Repurposing, Integrating, and Rating Serious Games as Learning Objects

Maurice Hendrix, Aristidis Protopsaltis, Ian Dunwell, Panagiotis Petridis, Sylvester Arnab and Sara de Freitas

Introduction

The use of computer games within educational contexts has been encouraged by a number of studies showing that, in certain circumstances, their use can allow educators to realize significant improvements over traditional teaching and training methods (Knight et al., 2010). Game-based approaches are being increasingly recognized for their potential to engage learners and improve learning by increasing learners' motivation through game-play and rich media delivery. The so-called "serious" games have been used for training purposes in many different fields of study, such as healthcare (Mautone, Spiker, & Karp, 2008), cultural heritage (Anderson et al., 2009), general education (De Freitas & Conole, 2010) and disaster management (Haferkamp & Kraemer, 2010; Sanders & Rhodes, 2007). In the vast majority of cases, these games are developed in a standalone fashion, requiring the educator to effectively integrate them into the learning environment himself/herself. To better support such integration through technology, a wide variety of e-learning systems might be, or have been, used to deliver game-based content. Currently some of the most popular e-learning systems are web-based systems for the delivery of educational content, called Learning Content Management Systems (LCMS). Adaptive systems such as AHA! (De Bra & Ruiter, 2001) and systems that focus more on delivering content according to common sets of pedagogies such as IMS-Learning Design (IMS, 2003) based systems (e.g. Reload, Copper), and systems that focus on activities such as LAMS (Dalziel, 2003) have also been developed. Adaptive systems have been integrated into LCMSs (Oneto, Abel, Herder, & Smits, 2009), thus allowing for not only content delivery but also user modelling (Abel et al., 2009), and authoring or course creation (Hendrix, De Bra, Pechenizkiy, Smits, & Cristea, 2008). Research in the area of e-learning systems has also lead to a number of different standards such as ADL-SCORM (2004) for sharing courses among systems, and

IEEE LOM (2001) for sharing content in reusable packages, so-called learning objects. This has led to the development of repositories of reusable learning objects (Duval et al., 2001) as well as the treatment of serious games as learning objects (e.g. Dunwell et al., 2011; Torrente Vigil, 2009).

However, despite potential, most of these well-established e-learning systems and standards were not designed for integration with serious games. It is suggested, therefore, that consideration of how this integration might be designed and implemented could allow for the improvement of the whole learning process, taking advantage of established techniques via traditional e-learning materials, whilst stimulating and motivating the learner through simultaneous and highly integrated game-based elements or content. Furthermore, this integration could increase the potential to reuse or repurpose serious games, thus allowing autonomous and efficient methods for content repurposing deployed within modern LCMSs to be applied to serious games. This chapter reviews the emerging trends in the repurposing of serious games, and shows, through the developed examples, how describing games as learning objects can significantly evolve the state of the art in how game-based learning approaches are conceived, deployed, and reused. For clarity, these trends are grouped into three major areas: reuse and repurposing, integration into e-learning environments, and metadata schemas for serious games.

The remainder of this chapter is organized as follows. First, relevant concepts and descriptions are introduced, followed by a review of how describing serious games as learning objects might facilitate reuse and repurposing. Second, an overview is provided of approaches to the integration of serious games directly into LCMSs, facilitated by descriptions of games as learning objects. Thirdly, it is shown how a contextualized rating of serious games, aimed at parents and teachers, can be achieved by describing games as learning objects. The chapter ends by discussing the potentials emerging from these recent trends.

Background

Classification and Evaluation of Games

Both entertainment and educational games come in a variety of established genres such as strategy, adventure, simulation, and role-playing. Similarly, they come in a wide range of fidelity levels, ranging from 2-dimensional turn-based environments to real-time 3-dimensional virtual worlds. Serious games have sought to tackle both high-level topics, such as ancient history, to business skills, as well as low-level cognitive skills development. Even these broad descriptions are not holistic, and are challenged by emerging forms of gaming on social networks and mobile devices. When describing games as learning objects, the classification of these games is clearly an important piece of information for educators, parents and students who want to (re)use a game. In addition, it impacts both the viability of the technological platform as well as the potential of the game to be integrated into various environments and contexts. Hence, in this section we review classification mechanisms for serious games.

