Chapter 2
Serious Games: A New Paradigm for Education?

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2.1 Introduction: Serious Games: A New Paradigm for Education?

The pervasiveness of gaming, the widespread use of the internet and the need to create more engaging educational practices have led to the emergence of serious games as a new form for education and training. While many have begun to see the potential of serious games to supplement and augment traditional formal education and informal non-curriculum training, the authors consider the potential of serious games to offer a paradigm shift in how education and training are delivered in the twenty-first century. The implications of this transition to a new paradigm of game-based learning will be broadly to adopt metaphors of games, or the ‘gamification’ of learning. The shift will include the adoption of: distributed tutoring models using avatar-driven scaffolded approaches, models of assessment and accreditation towards peer- and personalised modelling of the learner and provide an emphasis upon social interactive learning based upon dialogue and social interactions rather than tutor-based and individual study. This will increase opportunities for synchronous feedback and feedback loops, and mean the integration of multimodal interfaces including brain-computer interfaces (BCIs) and haptics.

Research work being undertaken by the authors and Research team at the Serious Games Institute (SGI) in the UK is bringing together different lines of research in educational research, computer science and neuropsychology to evaluate how this new paradigm might look and feel testing the principles outlined in this chapter in a model of ancient Rome populated by virtual agents and being evaluated with school children aged 11–14 years old.

To illustrate the conceptual basis of this shift, this chapter will explore the context for the new paradigm of learning in relation to the key critical concepts that centre around gamification, immersion and social interactivity, in this chapter we analyse these base critical concepts firstly in relation to the notion of ‘gamification’

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through the lens of an historical overview of serious games and secondly in a section exploring the need for an overall model for serious game design based upon four models and frameworks developed in past research work: the four dimensional framework (de Freitas and Oliver, 2006), exploratory learning model (de Freitas and Neumann, 2009), multimodal interface architecture model (White et al., 2007) and the game-based learning framework (Staalduinen and de Freitas, 2011). The chapter aims to set out the key conceptual territory for serious game design and bring together the main theoretical areas under consideration for future development of effective serious game content.

2.2 Historical Overview of Serious Games: The Gamification of Learning

The notion of ‘gamification’ has recently come to the fore as an expression of the pervasiveness of gaming in everyday. At the beginning of 2010 the games industry posted total sales of $1.17 billion just for the month of January. The value of serious games in 2008 was between $1 and 2 billion, recent reports circulating in US and Europe are talking about $9–11 billion. A recent study on gaming behaviour in Europe by the International Software Federation of Europe (ISFE, 2010) found that 74% of those aged 16–19 considered themselves gamers (n = 3000), 60% of those 20–24, 56% 25–29 and 38% 30–44. While 32% of the total UK population consider themselves gamers (n = 3000). Thirty one percent of females described themselves as gamers and 34% of males. These recent demographic studies show that the introduction of casual gaming and the wider appeal of online games have extended gaming audiences from the more traditional game-players of young males out to female audiences. Further, far from being age limited, the recent appeal of online games is extending games out to older game players.

Over the past decade there have been tremendous advances in entertainment computing technology and the gaming industry grew enormously ranging from console, PC and mobile based games. Real-time computer graphics can achieve near-photorealism and virtual game worlds are usually populated with considerable amounts of high quality content, creating a rich user experience, as well as reducing development costs considerably. As games in entertainment and leisure time increases its hold on us, so too does the power of games for non-entertainment purposes begin to take a more central role, and increasingly we begin to more clearly understand the mechanics that underpin its success. One of the best examples of ‘gamification’ – or how games are pervading our lives – is the example of serious games, educational gaming as well as games and virtual worlds that are specifically developed for educational purposes reveal the potential of these technologies to engage and motivate beyond leisure time activities (Anderson et al., 2009). A broad definition refers to serious games as computer games that have an educational and learning aspect and are not used just for entertainment purposes. Serious games are currently being used in a range of different contexts and two survey papers regarding
of serious games have been recently documented (Susi et al., 2007; Anderson et al., 2009).

