REUSABILITY IN SERIOUS GAMES ENVIRONMENT

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Abstract: The importance of interoperability in information technology is well known. The ability of systems to interoperate with another is a concern which must be considered simultaneously from technical, semantic and pragmatic perspectives and covering all the concerns relevant for different stakeholders. This paper addresses standardization, reusability and interoperability issues in serious games environments, with the purpose of highlighting their importance in building the efficiency of the serious game development processes. The authors introduce a Serious Games Multidimensional Interoperability Framework that enables the construction of interoperability scenarios, and detail reusability opportunities in the serious game mechanics and assessment areas. The research also pleads for the impact that creativity has on the development of new interoperability solutions.

Key words: Interoperability, Reusability, Standardization, Serious Games.

1. Introduction

It is often said that "the nice thing about standards is that there are so many to choose from." Having different standards for things like electrical plugs and mobile telephony is at best an inconvenience and at worst a significant expense. But in a field such as learning technology multiple standards may be an opportunity for efficiency.

The impact of standards in learning technology has been enormous. SCORM is one example. But even the many standards with minimal adoption have influenced the construction and functionality of learning management systems, assessment engines, learning content management systems, repositories, and other learning technologies.

Developing serious games in a way that enables interoperability is one means of increasing the depth and scope of instructional materials available to learners while reducing the overall development costs and time. Interoperability, the ability of computers and applications to communicate and share resources in a heterogeneous environment, is dependable on standards. Optimizing requirements of accessibility, interoperability, durabiliy, and reusability for maximizing cost efficiency start with a proper understanding and integration of standards. Interoperability standards often affect the design and development of serious games. Some standards are overlapping, while others are independent. Some standards complicate the development of serious games, yet the lack of a universal interoperability standard often hampers development.

In the technical context of serious games, interoperability concerns the ability to transfer and render useful data and other information across systems, applications, or components. Research has revealed that it is equally important to go beyond this core technical approach and explore a broader understanding of what interoperability means in different contexts and at different levels.

Interoperability can be employed in many contexts. SG consumers who want to be able to choose from a broad range of applications are advised to purchase systems that offer interoperability across different providers and services. SG developers who seek to develop and market their own SGs are usually more likely to succeed if they pursue an interoperability-based approach. SG Project Managers should strive for interoperability among teams, and workflows. Educational institutions can operate at lower costs and with greater efficiency, and thus can provide better experiences for learners.

Therefore, when creating or adjusting operational frameworks aimed at fostering SG innovation, it is necessary to consider various approaches that foster incentives for interoperability, as well as efficient methods to address unforeseen and undesirable consequences.

2. Core Issues in the Reuse and Sharing of Resources

2.1 How can digital resources be used to support learning effectiveness?

Digital resources are often conceptualized as blocks that could be interlinked as to produce a learning unit, in our case a serious game. Analogous with Lego bricks, these blocks can be recombined with other blocks and reused to develop a different serious game. This simplistic view, while helpful in certain circumstances – e.g. designing a new serious game -, produces a rather narrow model of the educational process. Teaching does not involve only the transmission of information, and the uncomplicated acquisition of knowledge and resources.

Game-based models of education place constructive activity at the heart of the teaching and learning exchange. Learners do not just acquire information; they also construct their own knowledge through diverse interactions – with learning materials, with other players, with tutors - in various game environments. Under this perspective, a key issue is how learning objects could be used to support different kinds of activities and interaction patterns.

In the context of SG interoperability, one way to approach this issue is to view the student learning activities and interaction patterns as resources themselves: as templates (for example a framework for discussion or a learning task) that SG developers/ teachers could access and use to create a serious game.

2.2. How can resources be reused within a range of educational models?

Content and learning activities only do not suffice to develop a serious game. They usually need to be combined in different ways to create new serious games based upon different educational models. Serious game design represents a middle layer that integrates the content and the learning activities within the framework of an educational model. Since there are numerous educational models, their complexity has been another issue that had to be tackled. The development of authoring tools aims to enable teachers to model and implement their own educational design. They can populate the SG with content and process resources and customize the SG according to specific learning objectives.

