Towards Effective Serious Games

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***Abstract*—In our current society, with plenty of distractions, traditional methods for learning or performing tasks are losing in effectiveness. Serious games have great potential to replace or complement these traditional methods, because they can take benefit of the intrinsic motivation of people to play and have fun. However, creating serious games that effectively achieve their serious purpose is not obvious. The paper discusses some key aspects required to take into consideration in order to come to more effective serious games. First, we identify and justify requirements for the development process, being tools to assist the multidisciplinary teams in the development, as well as dedicated methods, guidelines and knowledge, where it is a requirement that the methods and guidelines should explicitly deal with the interdisciplinary character of serious games. Next, we argue for two important aspects for the games themselves: the use of some form of personalization or adaptation to the target audience, and the incorporation of an explicit debriefing phase.**

Keywords—serious games; effectiveness, multidisciplinary tools; interdisciplinary development methods; interdisciplinary guidelines; personalization; adaptation; debriefing

I. INTRODUCTION

In general, serious games are characterized as (digital) games used for purposes other than mere entertainment. In [1] (p. 31) they are explained as follows: "Serious games use entertainment principles, creativity, and technology to build games that carry out a government or corporate objective". Nowadays, serious games usually refer to games used for training, education, rehabilitation, or have some business purpose. In the context of learning and training, they are used in the educational sector as well as in military, by governments, and companies. Also in the domain of healthcare, many serious games have been developed. They are used for physical fitness and rehabilitation (so-called "exergames"); to adjust habits and lifestyles; to learn how to deal with diseases and treatments; or for diagnosing and treating mental illness/conditions, such as ADHD (attention deficit hyperactivity disorder) and PTSD (post traumatic stress disorder); see e.g. [2], [3] for an overview in this context.

Although the primary objective of serious games is not entertainment, they should create playful and engaging experiences for their users, as they want to take benefit of the intrinsic motivation of people to play and have fun. To achieve such an engaging experience, motivating and fun features of entertainment games are applied in serious games.

An abundance of serious games have already been developed and a lot of publications report on how this has been done. However, very often ad hoc approaches have been used for the development and the results very much depend on the creativity and motivation of the authors. Developing a serious game that is successful and effective is not easy. There are two major challenges: (1) it should be an attractive and engaging game for its target audience and (2) it should achieve it serious purpose. The first challenge is about fun. Fun is not easy to achieve. It is well known that developing a successful entertainment game is a great challenge and quite risky. However, in the case of a serious game, the issue is even much more challenging because the serious purpose may interfere with the game elements and limit the possibilities to create fun.

To deal with the second challenge, i.e. ensuring that the serious game is effective, not much knowledge or methodologies are available. The objective of the paper is to explore major requirements for the development process and for the serious games themselves to ensure a greater degree of certainty that the serious game will indeed be effective.

The remainder of the paper is organized as follows: section II investigates several key requirements for the development process of serious games needed to be satisfied in order to have higher chances of realizing an effective serious game. Section III and section IV discuss requirements that are related to the serious game itself. Section III argues for some form of personalization or adaptation to the target audience, while section IV discusses the need for the incorporation of an explicit debriefing phase. Section V presents conclusions.

II. DEVELOPING EFFECTIVE SERIOUS GAMES

Although, serious games cover a broader domain than education, the issue of developing a serious game is comparable to the development of technology-enhanced education. According to the TPACK model [4], technology-enhanced education requires three main bodies of knowledge, i.e. content, pedagogy, and technology, which all need to

successfully interact. This model is also applicable to the development of serious games, although, and depending on the purpose of the serious game, the pedagogical knowledge should be replaced by (or extended with) knowledge from other domains such as psychology, physical training, or the medical domain. For instance, when behavior change is the purpose, pedagogical knowledge in combination with psychological knowledge is required; when fitness and physical rehabilitation is the goal, knowledge from the domain of physical training is needed; and when the game is in the context of medical therapies, knowledge from the medical domain as well as from psychology may be required.

When we apply this TPACK model to serious games, we see that knowledge is needed (1) about the subject matter or content (e.g. math or a medical condition), (2) about games (being the technology), and (3) depending on the purpose about one or more additional domains (pedagogy, psychology, sociology, medicine…). These additional domains will provide the knowledge on how to achieve the serious purpose (being for instance cognitive or skill learning, behavior change, or therapy adherence). We will refer in the rest of the paper to these additional domains as the "purpose domain(s)".

