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Implementing Digital Game-Based Learning in Schools: Augmented Learning Environment of 'Europe 2045'

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Abstract

It is widely agreed that the traditional process of schooling can benefit from the usage of computers as supportive tools. Of various approaches using computers in education over the last decade, e-learning and edutainment have become the most prominent. Recently, a number of authors have criticised these approaches arguing that they conserve traditional 'drill and practice' behaviouristic methods of teaching instead of enhancing and augmenting them. It has been proposed that a 'paradigm shift' is needed and that this shift may come through utilizing all the advantages of full-fledged videogames, so-called digital game-based learning (DGBL). However, several case-studies reported serious problems with the DGBL. Among the most notable issues are the lack of acceptance of games as an educational tool, problems with integration of games into formal schooling environments, and the so-called transfer problem, which is the problem of the inherent tension between game play and learning objectives, the tension that mitigates the ability of students to transfer knowledge gained in the videogame to the real-world context. Here, we present a framework for an Augmented Learning Environment (ALE), which verbalises one way of how these problems can be challenged. The ALE framework has been constructed based

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on our experience with the educational game, Europe 2045, which we developed and which has been implemented in a number of secondary schools in the Czech Republic during 2008. The key feature of this game is that it combines principles of on-line multi-player computer games with social, role-playing games. The evaluation which we present in this paper indicates the successful integration of the game and its acceptance by teachers and students. The ALE framework isolates key principles of the game contributing to this success, abstracts them into theoretical entities we call action-based spaces and causal and grounding links, and condenses them in a coherent methodological structure, which paves the way for further exploitation of the DGBL by educational game researchers and designers.

Keywords: digital game-based learning, educational games, serious games, formal schooling, Europe 2045, augmented learning environment, transfer problem

1. Introduction

There are many ways how computers can be used to support education. Perhaps the most prevalent today are the e-learning and edutainment approaches, which capitalise on traditional 'drill and practice' behaviouristic methods (Eigenfeldt-Nielsen, 2005; Weiss & Muller, 2008). While it is generally agreed that e-learning and edutainment tools can support the learning of facts, it has been argued that these tools have achieved only limited success in helping students to develop advanced knowledge and skills. The reasons mentioned in this regard are that such tools have been poorly designed, simplistic, boring, and repetitious, and do not allow users any possibilities for active exploration (Kirriemuir & McFarlane, 2004; Schank, 2005).

Other software applications that can be used to support education are *full-fledged videogames*, which brings us to the *digital game-based learning* paradigm (DGBL). The idea of DGBLhas been around for more than three decades (Coleman, 1971), but it got its second wind with the recent information technology and Internet boom. Many have suggested that full-fledged videogames can effectively support classic curricular schooling (Katz, 2000; Squire, 2005; Prensky, 2001).

Most full-fledged videogames depart from e-learning tools and basic edutainment games in two aspects. First, they create intrinsic motivation through fantasy, control, challenge, curiosity and competition (Cordova & Lepper, 1996; Malono, 1981). Second, they immerse players in complex and rich environments, allow them to explore numerous strategies for action and decision, and require them to complete demanding tasks with increasingly difficult objectives (Facer et al., 2007). Some authors argue that at least some full-fledged commercial videogames, most notably strategy games, simulations and role-playing games, are actually based on well-developed, sound theories of learning in order to engage players and instruct them how to play and win the game (Gee, 2005, see also Hopson, 2001). Many suggest that by situating players in these games' worlds, where they can freely move and act, the games can promote problem-solving, goal-oriented behavior, engagement and motivation; and, in cases of multi-player games, social networking (Gee, 2003; de Freitas, 2006; Squire, 2005; Sandford et al., 2007). Others argue that games help to develop strategic thinking, group decision-making, and higher cognitive skills (Arnseth, 2006; de Freitas, 2006). Generally, it seems that games could be particularly useful for generating a deeper understanding of certain key principles of given topics, mainly when dealing with complicated and multifaceted issues, which are hard to comprehend through factual knowledge only.

A seemingly, relatively simple way of using full-fledged videogames as supportive tools in schools is to integrate a commercial videogame into formal class structures, for instance history or geography lessons. Studies of commercial games – such as The Sims 2, Civilization III, and Europa Universalis (Egenfeldt-Nielsen, 2005; Sandford, 2007; Squire, 2004) – have demonstrated some positive learning effects. For example, Squire who introduced Civilization III into secondary school history classes in the US argued that one group of students, in the end, exhibited a deeper understanding of the broader geographical, social, and economic conditions determining historical processes (Squire, 2006). However, at the same time, these studies have also revealed certain ambiguities and problems. For instance, the same author reported that another group of students refused to continue in the course, opting for a normal history class instead.

In general, these studies point out a significant incompatibility of most commercial games with school environments. Conclusions from the studies also suggest that a more theoretically-grounded approach is needed for the development of games that are to be implemented in schools. Researchers and educational practitioners are increasingly turning their attention towards so-called *serious games*. These games depart (1) from commercial videogames in that education is the primary goal rather than entertainment (de Freitas, 2006) and (2) from edutainment tools in that their complexity approaches that of their commercial counterparts.