2.3 What is the role of standardization?

The reusability of different kinds of resources in many contexts implies some degree of standardization both of the description of the resources and of the tools and environments these resources inhabit.

In education, LOs have emerged from the need to support rapid deployments of instruction, and they were developed to enable searching based on carefully constructed metadata schema intended to make learning objects work seamlessly with learning management systems (LMSs) [1]. They were meant to revolutionize course design and dramatically lower the costs of instruction and training by facilitating rapid course assembly, "drag and drop" course design, and growing collections of shared materials. Educational institutions have clearly embraced the idea of applying reusable LOs to the development of content. LOs could take many forms, and the perspectives were promising. Today, LOs are typically very complex and detailed, many carry the load of the entire curricular component, they still hold the vision of rapid course assembly, and they have a great reusability potential in e-learning environments [2].

The debates on LOs have focused mainly on data standardization, interoperability, metadata, SCORM, and LOM, and very little on those responsible for designing instruction using LOs [3]. As a result, many of the objects and attributes that have been placed in massive learning object

repositories are infrequently used by designers or instructors [4]. This may be attributed to the lack of common features available in the collections or just the lack of understanding by designers and instructors on how these granular objects can be used in larger sets of instructions [5]. There might also be issues related to context or lack of intellectual property policies.

There is a growing dichotomy between the needs and the practices of TEL environments in terms of reusable learning materials, and this is even more obvious in SG ecosystems. The emergence of SGs has brought forward new challenges in terms of LOs reusability and has revealed other limitations in terms of LOs adaptability to specific SG requirements. SGs require a high degree of resource customization, and LOs are capable to adapt only partially.

In this context, it is necessary to consider the opportunities of LOs for SG ecosystems, assimilate the collected experiences, and address the emerging challenges related to SG reusability/ adaptability. Since not all LOs are reusable, it is necessary to differentiate reusable elements, as well as the particularities of the digital resources required to develop a SG.

To address these issues, the Serious Game Asset (SGA) has been defined as the smallest component of a SG that has individuality, can be reused, is modular and can be exchanged based on predefined rules. SGAs are to be identified and their properties are to be defined, in order to facilitate standardization efforts and LOs reusability.

In order to enable teachers to develop their own customized SG, it is important that they have access to SG assets. Without standardization it becomes exceedingly difficult for teachers to find the digital resources that fit their needs, to share these resources with others or to use them in different development environments.

Moreover, in industry, SG developers usually apply standardised or proprietary solutions. It is necessary to identify measures that facilitate the creation of an optimal blend that enable a win-win situation between academia and industry.

Under these premises, it is important to consider that anyone who produces resources for a digital repository has to provide a description of that resource in terms of standard metadata. Standards here ensure interoperability of resources across different environments and platforms. Another significant aspect relates to how easy can a teacher/ developer locate resources in, and retrieve them from a digital repository. This can be facilitated by taxonomies. Without an agreed classification system and terminology it is difficult to identify specific resources in a repository.

3. Reusability Opportunities in Serious Games Environments

Serious games development is a complex process that involves many factors with a high optimization potential. Interoperability is one of these factors and it has a major, positive impact upon learning effectiveness, if applied properly. Educational technology standards have tried to provide optimization patterns, but failed to reach their full potential, mainly because they have addressed particular issues and not an integrated perspective. To achieve success in SG interoperability it is important to consider the entirety of a SG Project development.

