied agents (EA) are interface agents that interact with the environment through a physical body within that environment. There are several approaches to include emotions in designing EAs: such as affective embodied agents [22], embodied conversational agents (ECAs) [32]. Intelligent virtual agents (IVAs) are synthetic, virtual, computer-controlled characters that can interact with humans [33]. IVAs can be capable of processing affective information [34]. Games and Learning Alliance (GALA) is European Network of Excellence on serious games [35]. E-learning is usually defined as studying at home using computers/smartphones/consoles and courses provided on the internet. The emotional Intelligent E-learning System is discussed in [36]. There are also some interesting results in physical education and sport, namely so called Teaching Games for Understanding (TGfU). Using emotions in designing learning experiences has been proved to enhance expertise acquisition in sport.

2.3. Game based learning

There is still lack of satisfactory empirical evidence in favor of serious games as a learning approach. It was highlighted in the paper of Hainey et al. [24] where highest quality empirical papers have been identified. The conclusion of their meta-analysis is that future research directions should follow proof-of-concept studies and longitudinal studies for serious games as well as comparison studies of game based learning with traditional teaching approaches. On the other hand, Clark et al. [37] argue that the most important question is to ask not "if" but "how" games can support learning. They draw the conclusion from their meta-analysis that it is rather game design than game medium alone that predicts learning outcomes and impacts. They state that future research on serious games should thus shift emphasis from proof-of concept-studies ("can games support learning?") and media-comparison analyses ("are games better or worse than other media for learning?") to value added comparisons and cognitive-consequences studies exploring how theoretically-driven design decisions influence learning outcomes and the impacts for the broad diversity of learners.

This paper does not address the question how some game mechanics' characteristics can prove effective for improving certain types of learning outcomes and impacts. We would like to suggest game design patterns that are suitable for design supporting learning, tracing appropriability and effectiveness of design decisions, and evaluating students' progress.

Let us give some examples of game features and game mechanics that can be advantageous for improving learning outcomes (knowledge acquisition/content understanding outcomes, affective and motivational outcomes, perceptual and cognitive skill outcomes, and behavioral change outcomes).

Game worlds can model complex systems [3]. Learning environment should be optimally complex where the learner knows enough to have expectations about what will happen [38]. Using games, one can combine easily different platforms: standalone applications, e-learning, mobile learning, augmented and virtual reality systems. One can use different advances of computer technology, the internet and communication interfaces. Games can be used for tutoring large and heterogeneous groups of students, without the limitations of time and place [39]. Game mechanics allow learners to experience situations that are impossible in the real world for reasons of safety, cost, time or logistics [40]. Games are a social medium providing the player with human-to-human like interactions and emotional responses [41].

Game mechanics can provide the player with an active experience and encourage him/her to learn by doing [41]. Game mechanics can provide role models for the player. The player can learn from the game characters and understand their behavioral experiences [41]. The learning environment can be customized to the player's specific learning needs or therapeutic goals [3,42]. Students can be situated in meaningful academic content in a way that is personally motivating, engaging, and less threatening to their scholarly self-esteem and affective dispositions [43]. Game mechanics can be participatory by providing the player with customized and instantaneous feedback [41]. Direct feedback has been shown to be beneficial in task learning situations [44]. Game mechanics can be motivating. It demands learning in order to succeed (if you do not learn, then you cannot succeed) [41]. Gameplay features like competition and collaboration are especially effective to motivate students [45]. Game mechanics can be engaging. Participation makes the player pay close attention. It demands thoughtful planning and decision making [41]. Game mechanics can be challenging [46]. McGonigal [47] observed that in good video games players are always playing on the very edge of their skill levels. There is nothing as engaging as the state of working at the very limits of abilities. Learning through gameplay can be a fun and enjoyable experience that encourages the player to more intensely engage with the game and its educational content [3]. Combining learning and fun is a major challenge of serious game design [48]. Games can adopt incremental learning [49]. The learning materials and activities are provided incrementally. Intended learning outcomes are addressed one by one and not all at once. Games can promote behavioral learning. The game gives the player rewards for behavior (points, power, rank, and so forth). This positive feedback in the game can encourage desired behaviors in real life [41]. Games offer consequences. These are not abstract or hypothetical; they are represented in the game directly. The player plays a character and identifies with him or her [41]. Success and failure map directly to the actions of the player. His/her ego and self-image are invested in the experience [41]. Games can enable students to develop 21st century skills [50]. In particular, information literacy — the ability to seek, locate, evaluate and navigate information effectively [22].

2.4. Emotions. Affective computing

Affective Computing is a paradigm in computer science established by Rosalind Picard from MIT in 1997. One of the first publications on the topic was her book "Affective Computing" [51]. AfC applies methodology of computer science — Artificial Intelligence, biomedical engineering, psychology and cognitive science. The main goal is to allow artificial systems to identify, process and simulate expression of emotions. It is rather practical approach motivated mainly in improving decision-making and HCI in sight. There exists a persuasive argument that if human–computer communication in the virtual world is to be similar to communication between humans in the physical world, then it must not be limited to the simple exchange of information [52]. Therefore, agents situated in the virtual environment should facilitate the communication of affects and react in a way that respects the affective context in which they find themselves. The relationship human–computer should become more conversational and relational. Building on the assumption expressed by Picard — that emotions are both physical (bodily) and cognitive (mental), affective computing is an interdisciplinary paradigm focused on modeling and creating systems that are able to gather, classify, process and simulate affects (emotions).

The idea that the methods and techniques of Affective Computing can be used as a foundation for affect-focused game design is discussed in [53,54]. It is crucial for any game to generate positive emotions [55]. Training in decision making processes should be supplemented by coaching with introspection and emotion regulation [56]. A recent review of the most relevant papers in affective games is given in [57]. This papers offers also a taxonomy for research on affective games.

There is also a strong belief that virtual learning systems (serious games) were improved if computers could be adapted according to the emotions of learners [58]. It is possible to design learning systems where the student's affective behavior is observed in order to detect affective responses that express interest, excitement, confusion, etc., and suggest a review of the actual interaction flow [52]. It bears resemblance to real world teaching.

Emotions are claimed to be a main mechanism that influences player's (learner's) immersion [59] and motivation [60]. Immersion is crucial both for gaming and learning. Emotions are the key to great experiences [61], and the player's great experiences imply an immersive experience [62]. Mandler [63] suggested a hypothesis that there is a complex interplay between cognition and emotion. Emotions are regularly affected by the knowledge and goals of the learner, and vice versa — one can deliberate entangled cognitive–affective states that play important role in learning [27].