Four Dimensional Framework

The four dimensional framework emerged from user studies (De Freitas & Oliver, 2005; De Freitas & Oliver, 2006) and is intended for the evaluation of serious games. The framework proposes four dimensions: the learner, the pedagogic models used, the representation used, and the context in which the learning takes place. Table 1 illustrates this framework.

Table 1: 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 records profiling and user or learner modelling information. This ensures a close match between learning activities and the required learning outcomes. The *pedagogy* dimension describes the pedagogic perspective of learning activities in serious games, for example, the kinds of learning and teaching models. The *representation* dimension records how active the learning experience needs to be, the levels of fidelity required and how immersive it should be. Finally, the *context* describes where the learning takes place, what resources the learner has and the topic being studied. This framework is an established framework for evaluating serious games, rather than a classification system per se. However, it is suggested here that the four dimensions form useful classifications for the description of serious games as learning objects, particularly when it comes to reuse. Since most elements will depend not only on the game, but also on the evaluator and the context the game was used in by the evaluator, one approach can be to allow multiple ratings according to the framework by the game players.

Classification based on Game Types and Styles

Prensky's classification of games (Prensky, 2003) is based on diverse content perspectives, shown in Table 2. This classification shows how games can be classified in terms of the different types of content. The learning activities are related to the pedagogy dimension of the four-dimensional framework, and the possible game styles are related to the representation dimension. This classification aims to classify a game independent of its use and thus does not take into account any specifics of the learner.

Table 2: Prensky's classification of games

"Content"	Learning activities	Possible Game Styles
Facts	Questions, memorization, association, drill	Game shows, 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, construction 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	Role playing games,

	practice, immersion	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

Sawyer and Smith propose a taxonomy of serious games by distinguishing the following 6 categories (Sawyer & Smith, 2008): Games for Health, Games for Advertising, Games for Training, Games for Education, Games for Science and Research, Production Games as Work. They also associate these categories with the areas of application such as Government and NGOs, Defence, Healthcare, Marketing and Communication, Education, Corporate and Industry, thus creating a matrix-like taxonomy which focuses on classifying games according to their content and application area.

Learning Objectives Based Game Classification

Learning objectives are important when describing a learning object. However, serious games often address multiple learning objectives in an indivisible unit. Standardized formats are needed to store and distribute learning objects, allowing the content to be reused across platforms and contexts. Pivec, Koubek, & Dondi (2004) 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. It also describes the Learning Objectives classified as follows:

- 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)

The challenge in classifying a serious game, therefore, is in harmonizing the broad range of information required on both pedagogic and technical levels.

Competences

Competences are the ability to perform a certain task or the possession of a certain amount of knowledge: any learner has a certain set of competences, and any formal learning activity aims to enable a learner to achieve a certain set of competences. These are often called the learning goals or learning outcomes. Describing and managing competences is important when it comes to describing serious games, especially since games can be used in many different contexts. Descriptions of competences are well researched and various standards have been proposed, such as IMS Reusable Definition of Competency or Educational Objective (RDCEO) (2002) and HR-XML (Allen, 2001). IMS RDCEO and HR-XML both contain an identifier, title, description, definition, taxonomy of the competency and personal information. HR-XML also adds weights and importance levels. Certain countries have adopted their own national standards for describing competences; for instance, France introduced ScoLOMfr (2010) that extends LOM with elements for identifying the learning objects being used, and is aimed at teachers and students in secondary education.

Metadata Schemas

Metadata are data semantically describing the information content within a system. In the context of serious games, metadata must logically describe the key characteristics of any given game. This makes a set of game descriptions searchable and, to some extent, machine-processable. However there are various different aspects that can be described in metadata and

there are various different ways and different formats in which metadata can be recorded.