While arguments against serious games have centred upon a lack of empirical evidence in support of its efficacy, two large studies in the UK and US respectively have demonstrated positive results in large sample groups, in one study on *Triage Trainer* considerable efficacy of game-based approaches over traditional learning techniques were demonstrated (Knight et al., 2010), while in another study on the game *Re:Mission* behavioural change in children with respect to medication adherence was proven in clinical trials (Kato et al., 2008). These studies have shown the ability for serious games to engage young and older learners, by targeting specific groups, and in both cases of experienced gamers and non-gamers have shown the efficacy of the game format for behavioural and attitudinal change. In another recent study, attitudinal change was found in a game *Floodsim* designed to raise awareness about flooding issues (Rebolledo-Mendez et al., 2009). Together the power of ‘immersive experiences’ is proving more engaging and motivating than standard approaches to training and education and more evidence of this efficacy is growing in the literature. The notion of ‘immersion’ itself is becoming considered as a central design tool as we move towards considering learning not only as knowledge construction but also as socialization, in our work we regard immersion as critical to good game design because it engages and motivates, and often includes components of interactivity, narrativity, ‘flow’ and fidelity (Csikszentmihalyi, 1990; de Freitas and Oliver, 2006).

In a recent book by the game designer Jane McGonigal, the author argues that reality is in general very unsatisfying for many, and how many people are finding happiness increasingly in games environments (McGonigal, 2011). Her thesis advances the notion that game elements could be used to engage and motivate more ‘real world’ activities, such as work and education. Her premise starts from a positive psychology as opposed to traditional psychology perspective, which aims to look at human behaviour not in terms of illness and depression, but in terms of happiness and wellness. Psychologists such as Mihaly Csikszentmihalyi have opened up this area of psychology that aims to express positive behaviours such as happiness, and these McGonigal argues are aspects that are mirrored in good game play (Csikszentmihalyi, 1990). In work examining animal play undertaken by Stuart Brown, he draws upon a synthesis study of psychopaths, the studies revealed that ‘normal play behaviour was virtually absent throughout the lives of highly violent, anti-social men, regardless of demography’ (Brown, 1998, p. 249). The work underlines the argument that the traditional approach to games and game play as being without value, and as being addictive or violent, is in fact the opposite of the truth. Games and play are incredibly powerful tools for socialization and collaboration and in fact indicate real potential for therapy and rehabilitation. McGonigal’s work shows that the ‘fixes’ of games can be overlaid upon real world activities to motivate and engage, and that play can be used effectively for socialization as well as therapy.

Previous studies illustrated that games can promote learning (e.g. van Eck, 2006). Spatial abilities can be also improved by playing arcade games (de Lisi and Wolford,
Further potential benefits of games include improved self-monitoring, problem recognition and problem-solving, decision-making, better short-term and long-term memory, and increased social skills such as collaboration, negotiation, and shared decision-making (Rieber, 1996; Mitchell and Savill-Smith, 2004). *Mingoville* (Sørensen and Meyer, 2007) is a serious game based on the idea that children learn and are motivated by problem-solving and game activities rather than traditional skills-based and textbook based material focusing on reading, writing, spelling and listening. The project intends to explore, build and implement prototypes in collaboration with companies, using their products and experience to develop knowledge about serious game challenges, educational design and assessment with the aim of innovation. In another study, a multi-player educational gaming platform that was designed for students combined content with pedagogy showing potentials to advance gaming theories and problem-based solving approaches in multi-player educational gaming platforms (Annetta et al., 2006).

The success of serious computer games in educational scenarios is based on the combination of audiovisual media that is prevalent in these games, which enhances the absorption of information in the learner’s memory (Paivio, 1990; Baddeley, 2000). This has been found to considerably improve the process of learning (Fadel, 2008). Different learners will have different preferential learning styles, so a serious game cannot automatically guarantee success, and there is some evidence of the learner’s gender playing a role in this (Hodgins, 2005), however the available evidence generally suggests that the visual medium that serious games employ has a positive effect (Solanki, 2009). Another factor for the success of educational serious games is the actual presentation of the subject matter in the form of computer games, which have been found to improve the players’ concentration and attention levels (Kirriemuir and McFarlane, 2006). This not only benefits the retention of information as such, but also increases the learners’ motivation, thereby improving the learning experience.