Emotions can be also regarded as a form of game interactivity [64]. Nowadays, games can make use of more advanced human–computer interactions with interfaces that cater to almost all human senses and sensors that monitor various physiological changes of the human body. If emotions match subjective responses of the human body, then rules for interactivity patterns are established by affective maps (affects versus sensor data).

Two crucial problems of affective computing are:

1. The physiological nature of the affect.
2. The ways in which the brain interprets the affect from physiological actions.

The first issue requires using sensors that capture data about human physiological states. Most popular channels include signals from the cardiovascular system (blood volume pressure [*BVP*], heart rate [*HR*], heart rate variability [*HRV*]) and electro-dermal activity [*EDA*] (galvanic skin response [*GSR*]), but also body position, prosody, facial expressions (including microexpressions). The second problem presupposes the possibility of creating models (and algorithms) for interpreting the relationship between internal bodily sensations and mental states.

A long-term goal of AfC is to apply models to harvested biophysical data and to create adequate software that could be used in affect-aware systems. Such computational models rely on cognitive and psychological explanatory constructs that aim to grasp the relation between mental and physical states of the human psychophysiological whole.

The issue of emotions is actually hard to grasp. There is no consensus on a definition of emotions. Most of nowadays theories have the origin at the beginning of modern psychology at the turn of the 19th and 20th century. William James is often regarded as "the father" of affective studies. In his works, he described emotions in terms of stimuli and reactions. Modern *appraisal theories* (including *embodied appraisals* theory by Jesse Prinz [65] — in our opinion the most operational approach and useful for affective computing) have their beginning in James' writings. Among appraisal-oriented theories the most noticeable are: this by Russell [66] where he generally classified emotions by their two independent components — arousal (intensity) and valence (pleasure/displeasure), and OCC theory [67] where they point out 22 emotion categories on the basis of consequences of events (happy/unhappy), aspects of objects (like/dislike), and actions of agents (approve/disapprove). The main advantage of described theories is that they rely on relatively easily quantifiable values that can be collected from sensors and interpreted in model ascribing various types of affects (i.e. positive self-attribution of high value is "pride").

Another popular theory is the Component Process Model (CPM) of emotions invented by Scherer [68]. Emotions are explained as the synchronization of many different cognitive and physiological components. Four appraisal objectives (types or classes of information required for human bodies to prepare appropriate reactions) are assumed: relevance detection, implication assessment, coping potential determination, and normative significance evaluation.

In practice, real-time computer applications like video games use fast algorithms that are based on highly simplified models to recognize affective states from sensor data (affective mapping). For instance, let us take a look at the fuzzy logic approach communicated in [69]. They collect the following sensor data: galvanic skin response (*GSR*), heart rate (*HR*), and electromyography of the face (EMG_{smile} and EMG_{frown}). Data are classified respectively as: *GSR*: high/mid-high/mid-low/low, and for *HR*, EMG_{smile}, EMG_{frown}: high/mid/low. Next, they provide the rules for transforming classified sensor data into arousal–valence space (e.g. if (*GSR* is low) and (*HR* is high) then (arousal is mid-low)). Finally, they provide rules for transforming arousal–valence space into five modeled emotional states: boredom, challenge, excitement, frustration, and fun (e.g. if (arousal is mid-high) and (valence is low) then (frustration is medium)).

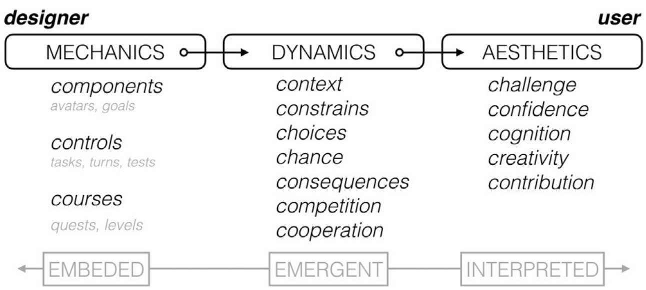

Fig. 2. MDA framework.

3. Preliminaries to the proposed framework — game structure, gameplay, affects

In our approach, we would like to use affect-oriented patterns for game design. **Game mechanics** are especially useful in the process of designing games, since they can be related easily to fundamental game elements. Miguel Sicart [70] formulated probably the most popular and useful definition: "game mechanics are methods invoked by agents, designed for interaction with the game state".

On the basis of the idea that the mechanics are essential, the Mechanics, Dynamics and Aesthetics framework (MDA) was created by Marc LeBlanc [71,72] to "clarify and strengthen the iterative processes of developers, scholars and researchers alike, making it easier for all parties to decompose, study and design a broad class of game designs and game artifacts" [73]. The MDA framework includes best design practices on one side, and user experiences on the other. Between, there is a space for active gameplay with dynamics — mechanics activated by the player. Activation of dynamics relies on possibilities generated by the designer and context-dependent operations performed by the user.

The designer is obviously the one that creates game rules. The rule system is instantiated in the game engine and some environment that the player can interact with is created. User input provides dynamics. In course of the process of creating the game, the designer is supervising a somewhat static set of mechanics and making plans on how they will be approached by the player (the dynamics). The primary method for ensuring gameplay stability and game balance is via testing by users. Some formal system to support the evaluation of game balance is given in [74].

As depicted in Fig. 2 — in MDA framework the most important part of the designer's work is the creation of mechanics. Next, he should ensure the balance of interacting game components and implement player's controls. He also creates game courses by setting up quests and levels. These are embedded properties of the game system and they are relatively stable, the elements of the game provided as the software (it includes scripts, objects, assets, etc.). These elements activated by the user in some context, and under some constraints allow for making choices and present their consequences. This part of the design process is emergent — it is very hard to predict exact outcomes, especially in big and open world games. As a result of emergent behavior of the system, the player may be challenged or affected. The player can engage cognitive processes and creativity to overcome obstacles and solve problems. This part of the game activity derives from player's interpretation and is available only using personal reports.