The use of metadata is well established in the field of e-learning and there are various standards that have emerged for describing learning content, usually focused on more traditional hypermedia content rather than serious games. Dublin Core (Dublin Core Metadata Initiative, 1999) is a general purpose standard for describing a wide range of resources. As a general purpose standard it does not have specific pedagogical attributes, but it has still inspired many of the more specific standards. Dublin Core has two levels: Simple and Qualified. Simple Dublin Core uses 15 simple elements like Title, Creator and Subject to describe resources. Qualified Dublin Core adds the following three more complex elements: Audience, Provenance and RightsHolder. One of the common metadata formats used in eLearning system is IEEE Learning Object Metadata (LOM) (2001). IEEE LOM focuses on the description of learning content as reusable objects and therefore avoids specifying how they should be used or delivered. In addition to general Dublin Core fields that are encapsulated into LOM, it defines vocabularies for describing pedagogical attributes of resources. Attributes include, among others, resource type, level of interactivity, semantic density, difficulty and description.

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

The ADL Sharable Content Object Reference Model (ADL-SCORM) (2004) defines reusable SCORM Content Objects. These objects are assembled into a content package using IMS Content Packaging (IMS-CP). SCORM forms a structured design pattern around the creation of interchangeable educational material. SCORM consists of a content aggregation model defining the components used for building a learning experience from learning resources, and how they are aggregated and organized in units of instruction. It also includes assets representing a collection of media. If it represents a single learning resource, this collection is called a

Sharable Content Object (SCO). Finally, activities can be included, which may be associated with an asset or be composed of sub-activities. Serious games can be included in a SCORM package, however, there are no specific facilities for describing them, and no explicit way for the receiving system to know how to run them. SCORM can cover packaging and deployment for serious games as well as communication between serious games and LCMSs.

IMS Learning Design (IMS-LD) (IMS, 2003) was developed by the Open University of the Netherlands. It was based on the Educational Modelling Language (EML) and an exhaustive survey of the different pedagogies in use in the field of online education. IMS-LD has different activities called acts, and people can have different roles. Activities can be conducted in an environment that is composed of several learning objects called Units of Learning. Three levels (A, B and C) of increasing complexity and several IMS-LD players such as CopperCore (Vogten & Martens, 2004) have been developed. However, because the use of serious games was not as popular in 2003 as it is today, there is no support for serious games in IMS-LD.

Standards such as SCORM and IMS-LD go into detail about the delivery of content, while IEEE LOM merely describes learning content as reusable objects. The advantage of the latter approach is that an educator can search for a LO in repositories such as ARIADNE (Duval et al., 2001) and use the retrieved learning object(s) in his or her own teaching either as is or in a modified form.

Reuse and Repurposing

Serious games have the potential to improve the learning experience, by increasing the learners' motivation and diversifying the content delivery media (Michael & Chen, 2005). However, considering the time, effort, resources, cost and complexity of developing serious games, it is essential that serious games can be changed, adapted and reused in curricula and educational practices often different from the original context (Protopsaltis et al., 2011). Repurposing can include changing the game's content, functionalities, and the technology and representations being used, as well as adapting the game to different pedagogies, different cultural elements, contexts and learners. Such repurposing is very desirable for both educators and

developers, because it reduces the use of organizational, monetary and technical resources, and opens up new opportunities for learning, by offering flexibility in using existing learning objects and maximizing their capabilities. Therefore, repurposing serious games offers potential to efficiently adapt and reuse serious games and game elements to meet the needs of wider audiences and application areas.

Often the terms reuse and repurpose are used interchangeably in the literature to indicate the use of the same resource in different contexts. However, these terms should be distinguished from each other. The term *repurposing* refers to the changing of a learning object from its original educational context to a new context (or contexts) (Dovrolis, Konstantinidis, Bamidis, & Kaldoudi, 2009). The term *reuse* refers to the use of a learning object without any changes, in the same or a very similar context (Meyer, Hildebrandt, Rensing, & Steinmetz, 2006).

So far, work in the field of repurposing learning objects has been focused mainly on automatic repurposing of learning objects such as PowerPoint presentations and creating new presentations from existing ones (Jovanovic, Gaševic, Verbert, & Duval, 2005; Verbert & Duval, 2008; Zaka, Kulathuramaiyer, Balke, & Maurer, 2008), creating adaptive teaching materials from existing documents on mathematics at undergraduate level (Lenski & Wette-Roch, 2001; Singh, 2004).