As argued by different authors [5]–[8], this complexity calls for a multidisciplinary team of experts including game developers, subject-matter experts, and experts from the purpose domain(s) (e.g., pedagogical experts, and/or psychologists, and/or therapists). When the game is based of a narrative, also narrative designers are included. Such multidisciplinary teams often experience communication and collaboration problems due to the different terminologies, backgrounds and concerns of the people involved [9]. Even in well-established serious game development teams, the subject matter experts will in general vary from serious game to serious game, and may be unfamiliar with serious game development and the other disciplines involved. To actively involve all experts in the design and development process, and to avoid communication and collaboration problems, suitable tools are required that allow the experts with a non-technical background (i.e. subject matter experts and experts from the purpose domains) to actively collaborate with the technical partners (i.e. the game developers). This identifies a first important requirement for the development of effective serious games: *multidisciplinary tools to assist the development of serious games.*

Tools developed for software development in general are not suitable as such for serious games, because of the special character of serious games. A first reason is that tools for software engineering are not developed for multidisciplinary teams but only for software engineers. Furthermore, they do not provide explicitly support for the interdisciplinary character of serious games, i.e. for the integration and application of theories and strategies from the purpose domain(s).

An example of a tool that is specifically developed to support multidisciplinary team is GuideaMaps [9].

GuideaMaps [9], [10] is a tablet app that supports the early phase of the development process of a serious game, i.e. the requirement elicitation phase. The software tool assists a multidisciplinary team in this first phase. Meetings in such a first phase and with that many different types of people, tend to become quite ineffective. To guide the participants through the process, the app provides a structured list of issues to consider, and assists in providing answers to these issues by providing explanations, possible solutions, and impact of choices. The issues to discuss and decide on can be defined in advance or predefined templates can be used. Depending on the purpose of the serious game, different issues should be considered. For instance, examples of such issues for a learning game for children are: learning goal; didactical approach; the age range of the target players; gender issues; competences of the players; learning styles and preferences of players; player styles of players; the platform on which to offer the game (PC, tablet, smartphone, the Web); the availability of the game (as closed environments or publicly available); the embedding of the game in a learning environments or in social networks; the involvement of teachers, parents, friends, and other coaching issues; issues about risks and privacy; the duration and the genre of the game; game mechanics to include/avoid; type of feedback; motivation for playing the game; available budget and resources …. Furthermore, the tool also documents choices made and issues considered, and indicates the impacts of choices.

Although, suitable tools and the involvement of different experts can help in the development of better serious games, this is not yet a guarantee for success or effectiveness. In software engineering in general, we revert to the use of *methods* to guide us in the development of software, where a method is defined as an established, habitual, logical, or prescribed practice or systematic process of achieving certain ends with accuracy and efficiency, usually in an ordered sequence of fixed steps[1].

Different methods have already been developed for serious game development. Examples are [11]–[14]. However, methods or tools that allow or provide a true integration of the methods or principles from the purpose domains are scarce.

An example of such a work is ATTAC-L [7], [15]. ATTAC-L provides a Domain-Specific Modeling Language to support the participation of experts with limited computer engineering background in the specification of narrative-based serious games [16], [17]. It combines a syntax based on a controlled natural language with flow chart modeling principles to allow both technical and non-technical people to model the narrative of a serious game. The output, a formal specification of the game narrative, can be processed automatically to generate parts of the code for the serious game. ATTAC-L does not aim to cover the complete design of a serious game; it focuses on the specification of the narrative. However, in addition to the narrative and related game actions, it also allows to integrate specifications from the purpose domains. For this an annotation system is used that allows expressing the connections that (should) exist between the narrative and the strategies developed to achieve the objectives of the serious game. As each purpose domain has its own theories and strategies, and each theory and strategy has its own principles, it is not possible to provide a single recipe for integrating such principles and strategies into a serious game.

[1] www.businessdictionary.com

Therefore, an annotation system is used as a general mechanism. Annotations allow to integrate different types of specifications into the narrative but without compromising the flow of the narrative and without complicating the understanding of the different specifications. Different types of annotations can be defined to allow for the integration of different theories and strategies. For instance, this has been done for Social Cognitive Theory (SCT) (a pedagogical theory) and for Intervention Mapping Protocol (IMP) (a pedagogical design strategy).