This point of view is significant from our perspective. To provide an adequate tool-set for affective serious game designers, we need to address problems that are located on the left side of Fig. 2. It means to support the creation of components (such as goals and avatars), controls (tasks, turns, tests) and courses (quests, levels) embedded in the game itself. To provide tools for the evaluation of user actual performance, we need to focus on emergent properties of a game as a running mechanism. We believe that the first issue can be resolved by using properly devised patterns and the second can be attained by utilization of Knowledge, Skills, Abilities (KSA) statements.

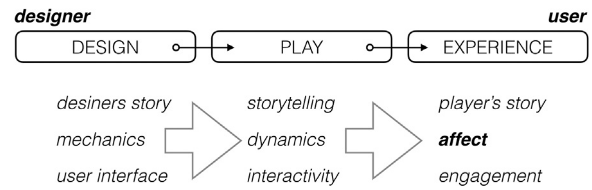

Fig. 3. DPE framework.

The MDA framework is successfully used for analyzing games [71], but it proves to be mechanics-centric and disregards other elements of gameplay. When it comes to the design of serious games more appropriate means need to be applied [75] (see Fig. 3).

In our proposition, we aim not only to target issues related to creating and evaluating serious games. We also insist upon more systematic inclusion of emotions into the process. The MDA framework is a very proper tool for the description of the origin of emergent properties of gameplay, but it lacks insight on the role of affects in the game system. The affects are apparently located on the players' side of the picture (hidden in cognitive components). The DPE (Design, Play, Experience) framework helps to indicate where emotions in game emerge (see Fig. 3). It was created as an enhancement of the MDA, but it addresses a wider range of problems related to game creation [72]. The principles are the same in both cases — the designer and the user are on two sides of the game system. Similarly to MDA, the primary element of DPE is the emphasis on the fact that the gameplay is a mediated experience. On the one side, a designer is planning to tell a story, creates a scenario, provides mechanics, designs an interface. On the other side, as a result of the playing process, the user creates an individual interpretation of the perceived narrative, he faces the effects of dynamics and experiences the engagement. Although the designer and the recipient finally deal with the same product, the experience of the game can be different. In particular, the player can read the content in the game subversively and ironically, so that his experience will be different than planned by the creator. For us, the most important issue is that dynamics, being mechanics invoked by the player, are among the crucial facilitators for immersion and affective states that the user experiences in the course of gameplay. In this way, we can directly relate the process of designing mechanics with emotional results the mechanics can evoke. We can associate design patterns used by creators with subjective players' affects and objective outcomes that can be accurately assessed.

4. Components of the proposed framework

As it was stated in the introduction, our original contribution in this paper is to combine knowledge from Affective Computing, serious games and game design theory and best practices (see Fig. 1) to derive a new type of design patterns that allow for more mechanics-oriented approach in creating and validating serious games. We choose Evidence Centered Design (ECD) [16] as a pivot for the whole framework. In our approach, ECD's task model is to interlink game design patterns [13] and to be supplemented by affective components.

Knowledge, Skills, Abilities (KSA) statements allow for the narrative description of learning outcomes. Competences obtained during serious games sessions are represented as particular practical and cognitive skills, personal, methodological and social abilities, theoretical and factual knowledge. Our framework allows to implement specific methods for evaluating KSAs.

4.1. Patterns in game design

As it was stated above, one of the most important elements of game design and creation are mechanics — essential building elements of the game structure. Games may be defined as: "an attempt to achieve a specific state of affairs [prelusory goal], using only means permitted by rules [lusory means], where the rules prohibit use of more efficient in favor of less efficient means [constitutive rules], and where the rules are accepted just because they make possible such activity [lusory attitude]" [20]. In that case, there are two main factors required to instantiate "gaming situation": the mental attitude of a player willing to play ("lusory attitude" [17]) and rules that prohibit the use of most effectual for less efficient means ("lusory means" [20]). The role of the game designer is to establish borders that make some special kind of activity (game, play) pleasurable and – more importantly – possible. It happens mainly through creating constitutive rules (mechanics) which result in dynamics causing affects (UX) when encountered by the player. Other pillars of the players' engagement are – as described in DPE framework – storytelling and interactivity (result in player's immersion).

The rules of the game can be expressed as the verbs that describe what player can or cannot do in frames of the game system. For instance, one can "move" the avatar, "kill" the monster, "find" the treasure, "solve" the riddle. The player is usually aware of the rules that govern the gameplay. Mechanics are very similar to "verbal" language constructs, but they include unperceived principles hidden deeper in the game system, embedded in the software, and rarely displayed in the user interface. Mechanics are repetitive. It depends mainly on game genre (for instance, in first-person shooters the main mechanic is to shoot the enemies). It is interesting that embedded mechanics have emergent properties. Different interpretations and game styles cannot be in a straight way deduced from the description of essential elements. It is possible that this is one of the sources of pleasure in operating game systems.

A repetitive character of game mechanics brings forth the idea of game design patterns. There are few overall structural frameworks to describe the components of games, and patterns of interaction that describe how components are used by players to affect various aspects of the gameplay. We use that proposed by S. Björk and J. Holopainen [13], created mainly as a language for the analysis of games: "there is a lack of terminology associated with the elements of gameplay. We offer a solution to this".

There are several interesting papers on how to analyze and assess serious games, e.g. Arnab et al. [76], Carvalho et al. [77], Roungas [78]. From our perspective, these works are interesting and, as we presume, compatible with the solutions we have developed. Our proposal differs in that we place much emphasis on the procedures of the game design in order to incorporate affective computing methods. Methodologies and tools for analysis and assessment of serious games are also discussed in [35].

The core concept of game design patterns are "general descriptions of particular areas of gameplay without using quantitative measures". They have forms of basic definitions followed by detailed descriptions. Basic relations include instantiation (some patterns tend to occur in the presence of others, some imply others), modulation (some patterns change others or are modified by the presence of others) and conflict (some patterns render the presence of others impossible). Some basic design pattern template contains the following elements: arbitrary name, core definition, general description, clues for using the pattern, consequences, relations, references. The handbook [13] contains almost 300 elementary patterns (see Fig. 4).

Timing

The effect on gameplay that actions have to be performed at certain points in game time to be performed at all or that the direct effect of actions varies greatly depending on when they are performed.

Example: Fighting games such as *Soul Calibur* or the *Tekken* series put heavy emphasis on *Timing*: it is required to successfully attack opponents before they parry and it is also required to parry incoming attacks. Further, special actions are triggered by the right *Timing* of what would otherwise be normal actions.

