Framing the Adoption of Serious Games in Formal Education

Sylvester Arnab[1], Riccardo Berta[2], Jeffrey Earp[3], Sara de Freitas[1], Maria Popescu[4], Margarida Romero[5], Ioana Stanescu[4], Mireia Usart[5]
[1] Serious Games Institute, University of Coventry, UK
[2] University of Genova, Italy
[3] Institute for Educational Technology, Italian National Research Council, Genova, Italy
[4] Carol I National Defence University, Bucharest, Romania
[5] Escuela Superior de Administración y Dirección de Empresas (ESADE), Barcelona, Spain

s.arnab@coventry.ac.uk
berta@elios.unige.it
jeffrey.earp@itd.cnr.it
s.defreitas@coventry.ac.uk
maria.popescu@adlnet.ro
margarida.romero@esade.edu
ioana.stanescu@adlnet.ro
mireia.usart@esade.edu

Abstract: Nowadays formal education systems are under increasing pressure to respond and adapt to rapid technological innovation and associated changes in the way we work and live. As well as accommodation of technology in its ever-diversifying forms, there is a fundamental need to enhance learning processes through evolution in pedagogical approaches, so as to make learning in formal education more engaging and, it is hoped, more effective. One opportunity attracting particularly close attention is Serious Games (SG), which offer considerable potential for facilitating both informal and formal learning. SG appear to offer the chance to "hook" today's (largely) digital-native generation of young learners, who are at risk of falling into an ever-widening gap between "networked" lifestyles and the relative stagnant environment they experience in school and university. However, there are a number of inhibitors preventing wider SG take-up in mainstream education. This paper investigates SG in formal education, initially by concentrating on pedagogical issues from two different but complementary perspectives, game design and game deployment. It then goes on to examine game based practice in formal settings and focuses on the pivotal role of the educator within the emerging panorama. This is followed by a brief look at some specific implementation strategies, collaboration and game building, which are opening up new possibilities. Finally some points for further consideration are offered.

Keywords/Key Phrases: serious games, game-based learning, pedagogical issues, formal learning, teacher's role, collaboration

1. Introduction

Over recent years considerable interest has been devoted to the pursuit of learning through, and with, digital games and particularly so-called Serious Games (SG). The latter are defined and interpreted from a range of different viewpoints: Zyda (2005) sees them as "a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives". More broadly, Michael & Chen (2005) see SG as "a computer based game with a primary purpose other than entertainment". Egenfeldt-Nielsen and colleagues (2008) shift the focus from game artefact to game process - from serious game to serious gaming - by stating that "any video game can be perceived as a serious game depending on its actual use and the player's perception of the game experience". Stone emphasises the learning dimension within this broader framework, describing SG as "games that support learning in its broadest sense" (Stone 2008). It is in the latter senses that the terms Serious Games (SG) and Game Based Learning (GBL) are used hereafter.
Many studies point to the positive qualities of SG, such as their persuasiveness and motivational appeal, which can support immersive, situated and learner-centred learning experiences (David & Watson 2011; Gee 2003; Aldrich 2009; Gibson 2006). Proponents of SG see them as a means for active construction, rather than passive reception, of knowledge and as prime opportunities to practice key soft skills like problem solving, decision making, inquiry, multitasking, collaboration and creativity. While some remain sceptical (Foster, Mishra & Kohler 2010), most agree SG have strong

Reference this paper as: Arnab S., Berta R., Earp J., de Freitas S., Popescu M., Romero M., Stanescu I. and Usart M. "Framing the Adoption of Serious Games in Formal Education" *Electronic Journal of e-Learning* Volume 10 Issue 2, 2012, (pp159-171), available online at www.ejel.com

potential for learning. That said, inhibitors to uptake need to be recognised and addressed if the potential is to realised in formal education (Williamson 2009; Sandford et al. 2006).
Gaining a better understanding of the potentials SG present for learning and how best they can be leveraged to enhance learning processes is one of the main objectives of partners in the Games and Learning Alliance (GALA), an EC-funded Network of Excellence on SG (see http://www.galanoe.eu/). These aspects are of particular concern to GaLA's pedagogy sub-group, whose joint reflections are encapsulated in the following discussions. These begin with examination of pedagogical issues from two different but complementary perspectives, game design and game deployment. Subsequently, game based practice in formal settings is explored, focusing on the pivotal role of the educator within the emerging panorama. This is followed by a brief look at some specific implementation strategies, collaboration and game building, which are opening up new possibilities. Finally some points for further consideration are offered.

1.1 Approaching pedagogy from a game oriented perspective

Investigating the potential of digital games for enhancing learning, many proponents have focused in the first instance on the nature and design of the game artefact. Some authors have taken a close look at popular video games (Bopp 2006; Becker 2006; Gee 2003; Prensky 2007), noting how these "guide" players towards understanding of the game-world and how they support acquisition of the knowledge and skills needed for successful gameplay, i.e. winning. These efforts have led to frameworks of design-based "learning principles" that, taken together, form a kind of video games pedagogy. The authors also advocate the adoption of such principles for the design of Serious Games, whose intrinsic vocation is to support learning processes, possibly by leveraging rather than eclipsing the fun factor. Some emphasise the need for SG design to be pedagogically informed and based on instructional design principles (Van Eck 2010).

An alternative, more "bottom-up" approach examines the learning dimension of games from the viewpoint of problem solving, i.e. game situations that the player has to tackle by applying problem-solving skills. These are seen by some authors as intrinsic and elemental to gameplay (Gee 2007; Kiili 2007; Van Eck & Hung 2010). The last of these authors proposes a problem-type taxonomy and posits the deconstruction of game problem-events into atomic units of minimal granularity as a foundation for systematically analysing (and also tackling) game design; the thinking is that in this way "instructional designers and game developers have a better idea of what types of gameplay will most appropriately afford given learning goals and objectives".

A slightly looser, more open-ended approach towards gaining that same understanding is through educational game design patterns, which are defined by Kiili (2010) as "semiformal interdependent descriptions of commonly reoccurring parts of the design of an educational game that concern and optimize gameplay from an educational perspective focusing on the integration of engagement and learning objectives". These text-based descriptions are proposed as methodological blueprints for analysing and tackling different aspects of game design, including those related to the learning dimension.

