Defining a Metadata Schema for Serious Games as Learning Objects

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Abstract— **Games are increasingly recognized for their educational potential. However, when used as a learning resource, games can differ substantially from other educational media. They often combine high-fidelity audio and video content with experiential, social, or exploratory pedagogy. As educators increasingly turn to technology to support the delivery and management of content, the capability to describe and package serious games effectively as reusable learning objects (LOs) is increasingly vital. Doing so requires developing the capability to express games not in terms of technical boundaries, but as coherent and discrete LOs, which can be reused and combined. Enabling this requires metadata be attached to games, whilst making the metadata schema explicit to allow the use of the metadata beyond its original scope. Furthermore, standardisation of metadata schema means that systems are able to work together and use data interchangeably. However, current standards for describing educational content cannot directly be utilized to describe these serious games as educational resources. This makes it difficult to include serious games in repositories of learning objects and to describe them in a coherent way in the various online repositories. This paper introduces a metadata schema for describing serious games as educational resources, based on existing standards, so that serious games content can be described within online repositories.**

Keywords-Serious Games; Game-based learning; Metadata; Repurposing; Rating; Web2.0

I. INTRODUCTION

Experts are increasingly recognizing the educational potential of serious games [1] and their use has been growing over recent years. Serious games can provide learning environments, which studies have shown can enhance efficacy over traditional learning [2]. According to Norman and Spohrer [3] a learner's motivation makes more difference to the learning outcome than any other factor. An advantage of computer-based instruction is that it can engage learners, particularly though its support of high-frequency feedback in novel forms [4]. Serious games often combine high fidelity audio or video with elements of game play, in order to offer a more immersive learning experience that provides even higher levels of engagement and direct feedback than more traditional computer-based learning materials.

The potential of computer-based education has been well established [3] and indeed various standard metadata schemas have been developed [5] to describe digital educational resources in a coherent way. The use of standards means that materials can be used and re-used across platforms and systems. However these standards are not capable of capturing serious games fully, missing out important aspects, such as the context a particular game can be used in, and what type of learner and age group it is suitable for. The most important aspect is pedagogic; particularly as serious games are often shown to work most effectively when blended with other instructional techniques and resources [6], [7] and the same may fit in different blended scenarios. Whilst standards exist, there are no general and complete standards for describing serious games as educational resources. Developing games is a complex and costly affair; games have been shown to work best in a blended approach and repurposing games is complicated as there is not always a one to one relationship between serious games and learning goals [8]. Therefore, it is essential to have the interoperability between different learning platforms and metadata standards. Torrente and colleagues [9] attempted to export games to self-contained Learning Objects (LO), which could be easily distributed through any Learning Management System (LMS) compliant with the current interoperability standards.

However, when attempting to create descriptions of serious games in a comprehensive interoperable manner, a standard is required. As such a standard does not currently exist, the authors of this paper propose a metadata schema for describing serious games as educational resources, based on existing metadata standards and a comprehensive four dimensional framework for evaluating serious games proposed in [10], [11]. The work is based on work around creating an educational metadata schema and repurposing of serious games in the mEducator project and, defining a rating tool for serious games in the EduGameLab project.

The rest of this paper is organized as follows. While it is beyond the scope of this paper to list all existing educational standards, Section II introduces a few related metadata

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standards. Framework for evaluating serious games as well as categorisations and classifications of games and their learning experience are briefly reviewed in section III, section IV describes standards for managing and describing competencies, section V introduces the proposed metadata schema and finally section VI outlines our plans for testing the proposed schema.

II. METADATA STANDARDS

In this section, we briefly review established Metadata Standards from the field of Technology Enhanced Learning, to identify possible candidates to base our metadata schema on.

A. IEEE LOM

When attempting to create a metadata schema for comprehensive descriptions of serious games in an interoperable manner, the starting point must be existing metadata standards. A well-known standard for educational resources, called learning objects, is the IEEE Learning Object Metadata (LOM) [12], [13] specification. LOM defines a number of vocabularies for describing pedagogical attributes of resources. It includes, for example, attributes like resource type, level of interactivity, semantic density, difficulty and description. In addition, LOM encapsulates the Dublin Core [14] elements. Dublin Core is a cross-disciplinary standard for describing a wide range of networked resources [15]. It consists of two levels: Simple and Qualified. Simple Dublin Core describes objects using 15 simple elements [14] like the Title, Creator and Subject. Qualified Dublin Core adds a group of element qualifiers and three additional elements: Audience, Provenance and RightsHolder.

Serious games are, however, different from most other educational resources as they often offer a game play delivery using high fidelity audio and media and can use a variety of different pedagogical approaches. LOM does not have the attributes to describe these aspects. However, serious games may be exported into self-contained Learning Objects (LO) that can then be combined into larger units/courses.