3.1 Serious Games Multidimensional Interoperability Framework

Sound interoperability exceeds the limits of technical and semantic solutions, especially since serious games apply to various areas, such as business, government, military, medicine, architecture, etc. [8]. Based on the above-mentioned considerations, it is obvious that interoperability is achieved through multiple tools and approaches. Consequently, it implies the need for collaboration at multidimensional levels that would reunite user communities (such as teachers and developers), software, hardware, standards, etc. Considering these various interactions and the complexity of interoperability, the researchers employ a Serious Games Multidimensional Interoperability Framework (SG-MIF) that would ease the comprehension and the adoption of SG interoperability through the integration of three core dimensions: SG Components, SG ecosystem and factors beyond SG [11,12].
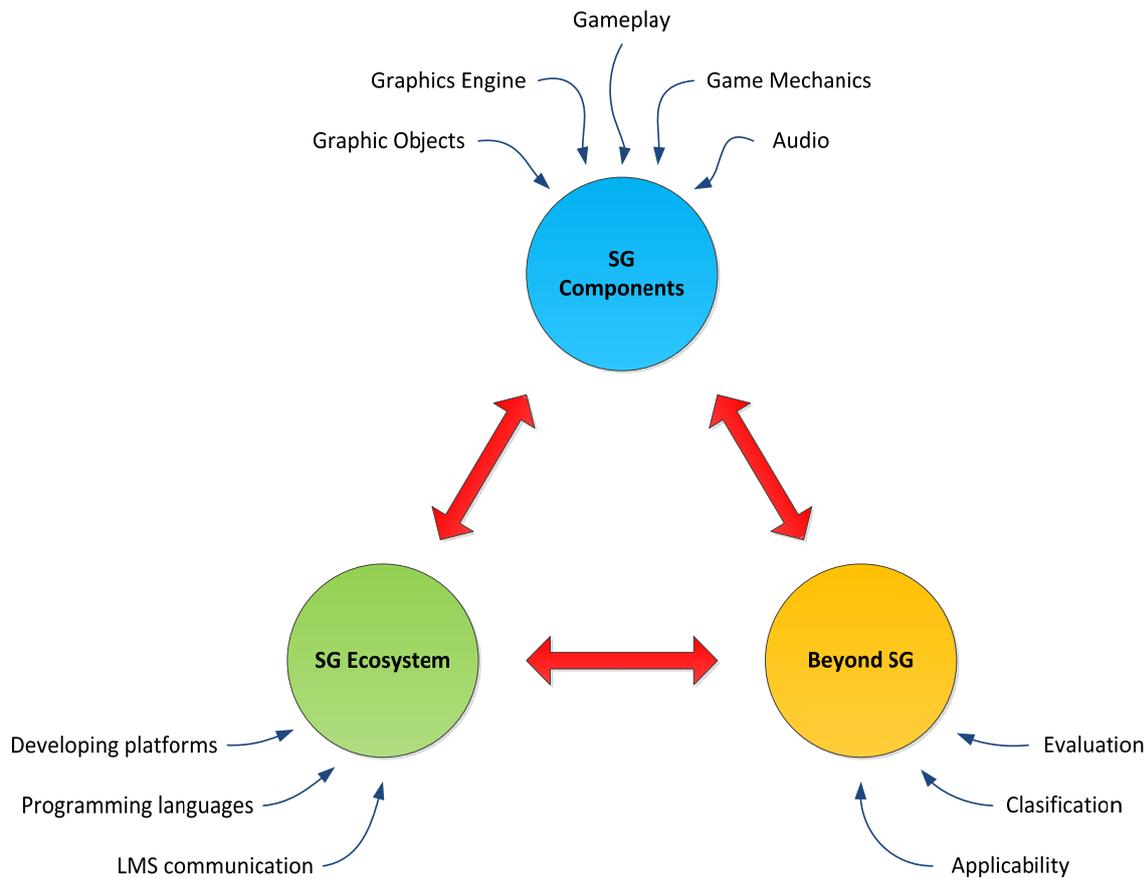
Figure 1. Serious Games Multidimensional Interoperability Framework (SG-MIF)

3.2 Serious Game Mechanics

Due to the role game mechanics play in games, as well as their potential complexity, the reusability of SG mechanics becomes an extremely important factor in the economy of a SG Project. SG mechanics represent a significant part of a SG budget and reusability solutions would ease the development process. Moreover, they bridge the gap between educators and developers, by enabling developers to follow the translation of technical components into pedagogical constructs.