Multimedia repurposing is another field that has also received attention. Some researchers have focused on developing systems such us MPEG-based personalized multimedia content delivery system (Steiger, Ebrahimi, & Sanjuan, 2003), while other researchers have focused on developing repurposing frameworks. Hjelsvold, Vdaygiri, & Léauté (2001), for example, developed a framework for web-based interactive videos while Hossain, Rahman, & El Saddik (2004) have introduced a multimedia content repurposing framework using Web Services.

Contrary to the area of multimedia repurposing, the area of games and especially serious games repurposing is still in its infancy and there is a very small amount of work addressing the issue. Burgos, Tattersall, & Koper (2007) examined repurposing of what they called “generic” games, referring to commercial games and focusing on different pedagogic approaches

in game repurposing. Protopsaltis, Panzoli, Dunwell, & Freitas (2010) developed a theoretical framework for repurposing serious games. It was developed using three case studies, based on the Climate Health Impact serious game developed by PlayGen (http://playgen.com). These case studies demonstrated the ability to repurpose a serious game into new learning objects, covering three different paradigms of content repurposing: language, content and pedagogy.

Different paradigms for content repurposing have been developed by the mEducator consortium (Dovrolis et al., 2009). This work has shown that educators need to have programming skills in order to be able to repurpose serious games, and identified this as a limiting factor for widespread repurposing of game content. Separation of a game's content is really important in order to facilitate efficient repurposing of a game. Content can be stored in separate files (e.g., XML files) and educators would only have to access and modify those files and nothing else. Such tasks do not require advanced programming skills and therefore educators would be able to complete them with relative ease. Another suggestion that could simplify serious games repurposing refers to scenario-based games repurposing (Protopsaltis et al., 2010; 2011). Scenario-based games are mainly branching scenarios where users' decisions lead to, both immediate and simulation wide altering of the events, characters and situations encountered. A scenario can be modified to fit individual needs and situations, and feedback is provided seamlessly as a natural progression throughout the experience. An editor, called mEditor (Protopsaltis et al., 2011), for serious games repurposing was created within the mEducator project, where players and educators can create their own scenarios and/or alter existing ones to address their educational needs. The XML files store references to the game engine's features as well as to branching generic features (such as "If Then Else"). These files are read by the game engine that subsequently "runs" the scenario, calling at the right moment its own dedicated functions. These functions can be accessed by authors via the scenario editor (Protopsaltis et al., 2011).

There are also other examples of authoring applications that allow for game editing. Such applications include, among others, the UnrealEd level editor of the Unreal 3 engine, and e-Adventure (Moreno-Ger, Martínez-Ortiz, Sierra, & Manjón, 2006). The UnrealEd editor was developed by and for professional game developers, and as such is very powerful, but also very

complex to use by non-technical experts. A different approach, proposed by van Est, Poelman, & Bidarra (2011) allows scenarios to be defined and edited, using high-level actions and events and some basic logic. This editor makes the editing process easier for non-specialists but still requires some expert knowledge. However, both these authoring applications focus more on providing alternative scenarios (a single repurposing category) rather than complete repurposing of serious games as learning objects. For repurposing to be successful, it needs to be easy to be implemented, requiring minimum technical skills, and covering at least more than one repurposing category.

Integrating Games in E-learning Environments

Game-based learning is rapidly emerging as a method for conveying educational content. However, designing pedagogical approaches that combine elements of entertainment gaming with instructional methods is a challenging task. To this end, Dunwell et al. (2011) show an integration of serious games into e-learning systems, streamlining the delivery of learning experience and supporting a blended approach to learning (Garrison & Vaughan, 2008). The proposed approach explicitly supports a blended learning environment. The reason behind this is that while simple tasks can be easily transferred to a game and trained in a very realistic way, more complex tasks require a greater level of abstraction between game representation and reality. Examples include stroke rehabilitation (Burke et al., 2009) and more complex behavioural aims defined towards the top of Bloom's taxonomy (Bloom & Krathwohl, 1956). The blended approach is essential, as it enables learners to make sense of the game experience so that learning can takes place (Egenfeldt-Nielsen, 2005; Vygotsky, 1978).