Instantiates: Rhythm-Based Actions, Game Mastery
Modulates: Turn-Based Games, Overcome, Real-Time Games, Configuration
Instantiated by: Aim & Shoot, Combat, Collaborative Actions, Stimulated Planning, Capture, Moveable Tiles, Geometric Rewards for Investments, Deadly Traps, Obstacles, Delayed Effects, Combos
Modulated by: No-Ops, Privileged Abilities, Stimulated Planning
Potentially conflicting with:

Fig. 4. Pattern *Timing*.
Source: [13].

The patterns in Game Design framework are to establish the language for analysis of games and to support the work of the game creators. It allows to easily detect potential problems and to identify circumstances where emergent properties are probable. One should choose some set of design patterns that can cause affective reactions of the player [79].

4.2. Evidence centered design — the conceptual assessment framework

Evidence Centered Design [16] is a design and evaluation method useful for serious games. It achieves learning goals through low-level game mechanics. It is both a design and evaluation method. The most important design concept is the Conceptual Assessment Framework (CAF). The CAF contains Student Model, Evidence Model(s), Task Model(s). The Student Model is a set of variables related to Knowledge, Skills, Abilities and other learner's attributes (KSA variables). These variables cannot be observed directly, so the Evidence Models defines which behaviors or performances in a given task situation constitute evidence about Student Model variables. There are two parts of the Evidence Model. The evaluative sub-model (evidence rules) is extracting the salient features of whatever the student says, does, or creates in the task situation (Observable Variables). The statistical sub-model (measurement rules) provides information about the probability-based connection between the observable variables and Student Model variables. The Task Model defines the types of tasks or situations that elicit behaviors or performances required by the Evidence Model. (See: Fig. 6.)

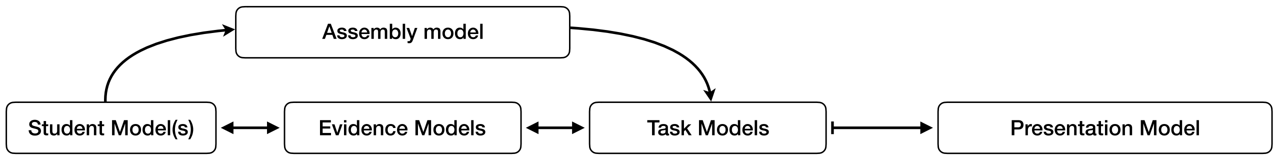

Fig. 5. ECD: Conceptual Assessment Framework delivery model.

4.3. New patterns with both ECD and affective components

In our framework, we include the Evidence Centered Design component (see Fig. 5) into the pattern language.

1. The first layer contains the Student Model that corresponds to DPE's:
   designer's story, plot/theme created by game author;
   mechanics, a set of meaningful elementary actions that defines the "implied player" [80];
   user interface, that allows the "implied player" to act.
2. The second layer contains Evidence Model(s) for evaluation of educational results.
3. The third layer contains Task Model(s), a set of distinct actions in relation to Evaluation Procedures and Materials & Presentation part of Evidence Model(s).

The three components described above define the Assembly Model that helps to create particular serious games on some platforms (Presentation Model). We demonstrate that the Assembly Model can be translated into the language of game design patterns. It is shown in Fig. 6 that the Assembly Template incorporates Design, Play, Experience framework.

It is the idea of this paper to enhance the patterns by two components: evidences (Fig. 7) and affects (Fig. 8). Evidences correspond to Evidence Model of ECD — they concern Work Products (their quality, accuracy, strategy used etc.) and result in Observable Variables via Evaluation Procedures. For example: if at some point of our serious game, we would like to test how students apply previously obtained knowledge on first aid to victims of accidents, we might decide to use the pattern *Timing* to test players' acquaintance with cardiopulmonary resuscitation. Within KSA, player has to **know** how to perform action, recognize timing pattern, perform skillfully actions via interface with certain accuracy. All those factors are reflected in pattern's Evidence component. Every Evidence has a clear counterpart in game structure. For the example, we can easily check if player performs the correct CPR sequence (ECD's Task Model Variables: regularity, precision, etc.).

ECD's Evaluation Procedures based on mechanics allow for collecting Observable Variables being DPE's dynamics. The process of play results in DPE's component of Experience. We can use player's story (individual actualization of provided narrative possibilities), measure engagement and affects as additional evidence metrics.

The idea of systematic inclusion of affective factor in (serious) games and interactive systems is not entirely new — Yannakakis and Paiva [15] point two possible emotion elicitors in games: game content and game non-player characters (NPCs). There are also three types of input: gameplay data on behavior of the player or NPCs in the game, sensor data on physiological bodily responses to game stimuli or body movements, and all game content and context which comprises of any player–agent interactions. The model's output is usually a set of particular affective states. Freeman [81] described 32 techniques for injecting emotions into computer games (he called the process "emotioneering"). A literature review of designing for emotion in video games is given in [64]. In 2009 paper [82] identified some principles for developing effective game-based learning solutions. Charoenying [43] described a framework for accountable game design and utilization. The framework is based on seven steps: (1) Consider the needs of the intended audience; (2) Define learning objectives; (3) Model dynamics and interactions for the student group; (4) Define complexity rules for games; (5) Define criteria for success; (6) Prepare the protocol of interaction; and (7) Choose media analyzing the relationship between games and technology. Several patterns for understanding emotions, socio-emotional interactions, and supporting learning in the affective domain have been collected in [83] (only positive emotions). Those patterns include: *Avatar Emotional Expression*, *NPCs With Emotional Masks*, *Avatar Display of Human Frailty*, *the Traumatized Avatar*, *Healing/Nurturing Others*, *Animal Companion Sims*, *Emotional Decision Making*, *Consequences of Long Ago Actions*, *Empowerment*. Examples of cognitive–affective agent architectures are given in [34]. Effective affective user interface design for games is discussed in [55]. The affective elements of UX framework for educational games are identified in [84]. Design patterns described in [48] try to combine learning aspects (how to make interaction instructive, how to initiate the reflective process, how to convey information without disturbing game immersion) with fun aspects (how to motivate users, how to help users advance in the game). They elaborated in detail seven patterns: *Serious Game*, *Game-Based Learning Blend*, *Instructive Gameplay*, *Time for Action/Time for Thought*, *Reified Knowledge*, *Museum*, *Fun Reward*. The questions about affective student modeling are discussed in [39,29,85]. A student model is the starting point for personalization in computer-based educational applications. The most popular approaches to construct a student model are: the overlay model (represents the student's knowledge level), the stereotype model (classifies students into groups) and the perturbation model (models the student's knowledge and misconceptions). Jeremic and Jovanovic [30] recommends Design Pattern Teaching Help System (DEPTHS) for ITS. The student model used there combines stereotype and overlay modeling. The evaluation of DEPTHS is performed by assessing the system's overall effectiveness and the accuracy of the student model. A review of the literature in affective design towards the development of video games is given in [86].