Each piece of code in a serious game has a definite objective and it is designed to be modular. If a developer changes a game mechanics in one area of the code, that mechanic is changed automatically throughout the player's entire experience of the game.

Game design is also modular in nature. This feature is more obvious in the case of a global design than in the case of a local design that is adjusted by the designer by combining and manipulating various assets. Local design usually implied a high degree of customisation and therefore it is basically not reusable, but all global deigns are potentially reusable, and their implementation generally involves a coder modifying precisely the sort of modular code mentioned above. This context reveals the fact that interoperable serious games mechanics do not deal exclusively with various classifications of mechanics, but also with different dimensions of these mechanics.
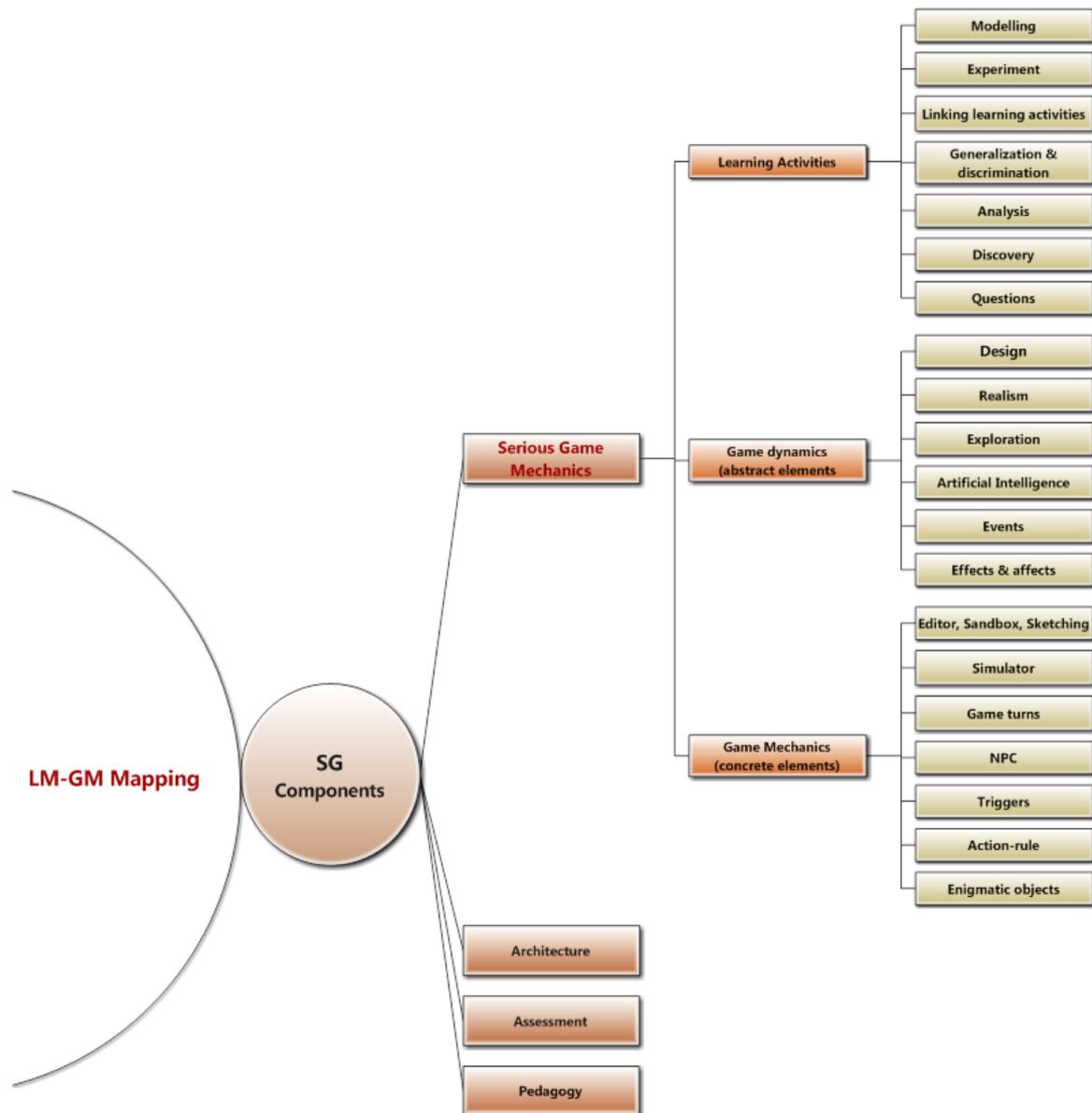
Figure 2. Interoperable serious games mechanics