Hirumi and Stapleton (2009) assume a slightly different vantage point that concentrates on development processes, equating the fields of game development on the one hand with instructional design on the other. They identify a number of key parallels and intersections between the two that call for coordinated effort in order to maximise the potential for enhancing learning opportunities and reaching objectives. They stress that game design should start with a suitable pedagogical approach, which is "critical for determining the nature of the learning environment and guiding the overall design and sequencing of critical learning interactions and game play… by basing the early entertainment development on pedagogy, any subsequent artistic choices will most always enhance, rather than obstruct achievement of the learning objectives." On this premise, the authors investigate how a given pedagogical approach might be reified within the game design process, positing the adoption of a general framework based on grounded instructional events associated with learning outcomes of different kinds. Similar efforts have been made to shed light on learning with Serious Games by mapping identifiable steps or events in game interaction against general learning activity frameworks. One reference adopted for interpreting game pedagogy is Gagné (1977), particularly his "nine events of instruction" (Van Eck 2010). But other models are referred to as well (Kickmeier-Rust et al., 2006), including the 8LEM model (Verpoorten et al. 2007) and Bloom's (revised) taxonomy (Krathwohl 2002). In the literature, Serious Games are often mentioned in conjunction with a set of pedagogical paradigms and approaches that are generally considered to be innovative, at least when set against

what is still considered established practice in much mainstream formal education, namely teacher-driven knowledge transmission of the "chalk and talk" kind. This set of "innovative" paradigms includes the likes of situated cognition/situated learning, learning-by-doing, discovery learning, problem-based learning, constructivist learning, among others. While the basis for such attributions can sometimes be sketchy, some serious efforts have been made to provide a systematic analysis. One such was carried out by Kebritchi and Hirumi (2008), who examined a broad set of Serious Games and sought to align these with recognized teaching/learning paradigms that the games are held to reify – or at least strongly resonate with. The basis for associating each game with a given paradigm was deduced from game designers' declarations and standpoints regarding the "pedagogical foundations" underpinning design decisions and strategies. The study grouped the vast majority of the 50 games considered under the chief pedagogical headings of situated cognition, experiential learning, discovery learning and constructivist learning (some games remaining unclassified). These four main categories are further sub-divided into sub-categories. For example, experiential learning (the most prevalent paradigm) is considered to comprise learning-by-doing, guided experiential learning, case-method teaching and experiential/inquiry-based learning. A high-level theoretical framework of this kind is quite evidently open to (re)interpretation and alternative arrangements, nonetheless the attempt at a pedagogical analysis, and classification, of a substantial set of SG grounded on an empirical study represents a useful reference point for further investigation. Indeed, some of the authors of the present paper are currently seeking to extend and enrich this pedagogical survey by adding further paradigms and more examples from the literature; this effort is an undertaking of the GEL Theme Team (see http://www.teleurope.eu/pg/groups/81989/gel-game-enhanced-learning/), an initiative supported by the STELLAR Network of Excellence (see www.stellarnoe.eu), co-funded by the EC under the Seventh Framework Programme.

1.2 Approaching pedagogy from a context oriented perspective

Thus far the discussion has concentrated on the inherent nature and features of games adopted for learning purposes. However, efforts to enhance formal education with serious games are influenced to a large degree by the particular learning context in which a game is deployed and – crucially – by how the educator adopts a game to address particular objectives and learning goals (Egenfeldt-Nielsen 2006). Specifically, a pivotal role is played by (a) the attitude educators assume to SG and game based learning environments, (b) the activity plans and scenarios they devise, (c) the roles, strategies and pedagogical approaches they assume when enacting those plans (Hanghøj & Brund 2010; Chattergee et al. 2011). These factors are discussed in greater detail in Section 2.1.

An important starting point is for educators to have an awareness of the particular approach that a particular game lends itself to. In an ideal world they would have access to a wide range of games that differ not just according to subject matter, target group addressed etc. but also in terms of the approach to learning that the game embodies (or might be suitable for), as discussed in Section 1.1. Informed choice on this last aspect is central to the educator's (a) preparedness for the dynamics actuated through interaction with the learning environment, and hence (b) the capacity to guide learning processes effectively towards predetermined learning goals.

Some recent field studies have sought to quantify the impact of context and pedagogical approach on learning outcomes generated within game based learning processes. For example, Chattergee and colleagues (2011) compared the learning outcomes of different student groups who played the same set of SG under different circumstances, i.e. with or without peer collaboration and facilitator support, or with both/neither of these. Although the scope of the tests was admittedly limited, careful statistical analysis of the outcomes confirmed that peer collaboration and facilitator support are factors that are "effective in promoting learning through game-play". It should be noted that 'collaboration' is intended here as students conversing and helping one another out during game sessions, rather than assuming collaborative roles within the games themselves. The authors note that their findings on collaboration substantiate earlier studies carried out by Ke (2008) amongst others, while the outcomes regarding facilitator support confirm the finding of Garris and colleagues (2002). In addition, their results are congruent the findings of a field study by Leemkuil & Hoog (2005), which revealed that some forms of *game-embedded* support actually have no positive impact on learning outcomes (indeed they may even have a detrimental "crutch" effect), while player cooperation and facilitator-initiated briefing/debriefing sessions prove to be effective support mechanisms.
As mentioned above, pedagogical context is considered another important factor influencing how – and how effectively – games are used for learning. To investigate this, Barendregt & Bekker (2011) conducted a field study comparing the expectations, attitudes and actual use of an educational game

by children attending schools of three fundamentally different types. The three settings presented children respectively with three distinct levels of freedom for choosing and pursuing learning activities (gameplay in this case), i.e. free choice, limited choice, and no choice. The authors monitored gameplay in both formal (school) and informal (free time) contexts in an effort to determine whether the three types of pedagogical setting impacted on students' informal game uptake – a key indicator of intrinsic motivation. Results showed that the strongest and most sustained engagement across both the formal/informal contexts was generated in the limited choice setting; in the free choice setting interest proved weaker in both contexts, while no choice (perhaps predictably) generated strong engagement exclusively in the formal context, which however was summarily truncated when the allotted class-time 'expired'. Once again the authors point to (a) the critical role of the educator in positioning gameplay within structured learning activities, guiding the unfolding of those activities, and facilitating learners, and (b) the importance of players' socialisation of game-play not just to lower the entry threshold for non-players but also to maintain engagement and enhance learning. These key aspects are discussed further in Section 2.

1.3 Towards multi-perspective frameworks and curriculum integration

The multiplicity of vantage points assumed for investigating learning with SG, exemplified by the efforts discussed thus far, suggests the need for high-level, overarching models and frameworks to provide both conceptual and practical support. Examples of such models include the four dimensional framework (de Freitas & Oliver 2006), the exploratory learning model (de Freitas & Neumann 2009), multimodal interface architecture model (White et al. 2007; Arnab et al. in submission) and the game-based learning framework (Van Staalduinen & de Freitas 2010).