The integration developed by Dunwell et al. (2011) facilitates a structured learning experience that still allows learners to explore non-linear environments. The pedagogy used deploys achievement systems, familiar from entertainment games, as feedback mechanisms and uses these to scaffold learning of real life successful behaviours. A key technical element of this integration is the description of serious games as learning objects. However, serious games have quite different characteristics from more traditional e-learning materials. In particular, they often have rich media content and their delivery technology is different from the Web-based technology used

in most e-learning systems for managing text, images, videos, etc. The integration thus requires establishing a communication between the e-learning system and the game, which for most other learning materials is natively handled by the web-based platform. These considerations also have implications for the description of games as learning objects.

Dunwell et al. (2011) developed a serious game for fire evacuation training. The game uses the Unity3D game engine (http://unity3d.com) and features a model of a school building that is on fire. Students have to then evacuate as quickly as possible, gaining points for following correct procedures, and losing points for disregarding guidelines such as using lifts. This game is integrated into the Intelligent Web Tutor LMS. Technically, this integration is achieved by creating an object in the LMS. Apart from other objects in the LMS which can be considered learning objects, the object used for the integration uses advanced HTML and JavaScript, rather than more usual hypermedia content. The result is a Web page, presentable in any modern browser, with the game integrated into it. The use of JavaScript allows the game to communicate with the page. As this page is part of the LMS, the game integrated into the page can communicate with the user profile, or user model, in the LMS. Hence, after a student has played the game, the LMS becomes aware of how well the student did. This approach allows using the game as an alternative form of a multiple-choice test, a feature present in most LMSs. Not only does it display the scores, it can alo inform teachers how well the class is getting on and suggest extra training materials for struggling students.

Metadata Schemas for Rating Serious Games in Context

Games often differ substantially from other educational media as they often combine high-fidelity audio and video with experiential, social, or exploratory pedagogies. Technology is increasingly being used to support the delivery and management of learning content, and that content is often packaged in reusable learning objects. However, expressing games in terms of learning objects is not an easy task, as it requires developing a way to express games in coherent and discrete terms that can be reused, rather than describing games in terms of their technical boundaries. Just like with other

forms of learning material, the context for which a game was intended is important information, as a particular game may work only for certain contexts. One of the aims of the EduGameLab project (http://edugamelab.eu) is to establish a rating tool for serious games, which records the game's context together with the ratings.

Hendrix et al. (2012) have defined a metadata schema for serious games, which allows for describing games with metadata elements from the IEEE LOM standard (IEEE, 2001). The proposed schema extends IEEE LOM with fields necessary for describing the unique technical characteristics of games. These fields are listed below in Table 3. For each field, Table 3 also provides its data type and the multiplicity, i.e. how many instances of this field a record for a serious game can have (1 = exactly 1 instance, * = 0 or more instances, + = 1 or more instances, [0..1) = 0 or 1).

Table 3: Additional technical and descriptive (metadata) fields for serious games

Field	Type	Contents	Multi-plicity
Game_developer	Text	Name of the developer/publisher of the game	1
Producer	Text	Name of the producer/ promoter if not the same as developer	1
Sponsor	Text	Name of the institution who commissioned or sponsored the development (if any)	*
Age_group	Enum	Intended age group: 0-3, 4-7, 8-12, 13-16, 17-18, 18+	+
Content_type	Enum	One of the types described in Table 2.	+
Game_genre	Enum	The game's genre: (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	Enum	Type of game (Entertainment, education, edutainment, other)	+
Representation	Enum	Virtual world, 3rd person, 1st person, board game, turn-based, card, other	1
Technical_ platform	Enum	E.g., PC, Mac, iPhone, Android, Playstation3, Wii, etc	+
Platform_type	Enum	(Pc, Console, Mobile, Other)	+
Multi_player	Enum	(No, on same device, online)	+
Subject	DBpedia category	General Subject	1
Performance _indicators	Enum	E.g., in-game score, time, completion, appreciation, success, failures	+

PEGI_rating (Pan European Game Information, http:// www.pegi.info)	Enum	PEGI rating, only if official rating is available: (3,7,12,16,18)	[0..1)
PEGI_reasoning	Enum	PEGI rating, only if official rating is available: (Bad Language, Discrimination, Drugs, Fear, Gambling, Sex, Violence, Online game play)	*
Review	Complex	See below	*

However, while the technical and descriptive fields listed in Table 3 are necessary to create truly reusable learning objects, they are not in themselves sufficient. In order to be able to reuse a game, some information about its context is necessary. It is also valuable to know the experiences of others by means of rating or evaluation of the effectiveness of a serious game in a particular context. Therefore, review entries (Table 4) recording reviews tied to the contexts the games were used in are also part of this metadata schema.