Several serious games have been developed recently for primary and secondary schooling. For example, *Global Conflicts: Palestine* is a 3-D role-playing game that deals with the Israeli-Palestinian conflict and is based on real personal stories. According to its evaluation, players demonstrated significantly better comprehension of the conflict's complexity, an ability to consider problems from a broad perspective, and higher levels of personal involvement in learning (Egenfeldt-Nielsen & Buch, 2006). Authors of *Global Conflicts* also suggested that the game is useful for stimulating debates and discussions between peer learners concerning the taught topic (see also de Freitas, 2006; Facer et al., 2007).

Still, there exist problems in integrating (even serious) games with formal education (Jantke 2006; Muller & Weiss 2008). First and most notably, there has been a *lack of acceptance* of games as educational tools among the majority of teachers and also many students; games tend to be perceived as a leisure time activity with no pedagogic value – except for developing IT skills. Although recent surveys show that this perception is about to change, people's deeply-rooted preconception of videogames as entertainment may mitigate educators' willingness to use them (de Freitas, 2006; Egenfeldt-Nielsen, 2005; Schrader et al., 2006).

The second notable issue is the *transfer problem* (e.g. Squire, 2002; Egenfeldt-Nielsen, 2005; Sandford 2007; see also Bransford & Schwartz, 2001). Players must develop a number of skills and acquire certain knowledge in order to achieve the game's objectives, but it is not clear whether these can be transferred into a real environment: into different contexts and different social practices. This applies both for commercial and serious games. Even if knowledge and skills developed through DGBL could in fact be transferred, it would not be guaranteed that this *possibility of transfer* will be *perceived* by students and teachers, amplifying the lack of acceptance of games as educational tools.

Finally, more practical barriers to using games in schools were reported, ranging from a lack of access to equipment, e.g. up-to-date video cards (de Freitas, 2006), to barriers posed by

fixed lesson times (mainly 45-50 minutes), which seem insufficient for DGBL (Sandfrod et al., 2007), to the unintelligibility of interfaces and game rules for some teachers (Egenfeldt-Nielsen, 2005; Squire, 2004).

We have developed a full-fledged serious game *Europe 2045*, which is designed to be a supportive educational tool for social science courses in secondary schools, attempting to familiarise players with political, economic and social issues in a united Europe and the present-day world. Apart from learning facts, the player develops a range of key skills – the ability to discuss, to negotiate, to think critically, and to work in a team – as well as an understanding of key socio-economical processes such as immigration or economical development. The most important aspect of the game is that it combines principles of *multi-player on-line videogames* (MOVG) with *social role-playing games* (SRPG): the game is played both at computers and in social spaces in classrooms at the same time. As far as we know, Europe 2045 is most likely the first game worldwide, designed specifically for use in social science courses, that combines principles of MOVGs and SRPGs.[1]

Each kind of game possesses its specific learning advantages. MOVG constructs complex virtual worlds, allowing non-linear interaction and exploration, as well as various forms of collaboration/competition among players. The distinctive features of MOVGs – team collaboration, problem solving, and group decision-making – have already proved successful in several educational projects (Zhan, 2004; Schrader et al., 2006). SRPGs enable players to choose and customize their character, intrinsically enhance motivation and engagement in the learning activities (de Freitas, 2006; Schrader et al., 2006) and can stimulate debates and discussions between peer learners concerning the topic being taught. Additionally, in SRPGs, the players can interact more freely than in MOVGs.

We chose the game's platform, designed the game's content and developed the methodology for the game's usage in order to address the problems identified in previous studies. Given that there is not yet any coherent and detailed theory that accounts for which game features make their integration into formal schooling systems possible, our core research question was *whether Europe 2045 could be successfully integrated into a formal schooling system*. This included questions on *whether it would increase learner motivation, and whether it would be well accepted both by students and teachers*. Evaluation of the game based on case-studies from 8 secondary school classes in the Czech Republic indicated that the answers to all three questions are affirmative. The first goal of this paper is to present these data and, more importantly, to discuss - on the basis of our evaluation - which features of Europe 2045 contributed most to its acceptance.

The most pressing question would be whether students benefited more from the game compared to a control group being taught traditionally. As far as we know, there is no study of this kind concerning full-fledged, serious games; case-studies report that a particular game is engaging but without tests of actual knowledge (e.g. Egenfeldt-Nielsen & Buch, 2006). The field is immature; the research methodologies of longitudinal studies and of assessing advance of key skills developed via DGBL are missing and full-fledged games that could be subject to these tests, that is, that have been accepted by majority of the class, are scarce (as opposed to general edutainment software).

[1] See SimPark, 2009 for similar approach in environmental management learning.

Instead, we attempted to isolate several key features we thought contributed most to the successful acceptance of Europe 2045, to abstract them and to organize them in a theoretical framework that we call the *Augmented Learning Environment* (ALE). Thus, the second goal of this paper is to present this Augmented Learning Environment. Our motivation was twofold. First, we aimed at verbalizing one possible way how to design educational games similar to Europe 2045 so that they can be successfully integrated into formal schooling systems and accepted by both by teachers and students. Second, we aimed at developing a scientific hypothesis that can be challenged in future studies on real knowledge acquisition via DGBL.