In particular the four dimensional framework (fig 1) advocates the use of pedagogy, an emphasis on learner modelling, the required amounts of fidelity, interactivity and immersion in the representation of the game, and consideration of the context within which learning takes place (Rebolledo-Mendez et al. 2009; de Freitas & Jarvis 2008).

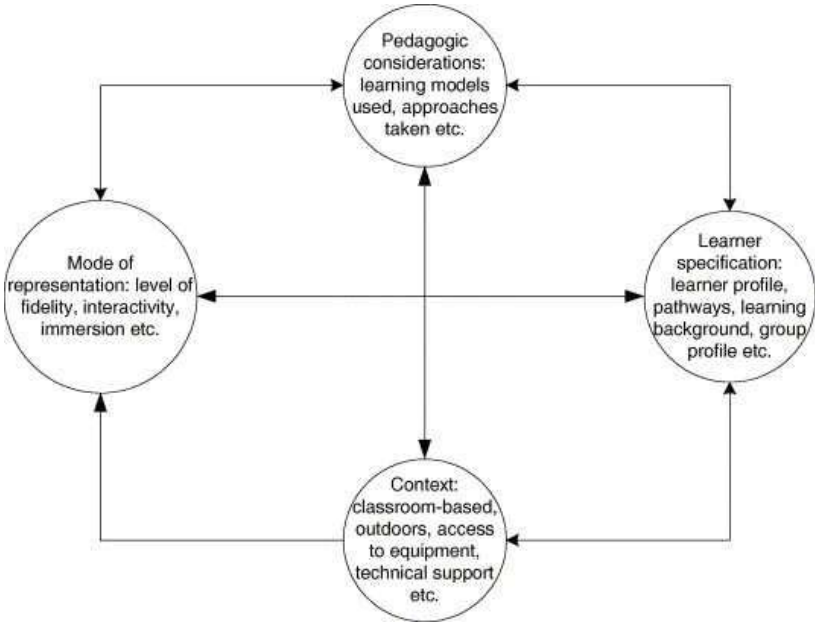

Figure.1: the Four Dimensional Framework

Each of these four dimensions encompasses aspects that are essential not only for game design and evaluation but also for effective adoption in educational processes. Learning specification involves elicitation of the characteristics defining the learner population so that the intervention can be tailored to meet requirements and optimise outcomes. Representation regards key attributes of SG such as immersion and interactivity which, when successfully implemented, can open the way to the sorts of flow-driven learning experiences recognised as being among the chief potentials of game based learning (Csikszentmihalyi 1990). Context is a key consideration in technology enhanced learning

generally; as discussed in the following section, it plays a particularly important role in shaping learner expectations as far as SG are concerned. Pedagogical considerations represent the cornerstone of any instructional intervention, encompassing models and approaches (e.g. associative, cognitive, situative) adopted in pursuit of learning objectives.

Research has yet to present educators with clear guidelines to help them incorporate games in practice in such a way as to ensure a smooth continuum from theory/planning to deployment and evaluation. So as well as informing research into SG, conceptual frameworks such the one above can also represent a useful bridge to support transfer and exchange among those involved in different capacities and at different levels in the SG ecosystem. This is also true for those concerned with curriculum innovation, in this case via integration of SG into curriculum frameworks.

The curriculum is an embodiment of an educational system, be it school (K12), Higher Education or company training. It is a complex and evolving set of rules, experiences and documents, a complex pedagogical project that contains design, practice and assessment stages, guidelines on practice and the competences to be formed, along with assessment types.

The so-called 21st century curriculum is competency based, centred on what students know and can do. It is a curriculum focused on the upper levels of Bloom's taxonomy - analysing, evaluating, creating (Krathwohl 2002). It is research driven and based on active learning processes whereby the student is no longer spoon-fed, but is encouraged to engage actively with appropriate levels of guidance and scaffolding. It is a curriculum connected to students' interests, experience and talent, and relates to the real world. It allows students a certain degree of freedom in selecting what, when and how to learn, according to their cognitive and metacognitive abilities. Given that the educational value of games has already been recognised (Gredler 1996), considerable benefit would be gained from aligning games with the curriculum. However, introducing SG into the curriculum requires careful consideration by decision-making bodies and teachers alike.

2. Game based learning in formal settings

The most fundamental distinction that can be made with regard to the context of SG use is between formal and informal settings. To date much of the attention dedicated to SG has regarded their design for, and use in, informal settings, i.e. "daily work-related, family or leisure activities" in which learning is largely unintentional on the part of those involved (Tissot 2004). In this light, it is truly safe to say that, where SGs are concerned, "the game's the thing". By the same token, however, players may not necessarily be adverse to playing games with a fairly explicit educational agenda. This is borne out by a recent wide-scale survey of students in which the majority of those questioned stated that they did not mind using games with overtly educational objectives in an informal setting (Dunwell et al. 2011). Evidently what counts first and foremost is the expectation of playing a game that features good playability and offers a rich and engaging gaming experience, irrespective of whether there are overtly educational objectives or not. Indeed, the question of expectation is an important one both for SG design and deployment.

While the initial spotlight has been trained mostly on informal contexts, a growing body of experience is being accrued in the deployment of SGs within formal education settings as well. Games are becoming increasingly pervasive in a whole range of contexts, particularly in the lives of young people, and this trend is encouraging education policy makers and practitioners to seriously consider game use in classes. Strong impetus in this direction is already coming from the recognised need to (re)engage disaffected learners, and game based learning is seen as a potentially effective response. As a result, we are more likely to see serious gaming become an integral part of curricula over the coming years. As will be discussed in Section 3, there are issues regarding practitioners' positioning with respect to SG, nonetheless game based learning represents an opportunity for more creative approaches that could have a significant and positive impact on teaching practices.

Many experiences of game deployment in educational settings carried out to date have concerned commercial off-the-shelf games, also known as COTS. By contrast, digital games purposely designed to pursue a more overtly educational agenda, related in some way to curriculum (or cross-curriculum) concerns, have figured to a somewhat lesser degree. A number of factors might be behind this: the range and ready availability of COTS, greater student (and teacher) familiarity with these games and their formats, the perception that they represent a refreshingly engaging alternative to entrenched

subject-based teaching (Sandford et al. 2006). Another consideration, which was alluded to at the beginning of Section 1, is that these commercially successful video games often embody sound game design, generating compelling gameplay experiences. In this sense COTS may well be seen as "quality" game environments that resonate with: (a) Malone's idea (Malone 1981) of intrinsically motivation fostered through challenge, fantasy and curiosity; (b) Csikszentmihalyi's idea of flow (Csikszentmihalyi 1990). Educational/Serious Games conceived explicitly in response to educational requirements are not always seen in the same positive light.