3.3 Serious Games Assessment

Serious games, like any other educational tool, must be able to show that the necessary learning has occurred. Both the medium of serious games itself and its newness create certain challenges that can make assessment difficult. The SG assessment can take different forms:

- Completion Assessment - Did the player complete the lesson or pass the test?

- In-Process Assessment - How did the player choose his or her actions? Did he or she change their mind? If so, at what point? And so on.

- Teacher Evaluation - Based on observations of the student, does the teacher think the student now knows/understands the material?
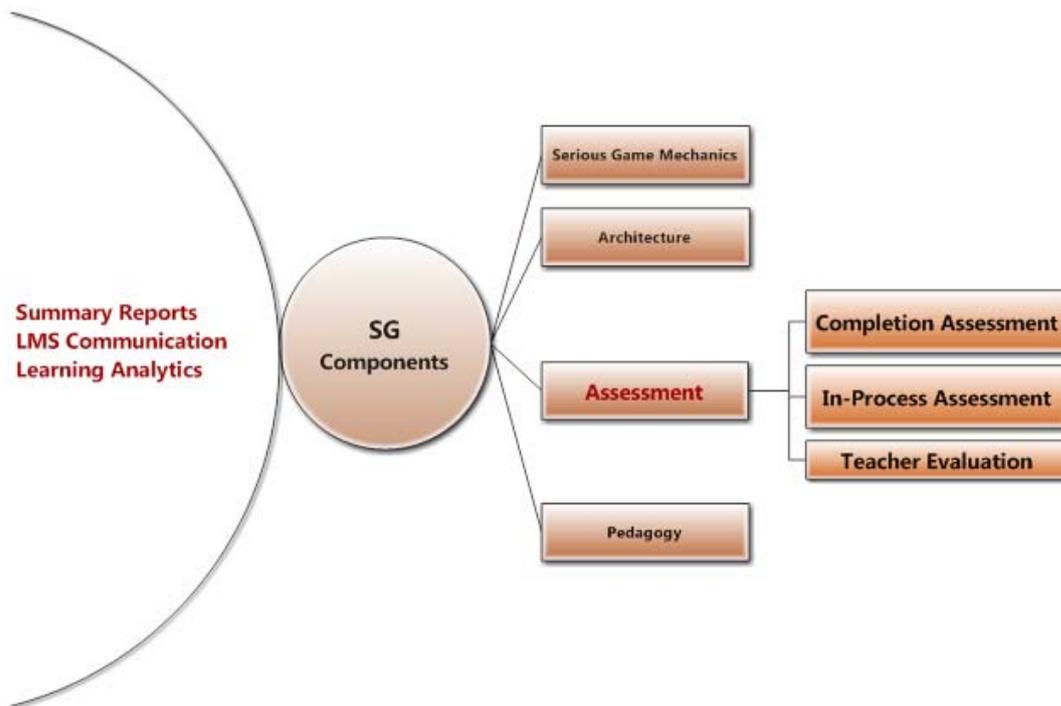
Figure 3. Reusability and Serious Games assessment

In-game assessment and reporting

- A common structure for the assessment reports promotes the analysis learner performance as a repeatable task, that is, once the teacher understands the structure of the report the first time he / she can go directly to the section that he / she is interested.