In our approach we would like to regard affects as DPE's Experience component that influences Evidence Model (Observable Variables/Dynamics and Measurement Models/Student Model Variables), being a part of the main game loop. We propose to enhance game design patterns by another component, namely the Affect. Some patterns have clear affective associations. They can be used to create *affective loop* within the gameplay, namely some dynamics have outcomes measurable by means of Affective Computing. Outcomes can be evaluated based on the game context (DPE's player story vs designer's story) and other mechanics can be used to amplify or suppress emotional responses. Basic labels of the responses are "weak", "medium" and "strong". More sophisticated metrics can be applied [65]. Nencki Affective Picture System dataset contains hundreds of standardized images with normative ratings of valence and arousal.

5. Proof of concept — OSH affective serious game

5.1. OSH affective serious game design

A design of HOPA (Hidden Object Puzzle Adventure) serious game was created as the example proving that the proposed design

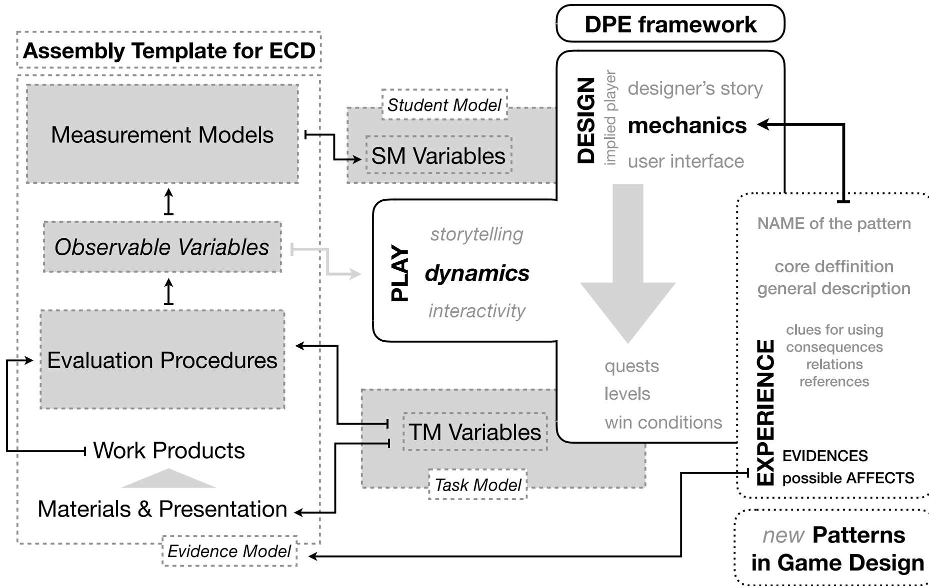

Fig. 6. Proposed framework including ECD, DPE and enhanced (*new*) patterns in Game Design.

Timing

The effect on gameplay that actions have to be performed at certain points in game time to be performed at all or that the direct effect of actions varies greatly depending on when they are performed.

Example: Fighting games such as *Soul Calibur* or the ...

Evidence:
(K) Player knows how to perform action. Recognizes time pattern.
(S) Player performs action with certain accuracy/precision.
(A) Player efficiently joins the action when prompted.

Affect: potential *medium* affective influence
or
Affect: potential medium arousal with neutral valence detectable via GSR

Instantiates: Rhythm-Based Actions, Game Mastery
Modulates: Turn-Based Games, Overcome, Real-Time Games,
Instantiated by: Aim & Shoot, Combat, Collaborative Actions, Stimulated Planning, Capture, Moveable Tiles
Modulated by: No-Ops, Privileged Abilities,

Fig. 7. Evidence enhanced pattern *Timing*.

Timing

The effect on gameplay that actions have to be performed at certain points in game time to be performed at all or that the direct effect of actions varies greatly depending on when they are performed.

Example: Fighting games such as *Soul Calibur* or the ...

Evidence:
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Modulates: Turn-Based Games, Overcome, Real-Time Games,
Instantiated by: Aim & Shoot, Combat, Collaborative Actions, Stimulated Planning, Capture, Moveable Tiles
Modulated by: No-Ops, Privileged Abilities,

Fig. 8. Evidence & affective enhanced pattern *Timing*.

and evaluation framework is useful. The basic modes of interaction for this type of game are: search for the object indicated in the list (point and click), solve the puzzle (minigame), use of an object on another object (drag and drop), make decision/dialogue window (point the answer). HOPA games are very well situated for testing due to relatively simple gameplay.

The serious game design is OSH (Occupational Safety and Health) simulation. According to regulations in force, it is obligatory for employees to repeat such training recurrently. The Knowledge, Skills and Abilities required from the trainee are well defined. The game consists of one level with six locations (see Fig. 9). At the beginning, the trainee is offered a guide to the most important safety and fire prevention procedures. After launching the main program, the trainee finds himself in the laboratory. The player is free to move between locations until he leaves the building (evacuation route) or fails (he dies). At the end of the game, the player will receive information about his behavior compliance with OSH rules and procedures.