A number of successful deployments of COTS in formal education settings have been documented. One example is Blunt's adoption of COTS management simulation videogames (Industry Giant II, Zapitalism and Virtual U) for business studies (Blunt 2007). Other COTS games already being used in the classroom include Civilization (history), Age of Empires II (history), CSI (forensics and criminal justice), The Sims 2 (making complex social relationships), Rollercoaster Tycoon (engineering and business management), and SimCity 4 (civil engineering and government). For some of these there is a clear match between the game's explicit content and classroom subject; for others, a match is sought between the aims and skills involved in the course of study and the game's underlying strategies and gameplay. Other noteworthy initiatives that have used these and other COTS include Learning & Teaching Scotland's Consolarium, the Institute of Play's Quest to Learn Middle School in New York, North West Learning Grid's DiDa program in England (Derryberry 2007) and Futurelab's Teaching with Games project (Sandford et al. 2006).

While such experiences indicate that games have strong potential for enhancing learning, there is still a relative lack of solid and reliable research findings about integration of SGs into teaching and learning. This leaves questions unanswered and as a result the potential remains largely untapped in mainstream formal education. In order to understand how games can best be exploited within a formally structured educational context, we need to look not just at the *nature* of the game as such but also at *how* the game and its characteristics can be adopted and leveraged to enhance learning within the structural, organisational and cultural constraints of institutional education (Johnston & Whitehead 2008). This entails broad consideration of ICT-supported innovation in formal education, which is informed and driven by a multiplicity of interrelated factors like new tools and pedagogies, as well as the new organisational roles and relationships that are shaped by learner-centred and collaborative approaches to the learning process.

2.3 The educator within the emerging panorama

The educational panorama presently defined as "new" by most researchers (Ala-Mutka et al. 2008) has been (and still is) deeply influenced by the availability of new ICT tools, and learners are now more adept at using these tools. As stated above, SG can play a major role here in instilling innovation in learning processes: they present immersive educational worlds (de Freitas & Neumann 2009) where students can be more deeply and actively involved in educational activities. As proposed by Ott (2011), figure 2 contrasts the traditional learning situation in many formal educational contexts (left) with that (right) typified by the new learning community.

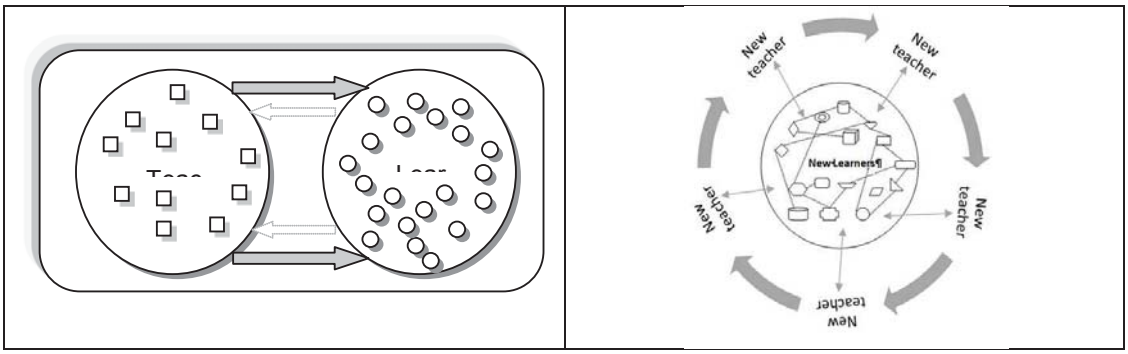

Figure.2: Traditional relationship between teachers-learners (left) vs. the new learning community (right)

In the former, teachers mainly act as the information providers and students the recipients, with a prevailingly unidirectional information flow between the two groups. In addition, the two groups are

strictly separate and their respective members (teachers/learners) are depicted as being similar / identical to each other (teachers-squares; students-circles) since the (reductive) nature of the information transmission-reception paradigm attributes little real value to the actors' individual characteristics.

By contrast, the second picture represents a vision that is both learner centred and based on dynamic collaboration among all the actors involved. Here learners are represented by different shapes, encapsulating the value of their individual differences. They assume the central position, are peer linked (work together, cooperate, network) and have reciprocal, frequent interactions with teachers, who also work in a team and not in isolation.

Facilitating educational processes with technology is a multi-faceted process, one that often places particularly high demands on the educator. In order to fully exploit the potential on offer, educators are called on to possess a range of qualities, attitudes and competencies, and to assume a variety of (sometimes challenging) roles. Beyond possessing subject matter and technological expertise, they need to be (amongst other things) competent instructional designers, strong team-players, critical self-analysts, confident risk-takers, and path-finding innovators pedagogically open to new ways of approaching the curriculum and tailoring classes assisted by technology (Midoro 1995; UNESCO 2011).

When it comes to SG, successful adoption does entail practical steps like identifying a suitable game for a given subject and gaining familiarity with that game. But it also calls for broader know-how that includes awareness of what subjects and skills can benefit from a games-based approach, when and how a SG is best deployed, what stage of the learning path is most appropriate, and how to account for and manage contextual factors.

Hanghøj & Brund (2010) argue that, with some notable exceptions, research in the field of educational games has been dominated by a determinist, game-as-learning-machine view which has largely overshadowed consideration for the teacher's role. They postulate that "game-based teaching can be understood as a complex series of pedagogical choices, practices and meaning-making processes, which can be analysed through the complimentary notions of teacher roles, game modalities, and positionings". To a certain degree this teacher-centred standpoint can be seen as an alternative, or complementary, take on the four dimensional model presented in Fig.1. Drawing on field studies in which teachers adopt the Global Conflicts series of Serious Games, the authors identify a repertoire of different, shifting roles that teachers assume through the process, namely that of instructor, playmaker, guide and explorer. These correspond to different phases in the deployment process and can be mapped (fig. 3) onto axes according to the type of knowledge (curricular/game) and perspective (outsider/participant) involved (Hanghøj & Magnussen 2010). The resulting "analytical lens" provides a general framework for gaining a more concrete understanding of game based learning dynamics from the educator's perspective.