This paper proceeds as follows. Section 2 further discusses the crucial problems of using full-fledged games in curricular education. Section 3 introduces Europe 2045. Section 4 presents key findings from our evaluation and pinpoints key principles that, in our opinion, contributed most to the success of the game. Section 5 presents the ALE concept and identifies how its components possibly transcend the problems with DGBL detailed in Section 2. Section 5 also illustrates how they are implemented in Europe 2045. Each section ends with its own discussion.

The concept of ALE was first presented in (Šisler et al., 2008b) but has undergone major changes since then. Some remarks on the design methodology of Europe 2045 have been also made in (Šisler et al., 2008a).

2. Problems with full-fledged games in curricular education

The two most notable DGBL problems dealt with in this paper are a) the lack of acceptance of games as educational tools (e.g. de Freitas, 2006; Egenfeldt-Nielsen, 2005; Schrader et al., 2006), and b) transferring skills developed through game-based learning into a real environment, the transfer problem (e.g. Egenfeldt-Nielsen, 2005; Sandford, 2007). Arguably, these problems are interconnected: the primarily cause of the lack of acceptance, in our opinion, is that students and teachers do not perceive the DGBL paradigm as one that promotes awareness of how real-world related skills and knowledge are being developed (see also de Freitas, 2006; Schrader et al., 2006). Consequently, they are not motivated to use the game.

The evaluation of Europe 2045 indicates that the game has been accepted and well integrated into the formal schooling environment. This is a crucial finding, for it suggests that both students and teachers perceive the game as a useful educational tool. Even if we cannot evaluate the real learning effect based on our present data, we can isolate the reasons for the successful acceptance of the game and formulate a theoretical framework for developing other similar games.

Before this framework – Augmented Learning Environment – will be presented, we have to elaborate more on why the acceptance of many games in curricular education has been mediocre or poor in general. We can break down the bulk of crucial problems into the following three issues:

A. *The tension issue*: There is an inherent tension between learning objectives and gaming objectives.

B. *The context-dependency issue*: The context of a videogame is dissimilar to the real-world context, which makes it difficult for the students to transfer the knowledge.[2]

C. *The disbelief issue*. The audience does not perceive games as an educational tool and is not aware of how they develop real-world-related skills and knowledge.

A. The tension between learning and play

The primary goal of most videogames is *to achieve success* in the game. This can be exemplified in many ways: one can shoot the highest number of opponents (action games), win a race or a match (sport/racing games), develop his/her game character and accomplish the Quest (RPGs) or develop a sustainable company or society (simulation games). Generally, these goals are different from the educational goal, which is *to acquire "real world- related" knowledge or skills*. This causes an inherent tension, which reduces engagement in either of the activities. On the one hand, attempts to make a game more educational tend to undermine its gaming objective, which may make the game less interesting or possibly even boring. On the other hand, attempts to make educational materials more game-like may mitigate the educational objectives and cause frustration and lack of acceptance. Some authors argue that most of the e-learning software, commercial games in education, and simple "game as a reward" edutainment applications exemplify these problems (Jantke, 2006; Weiss & Muller, 2008). For instance in "game as a reward" applications, the player has to switch between the learning part and the gaming part without clear understanding why he or she should do this. As Jantke (2006) puts it:

"One of the biggest mistakes – may be, the biggest among all – in games for educational purposes is to cause frustration originating from a conflict between game play and teaching material. Interactions of learning should not interrupt the flow of game play and should not disturb the player's immersion. Interactions of learning shall not hinder the player from reaching her/his goals, but shall be supportive. ...a game should not fall apart into its playing part and an educational add-on. Interactions of learning should appear as inherent constituents of the play." (sic)

B. The context-dependency issue

The underlying problem is that some researchers in the field of DGBL seem to assume that games can sometimes teach something implicitly (see e.g. Jantke, 2006; p. 39). It further seems that these researchers by using the term "implicit learning" mean that the knowledge acquired is transferred easily, thus, that the whole transfer problem is non-existent (cf. Prensky, 2001). We will now argue that these assumptions are at odds with general psychological findings.

[2] In fact, transfer is one of many key issues in learning and education in general (reviewed in Perkins & Salomon, 1994; Bransford & Schwartz, 2001). As such, it has more facets than presented here. For example, Dudai refers to the transfer of training, that is, to "the contribution of training in one skill to the performance on a different skill" (Dudai, 2004, p. 247). Here, we restrict ourselves only to the transfer between a game's world to the real-world context.