To win the game the player has to find his way outside the building by following evacuation route signs. Wandering around may result in dangerous encounters, and trying to use alternative exits (elevators, window) may end up with death. An additional

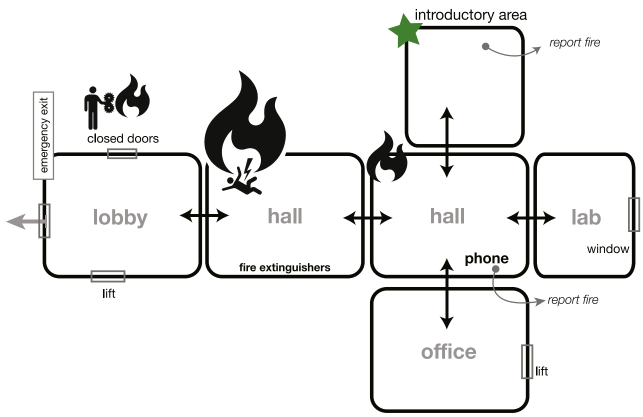

Fig. 9. Plan of locations in OSH game.

objective of the game is to make correct decisions (in the light of mandatory OSH provisions) in the events of encountering obstacles. Significant interactions include: selection of the direction of movement (proper route is marked by the escape route plates, it is not advisable to wander around or return); opening the door (choice of opening method, i.e., the possibility of grasping the handle firmly or checking it with the back of the hand: grasp may cause burns if handle is hot from fire on the other side); searching for objects in the room (“hidden object” element); choosing which objects to take (in the case of fire we first save people — including ourselves, later animals, then property); usage of items (selection of a appropriate fire extinguisher); dialogue box decisions (correct phone report on breaking fire). There is the unconscious person lying at the floor near to plug-in coffee machine, surrounded by fire. Correct behavior is to undertake a rescue attempt by plugging-out coffee machine (“puzzle” element), using an appropriate extinguishing agent and providing first aid.

User interface contains static, first-person perspective view of the scene, the arrows pointing out possible moving directions, the inventory and the list of available objects.

This is a blueprint for interactive simulation in which elements of Knowledge, Skills and Abilities from some domain are tested using DPE/ECD mechanics/evidences. The player has enough time to decide, and the evaluation relies on checking whether the decisions were taken correctly. Involvement, immersion, or emotional relationship are relatively minor — the only challenge is in solving the problem of the unconscious person in the hall. We have used affectively enhanced patterns that also provide information on associated evidences. Basic (non-affective) version of the game is focused on procedures — crucial mechanics are OSH related actions that provide simple evidences of KSA variables regarding player’s safety training. When creating the design first, we used our proposed framework to establish Student Model (and previously mentioned variables i.e. *student has to know which an extinguishing agent should be used in some situation*). SM includes all KSA’s evidences that we want to test in our serious game in relation to Measure Models. Secondly, we established ECD’s Task Model which corresponds with DPE’s Design component. The building elements are: the level (laboratory on fire), the quests (to escape the building, to help the victim), and win conditions (to leave the building, to provide help). The building blocks of Task Model are mechanics, UI and designer’s story. Here we can use mechanics patterns to establish Task Model variables for later evidence evaluation (i.e. pattern *Clues* — signage in the building provides information on the correct escape route but you have to know how to read them). While the game is in progress, Materials & Presentation part of Evidence Model is presented to player (the application, with visual layer and GUI). Interactions result in Work Products that in the light of Task Model variables allow for Evaluation Procedures. It provides Observable Variables, corresponding to the gameplay (DPE’s Play component: storytelling, dynamics and interactivity). Observable Variables can be easily inspected. Measure Models provide information on player’s performance. The operations are presented in Fig. 6.

To enhance the basic game with more engaging content, we need to look into DPE’s Experience component. Out of the set of design patterns proposed by Björk and Holopainen [13], we choose six affective patterns. Note that the use of enhanced patterns not only upgrades gameplay on the level of player’s experience, but also provides additional information to be used in Evidence Model. Another added value is through provided information on possible detection channels for Affective Computing methods. If we want to use bodily sensors, we can use that information to create reliable affective loop within main game loop.

In the discussed design following enhanced patterns were applied (see Fig. 10):

1. **Alarms**: player is constantly reminded of danger (sirens, voice from security systems);
2. **Anticipation**: player can see that something will happen (fire progress near tank with alcohol);
3. **Cognitive immersion**: player needs to solve problems (repair the phone, fix fire extinguisher, unblock doors);
4. **Damage**: player’s avatar can be visibly hurt (icon — damage indicator, momentary blur of vision) as result of bad decisions (grabbing the door handle without checking, bad choice of extinguishing agent);
5. **Surprises**: player encounters unexpected, sudden events (explosions, falling ceiling parts);
6. **Tension**: the appearance of a climax, an important event that player does not fully control and which requires his fast action (injured human who needs help and time counter is ticking);

The layout of the patterns on the game map is shown in Fig. 11.

Finally, the affective version of the serious game provides the modified Task Model. For instance, in the middle room there is an injured person near coffee machine (see Fig. 9); previous mechanics for providing help include: unplugging machine, using proper extinguishing agent, performing CPR. Enhanced mechanics have added *Surprises*, *Damage* and *Tension* (4,5,6) (see Fig. 11). *Surprises* such as explosion of fire, failing ceiling parts have affective influence that can be measured using GSR. ECD’s tasks related to this pattern provide evidences for player **skills** in evaluating changing situations and ability to improvise and concentrate when needed. *Damage* is a special pattern that occurs in the case of wrong decision — choosing bad extinguishing agent or attempt to use water without unplugging coffee machine first will result in visible “harm” to the player’s avatar (scream, red tinted screen). This pattern provides strong affective influence and evidences for possible lack of OSH **knowledge** and **skills**. *Tension* is a general pattern that represents overall conditions in the room – injured human asking dramatically for help, line of fire approaching victim, spilled water near electrical cable. *Tension* provides potentially strong affective influence that can be detected using GSR, HR and HRV sensors. It supports evidences for skills (acting fast in difficult conditions) and ability to stay calm and focus when needed.

As we can see, the provided framework allows for creation evidence based serious games in the paradigm of Evidence Centered Design without loosing crucial gaming properties provided by Design–Play–Experience frame. The whole concept allows for coherent inclusion of Affective Computing techniques in order to deepen the gameplay and control additional, emotional evidences.

Alarms

Alarms are abstract game elements that provide information about particular game state changes.

Example: Some team-based first-person shooters include *Alarms* to inform the players about events that are relevant on a team level, e. g., that a particular goal has been completed or that a certain activity has been initiated by the other team.

Evidence:
(K) Player recognize provided information,
(S) *n.a.*,
(A) Player is able to perform accordingly to provided information

Affect: potential *medium* affective influence of *negative* or *positive valence* detectable via *GSR, HR, HRV*

Instantiates: Disruption of Focused Attention
Modulates: Rescue, Reconnaissance, Stealth, Enemies, Game State Overview
Instantiated by:
Modulated by: Outstanding Features, Bluffing
Potentially conflicting with:

Anticipation

The feeling of being able to predict future game events in the games to which one has emotional attachments.