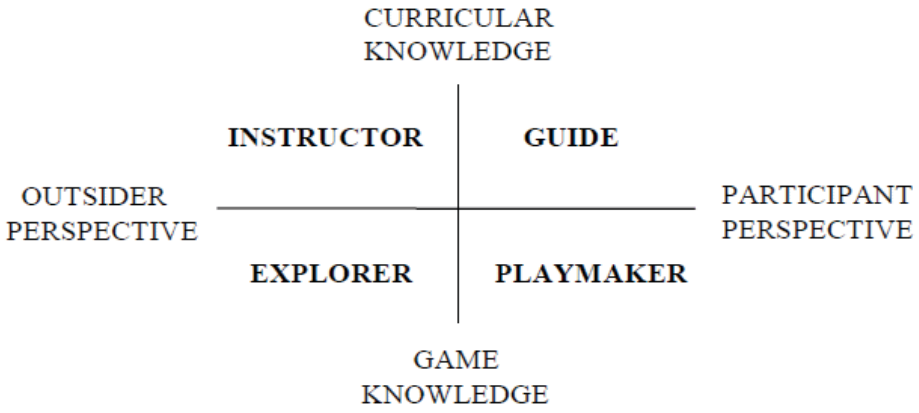

Figure.3: The relationship between different game-based teaching roles

Examining the teacher's relationship with game *modalities*, the authors note how the multimodal form of inquiry typically fostered by SG can result in teachers assuming a marginalised, largely passive and

ineffectual role, to the detriment of learning outcomes. This raises a key question: how to embed features in a game environment that support effective deployment in formal education contexts (i.e. that are "teacher sensitive") without compromising playability. With regard to teachers' *positioning*, the authors point to the importance of foregrounding the links between games, curriculum goals and learning outcomes as part of critical planning and enactment of game scenarios.

This study confirms the widely held position that general enthusiasm for SG needs to be matched by critical awareness so as to make the learning experience meaningful for each student. Indeed, not only should teachers know the game well, propose specific learning trajectories and verify effectiveness, they also need to engage in mediation, foster post-game discussions, and encourage reflection (Bellotti et al. 2010; Whitton 2010).

When considering the learning activities to complement and reinforce gameplay, it is important for teachers to "preserve the context (situated cognition) of the game, e.g. by extending the goals and character roles of the game into the classroom" (Van Eck 2006). Once again, this requires solid understanding of the game and means planning appropriate learning paths and monitoring their implementation to ensure effective learning; most importantly it means setting the gaming experience in a sound overall educational framework. This work is all the more important when considering that "games may not always meet the individual requirements of lecturers whose courses are tied to specific learning outcomes" (Rooney et al. 2009).

The transition from learning-by-listening to learning-by-doing generally implied in game based learning brings with it a change in the respective roles of instructors and learners, as illustrated in Fig. 2. Greater emphasis is place on orchestration of the actors on the stage (Garris et al. 2002) by the teacher, who fosters participation and engagement, provides support and feedback, and implements assessment. A key part of this support strategy is pre-game briefing and, perhaps most importantly, post-game debriefing, in which the chance to socialise and reflect on the game experience is key to consolidation of learning gained (Egenfeldt-Nielsen 2006).

3. Two implementation strategies: collaboration and game building

A central thread running through current ideas on education generally and technology enhanced learning in particular is the socialisation of learning processes. This is also reflected in current thinking in the Serious Games field and is generating new scenarios for game based learning in formal education contexts. One direction gaining increasing attention is collaborative gaming, whereby learners interact with one another in competitive/cooperative activities embedded in a multiplayer digital environment. Another approach that is opening the way for increased socialisation of students' game experience in formal education is learning through game design and building; here, instead of being given a game to play, students have the task of designing, constructing and sharing their own games as part of cross-curricular learning. Some brief discussion and examples of these two approaches are given in this section.

3.1 Focus on collaboration

In the new learning panorama outlined in Section 2, teachers and learners collaborate to achieve learning goals. Interest in collaborative learning has grown in recent decades, supported by studies showing how peers really learn while performing group activities. Learners can build on each other's knowledge and provide mutual feedback (Dillenbourg et al. 2009). Advantageous peer interactions such as providing and receiving explanations, co-constructing ideas, and negotiating meaning can be found in collaborative learning environments.

In the world of SG, new technological functionalities have recently emerged that have led to the development of engaging collaborative game environments for learning. Accordingly, collaborative SG should be taken into account as potential multi-sensorial learning tools that combine the benefits of collaborative and game based learning. Following Gee (2005), collaborative games not only allow individuals to participate in the same game, but open up a field for learners to construct understandings by interacting with information, tools and materials as well as collaborating with others.

There are still few examples of SG that embed a collaborative pedagogical approach. One is Gersang, a pedagogical adaptation of a commercial Massively Multiplayer Online Role-Playing Game (MMORPG) (Kimet et al. 2009). Deployment of this game in a middle school classroom permitted a

qualitative and economic solution for enhancing students' social problem-solving abilities through think-aloud and modelling processes. In higher education, Baker and colleagues (2004) designed and tested Programs and Programmers, a dyad game intended to help software engineering students gain better understand of software development processes through active, collaborative and competitive gaming practices. Mawdesley (2010) studied how the introduction of two different SG could improve the learning experience in an applied construction project management program: the Mug Game and Canal Game case studies revealed significant improvement in the communication and presentation skills between peers that had used those games. Chang and colleagues (2009) developed and implemented SIMPLE, a SG environment for management students designed to raise teaching effectiveness and improve classroom practice. Some interesting results could be seen from collaborative playing experiences; students developed internalized knowledge and appeared more interested in the real world applications of the concepts practiced. Another recent initiative in collaborative SG is MetaVals (Romero et al. 2011).

These experiences showed how deployment of both COTS and SG can help students practice and improve metacognitive processes and lead to more concrete problem-solving behaviours among peers. To make collaborative learning effective in terms of learning outcomes and reduced organizational loads, guidance and a scaffolding process are required (Kreijns et al. 2003). This applies especially to SG, where students' cognitive load should be devoted to the activities leading to attainment of learning objectives.

An interesting term that shows up when introducing SG in management education is "coopetition", defined as collaboration within the group and competition between groups (Fu & Yu 2008). Competing while cooperating to win a game can be regarded as a successful learning strategy, as it stimulates different types of knowledge acquisition (Ke & Grabowski 2007). Competitive learning environments encourage students to develop higher analytical skills, while collaborative learning situations prompt students to demonstrate higher synthesis skills. Competition and collaborative pedagogies have proved to be effective techniques for enhancing learning performance in face-to-face learning environments.