B. Sharable Content Object Reference Model (SCORM)

The Sharable Content Object Reference Model aims to bring together previous e-learning standards in a single distributable package and forms a structured design pattern around the creation of interchangeable educational material. SCORM uses IMS Content Packaging [16] for distributing its content and consists of the following parts.

- A Content Aggregation Model defining the components used to build a learning experience from learning resources, and how they are aggregated and organised in units of instruction.
- Assets representing a collection of media. This collection is called a Sharable Content Object (SCO) if it represents a single learning resource.
- An activity, which is a unit of learning, may provide an asset or be composed of sub-activities.

While games can be included in a SCORM package, there are no separate facilities for describing serious games. Therefore there is no particular standard way of including them.

C. IMS Learning Design (IMS-LD)

IMS Learning Design (IMS LD) [17] was developed by the Open University of the Netherlands and released as a standard by the IMS consortium in 2003. IMS LD is a meta language that evolved from the Educational Modeling Language (EML). There are various activities called acts and people can have different roles. Activities and are conducted in an environment that is composed of several learning objects called Units of Learning. There are three levels (A, B and C), in increasing complexity and several players have been developed, such as CopperCore [18] and .LRN [19]. .LRN is integrated into a learning management system. However there is no native support for serious games. The XML-based format can describe a game only in general learning object terms.

III. EVALUATION FRAMEWORKS AND CLASSIFICATIONS OF SERIOUS GAMES

In this section, we briefly review established frameworks and classification methods for serious games. Our proposed metadata scheme is based on the elements used in the evaluation and classification in these frameworks.

A. Four Dimensional Framework

The four dimensional framework, which emerged from user studies, has been proposed previously in [10], [11] and its value has been shown in a number of studies since [20][18], [21]. The framework for evaluating serious games proposes four dimensions: the learner, the pedagogic models used, the representation used and the context, in which the learning takes place. The table below shows the framework schematically. Since the framework is an established framework for evaluating serious games, the metadata schema proposed in Section V should be able to express this evaluation.

TABLE I. FOUR DIMENSIONAL FRAMEWORK

Four Dimensional Framework	
Learner Specifics	***Pedagogy***
Profile	Associative
Role	Cognitive
Competences	Social / situative
Representation	***Context***
Fidelity	Environment
Interactivity	Access to learning
Immersion	Supporting resources
	Topic being studied

The learner specifics dimension involves profiling and modelling the learner to ensure a close match between learning activities and the required outcomes. The second dimension analyses the pedagogic perspective of the learning activities in the serious games such as the kinds of learning and teaching models. The third dimension is the representation, how active the learning experience needs to

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be, what levels of fidelity are required and how immersive the experience needs to be. Finally, the context describes where the learning is taking place, what resources the learner has access to but also the topic being studied. The context the game is used in can vary and different evaluators may evaluate the game differently depending on their own experiences. Therefore, one game can have multiple evaluations.

B. Different Types and Styles of Games

Mark Prensky proposes a classification of games [22] based on diverse content perspectives, shown in Table II. While his work is controversial and this classification does not provide a comprehensive evaluation framework, it does show how games can be classified in terms of the different types of content. The learning activities are related to the pedagogy dimension and the game styles are related to the representation dimension. The classification of games does not take into account any specifics of the learner, as it does not seek to evaluate its use with particular learners but is merely intended to group games in categories.

Sawyer and Smith [23] have created taxonomy of serious games by distinguishing into 6 categories, Games for Health, Advergames (games for advertising), Games for Training, Games for Education, Games for Science and Research, Production Games as Work. However, they noted that this is work in progress and it can continuously be modified. This taxonomy again is focusing more on the content of the games and does not focus on the learning needs of the user/learner. However, they are associating these categories with the areas of application such as Government and NGO, Defence, Healthcare, Marketing and Communication, Education, Corporate and Industry creating a matrix like taxonomy.

Similarly, Alvarez and Rampnoux [24] have attempted to classify serious games in 5 main categories: Advergaming, Edutainment, Edumarket game, Diverted game and Simulation game.

C. Learning Objectives Based Game Classification

Educational games can be produced as self-contained distributable Learning Objects (LO) [9] in support for the principles of the LO model [12], [13] that deploys the learning contents as small self-contained objects that can then be combined into larger units/courses. However, particular challenges exist when considering games, which might address multiple learning objectives, and therefore by definition encapsulate multiple LOs, or games, which are blended with other materials, and therefore to function as a repurposable LO require these materials to be included. Standardized formats should be used to store and distribute learning objects, allowing the content to be reused across platforms and contexts. Pivec and Moretti [25] have introduced a Learning Objectives-based classification for serious games. The classification describes a definition of the game, the features required, the typology and number of players. The Learning Objectives can be classified in the following groups.