A popular platform for serious games is online gaming on virtual worlds for greater open-ended exploration and on games engines designed for more quests and missions and narrative-based games. The availability of various virtual world platforms such as Second Life (Linden Research, 2008), Active Worlds (Active Words, 2008) and the OLIVE platform (Forterra Systems, 2008), allows for a number of operations in virtual environments. Some of them include: social networking, collaboration, learning, training, experimentation as well as custom-based applications. A characteristic application is the Stanford Medical School project which used the Olive platform to practice innovation through supporting training for cardio-pulmonary resuscitation (CPR), mass casualty and assessment in acute-care medicine (de Freitas and Neumann, 2009). An example of a serious game application developed on a game engine, is one used to train traffic accident investigators how to attend a virtual traffic accident (BinSubaih et al., 2006). To measure the system’s effectiveness it was empirically evaluated with 56 police officers. The SG-ETS project developed three serious games demonstrators and results showed distinct gender and age differences with respect to game type favoured and levels of gaming (de Freitas and Jarvis, 2008). Another example is a serious
game that allows users to interact with 3D Web content (Web3D) using virtual and augmented reality (AR) in engineering education and learning (Liarokapis et al., 2004).

This trend towards using games technologies in non-leisure as well as in entertainment contexts constitutes a gamification of our everyday lives. Games are becoming more pervasive and this pervasiveness which in the past was regarded negatively taking up valuable recreation time and making children addictive, is now being seen in a more balanced light, as a means for educating children, for providing therapy and enriching our everyday lives with greater happiness and fulfilment. Gamification here includes the use of games not only as a cultural form, but can be used effectively as metaphors for achieving behavioural and attitudinal changes. As we have seen in *Re:Mission* where games were used for supporting behavioural change in children taking treatment for cancer, or as in *Triage Trainer* where games can be used to simulate reality to support learning transfer or as in *Floodsim* where games were used effectively for supporting attitudinal change about environmental issues. Other cultural forms of games such as mixed reality games that blend real and virtual world activities together have real capabilities for informing behavioural change as well. In the mixed reality game, *Chore Wars* for example, the game elements of competition and scoreboards encourage players to do the vacuuming and cleaning in their homes. *World Without Oil* is a game used to envisage the world when oil has run out and *Quest to Learn* is a US public school using games to transform the curriculum and education. These, and other examples, show the range of ways that gamification is changing many activities in our lives, increasing the fun in our lives, making us more aware of social and environmental issues and providing a new paradigm for curriculum-based education. But how can this capability be harnessed for future serious game design and how can we create more engaging and motivating experiences in a more replicable way?

### 2.3 Serious Game Design: A New Model for Experience Design?

At the heart of the challenge of designing effective serious games, there is a significant debate between game designers and instructional designers as to the exact role of pedagogy in serious games. While the authors have argued in their work that pedagogy needs to be a central aspect of serious game design (e.g. de Freitas and Oliver, 2006), others including Zyda argue pedagogy must be subordinate to story and that the entertainment component comes first (Zyda, 2005). Getting a balance between the demands of good game design with the requirements to measure and show learning outcomes has driven much of the conceptual work in the field. At the SGI it has led to the development of four models and frameworks that are being adapted in current evaluation work, and tested in the Roma Nova test-bed project.

Over the last 3 years the SGI has been examining the implementation of theory-predicated serious game design, work has aimed to bring together a theoretical basis for serious game design, including developing and testing the following models and frameworks, which placed pedagogy at the centre of serious game design:
• The four dimensional framework (4DF) which brought together four dimensions of the learner, the context of learning, the representation of the game and the pedagogies adopted (for example, associative, cognitive, situative learning theories) (de Freitas and Oliver, 2006). Work here has centred upon using the framework for evaluating games and for developing games leading to the exploratory learning game design model (below).