3.2 Focus on game building

Over recent years, a general view has permeated education communities worldwide that the entrenched power balance within education systems ought to be redressed. It is held that students should be empowered to take a more proactive role in their own learning and in this way they will become more engaged, and hence more effective, learners. The view is encapsulated schematically in Fig. 2; Lim (2008) – to quote just one source – expresses it thus: "engaged learning is (only likely) to happen when students are empowered to take charge of their own learning by co-designing their learning experiences with teachers and other students."

As mentioned earlier, one of the chief added values identified with game based learning is the opportunity to bolster learners' intrinsic motivation and engagement (Ott & Tavella 2010). So combining student-driven and game-based learning could be a positive step. According to Lim, one way (forward) is for students to design their own computer games based on their own interpretations of the school curriculum.

A number of efforts in this direction have already been reported and analysed (Prensky 2008; Games 2009). Prensky offers a vision in which students' game building not only permeates educational practice but even becomes a force in the SG ecosystem. Beyond the product-centred view, he recognises that the true value of game-making for learning lies in the creation process and attendant meta-learning. Such constructionist-oriented thinking is closely associated with the work of Seymour Papert (Ackermann 2001) and underpins the efforts in the field of Kafai (2006) and others. A key aspect in this regard is supporting socialisation processes and developing students' creativity by means of collaborative interactions (Ott & Pozzi 2009). Students' game construction still occupies a relative niche position within game based learning. However, pilot experiences - especially those run in the US (Mawdesley et al. 2011; Li 2010; Kafai 2006) - are indicating that game building activities can support the acquisition of knowledge and skills in a number of areas, not just in game content and procedure but also with regard to key transversal skills (Bates et al. 2008). Established digital authoring tools like GameMaker and Scratch are being joined by an ever-growing number of platforms such as GameStar Mechanic and Kodu, which are helping to lay the foundations for the sort of scenario envisioned by Prensky above.

Building on the growing body of work being carried out in this direction, a group of European researchers is currently investigating ways of supporting students' collaborative game building. This effort is part of a project called MAGICAL (Making Games in Collaboration for Learning), which is co-funded by the European Commission under the Lifelong Learning Programme. MAGICAL explores collaborative design of educational games as part of learning processes enacted in primary and lower secondary schools; it applies a holistic approach that encompasses education/training of teachers and professionals in inclusion. Indeed, as described in Section 2.1, educators play a pivotal role in enacting and orchestrating game based learning activities in formal education and this is particularly crucial when it comes to dealing with the often complex dynamics of students' peer collaboration within a constructionist-oriented framework. Moreover, by addressing teacher education/training from a multi-faceted transnational perspective, it is hoped that MAGICAL will build a basis for wider transfer to contexts beyond the project's immediate confines.

4. Final reflections

This paper has sought to frame the adoption of Serious Games in formal education by discussing some key pedagogically-related aspects that have emerged from discussions within a sub-group of partners in the Games and Learning Alliance (GALA). It is believed that adopting a multifaceted view on the subject is a fruitful way of gaining deeper understanding and yields a range of indications for educators' SG uptake, thus supporting wider adoption in formal educational settings. It is clear that a number of concrete steps need to be taken in this direction, including: better training for practitioners, simpler tools for authoring educational game activities, dedicated web based communities and resources for practitioners, more institutional support structures, and wide-scale access to pedagogically effective games, use cases and potential game content.

Game-based environments are evolving rapidly, and the game experience is set to become even more immersive, both by way of game design and via the technologies with which players will engage. By the same token, there is a good chance that new developments will emerge that more explicitly address the formal learning sector; these may include new tools for tutors to create personalised learning scenarios, intelligent tutoring environments that allow educators and students to author and choreograph experiences (de Freitas & Neumann 2009), greater learner game creation (Vos, Meijden & Denesen 2011), integration of tools for supporting metacognition and also for fostering collaborative gameplay. In this light, the issues discussed in this paper are destined to take on even greater significance. Among the key challenges that lie ahead are adaption of SG across cultural contexts and ensuring the inclusion of all learners in game based activities.

References

Ackermann, E. (2001). Piaget's constructivism, Papert's constructionism: What's the difference? Future of learning group publication, 5(3), 438. MIT Future of learning group publication.

Ala-Mutka, K., Punie Y. and Redecker C. (2008) "ICT for Learning, Innovation and Creativity" FJRC Technical Notes. European Commission, Joint Research Centre, Institute for Prospective Technological Studies. [online]: http://ftp.jrc.es/EURdoc/JRC48707.TN.pdf (accessed 15/05/2011)

Aldrich, C. (2009). The Complete Guide to Simulations and Serious Games: How the Most Valuable Content Will be Created in the Age Beyond Gutenberg to Google. San Francisco: Pfeiffer

Arnab, S., Petridis, P., Dunwell, I., de Freitas, S. (2011) "Tactile Interaction in an Ancient World on a Web Browser". International Journal of Computer Information Systems and Industrial Management Applications (IJCISIM), (in press).

Baker, A., Navarro E.O. & van der Hoek, A. (2004). "An experimental card game for teaching software engineering processes" The Journal of Systems and Software 75(3)

Barendregt, W., & Bekker, T. M. (2011). "The influence of the level of free-choice learning activities on the use of an educational computer game". Computers & Education, 56(1), 80-90. Elsevier Ltd.

Bates M., Brown D., Cranton W., Lewis J. (2008) "Gaming and the Firewall: Exploring Learning Through Play via Game Design With Children". In: Proceedings of The 3rd European Conference on Games Based Learning Pages: 8-17

Becker, K. (2006). "Video Game Pedagogy: Good Games = Good Pedagogy". Journal of Design Research, 5, 2.