First, it is known that learning is context-dependent in many situations. For instance, it was pointed out by Locke no later than in the 17th century that procedural memory[3] is *not* immune to transfer problems in general:

"... a young gentleman, who, having learnt to dance, and that to great perfection, there happened to stand an old trunk in the room where he learnt. The idea of this remarkable piece of household stuff so mixed itself with the turns and steps of all his dance, that though in that chamber he could dance excellently well, yet it was only whilst the trunk was there; not could he perform well in any other place, unless that or some such other trunk had its due position in the room." (Locke, 1690, pp. 339-340; cited from Dudai, 2004, p. 61)

It is also known that semantic knowledge, such as lists of words, can be context-dependent in some situations, e.g. lists learnt by a diver underwater are more easily recalled underwater than on land (Godden & Baddeley, 1975). This can be considered an extreme situation, but is the immersion in a fictitious world of a videogame less extreme? For instance, why should knowledge about, say, assigning budget priorities in an ancient empire in a strategy game be of any relevance to how people spend their money in their households or companies?

However, situations exist in which the impact of contextual change is small, if any. For example, students perform more or less the same when examined in the room in which they took classes as opposed to another room (Saufley et al., 1986; cited from Baddeley, 1986; p. 196). From a similar position, general educational literature refers to near transfer and far transfer, a distinction made based on the similarity of contexts[4]; "spontaneous" near transfer is much more likely than far transfer (Perkins and Salomon, 1994). It is also known that it may help to recall the original learning environment at the time of recalling the factual knowledge in the new environment (Baddeley, 1986; p. 196).

Second, psychology does indeed make a distinction between *explicit learning*, in which the subject actively responds to the stimuli, and *implicit learning*, in which executive and strategic processes play little or no part (Baddeley 1986, p. 335; see also Dudai, 2004; pp. 141-143; Toth, 2000). The latter term often characterises the acquisition of procedural knowledge (Baddeley, 1986; p. 335), even though skills can be acquired both with and without conscious awareness (Dudai, 2004, p. 229). However, none of this implies that transfer comes easy for what is learned implicitly; evidently, Locke's dancer, who presumably learned at least partly implicitly, had the transfer problem.

In summation, it seems safe to claim that a) some knowledge is more prone to the transfer problem and some less, and b) we will not know whether a particular kind of knowledge is prone or not until we explicitly test it. This idea actually is not new in general educational

[3] The dominant psychological taxonomy of long-term memories makes a distinction between semantic, episodic, and procedural kinds of knowledge (and memory) (e.g. Baddeley, 1986; Tulving & Donaldson, 1972). Procedural memory covers processes related mainly to perceptual-motor skill learning where the subjective experience is not emphasised (Baddeley, 1986). This distinction is widely agreed upon, though other classifications, detailed sub-classifications, and "border" issues exist (e.g. Squire & Zola-Morgan, 1991; Eichenbaum & Cohen, 2001).

[4] The term "similarity" is not meant in any strict, quantitative way, but intuitively. The term "context" has a slightly broader meaning here than in the case of context-dependency in psychology. Similarly, recall that the term "transfer" has a broader meaning in general education than as defined in this section.

literature (cf. e.g. Perkins and Salomon, 1994; Bransford & Schwartz, 2001), but has not been emphasised much in the context of DGBL.

C. The disbelief issue

The tension between learning objectives and gaming objectives (A) means, just by rephrasing, that it is not clear how one could learn anything useful from a game. The perception of context-dependency (B) means that even if one believes that something potentially useful can be learnt in a game, one still doubts whether this knowledge will be available later on in other contexts. Furthermore, it is not guaranteed that these disbeliefs diminish automatically when Points A and B are reconciled. Thus, a DGBL designer not only has to resolve Points A and B, but also to explain to the audience that these problems have been solved and how this has been done. Additionally, this has to be done via a relatively simple interface which accommodates also students and teachers who are not regular videogame players (see also Squire, 2004).

Summary

Any theoretical framework for DGBL should organise solutions to all three issues. Presently, our evaluation allows us to claim that the ALE successfully helps with the tension issue (A) and the disbelief issue (C). It remains to be investigated whether the components of ALE aimed at tackling the context-dependency issue (B) really resolves this point as well.

Prior to presenting our concept for ALE, we summarize the strategies it adopts for tackling the above-mentioned problems:

I. To make real-world educational materials *visibly* relevant for the content of the game and gaming material *visibly* relevant for curricular education (or more generally, the real-world context).

II. To let students actively use knowledge gained in the game to solve real-world problems, that is, to use this knowledge in a real-world context; or vice versa: to recall real-world knowledge during the game and to use it in the game. The promise here is to gain from the fact that the knowledge is "perceived" by the student from perspectives of the two different contexts (the gaming one and the real-world one) at the same time. The fact that students will use their knowledge in this way should be also understood by them (Point I).

III. To transfer knowledge gained in a context that differs substantially from the real-world context to the real-world context through another, intermediate context. The hope is that students will somehow transfer the knowledge from the intermediate context to the real context on their own.

Note that II is actually a variation of a more general educational idea of presenting materials in multiple contexts (Bransford & Schwartz, 2001) and III is fostering far transfer via two near transfers (Perkins and Salomon, 1994). However, again, these two ideas have not been elaborated sufficiently in the context of DGBL.