Example: *Anticipation* is common in roleplaying games when players have planned the development of their characters and they near points where the characters will advance.

Evidence:
(K) Player knows consequences of anticipated events,
(S) Player performs actions according to anticipated events,
(A) Player is able to plan according to anticipated events.

Affect: potential *high* affective influence of *negative* or *positive valence* detectable via *GSR, HR, HRV*

Instantiates: Emotional Immersion Modulates: Tension
Instantiated by: Predictable Consequences, Spatial Immersion, Cognitive Immersion, Emotional Immersion, Downtime, Rewards
Modulated by: Time Limits, Near Miss Indicators, Betrayal, Imperfect Information, Red Herrings
Potentially conflicting with: Surprises, Analysis Paralysis

Cognitive Immersion

Player attention focused upon problem-solving aspects of a game.

Example: laying puzzles can be seen as a game where the *Cognitive Immersion* is completely externalized by the rearrangement of pieces players make while completing the puzzle

Evidence:
(K) Player knows facts and procedures to solve the problem,
(S) Player efficiently solve the problem,
(A) Player is able to approach the problem.

Affect: potential *weak* affective influence of *neutral* valence

Instantiates: Emotional Immersion Modulates: Tension
Instantiated by: Predictable Consequences, Spatial Immersion, Cognitive Immersion, Emotional Immersion, Downtime, Rewards
Modulated by: Time Limits, Near Miss Indicators, Betrayal, Imperfect Information, Red Herrings
Potentially conflicting with: Surprises, Analysis Paralysis

Damage

Effects from actions or events that lead to negative consequences.

Example: In the board game *RoboRally* the first points of *Damage* reduced the number of cards received each round.

Evidence:
(K) Possible negative evidence of lack of knowledge,
(S) Possible negative evidence for lack of required skills,
(A) *n.a.*

Affect: potential *strong* affective influence of *negative* valence detectable via GSR, HRV

Instantiates: Predictable Consequences, Randomness, Orthogonal Unit Differentiation, Tension
Modulates: Strategic Knowledge, Lives, Deadly Traps, Combat, Units, Evade, King of the Hill, Consumers,
Instantiated by: Deadly Traps
Modulated by: Penalties, Achilles' Heels, Status Indicators, Ability Losses, Downtime, Renewable Resources
Potentially conflicting with:

Surprises

Events and consequences that are unexpected by players and disturb their attention.

Example: One of the primary rewards for being a game master in roleplaying games is to be surprised by what the players do with the *Game World* and the story one has constructed.

Evidence:
(K) *n.a.*, in some cases: knowledge about emergency protocols
(S) Player evaluates fast changing conditions,
(A) Player is able to improvise and stay focus when needed.

Affect: potential *strong* affective influence of *negative* or *positive* valence detectable via GSR.

Instantiates: Attention Swapping, Immersion, Spatial Immersion
Modulates: Dexterity-Based Actions, Exploration
Instantiated by: Deadly Traps, Game Masters, Construction, (...)
Modulated by: Damage, Predictable Consequences, Levels, (...)
Potentially conflicting with: Predictable Consequences (...)

Tension

The feeling of caring about the outcome of actions or events in a game without having full control over them.

Example: The dark and claustrophobic environments in the *Doom* games easily cause *Tension* as players guide their *Avatars* through rooms and corridors, expecting monsters to appear.

Evidence:
(K) *n.a.*,
(S) Player acts efficiently in fast changing conditions,
(A) Player is able to stay calm and focus when needed.

Affect: potential *strong* affective influence of *negative* valence detectable via GSR, HR, HRV.

Instantiates: Emotional Immersion
Modulates:
Instantiated by: Attention Swapping, Early Elimination, (...)
Modulated by: Time Limits, Status Indicators (...)
Potentially conflicting with: Perceivable Margins, Downtime, Perfect Information, Replayability, Turn Taking, Reversability

Fig. 10. Set of selected patterns.

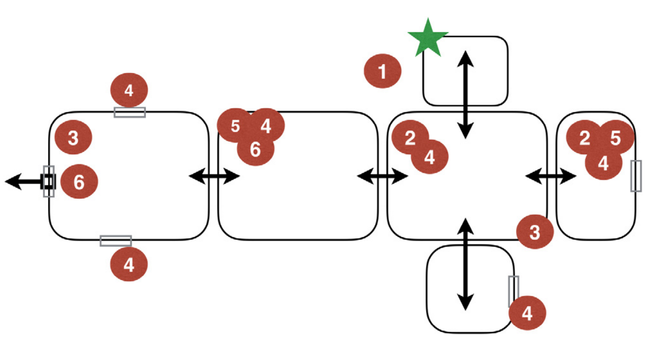

Fig. 11. Plan of affective patterns occurrence in game.

6. User acceptance survey

Since the presented solution is primarily a tool for creating affective serious games that allows for educational evaluation and direct feedback from potential users — game industry specialists' and researchers' opinions are important. In our examination, we prepared a presentation of the proposed tool to some group of game developers. Next, we conducted a survey to study user acceptance of technology. We relied on a very popular model for explaining and predicting tool use based on the work of Davis [87] and follow up studies (e.g. Adams et al. [88] and Chuttur [89]).

We collected a trial group of 40 participants for the user acceptance survey. People belonging to the trial group are all active members of Krakow's gamedev community (including startup scene, gamejam scene, IT clubs etc.). That makes them somewhat representative for the local population of game creators. However, we did not perform any random selection of experimental group but we collected only people who agreed to participate in the survey. Of course, all of them are active game developers. They all work on a daily basis in various companies related to the creation of computer games: both small, local independent studios and large companies with international reach.

6.1. Study of Perceived Usefulness and Perceived Ease-of-Use

TAM (*Technology Acceptance Model*) [87,89] is the theory of information systems that is used to measure likelihood that new technologies will be adopted for use by the target audience. In the TAM, two main observables are distinguished:

1. **Perceived Usefulness (PUSE)** — defined as the degree to which the person believes in benefiting from implementation of new technology.
2. **Perceived Ease-of-Use (PEOU)** — defined as the degree to which the person believes that use of presented technology will be seamless and hassle-free.