• The exploratory learning model (ELM) (de Freitas and Neumann, 2009) was a learning model extending exploratory learning from Kolb’s experiential learning cycle (Kolb, 1984), where social interaction becomes the heart of more interactive and engaging learning processes.

• The work of the 4DF and ELM led broadly to developments in the SG-ETS project that led to the exploratory learning game design model, which aimed to bring together game and product design together with participatory design models for enhancing more learner-centred design and evaluation strategies (e.g. de Freitas and Jarvis, 2008; Jarvis and de Freitas, 2009).

• The game-based learning framework, which aimed to bring together a number of different learning frameworks and models, including the 4DF and the Garris model of game motivation (Staalduinen and de Freitas, 2011). See Fig. 2.1.

In general, this work can be demonstrated to show the necessity of bringing together game design and pedagogic modelling strategies however the approach is not always a seamless one – and the work has led to a paradigm change in evaluation and learning design that has crystallised in the Roma Nova test-bed project. From
the outset, and in all research projects, researchers have deployed a participatory design methodology that centres upon learner profiling and modelling, and involvement in all the design phases. See Fig. 2.2. This method has allowed for incremental advances in the development of serious game design approaches that have led to the Roma Nova implementation (Panzoli et al., 2010).

The research work has found varied outcomes, in particular the importance of feedback and the need for more sophisticated measures of in-game feedback (e.g. Dunwell and de Freitas, 2011), in addition the wider use of social interactive learning – in need of a model for evaluation – and the general pedagogic drive towards ‘situative learning theories’ that centre upon social learning and interactions. Based upon these research findings and considerations, the Roma Nova implementation sought to bring together agent technologies within a high-fidelity virtual environment, with the use of serious games elements. Through social interactions within the environment, both through questing and with the use of dialogic-based interactions with the avatars a greater sense of immersion and interactivity could, we hypothesised, be produced with the benefit of increased knowledge through experience-based learning.

We asserted that this might lead to greater retention of knowledge learnt in this way – an aspect still to be proven in the ongoing evaluation work (results forthcoming). In an attempt to frame this evaluation drive, we are considering the neuropsychological aspects of learning and so one line of ongoing research is focusing upon neuropsychological studies with children using the system. The migration of education and training from the physical world to the virtual world in the Roma Nova instance is being supported by a game-based environment which supports a

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**Fig. 2.2** Exploratory game design model  
*Source: de Freitas and Jarvis (2008)*
range of functionality including social interactions, modelling real environments, document sharing and recording facilities that allow users to replay activities undertaken in-world. Apart from the provision of educational content, the student’s learning experience may be improved through targeted social interactions with real and realistic virtual tutors that they can interact with directly, allowing for personalised assessment and on-the-fly adaption of content. These autonomous intelligent tutoring systems it is envisaged will allow users to learn at a pace that they have set themselves by adjusting their educational and learning strategies according to their needs (Groenewegen and Strassner, 2004).

The Roma Nova game in particular builds from the formal curriculum a basis for missions undertaken within dialogic environments, where children interrogate virtual and human driven avatars in an exploratory model of ancient Rome. The idea is to provide a test-bed environment for testing conceptual and pedagogically driven design experiments, and so drive iterative development of the environment with a participatory design methodology at its heart as children will be playing and helping to design the system over a long period – with alternate design and testing phases through the year to fit around teaching timetables. The project has so far been developed and two testing phases are planned for March for usability testing using heuristics with computer science students, and in Malta in April with 200 school children for usability, as well as educational research methods for establishing the learning objectives and favoured feedback mechanisms. In the future, we envisage a socially driven and participatory model for developing all interactive exploratory learning environments, and argue that the four dimensional framework (see Fig. 2.3, de Freitas and Oliver, 2006) and the exploratory learning model (de Freitas and Neumann, 2009) will be used as a conceptual basis for designing and testing these environments and approaches.