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3. Europe 2045

Europe 2045 is a game played in teams. Each student represents a member state of the European Union and the whole class represents the EU. The game can be played with between 8 and 24 students, while the teacher assumes the role of coach/tutor. At the beginning of the match, the game situation closely copies the real state of affairs in Europe in the year 2008 – the initial state is based on real-world data. The game proceeds in rounds with each round representing one year. The game employs both cooperative and competitive principles at the same time. It was designed to support two modes of play: during regular classes over the term, or during a special one-day seminar.

Educational objectives

The game attempts to teach students three kinds of knowledge. The first goal is to improve students' high-level skills; to increase their ability to discuss, negotiate, work in teams, and make group decisions. The second goal is that students learn facts, such as geographies of European countries, EU institutions and policies, typologies of political inclinations, etc. The third goal is that students acquire mental models of large-scale processes and socio-political notions such as a model of "energy dependence" or "liberalism".

Mental models (Johnson-Laird, 1983; Gentner & Stevens, 1983) are internal representations of the possible behaviour of devices and systems, and the possible development and resolution of situations and problems. This includes the depiction of causalities and the ability to draw inferences and to make predictions. As Johnson-Laird (2006, p. 16) put it: "We construct mental models of situations, and we use these models to represent possibilities." Mental models depart from skills in that they are *about* something, they represent an entity. And mental models are not facts, but they may organise facts and process them. The factual knowledge about who are conservative politicians is a set of sentences describing these politicians and/or their names. However, only one who has a mental model of conservative politicians is able to estimate their behaviour and to judge whether someone belongs to this category or not. Many learning components in Europe 2045 afford students the possibility for development of a respective mental model.

Game-play in Europe 2045

As already stated, Europe 2045 combines principles of two game genres: multi-player on-line videogames and social role-playing games. Note that while the former is a videogame, the latter is not. Both games are interconnected, which is a key feature of Europe 2045 and, as will be described in detail later, also of the ALE framework.

Europe 2045 features three layers of game-play: the economic layer, the diplomatic layer, and the storytelling layer. In the *economic layer*, every student defines the domestic policy of his/her state beginning with tax levels and environmental protection and graduating on to issues such as the legalisation of same-sex marriage, privacy protection and security policies. Also, the player offers subsidies designed to persuade investors to invest in his/her country.

On the *diplomatic layer*, the player has an opportunity to present drafts for policy changes to the EU (for issues such as common immigration policy, stem-cell research or agricultural

quotas). The discussions about these changes take place in the classroom, where they are moderated by the teacher, who can also give short lectures and contextualise gaming issues. Every player has his/her own project to try to push through at the European level. A project is basically a vision of how the EU should look in the future and it is formally defined by: a) a set of policies that should be put in force, b) a set that should be suspended, and c) a set to which the project is indifferent (e.g., the Green Europe project supports environmental protection and investment into alternative power resources, while the Conservative Europe project strives to preserve traditional values). From the gaming perspective, projects present roles the students can play. The important aspect is that every player can choose his/her project. Because some projects agree or disagree upon the same subset of policies, each player can find a team-mate to support his/her intended particular policy change. The final appearance of Europe at the end of each match is thus the result of intense negotiations and voting in a given player group.

On the *storytelling layer*, players face various simulated scenarios and crises relating to key contemporary issues the unified Europe faces (such as the humanitarian crisis in Darfur or the integration of Turkey into the EU). The players must react to all these events and, in co-operation with fellow players, seek appropriate solutions. During the course of the game, the students typically witness the short- and/or long-term effects of their decisions. The storytelling layer has been detailed in (Brom et al., 2007).

The economic layer is a part of the MOVG, i.e. it is completely simulated on computers. The diplomatic layer is a part of the SRPG and plays out in the classroom, but voting takes place solely in MOVG, which computes the results. The scenarios of the storytelling layer are generated by the MOVG, but discussions take place as a part of the SRPG. Here, we see interconnections between the two gaming components, an issue that will be elaborated later in greater detail.

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Fig. 1. A screenshot from the game, *Europe 2045*: interaction with an environment minister.

Fig. 2. Students at Jan Palach High School playing the game "Europe 2045" (Jan, 2009). Courtesy of Dana Hilská. Used with permission.

The game's interface

The MOVG part of Europe 2045 is played via the Internet. The interface is programmed in Flash or in plain html (Fig. l, 2) in order to make the game suitable to the technology standards in Czech secondary schools (e.g. slower Internet connections) and make it ready to use without the need for self-installation. The interface is also as simple as possible. Such issues seem to have proven problematic in the past, according to many case studies (e.g. Egenfeldt-Nielsen, 2005; Squire, 2004; see also Šisler et al., 2008a).

In-game encyclopedia and on-line forums

An important component of Europe 2045 is an *in-game encyclopedia* (Fig. 3). This structured, hypertext-linked set of web-pages provides supplementary information, which is *both* relevant for success in the game and which summarises related real world information. The encyclopedia also provides links to additional Internet resources.