In addition to methods, software developers also use guidelines, which are based on research findings and good practice and are rather method-independent. Also general and specific knowledge about the development of ICT are used. Again, guidelines and knowledge developed for software development in general are not always suitable because they do not take into consideration the interdisciplinary aspects of serious games and the specific requirements of games.

This observation results in two other major requirements to come to effective serious games: *guidelines for developing serious games* and *knowledge about serious games*. Already some guidelines and specific knowledge for serious games development have been developed. Some examples are [18]–[20].

III. Do Away with the "One Size Fits All" Approach

Although, dedicated tools, methods, guidelines and knowledge are essential to realize effective serious games, they still are not a guarantee for success. The first reason is that all people are different: they have different preferences, different abilities, different performance motivations, different personality treats, and so on. What works for one person, may not work for another person. A (serious) game that is engaging and effective for one person may not be engaging and effective for another person.

In education, personalization is argued to be an effective way to positively affect the learning outcomes of individuals (see e.g. [21], [22]). Because most of the time a serious game is about learning (in the very broad sense of the word), we argue that this is also the case for serious games. Research has shown that good game experience is positively correlated with better learning. It is argued [23], [24] that good game experience could lead to a state of absolute absorption into a task. In this "flow state", the activity itself becomes rewarding in its own and enables individuals to function at their fullest capacity [25]. By considering the needs, abilities and preferences of players, one could create games that can positively influence the game experience of the players, which, in turn, will positively affect their effectiveness. Therefore, a promising avenue to deal with (some of) the challenge of effectiveness is to make sure that the serious game is adapted to the characteristics of the individual player. However, how serious games can be personalized, which factors can be used to personalize (e.g. personality, gender, learning types, user abilities, player types, user states, contextual/situational variables, …), what effect personalization has (e.g. on player/user experience), and whether there is any return on investment is still largely unexplored [26].

To be able to offer a personalized serious game, one must first understand the user's needs, abilities and preferences and then adapt or construct the product or service accordingly. Personalization exists in different flavors, can be at different levels of depth, and realized at different moments in time. For instance, the product (in our case the serious game) can be tailored in advance (i.e. during design, also called *player-centered design*), or adapted at the start of its use (often called *static adaptation*), or can happen completely dynamically while using it (often called *dynamic adaptation or adaptivity*). Furthermore, it can range from adapting the serious game to a specific target group to true personalization where the serious game is completely tailored to the individual user. Furthermore, different aspects of the serious game can be subject of adaptation, ranging from content and difficulty level, over game objects, game environment, NPC behavior, and music, up to a tailored game logic, narrative, interaction modalities, and game mechanics. In the context of adaptive hypermedia, Brusilovsky [27] calls this the "what to adapt" question. Next, numerous aspects of a user can be taken into account as inputs for the adaptation, for instance performance, background, expertise, prior knowledge, skills, preferences, learning style, intelligence levels, personality traits, affective states, etc. Brusilovsky calls this: the "to what to adapt" question. The aspects used for the adaptation can be measured or obtained either prior to using the system, or while the user is using it. Measuring aspects during the use of the system is only useful if the values of an aspect tend to change considerably during the use of the system, like the performance or affective states. Finally, systems can differ in how they realized the adaptation (the "how" question of Brusilovsky). Often, some form of "adaptation rules" is used. For instance, in the case of player-centered design, the "how" is about following rules (guidelines) that suggest certain aspects of the system based on aspects of the user. In the case of a dynamic adaptation on the other hand, adaptation rules are defined which are deployed in real-time based on the real-time measurements of the aspects of the user and the objectives of the system. Instead of rules also some form of artificial intelligence can be applied. A general framework covering all these aspects has been presented in [28] (a previous version of the framework can be found in [29])

In general, the adaptation is limited to a few of these factors and in practice most frequently to performance and prior knowledge. In research, also adaptation to more advanced factors has been considered, e.g. boredom, engagement and anxiety [30]; heart rate and breathing [31]; attention [32]; learning style [33]; and player type [34]. But other factors are also possible. For instance, in [35] adaptation to the Theory of Multiple Intelligence (MI) [36] is considered. The theory of MI states that the intelligence of a human being is multi-dimensional, as opposed to the common one-dimensional understanding of intelligence (i.e. expressible as Intelligence Quotient). In MI eight different dimensions are recognized. The Theory of MI states that everyone possesses all intelligences but to different degrees. The research presented in [35] explored the applicability of the Theory of MI for personalized and player-centered (serious) game design by looking for empirical evidence. The investigation shows that there is a correlation between gamers' intelligences, their preference for games, and game mechanics. In this way, the