We formulated basic **objectives** of proposed framework:

Obj. 1 Creating the tool and conceptual framework for designing videogames;
Obj. 2 Allowing for easy inclusion of affects in mechanics-oriented framework;
Obj. 3 Enabling Evidence Centered Design methods for evaluation of obtained results;

Based on this objectives **hypotheses** were formulated for testing:

Hyp. 1 Proposed solution simplifies the game design process by providing conceptual tools;
Hyp. 2 Presented tools allow for easy integration of the complex phenomena of emotions into the game system through specific elementary mechanics;
Hyp. 3 Patterns enrich and accelerate the evaluation of the effectiveness of serious games at the level of specific evidences;

In order to validate the hypotheses, the survey based inquiry was conducted. There were 40 participants in the study aged between 21–41. All participants (gamedev professionals and researchers) declared interest and practice in the serious game development. The proposed framework and the example OSH project had been presented to this group. Information on the theoretical basis and mechanisms for using the tool had been provided. After that, the participants were asked to answer questions in the survey and informed about the way of answering the Likert-Type Questions (a five-point scale where the first element means extremely negative, and the last — the most positive answer). According to the TAM [87], the questions were aimed to a measurement of the Perceived Usefulness (PUSE):

PUSE-Q1 Do you understand the idea behind the presented tools?
PUSE-Q2 Do you find pattern-oriented design methods useful?
PUSE-Q3 Do you think that having predefined set of patterns makes it easier to include affects into a gameplay?
PUSE-Q4 Do you think that patterns for evidence centered design make it easier to evaluate serious games?
PUSE-Q5 Would you use presented tools in your project?

and Perceived Ease-of-Use (PEOU):

PEOU-Q1 Do you feel able to design games using presented concepts?
PEOU-Q2 Do you think that presented solution is overcomplicated?

The results of the survey for the Perceived Usefulness (PUSE):

PUSE-Q1 : 1: 0% (0), 2: 0% (0), 3: 17.5% (7), 4: 55% (22), 5: 27.5% (11)
1: "I don't understand", 3: "I am neutral about it", 5: "I understand very well"
PUSE-Q2 : 1: 2.5% (1), 2: 2.5% (1), 3: 12.5% (5), 4: 55% (22), 5: 27.5% (11)
1: "Useless", 3: "Neutral", 5: "Highly useful"
PUSE-Q3 : 1: 2.5% (1), 2: 2.5% (1), 3: 12.5% (5), 4: 55% (22), 5: 27.5% (11)
1: "Doesn't make it easier", 3: "Neutral", 5: "Makes it much easier"
PUSE-Q4 : 1: 5% (2), 2: 2.5% (1), 3: 27.5% (11), 4: 37.5% (15), 5: 27.5% (11)
1: "Doesn't make it easier", 3: "Neutral", 5: "Makes it much easier"
PUSE-Q5 : 1: 2.5% (1), 2: 10% (4), 3: 22.5% (9), 4: 32.5% (13), 5: 32.5% (13)
1: "Definitely no", 2: "Neutral", 3: "Definitely yes"

and for the Perceived Ease-of-Use (PEOU):

PEOU-Q1 : 1: 0% (0), 2: 7.5% (3), 3: 12.5% (5), 4: 52.5% (21), 5: 27.5% (11)
1: "Definitely no", 3: "Neutral", 5: "Definitely yes"
PEOU-Q2 : 1: 0% (0), 2: 2.5% (1), 3: 30% (12), 4: 45% (18), 5: 22.5% (9)
1: "It is very complicated", 3: "Neutral", 5: "It is not complicated"

The above results seem to indicate that the professional game developers and researchers well understand need for systematic, pattern-based approach. It shows that the responders of the survey recognized the presented tool as useful and convenient to use. However, it is only a preliminary survey. It is good enough to check that our tool can be recommended for professional teams to design affective serious games. We will do the next evaluation of our tool after it has been used in a couple of game development projects.

7. Future work

We point out several promising research directions for the affective serious games (we refer here predominantly to the Oxford Handbook of Affective Computing [15]):

- machine learning techniques for automated observation of player's actions, behavior, learning outcomes, and sensor data (game data mining);
- mixed-initiative experience design (human–machine co-creation);
- integration of emotion research in the pipeline of serious game production;
- design of learning methods for skills that are not primarily content knowledge-based, like collaboration, communication, ICT literacy, social and cultural skills, creativity (deep learning, soft skills or 21st century skills [90]);
- automated procedural content generation techniques for the design of better games;
- multimodal serious game interaction;
- better methods for evaluation of affective serious games;

8. Conclusions

We have ascertained that Pattern Design and Pattern Language are appropriate means and tools to incorporate knowledge and best practices from different fields. Merging different concepts and ideas into patterns can be consistent for affective serious games. In this paper, affective serious games have been recognized as serious games that benefit from our current understanding of affective game design and emotions role in learning, motivation and engagement. It is imperative for such games to incorporate learning principles, to implement formative and/or summative assessment, to comprise affective aspects of learning, and to be motivating and engaging games.

Our goal was to propose a streamlined approach to design affective serious games. We have reviewed the literature on video game designing, serious games and affective computing, and we have selected some approaches that are either inherently based on or prone to be easily translated into game mechanics oriented design patterns. We have decided the best option for the implementation of MDA and DPE frameworks is to choose Björk's and Holopainen's design patterns [13]. Next, the description of learning goals, outcomes and impacts can be done with ECD framework [16]. The ECD Assembly Model can be translated into the language of game design pattern and merged with DPE framework. Finally, using design patterns [13] we can target issues related to affective computing design paradigms [15].

To conclude briefly, looking for the synergy between gaming, learning and affective control, we started from game design patterns [13] and enhanced them with evidences for educational assessment [16] and affective metrics [15]. Since the game design patterns rely on game mechanics (methods invoked by agents designed for interaction with the game state), it was straightforward to provide that educational evidences and affective states are registered as quantitative data. Moreover, the patterns are communicative for game designers, educational experts, affective researchers as well as for gamers/learners. The impact of theoretically-driven design decisions that influence learning outcomes can be traced with quantitative data and qualitative enquirers. The potential usefulness of the enhanced pattern has been checked with one sample serious game. We have also checked the Perceived Usefulness (PUSE) and Perceived Ease-of-use (PEOU) of the presented technology on the group of professional game developers and game researchers.

Affective serious games can serve as testing environment for affective computing solutions and their psycho-physiological models and cognitive theories. They can be also used in education for learning knowledge, skills and attitudes that are difficult for traditional education to cope with 21st century skills. Finally, affective serious games can operate as mines of data for investigating learning, affective, social and other processes.

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