All the game's learning elements (i.e. EU policies, simulated events, economic terms etc.) are directly linked to the in-game encyclopedia via contextualized hints in the game, which help focus players' attention on relevant information. Moreover, Europe 2045 is equipped with a *multi-thread bulletin board*, which enables communications on several levels, ranging from public message boards to peer-to-peer communication. This enables students to continue in private discussions and negotiations that started during the teacher-supervised class activity.

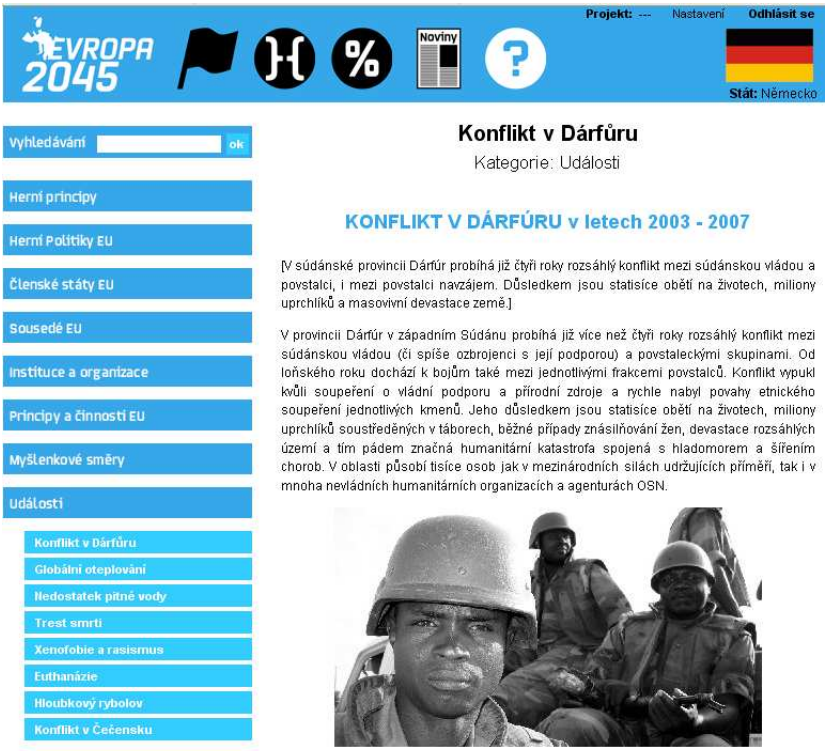

Fig. 3. In-game encyclopedia: supplementary text concerning the crisis in Darfur.

Support for teachers

Instructional courses for teachers were developed in order to familiarise them with the game and provide them with practical training on how to use the game in various settings. Teachers have both access to the in-game encyclopedia as well as to a supplementary handbook. The initial teacher support feature turned out to be quite essential, yet some similar projects seem to have disregarded it.

4. Evaluation study

The motivation of the study was to investigate acceptance of Europe 2045 as a supplementary tool for social sciences and humanities education. In other words, we asked whether the game was successfully integrated into the formal schooling system and, if this was the case, what properties of the game contributed most to this success. When preparing the study, we hypothesised that the key properties might be: a) the game's intelligibility (e.g. in comparison with commercial games), b) social role-playing, c) its grounding in real-world data, d) storytelling, e) support from teachers. As said in the Introduction to this paper, we have not conducted a formal assessment of students' knowledge apart from collecting their own feedback (assessments) and conducting in-depth interviews with the teachers.

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The formal evaluation took place during spring 2008, producing both qualitative and quantitative data. The study involved 220 students (F=122, M=98) aged from 16 to 18. The students were recruited from 8 secondary schools in Prague, Czech Republic. The study consisted of pre-tests, video surveillance and field notes, post-tests, and in-depth interviews with students and teachers. Pre-tests and post-tests of 32 students were excluded from the final evaluation due to the fact that they were incomplete; the data presented here are based on reports from 188 students (F=102, M=86).

Main data

This section summarises key data that speak to the game's success. The next section discusses data that help us to identify the parts of the game that are crucial for its success. Additional, minor findings will be presented in Sec. 5. The main quantitative findings are summarised in Tab. 1[5].

Tab. 1. Summary of the main findings. Each cell contains three numbers in this order: total, girls, and boys.

A1. Overall evaluation of Europe 2045 by students:

Excellent	Good	Average	Bad	Very bad
37% (22% / 50%)	41% (39% / 42%)	16% (30% / 5%)	4% (6% / 2%)	2% (3% / 1%)

A2. What is the impact of the game on learning (in your opinion):

Large, positive	Middle, positive	Small, positive	None	Negative
23% (21% / 26%)	51% (56% / 44%)	15% (13% / 19%)	10% (10% / 10%)	1% (0% / 1%)

A3. Do you think you have learned during the course of playing?

Yes	Probably yes	I don't know	Probably not	No
18% (20% / 15%)	39% (36% / 42%)	29% (31% / 27%)	8% (8% / 8%)	6% (5% / 8%)

B1. Was the game complicated for you?