Theory of MI could be an interesting path to follow for the adaptation of game mechanics to the preferences of players. In [37], [38], the results have been applied in two use cases. The (serious) games developed for these use cases were designed and developed specifically for people with high intelligences in one of the dimensions of MI. Based on the mappings proposed in [35], the design process included the selection and incorporation of game mechanics that were identified to be positively related with these dimension of MI. The performed evaluations confirmed the hypothesis that the proposed adaptations would have a positive effect on game experience and learning outcome. In addition, to allow developers to benefit from the findings, a recommendation system has been developed that provides information about appropriate and non-appropriated game mechanics for different intelligence dimensions [35].

IV. Debriefing

While a lot of articles have been published that provide an evaluation of the serious game under consideration, evaluations that measure the transfer of learning to real-world settings are scarce. It is not because the player performs well in the serious game that this person will also show the same performance in the real world and over time. Therefore, a question related to effectiveness concerns how to increase the chance that learning transfer takes place. D*ebriefing* could be considered for this purpose. Debriefing in serious games can be described as the activity of reflecting on the gaming experience to turn it into learning [39]. It is argued in the literature [39]–[42] that reflecting on the in-game performance is important for facilitating learning transfer. Although they may be different ways to support reflections (e.g. reflection amplifiers [43] and self-regulation [44]), one possible way to facilitate such a reflection is by means of a so-called debriefing phase. Most digital serious games however do not include an explicit debriefing phase. If a debriefing phase is considered, it is usually performed with the help of a human facilitator who discuss the game results with the player. Although such an approach may be quite effective, it is expensive, time consuming, and not possible when the serious game is used in a non-facilitating space (e.g. at home) or when no expert-facilitator is available. Therefore, an automatic debriefing facility for serious games would be more optimal. However, a general approach for creating an automatic debriefing system for serious games doesn't exist. Moreover, the development of such an approach is complicated by the fact that there are many different types of serious games, which may require different approaches.

In [45], some first results on an automatic self-debriefing system for a serious game to deal with cyber bullying in social networks are presented. The considered serious game displays realistic behavior based on AI and has multiple possible paths to a solution, which makes it not trivial to inform the player on the outcome of the game in a way that would allow reflection and understanding. Therefore, it was decided to provide explanations on the course and outcome of the serious game without explaining the details of the inner logic used by the serious game. In the paper, three different visualizations for such an automatic debriefing are described. Visualizations were used because they allow to display a large amount of data in a compact way. Each type of visualizations focused on a different aspect: events that occurred in the course of time (time-based visualization), the activities of the different characters involved in the serious game (character-based visualization), and the interactions that took place in the serious games (interaction-based visualization). A working prototype was implemented and evaluated in a pilot study. The results indicate that the visualizations did help the participants in understanding the outcome of the game better and that the interaction-oriented visualization scored best.

V. Conclusions

While many serious games have been developed, it is not always clear whether they are indeed achieving their purpose, i.e. if they are effective, and whether there is transfer to reality, i.e. will players apply what they learned or did in the game also in real life.

The paper explores some major requirements for the development process of serious games to ensure a greater degree of certainty that the serious game will indeed be effective. Based on the TPACK model, we identified three major bodies of knowledge needed for the development of serious games: knowledge about (1) the subject matter or content, (2) about games, and (3) depending on the purpose of the serious game about one or more additional domains (pedagogy, psychology, sociology, medicine…) (referred as purpose domains) that provide the knowledge on how to achieve the serious purpose. Based on this, we identified and justified the need for *multidisciplinary tools to assist the development of serious games*, as well as *dedicated methods, guidelines* and *knowledge about serious games*. Essential is that these tools, methods and guidelines explicitly support the integration of knowledge from the purpose domains, i.e. they deal with the interdisciplinary character of serious games.

In addition to the key requirements for the development process, we also identified two requirements for the serious games themselves: *some form of personalization or adaptation to the target audience* and *the incorporation of an explicit debriefing phase*. The first one is justified by the fact that everybody is different and has different needs and this should be considered to come to effective serious games; the second one is used to allow the player to reflect on the outcome and course of the serious game in order to facilitate transfer to reality, which is also an aspect of effectiveness.

A brief overview of the state of the art with respect to these different requirements is provided and recent research efforts are briefly described to illustrate how we can deal with those requirements.

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