Bellotti F., Berta R., De Gloria A. (2010) "Designing Effective Serious Games: Opportunities and Challenges for Research". International Journal of Emerging Technologies in Learning (iJET), Vol. 5 pp22-35

Blunt, R. (2007). "Does Game-Based Learning Work? Results from Three Recent Studies". In

Bopp M. (2006). "Didactic Analysis of Digital Games and Game-Based Learning". In Maja Pivec (Ed.) Affective and Emotional Aspects of Human-Computer Interaction - Game-Based and Innovative Learning Approaches. The Future of Learning, Volume 1. IOS Press

Chang, Y.-C., Chen, W.-C., Yang, Y.-N., & Chao, H.-C. (2009). "A flexible web-based simulation game for production and logistics management courses".Simulation Modelling Practice and Theory, 17(7) pp. 1241-1253
Csikszentmihalyi M., (1990), Flow: The Psychology of Optimal Experience, New York: Harper & Row.
David, M.M. & Watson, A. (2010). "*Participating In What? Using Situated Cognition Theory To Illuminate Differences In Classroom Practices".* In A. Watson and P New Winbourne (Eds.) Directions for Situated Cognition in Mathematics. New York, NY: Springer
de Freitas, S. & Neumann, T. (2009). "The use of 'exploratory learning' for supporting immersive learning in virtual environments". Computers and Education, 52(2): 343-352.
de Freitas, S. & Oliver, M. (2006). "How can exploratory learning with games and simulations within the curriculum be most effectively evaluated?".Computers and Education, 46 (3): 249-264.
de Freitas, S., & Jarvis, S. (2008). "Towards a development approach for serious games". In T.M. Connolly, M. Stansfield, & E. Boyle (Ed.), Games-based learning advancements for multi-sensory human-computer interfaces: Techniques and effective practices. Hershey, PA: IGI Global
Derryberry A. (2007) "Serious games: online games for learning". Adobe White Paper. [online]:http://www.adobe.com/resources/elearning/pdfs/serious_games_wp.pdf(accessed 20/04/2011).
Design". [online]:www.eece.bham.ac.uk/Default.aspx?tabid=154 Last accessed 20/04/2011.
Dillenbourg, P., Järvelä, S., & Fischer, F. (2009). "The evolution of research on computer-supported collaborative learning: from design to orchestration". In Balacheff, N. Ludvigsen, S. de JongT., Lazonder T., A. & BarnesS.(eds). Technology-Enhanced Learning. Springer.
Dunwell, I., Christmas, S., de Freitas, S. (2011) "Code of Everand Evaluation report". London Department for Transport (in press).
Egenfeldt-Nielsen S. (2006). "Overview of research on the educational use of video games". Digital Kompetanse 3-2006 Vol. 1 pp184–213
Egenfeldt-Nielsen, S., Smith, J.H. & Tosca, S.P., (2008). Understanding Video Games: the Essential
Fengfeng Ke (2008) "Alternative goal structures for computer game-based learning". International Journal of Computer-Supported Collaborative Learning 3 (4) Springer New York, Pages: 429-445 ISSN: 15561607
Foster, A., Mishra, P., & Koehler, M. (2010). "Pedagogical Content Knowledge Framework to Determinate the Affordance of a Game for Learning", Ed. Khnine, M.S., Learning to Play (New Literacies and Digital Epistemologies), New York: Peter Lang Publishing Inc.
Fu, F.-L., Yu, S.-C., (2008). "Three layered thinking model for designing web-based educational games". Lecture Notes in Computer Science, Volume 5145/2008, pp 265-274
Games, I. A. (2009). "21st century language and literacy in Gamestar mechanic: middle school students' appropriation through play of the discourse of computer game designers". PhD dissertation. University of Wisconsin.
Garris, R. Ahlers, R. Driskell, J. E. (2002) "Games, motivation and learning: A research and practice model". Simulation & Gaming, 33 (4), pp. 441-467
Gee, J. P. (2003). What Video Games Have to Teach Us About Learning and Literacy. New York: Palgrave MacMillan.
Gee, J. P. (2005). "Good video games and good learning". Phi Kappa Phi Forum, 85 (2) pp. 33-37
Gibson, D. (2006). Games And Simulations in Online Learning: Research And Development Frameworks, Hershey, PA: Information Science Publishing.
Gredler M.E.(1996). "Educational Games and Simulations: A technology in search of a research paradigm", in Handbook of Research for Educational Communications and technology, New York
Hanghøj T., Engel Brund C. (2010) "Teacher Roles and Positionings in Relation to Educational Games" ECGBL-4th European Conference on Games Based Learning - Copenhagen, Denmark. p. 115 ISBN: 978-1-906638-78-8
Hanghøj T., Magnussen R., (2010) "The role of the teacher in facilitating educational games – Outline of a game pedagogy". Abstract presented at Designs for Learning, Stockholm.
Hirumi A. & Stapleton C. (2009) Applying Pedagogy during Game Development to Enhance Game-Based Learning. Games: Purpose And Potential In Education, 1-36
http://archive.futurelab.org.uk/resources/documents/project_reports/becta/Games_and_Learning_educators_report.pdf (accessed 20/04/2011).
Interservice/Industry Training, Simulation & Education Conference (I/ITSEC). Orlando, Florida,
Introduction, Routledge.
Johnston H. and Whitehead A. (2009)."Distinguishing Games, Serious Games, and Training Simulators on the Basis of Intent". Educational Research. ACM Press, pp: 9-10
Kafai, Y. B. (2006). Playing and Making Games for Learning: Instructionist and Constructionist Perspectives for Game Studies. Games and Culture, 1(1), 36-40. SAGE.
Ke, F., & Grabowski, B. (2007). "Gameplaying for maths learning: cooperative or not?". British Journal of Educational Technology, 38 (2) 249-259.
Kickmeier-Rust M., Schwarz D., Albert D., Verpoorten D., Castaigne J.L., Bopp M. (2006). "The ELEKTRA project: Towards a new learning experience." M3, 3(4), 19-48. Citeseer. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:The+ELEKTRA+Project:+Towards+a+new+learning+experience#0
Kiili K. (2010) "Call for Learning-Game Design Patterns". In: Educational Games: Design, Learning and Applications Eds: Edvardsen F., Kulle H., Nova ISBN: 978-1-61209-103-7