Very easy	Easy	Normal	Hard	Very hard
22% (21% / 24%)	33% (34% / 31%)	40% (36% / 44%)	4% (7% / 1%)	1% (2% / 0%)

B2. Was it complicated for you to understand the rules of the game?

Very easy	Easy	Normal	Hard	Very hard
44% (47% / 41%)	32% (25% / 40%)	17% (17% / 17%)	6% (10% / 2%)	1% (1% / 0%)

[5] Some of these findings have already been presented in (Šisler et al., 2008b). The numbers presented in that paper differ from the present numbers in several minor details, because a different number of students was included in the analysis of that paper.

B3. Was the videogame interface complicated for you?

Very easy	Easy	Normal	Hard	Very hard
41% (30% / 53%)	38% (45% / 30%)	20% (23% / 17%)	1% (2% / 0%)	0%

C1. The most interesting part of the game is:

Discussion, negotiations	Simulation	Encyclopedia reading
49% (50% / 48%)	37% (34% / 42%)	13% (16% / 10%)

C2. I gained most information from:

Teacher	Simulation	(3)*	(4)*	Encyclop.	(6)*
8% (6% / 11%)	6% (5% / 7%)	16% (13% / 14%)	34% (36% / 37%)	30% (31% / 29%)	3% (4% / 2%)

C3. How interesting was the text material (the encyclopedia and the news) for you?

Very interesting	Interesting	Neutral	Somewhat Interesting	Not interesting at all
32% (42% / 22%)	44% (29% / 62%)	20% (25% / 13%)	3% (4% / 2%)	1% (0% / 1%)

D1. Is it important for you that you can choose your project?

Yes	Probably yes	I don't know	Probably not	No
59% (58% / 61%)	21% (22%/ 20%)	11% (9% / 14%)	5% (6% / 3%)	4% (5% / 2%)

D2. I identify myself with the role (i.e. the project) I play in the game:

Yes	Probably yes	I don't know	Probably not	No
15% (17% / 14%)	26% (25% / 27%)	45% (42% / 47%)	9% (10% / 7%)	5% (6% / 5%)

E. Is it important for you that the game is based on real data?

Yes	Probably yes	I don't know	Probably not	No
49% (49% / 49%)	26% (29% / 21%)	16% (13% / 20%)	5% (4% / 7%)	4% (5% / 3%)

* (3) Diplomatic negotiations, (4) Classroom discussions, (6) Additional research.

Questions A1-3 suggest that the game concept was successful. Qualitative data indicate a similar finding. During the pilot implementation of *Europe 2045*, the students clearly demonstrated higher engagement and willingness to study what are otherwise rather complicated and unappealing issues relating to the European Union (i.e. in comparison with traditional class lectures). More importantly, they claimed that the game contributed positively to education (A2) and that they learned something in the course of playing (A3).

We have also conducted in-depth interviews with teachers immediately after playing the game and/or they have sent us reports afterwards. Their responses were mainly positive:

"Students can test on a practical level their concepts and ideas about how the European politics should be formulated. They find out that in order to realize their ideas successfully they have to persuade others by means which stem from real politics, i.e. negotiations, lobbying, discussions, etc. Over the course of the game they actually learn such techniques. Moreover, they immediately see the results of their actions. This effectively replaces commonly unappealing theoretical lectures about how the European Union works." (Social sciences teacher, Gymnázium Omská – Omská High School)

"During my previous lectures about the European Union the students were never so engaged and motivated to study this topic." (Geography teacher, Gymnázium Sázavská – Sázavská High School)

"I appreciate that players study and comprehend complicated issues and familiarize themselves with the terminology. I also like that discussion is a key part of the game and that socially aware students can win." (Teacher, Gymnázium Jana Palacha – Jan Palach High School)

Crucial parts of the game

Let us now return to the hypothesis stated in the beginning of this section and pinpoint five reasons why, according to our interpretation of the data and to participant and non-participant observation, the game was positively assessed.

1) The game was relatively easy to understand.

Question B1-3 shows that students, both girls and boys, had no problems in mastering the game. The reasons are arguably as follows: a) we intentionally designed a simple DGBL interface, b) a substantial part of Europe 2045 is the SRPG, which is a genre that may be easier to master then a regular videogame, c) the in-game encyclopedia provides many hints on how to play the game, allowing for incremental game mastery, d) the socio-economic simulation does not allow a player to bankrupt his/her state.

2) Students enjoy social role-playing.

Qualitative data shows that many students appreciate role-playing, including customising their game portraits with photos of contemporary or historical political figures and mimicking/parodying real-world political discourse.

"The Italian government expresses its deep sympathy to the citizens of Norway in the moment they grieve over this terrible ecological catastrophe. Our government has decided to act importunately and send a group of volunteers who will help wash the seals in those regions which have been struck most heavily. At the same time, the Italian government initiates immediate negotiations about a structural and complex solution for these kind of situations, now and in the future." (2008-10-03 23:07:49)[6]

More importantly, students apparently enjoy the diplomatic aspect of the game, including discussions, argumentation, and secret diplomatic negotiations.

[6] All quotations are texts posted to the Europe 2045 on-line forums by students. All names and nicknames have been changed.