- Memory/Repetition/Retention (factual knowledge)
- Dexterity/Spread/Precision (sensorial/dexterous knowledge)
- Applying Concepts/Rules (translate knowledge into new context; use information, methods, concepts, theories in new situations)
- Decision-making (strategy & problem-solving)
- Social Interaction/values/cultures (understanding the social environment of others)
- Ability to learn/self-assessment (evaluation)

Below we see an example describing John Smith, who wants to find a learning resource that extends his skills in web editing and is a president at learNR.

```
<PersonName>
    <GivenName>John</GivenName>
    <FamilyName>Smith</FamilyName>
    <Objective>Find a learning resource that
extends his skills in web editing </Objective>
<EmploymentHistory>
    <EmployerOrg>
        <EmployerOrgName>learNR</EmployerOrgName>
        <PositionHistory>
            <Title> President</Title>
            <OrgName>
              <OrganizationName>Paper
              </OrganizationName>
            </OrgName>
            <Description>Key Player</Description>
            <StartDate>
                <AnyDate>2002-02-01</AnyDate>
            </StartDate>
        </PositionHistory>
    </EmployerOrg>
</EmploymentHistory>
</PersonName>
```

As we can see in Table II most of these groups have been covered in the four dimensional framework and the existing classifications and taxonomies. Our classification of game styles in Table II is not intended to imply the game style will necessarily include a given content type; rather, that these game styles are amongst the most common and relevant when attempting to categorise serious games.

IV. COMPETENCIES

The learner will have a certain set of competences, as suggested in the Learner Specifics dimension of the four dimensional framework. The learner will also be acquiring new competencies. Describing and managing competences is a well researched topic and is very relevant for serious games. Various different standards for describing competencies have been proposed [26], most notably the IMS Reusable Definition of Competency or Educational Objective (RDCEO) [27], IEEE Reusable Competency Definitions (RCD) [28] and HR-XML [29] competencies. Both IMS RDCEO and HR-XML identify the following.

- An identification of the competency
- A title for the competency
- A description
- A definition
- A taxonomy of the competency
- Personal information

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TABLE II. PRENSKY'S CLASSIFICATION OF GAMES [22]

"Content"	Learning activities	Possible Game Styles
Facts	Questions, memorization, association, drill	Game show, competitions flashcard type games mnemonics action, sports games
Skills	Imitation, feedback coaching, continuous practice, increasing challenge	Persistent state games, role-play games, adventure games, detective games
Judgment	Reviewing cases, asking questions, making choices (practice), feedback coaching	Role play games, detective games, multiplayer interaction, adventure games, strategy games
Behaviours	Imitation, feedback coaching, practice	Role playing games
Theories	Logic, experimentation, questioning	Open ended simulation games, building games, constructing games, reality testing games
Reasoning	Problems, examples	Puzzles
Process	System analysis and Deconstruction, practice	Strategy games, adventure games
Procedures	Imitation practice	Timed games, reflex games
Creativity	Play	Puzzles, invention games
Language	Imitation, continuous practice, immersion	Role playing games, reflex games, flashcard games
Systems	Understanding principles, graduated tasks, playing in micro worlds	Simulation games
Observation	Observing, feedback	Concentration games, adventure games
Communication	Imitation, practice	Role playing games, reflex games

In addition to this some European countries have developed their own set of standards to describe competencies, e.g., France is implementing ScoLOMfr [30], which extends LOM with vocabularies to classify learning objects used by teachers and students in secondary education.

- HR-XML also has measurable weights and importance levels. The European Union established various standards in the Lisbon treaty [31], which define what should be acquired through education, is based on this. However its focus is very narrow and mainly on the competences that must be acquired through formal school education and therefore the standard exists of the following seven blocks of competences.Mother tongue knowledge
- Practice of a foreign language
- Math, scientific and technological culture
- Visual information and communication's techniques
- Humanities culture
- Social and civic competences
- Autonomy, initiative

V. SERIOUS GAMES METADATA

As the IEEE LOM standard is widely used for describing learning objects, the metadata schema we propose for serious games is an extension to IEEE LOM. When describing serious games, we face a challenge not dissimilar to the challenge standards such as IMS-LD and Dublin Core faced when they were being developed. A human can read and write full-text with ease but can be confused by complex compound structures. However, free-text is difficult to process automatically and a more complex compound structure using complex data types can make automatic processing more feasible. Therefore our proposed metadata schema, which adds a number of fields to IEEE LOM, will have two different levels. The first level that focuses on human readability and the second level that focuses on machine processability. The elements are the same, but the types are stricter in Level 2. Our proposed schema mainly focuses on descriptive and review elements of serious games. In Tables III and IV, we describe the fields that we propose to add to IEEE LOM. We show the type for Level 1 and Level 2. The proposed metadata schema allows for a number of reviews in addition to technical and descriptive fields, therefore, we make a distinction between these technical and descriptive fields on the one hand and the set of review fields on the other hand.