Other more development focused work being undertaken in the Research & Development Group is developing multimodal architectures to allow human computer interfaces to be easily incorporated in the environments. See Fig. 2.4. The MIM model proposed by White et al. (2007) and being developed in current work by Petridis and colleagues, outlines an architecture for achieving this integration and we are currently testing the model using BCIs, haptics and other input devices (Arnab et al., 2010).

The idea of serious games design has led us to a hybrid approach to design that incorporates both pedagogic and game design principles and blends elements of games with simulation and modelling. The main outcome for the work is the evaluation-based approaches that have led to iterative design strategies, heuristics and educational research methods when combined with social network analysis. In another project, the game Code of Everand has been evaluated. 90,000 children in the UK have played the game and initial data analysis using clique percolation social network analysis methodology have found interesting correlations between game play and social interactivity, correlations that could be used to inform game design for supporting more collaborative learning approaches, when combined with real-time on-the-fly adaptivity will open even greater capabilities for providing personalised feedback and content retrieval.
Through the holistic approach to research and design, and through the inductive method of bringing together a range of different methods for data collection and analysis, it is envisaged that future uses of data coming from the user may be used to inform the ‘play’ of the gamer within the learning environment. Just as more sophisticated feedback mechanisms will be integrated in the virtual environment, so too will the ability for us to create more advanced methods for the feedback loop in the game and during game play. We postulate that two elements are in need of more research in advance of better deployment of serious games towards the end of greater immersion: the learner model, and this will be more detailed, dynamic and able to change on-the-fly and second, the game responsiveness, and this will be through different and varied data capture of the learner, possibly through biofeedback mechanisms or other interface devices, e.g. haptics, virtual reality interaction devices. Through the learner model and greater game responsiveness the serious game mechanisms can be improved and consolidated as part of the more immersive and interactive environment. Realism and fidelity may be controlled to greater or lesser extent depending upon budgets and target user groups, but improved learner modelling and game responsiveness can together alter the level of interaction of the user and support a more multidimensional journey of user in the virtual (and real) environments that they are playing within.

Game design in this new paradigm therefore will need to reflect better the learner and their requirements through engagement with their changing user model, but
will also need to respond on-the-fly to changes with respect to missions, narrative, flow and feedback levels in a multimodal way, adapting to the position, context and previous behaviour, as well as to their physiological state and mental attention and affect. The next version of the exploratory game design model therefore, outlined in previous work (see Fig. 2.2) will need to bring together more closely the dynamic learner/user model, the physiological measures of the user and the serious game design elements. Using the level of interaction model within the environment, a more adaptive and sensitised set of interactions between the user and the environment may be then effected (Panzoli et al., 2010).

The main learning point from the varied studies of existing serious games included in this chapter has been a move in pedagogic terms from a constructivist or cognitive-centred theoretical basis towards a more social and interactive position. In particular, it is worth here noting the importance of social networks and communities in current learning practices. The growth of social networks has been a significant phenomenon, and has led many in society, not just students, to substantially change their communicational behaviours. The use of Skype in business contexts and Facebook in educational environments shows the pervasiveness not just of games but of social networking, and increasingly these modes are being considered for marketing, training and product testing, amongst other uses.
As social network tools become more central to our lives, a deeper socialization goes in tandem with the blurring between domains of work and leisure, physical and virtual spaces, therefore social and cultural elements, as well as technological issues are becoming major drivers for a greater reliance upon a socialization based increasingly upon community-based models, not just of communication, but also for business models and social organisation. Online virtual communities are particularly popular among the younger generation as they enable discussion around shared interests (communities of interest), developing social relationships (communities of relationships) and exploring new identities (communities of fantasy) (Hagel and Armstrong, 1997). Several of these also provide access to games and serious games, however, not all online virtual communities that propose serious games are successful in attracting large numbers of users due to issues of engagement and complexities with building long lasting communities (Losh, 2008). The power of immersive experiences seems to be predicated upon the level of interaction and the social interconnections within the game environment, where building and engagement with the users is central like in World of Warcraft is manifest communities seem to have greater strength and longevity (MacCallum-Stewart, 2011). However there is still very little research to demonstrate the tipping points of these gaming communities and in general it is fair to say that it is the communities and community models that hold the environments together.