- The integration with Learning Management Systems (LMS) provides de ability to collect the assessment information in one place (in addition to the other assessment and evaluation activities done in the LMS).

External game assessment

- The ability of doing an external (not directly done by the game itself) and a posteriori analysis and evaluation of the game play sessions provides more control over the assessment process.

4. Creative SG Interoperability Solutions

Standard conformity often entails behaving and thinking in a certain way, not questioning, complying, and doing what is generally expected [4]. Standards aim to enable a solid framework for the sustainable development of SG Projects. They provide patterns for automatic assignment of solutions that usually are perceived to reside in complete opposition with the creative spectrum.

To bridge creativity and standardization, it is necessary to enable an innovative approach to standard implementation and development, and consider creativity driven factors in SG environments. On one hand, it is important to consider that all creative works build on what came before [6]. On the other hand, creative development needs to consider the inherent issues and the limitations that standards imply, since every creative journey begins with a problem [7]. Few of these journeys, even if they are driven by great ideas, reach a practical maturity [3]. To address this problem, it is important to create a flexible framework that supports the assimilation of creative and disruptive approaches in standardization and interoperability.

To effectively implement standards in creative SG development ecosystems it is important to consider the elements that stimulate creativity:

- Enabling environments: Provide a stimulating environment in which creativity, originality,

and expressiveness are values and fostered.

- Creative relationships: Give opportunities for SG developers to interact with teachers, students, other SG/ IT developers, etc., so that they see at first hand different perspectives, they can communicate ideas and collect various responses.

- Knowledge sharing: Include resources and knowledge from a variety of domain in order to stimulate new ideas, disruptive approaches, and different ways of thinking.

To facilitate standards adoption it is necessary to consider and operate on different dimensions that impact upon implementation:

- The technological layer. From a technological point of view, interoperability deals with hardware and software components and their ability to connect to one another and to be reused.

- The human layer. Interoperability often succeeds or fails based on the ability of the human factors involved to communicate.

- The institutional layer. Interoperability should be considered both from the point of view of an organisation and from the point of view of cross-organisation cooperation.

- The benefits that standards and interoperability solutions can bring to a SG Project are not always employed at full potential because key potential users are not aware of the positive impact they can have. To increase awareness, the following specific measures have been identified: increasing attention to standards use; carry out evaluation processes; orientation to stakeholders' needs; and consider the level of standardization.

5. Conclusions

Serious games introduce significant new requirements for robustness and interoperability, and encourage game developers to better align their practices with trends in the educational domain. In addition to new languages and middleware, developing and adopting standards for interoperability could benefit both the developers and the serious games user communities, and facilitate growth of the genre.

To obtain sustainable results, it is important to identify and analyse the interoperability opportunities that occur during the development process of a SG Project. By modelling the workflow of a SG development lifecycle as a value stream and then create an interoperability tracking and visualization system, interoperability opportunities can be identified, analysed, customised and implemented. Such a system has to rely on an extensive mapping of interoperable SG assets that presents best practices, and details the strengths and weaknesses of each case scenario.

This paper addresses the core issues in resource reusability and presents two scenarios of reusability in SG environments, based on a Serious Games Multidimensional Interoperability Framework. The development of the Serious Games Multidimensional Interoperability Framework aims to enable educators and developers reach a common understanding and implement cost-efficient, qualitative SG interoperability solutions. The framework considers the three key topics that impact SG interoperability: the components included in a serious game, the ecosystem where the serious game will be implemented and external factors that go beyond the core technical aspects of a serious game. The authors also consider the impact that creativity has in the development of new solutions, highlighting the need to enhance interoperability opportunities.

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