VI. CONCLUSION AND FURTHER WORK

Existing standards for describing learning resources are incomplete when it comes to describing serious games. Any automated system that stores and retrieves serious games as objects, needs a metadata schema to describe them. Hence, a general metadata standard for describing serious games is needed. In this paper, we introduced our proposed metadata schema, based on existing technology enhanced learning and standards and metadata standards, also taking into account existing frameworks for evaluating serious games.

We plan to test our metadata schema, which was inspired by previous work in the mEducator project, by integrating it into a rating tool for serious games. The rating tool is being developed in the course of the EduGameLab project, which is aimed at parents and teachers. The rating tool will enable rating and sharing of experiences with individual games. For this purpose the metadata schema will be used to describe the games.

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TABLE III. ADDITIONAL TECHNICAL AND DESCRIPTIVE FIELDS FOR SERIOUS GAMES

Field	L1 type	L2 type	Contents	Multiplicity
Game_developer	Text	Text	Name of the developer/publisher of the game	1
Producer	Text	Text	Name of the producer/ promoter if not the same as developer	1
Sponsor	Text	Text	Name of the institution who commissioned or sponsored the development (if any)	*
Age_group	Enum[a]	Enum	Intended age group: 0-3, 4-7, 8-12, 13-16, 17-18, 18+	+
Content_type	Text	Enum	One of the types described in Section III C.	+[b]
Game_genre	Text	Enum	The genre of games: (Action shooter, action-adventure, adventure, role-playing, construction and management simulation, life simulation, vehicle simulation, simulation, strategy, music, exercise/ training, sports game)	+
Type_of_game	Text	Enum	Type of game (Entertainment, education, edutainment, other)	+
Representation	Text	Enum	Virtual world, 3rd person, 1st person, board game, turn-based, card, other	1
Technical_platform	Text	Enum	E.g., PC, Mac, iPhone, Android, Playstation3, Wii etc	+
Platform_type	Enum	Enum	(Pc, Console, Mobile, Other)	+
Multi_player	Enum	Enum	(No, on same device, online)	+
Subject	Text	DBpedia category	General Subject	1
Performance indicators	Text	Enum	E.g., In game score, time, completion, appreciation, success, failures	+
PEGI_rating	Enum	Enum	PEGI rating, only if official rating is available: (3,7,12,16,18)	[0..1)
PEGI_reasoning	Enum	Enum	PEGI rating, only if official rating is available: (Bad Language, Discrimination, Drugs, Fear, Gambling, Sex, Violence, Online game play)	*[c]
Review	Complex	Complex	See below	*

a. Enumeration, i.e., a choice out of a given list of values

b. * = any number, += 1 or more

c. If there is a PEGI rating other than 3 than the multiplicity is + otherwise 0

It will be tested in user-panels that are due to be set up within the project.

Significant future challenges surrounding the use of serious games within LMS and LCMS systems include the capacity to define and extract multiple LOs from single games, as well as support fully games, which function as part of blended learning activities, and therefore can represent an element of content within a larger LO. Our schema has addressed, on a technical level, some key considerations, which are essential to allow functional repurposing of game-based learning content. Future work must couple this with a full pedagogic consideration of how this technical capacity may be used to support the implementation of serious games into LMS and LCMS systems.

Achieving this is particularly challenging, as game-based learning is frequently deployed in blended contexts; and can be difficult to define independently from its given context. not in terms of the boundaries arbitrarily placed by the interface between game engine and LMS, but instead in pedagogic terms, thus allowing them to adhere to best practices for LO definition, as well as best practices for the implementation of game-based learning approaches.

TABLE IV. ELEMENTS CONTAINED IN A REVIEW ENTRY

Field	L1 type	L2 type	Contents	Multiplicity
Learner Specifics	Complex	Complex	Composed of each of the following sub-fields: Age Occupation (e.g., In full-time education, unemployed or one of the items of the Standard Occupational Classification 2010 [32]) Subject area if in full-time higher and further education, e.g., one of the topics from Wikipedia for easy translation (0 or more) competences using either HR-XML, IEEE RCD or IMS RDCEO	+
Pedagogy	Enum	Enum	Point on Kolb's learning cycle [33], or other pedagogical models such as Boolms taxonomy [34], or Gees Learning Principles [35]	[0..1)
Context	Complex	Complex	Context the game is used in (by the reviewer) composed of each of the following sub-fields: Place (one of school, home, museum, mobile, other) Subject (free text / Wikipedia topic for easy translation) Time of the pedagogical activity involving the game (0 or more) supporting resources	+
Star rating	Enum	Enum	(0,1,2,3,4,5) indicating the subjective pedagogical quality, based on the distance between the aim and the result of the evaluator, compared to their usual approach	1

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