Kiili, K. (2007) “Foundation for problem-based gaming”. British Journal of Educational Technology, 38(3), 394-404. Blackwell Synergy.
Kim, B., Park, H., Baek, Y. (2009). “Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning”. Computers & Education, 52, 4, 800-810
Kirkland, K., Ullicsak,M., Harlington,M., (2010). “Game-based learning experiences: Testing the principles with teachers and students”, [online]:www.futurelab.org.uk (accessed 05/05/2011)
Krathwohl D. (2002) A Revision of Bloom's Taxonomy: An Overview. Theory into Practice, 41, 4, 212-218 College of Education, Ohio State University. H.W. Wilson Company.
Kreijns K. et al. (2003) “Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: a review of the research”. Computers in Human Behavior 19 (2003) pp335–353. Pergamon.
Leemkuil H.H., Jong T. de, Hoog R. de, Christoph N., (2003). “KM QUEST: A collaborative Internet-based simulation game”, Simulation & Gaming, 34 (1). pp. 89-111.
Leemkuil, H.H., & Hoog, R. de (2005). “Is support really necessary within educational games?” In C. Conati & S. Ramachandran (Eds.), Educational games as intelligent learning environments. (pp. 21-31). Amsterdam. http://www.cs.ubc.ca/~conati/aied-games/leemkuil.pdf
Li Q. (2010) “Digital game building: learning in a participatory culture”. Educational Research 52 (4) pp 427-443
Malone T.W. (1981) “Toward a theory of intrinsically motivating instruction”. Cognitive Science 5 (4) pp 333-369. Elsevier
Mawdesley, M., Long, G., Al-Jibouri, S., Scott, D. (2011). “The enhancement of simulation based learning exercises through formalised reflection, focus groups and group presentation”. Computers and Education, 56 (1) pp. 44-52.
Midoro V. (ed.) (2005) A Common European Framework for Teachers' Professional Profile in ICT for Education Edizioni Menabò DIDATTICA 2005 ISSN: 1970-061X
Newman, B. M. & Newman, P.R. (2007).Theories of Human Development, New Jersey, NJ: Psychology Press.
Ott M., (2011) “School of the Future: E-Tools and New Pedagogies to Build Up an Inclusive Learning Community”, Ordonez de Pablos P., Zhao Jingyuan,Tennyson R. (eds), In: Technology Enhanced Learning for People with Disabilities: Approaches and Applications, Chapter 8, pp. 105-120. ISBN 978-1-61520-923-1 IGI Global, Hershey, Pa, USA,
Ott M., Tavella M. (2010) “Motivation and engagement in computer-based learning tasks: investigating key contributing factors”. In: World Journal on Educational Technology, vol. 2 (1) pp. 1 - 15. Academic World Education & Research Center
Pozzi F., Ott M. (2009) “Fostering creativity in online collaborative learning environments”. In: ECTEL 2009 - Methods & Tools for Computer Supported Collaborative Creativity Process: Linking creativity & informal learning (Nice, France, 30 September 2009). Proceedings, vol. 536 pp. 1 - 6. S. Retalis, P.Sloep (eds.). CEUR-WS.org
Prensky, M. (2007). Digital Game-Based Learning. Paragon House
Prensky, M. (2008). “Students as designers and creators of educational computer games: Who else?” British Journal of Educational Technology, 39(6), 1004-1019. Blackwell Publishing.
Rebolledo-Mendez, G., Avramides, K., de Freitas, S., Memarzia, K. (2009). “Societal impact of a Serious Game on raising public awareness: the case of FloodSim”. In Proceedings of the 2009 ACM SIGGRAPH Symposium on Video Games. New Orleans, Louisiana, pp. 15-22
Retrieved from http://gamestarmechanic.com/static/pdfs/Games_PhD_Gamestar.pdf
Romero, M., Usart, M., Almirall, E. (2011). “Serious games in a finance course promoting the knowledge group awareness”. EDULEARN11 Proceedings, 3490-3492
Rooney P., O'Rourke K.C., Burke G., MacNamee B., Igbrude C., (2009). “Cross-Disciplinary Approaches for Developing Serious Games in Higher Education”, In Proceedings of the First International IEEE Conference in Serious Games and Virtual Worlds (VS-Games '09), 2009
Sandford R., Ulicsak M., Facer K., Rudd T., (2006). “Teaching with Games”. Futurelab report. [online]:http://archive.futurelab.org.uk/resources/documents/project_reports/teaching_with_games/TWG_report.pdf (accessed 20/04/2011).
Souza e Silva A., Delacruz, G.C., (2006). “Hybrid Reality Games Reframed: Potential Uses in Educational Contexts”, Games and Culture, 1 (3), pp. 231-251.
Stone, B. (2008). “Human Factors Guidelines for interactive 3D and Games-based training Systems
Tissot, P., (2004) “A multilingual Glossary for an enlarged Europe: Terminology of vocational training policy”. CEDEFOP - European Centre for the Development of Vocational Training. [online]:http://www.cedefop.europa.eu/EN/about-cedefop/projects/validation-of-non-formal-and-informal-learning/european-inventory-glossary.aspx#i. (accessed 20/04/2011).
UNESCO ICT Competency Framework For Teachers (2011)
United Nations Educational, Scientific and Cultural Organization, Paris
[online]: http://unesdoc.unesco.org/images/0021/002134/213475E.pdf
USA: NTSA.
Van Eck, R. (2006). “Building Artificially Intelligent Learning Games”. In David Gibson, Clark Aldrich, & Marc Prensky (eds) Games and Simulations in Online Learning. Hershey, PA: Idea Group.
Van Eck, R. (2010). Gaming and Cognition: Theories and Practice from the Learning Sciences. Hershey, PA: Information Science Publishing
Van Eck, R., & Hung, W. (2010). “A taxonomy and framework for designing educational games to promote problem solving.” Paper presentation at the Videogame Cultures & the Future of Interactive Entertainment

Annual Conference of the Inter-Disciplinary.net Group, July 7–9, 2010, Mansfield College, Oxford, United Kingdom.
van Staalduinen, J. P. & de Freitas, S. (2010) “A Game-Based Learning Framework: Linking Game Design and Learning Outcomes”.In Learning to Play: Exploring the Future of Education with Video Games. Khine, MyintSwe (ed.). Peter Lang Publishers New York.
Verpoorten, D., Poumay, M., Leclercq, D. (2007). “The eight learning events model: A pedagogic conceptual tool supporting diversification of learning methods”. In: Interactive Learning Environments, 15(2), 151-160. Routledge.
Walqui, A. & Van Lier, L. (2010). Scaffolding the Academic Success of Adolescent English Language Learners: A Pedagogy of Promise. San Francisco, CA: WestEd.
White, M., Petridis, P., Liarokapis, F., Plecinckx, D.(2007). “Multimodal Mixed Reality Interfaces for Visualizing Digital Heritage”. International Journal of Architectural Computing (IJAC), Special Issue on Cultural Heritage 5, 2, Multi-Science Publishing Co Ltd, 322-337
Whitton, N. (2010). Learning with Digital Games: A Practical Guide to engaging students in higher education. New York, NY; Abingdon, Routledge.
Williamson B. (2009) “Computer games, schools, and young people”. Futurelab Report [online]:
Zyda, M. (2005). From visual simulation to virtual reality to games. Computer, 38(9), 25-32. IEEE Computer Society.