To support more social interactive learning, we have been developing a game-based exploratory learning model, which places greater emphasis upon exploration in virtual environments and gives greater emphasis to social interactions taking place in-world (extending from work based upon Jarvis and de Freitas, 2009). This exploratory learning model is based upon Kolb’s experiential learning cycle, but while Kolb encourages reflection upon real world interactions, the exploratory learning model focuses upon explorations of the virtual and real spaces, and centres upon dialogic exchanges as a basis for learning (from Socrates). Alongside the social interactions built into the game environment through dialogues between the learners and the human and virtual driven characters in the game, we are taking the best designs from commercial entertainment games and bringing these advanced artificial intelligence and multimodal interactions together with curriculum based objectives in an engaging and high fidelity environment. The Roma Nova project is the beginning of a new approach to serious games design that provides high quality interactions, provides full feedback and adapts to the learners requirements on-the-fly. It supports a social interactive learning approach and operates using a distributed model of tutoring within a hybrid environment that blends virtual world exploration with gaming elements and structure in terms of narrative and quests. Through using the participatory design model as a core design tool in the development process we are altering the way development and evaluation are considered. In the future all games will be designed iteratively like this, and we hope to set a new benchmark for good design within the education area of game design.
2.4 Conclusions: Future of Serious Games

The work to date has led us rather unexpectedly to a vision for future learning, and that is a vision that in the future all learning will involve game-based and immersive, social and interactive elements. While our initial research never intended this outcome, as many researchers the world over appreciate research is not an exact science and often we do not find what we set out to find. In the *Roma Nova* project we see the confluence of the three elements of gamification, serious games elements and social interactive pedagogies. Together the power of immersive experiences has the potential to change how we learn, by creating immersive and distributed tutoring environments where the environment is a wrapper for a range of different e-learning resources and materials all brought into a single interface of a physically engaging environment that can be traversed and engaged with through games, narratives and missions. Social interactive learning models underpinning exploratory learning of the environments and populated with virtual agents that can provide customised and personalised information when needed and adapted to the user’s requirements to scaffold the processes of learning.

The *Roma Nova* project has allowed us to experiment with different methods of feedback and interaction, aspects which will be the bedrock of successful systems for education in the future. Not only can data be presented more meaningfully, but also a context for peer interactions can be presented through collaborative missions and objectives. Shared goals and outcomes can be designed through simple scenario editing and players can be monitored and assessed seamlessly through performance in the environment and levelling up through the game. As we have seen in the *Code of Ever* and *evaluation*, a large amount of data can be collected from the user, and as a method of analysis of performance and in terms of reduced workload for the tutor, game-based assessment has substantial benefits over traditional methods. More sophisticated measures and assessment can be built into the system through feedback mechanisms, and in addition the scope for collecting and using biofeedback and physiological measures can also help to assess and more objectively validate and benchmark performance against previous performance or in relation to others in the same class or category, or just as a relative measure.

The future of serious gaming includes three significant aspects: convergent technologies, widening application areas and efficacy proofs that together will power the wider uptake of these applications over the next 3–5 years. Particular emphasis will be given to the value of immersive applications in serious games which offer the potential of transforming the way we perceive training and multimodal learning. Moreover, serious games in the future will have many new capabilities and we are only just beginning to scrape the surface of the real capabilities that will exist. However there is a need for continued and sustained research, development and assessment of the efficacy of game-based approaches, a requirement for standards and a drive towards greater iterations of evaluation and design cycles. The new paradigm for learning therefore will continue to drive innovation across education, and it is important to involve all the stakeholders: educationalists, game designers and developers, researchers and centrally the learner in all stages of the design and
Serious games are a new and emerging sector of the games industry, but they are here to stay and could solve many of our key problems and challenges with engaging learners as well as supporting social learning long into the twenty-first century.

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