Table 4: Elements contained in a review entry

Field	**Type**	**Contents**	**Multiplicity**
Learner Specifics	Complex	Composed of each of the following subfields: Age Occupation (e.g., In full-time education, unemployed or one of the items of the Standard Occupational Classification 2010 (Elias & Birch, 2010)) 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	Learner Specifics
Pedagogy	Enum	Point on Kolb's learning cycle (Kolb & others, 1984), or other pedagogical models such as Boolms taxonomy (Bloom & Krathwohl, 1956), or Gee's Learning	Pedagogy

		Principles (Gee, 2003)	
Context	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	Context
Star rating	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	Star rating

Serious games are often difficult to disassemble into pedagogically valid subcomponents, since games often contain closely linked learning content and game play mechanisms. Serious games also often include multiple learning objectives. This is due to the development cost consideration and the fact that many types of games, especially immersive 3D games, have greater user appeal if they can make available larger environments for exploration. Therefore, while not traditionally part of a learning object description, it could be argued that recording what type of learners particular games are successful with, and in what sort of context and with which topic of study is of particular significance.

Discussion and Conclusions

As discussed in this chapter, the use of games in education is becoming increasingly popular, as it can, in some cases, significantly improve learning outcomes over traditional methods (Knight et al., 2010). At the same time, a blended learning approach (Garrison & Vaughan, 2008), in which the use of games is combined with other technologies and classroom-based education is becoming increasingly popular.

A significant volume of research has been conducted into the area of e-learning, and a number of standards have emerged. However, these standards focus mostly on traditional digital media such as text, images, and video. As discussed in this chapter, games differ from many other forms of educational media as they often bundle multiple learning objectives into a package coupled with game play mechanics and dynamics. This makes

brick-based approaches to assembling content from game-based learning objects, or disassembling games into discrete learning objects, a problematic process. Recent advances in methods for dealing with this challenge have been reviewed in the chapter. These include an approach to game repurposing, which makes it possible to modify a game and use it for a different purpose. This is one of the first real advances with respect to the capacity to single out specific aspects or learning objectives, and extract them from a game-based learning environment. While a game may still have multiple learning objectives, an educator can repurpose the game by adding or removing elements as required for his/her own purpose. This could be considered as a significant advancement towards being able to treat a serious game as a self-contained learning object. Provision of tools necessary to empower educators with the ability to undertake the repurposing task in a simple and effective fashion is a key area for future work.

Many institutions have adopted an LMS, where the course contents get uploaded and where students can log in, explore the course contents, take tests or engage in learning activities. While LMSs are useful for distance education only courses, they are increasingly regularly used in conjunction with traditional classroom-based courses in a blended approach. As we have discussed, games can be integrated into an LMS, which is an important step for the integration of games into blended learning approaches. It also presents a significant step towards being able to create self-contained and reusable learning objects that can be used in real learning environments. An emergent question here is the role that game-based approaches to learning will play in evolving not only learning content itself, but also how it is managed. Under a game-based content management paradigm, the game might itself become the LMS, taking other learning objects and "gamifying" them through overarching gameplay.

The final advancement described in this chapter is the definition of a metadata schema for describing serious games and contextualized ratings of serious games as learning objects. The described metadata schema builds on the IEEE LOM standard and incorporates fields for describing technical constraints of a game and classifying the game, as well as fields for rating the use of the game in a particular context. This is one of the first attempts at creating a standardized metadata schema for describing games as learning objects. Future research directions in this area lie in building on this work

through both evaluation and further standardization of the proposed metadata schema, leading to a general purpose metadata schema for describing any serious game as a reusable self-contained learning object. Digital games, unlike most other forms of media, rely to a large part on proprietary engines and APIs, with commercial games often proprietary and closed source in nature. This poses a significant challenge to the integration of games into the blended learning process, and the extent to which they can be repurposed. It also challenges the description of games as learning objects especially with regards to the aspects of being self-contained and reusable.

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