"For Spain France's proposal to invite Ukraine to the EU is a hard pill to swallow. But we are ready to vote for it, if France supports the abolition of the European Army. If France agrees, Spain may even find more states willing to support the Ukrainian case. Answer ASAP, via private messaging." (2009-02-10 20:15:12)

Apparently, the concept of SRPG is a strong one; in fact, students regard it to be more interesting than the videogame (Tab. 1, C1) and they think they gained much more during discussions than from the simulation (C2). Question D1 further supports the claim that students appreciate role-playing: they prefer to choose their roles (i.e. projects) even though they may not identify with them personally (D2).

3) Students appreciate real data.

Question E clearly shows that it is important for students that the game is based on real data. Furthermore, according to our observations, they often cite encyclopedia references during discussions in order to support their arguments (see also C2), which is likely a consequence of the relevance of the text materials (C3). Similarly, Egenfeldt-Nielsen's findings prove that students strongly appreciate real-world data in educational games (Egenfeldt-Nielsen, 2006). Also discussions in Europe 2045 have shown that many students conduct extensive research, both in consulting the encyclopedia and browsing the Internet, in order to support their arguments.

"Spain has to oppose the Danish Kingdom's opinion that a smoking ban is the best solution. The number of EU inhabitants in 2007 was 492.8 million, with 164.2 million (33%) of them being smokers. See http://europa.eu/abc/history/2000_today/2007/index_cs.htm. How does Denmark wish to solve smoking regulations in places of work? In the same radical way?" (2009-02-14 20:28:51)

4) Students appreciate storytelling.

According to our observations, students appreciate the simulated scenarios and crises. Moreover, they often discuss the consequences of their decisions, and they are interested in the results of their actions.

"The Netherlands thinks that the EU member states should not interfere with the stormy situation in Chechnya. If we express support for Chechnya in that matter, our relationship with Russia would be significantly worsened. On the other hand, if we openly back Russia, we would face critique from or even terrorist attacks from separatist groups. So the Netherlands calls all competent states to maintain their neutrality and not to exacerbate this already precarious situation." (2009-02-14 17:43:22)

"Great Britain is for accepting Ukraine into the EU. Ukraine has met all conditions for joining the EU. By accepting it (as a member) we will enlarge our free-market zone. We will ensure that Ukrainians will no longer be a source of cheap labor and effectively prevent human trafficking and enhance the country's standard of living. Moreover, there is an apparent strategic advantage - by moving EU borders closer to Russia we will have better control over the energy routes leading from Russia." (2009-03-15 14:42:49)

5) Support for teachers

It turned out that the instructional courses for teachers and handbook were absolutely necessary. Even though a few teachers were able to use the game just after reading the

manual, most of them were not. In fact, even after the seminars, many teachers were still not able to implement the game alone within their classrooms and needed further assistance.

Discussion

We have identified five key facts that arguably contributed to Europe 2045's successful acceptance and integration into formal schooling environments: 1) its intelligibility, 2) social role-playing, 3) its grounding in real data, 4) story-telling, and 5) support for teachers. It was found that, on average, the game is appreciated both by girls and boys (see A1 and B3).

We have to emphasize again that we have not tested the real knowledge students gained; students only claimed they had learned something. Correspondingly, teachers have only claimed an overall better learning outcome in comparison with traditional lessons (see Egenfeldt-Nielsen & Buch, 2006, for a similar approach). Tests of factual knowledge are planed as part of future work. Furthermore, our case study sample was not unbiased. We can assume that the teachers who voluntarily attended our instructional seminars and implemented the game in their courses represent a sample of the more avant-garde educators from among Czech secondary school social science teachers. Tests of students' ICT knowledge also indicated that these students are above average. Presently, the game is used in about five more secondary schools. Its integration into the formal educational system on a major scale remains a future challenge.

Therefore, we will not know whether our findings are general until someone implements another game similar to Europe 2045. In the next section, we will abstract the key findings presented above and consolidate them into a coherent methodological framework for designing educational games – Augmented Learning Environment – which is the first necessary step to allow for such an implementation. Even though we have not fully evaluated the learning effect of Europe 2045, the data we have acquired so far suggest that Europe 2045 solves the two main problems indicated in Section 2 – namely the (A) tension between the learning and the play and (C) the disbelief issue. That suggests that a future project based on ALE will be a promising enterprise.

5. Augmented Learning Environment

This section introduces the concept of a Augmented Learning environment (ALE). ALE abstracts the key aspects that seem to contribute most to acceptance and integration of Europe 2045, encapsulating them in a coherent methodological framework for educational game researchers and designers.

ALE understands the DGBL as a complex set of processes related to a) development of the game, b) teaching of teachers, c) teaching of students, and d) learning by students. Note that we mean by (c) a process of constructing an appropriate schooling environment and of its continuous readjustment according the students' needs, that is to say what happens around students, while by (d) we mean the process of formation of new knowledge and the expansion of previous knowledge by students themselves. Obviously, (c) and (d) are interconnected.

ALE organizes features of DGBL in two layers; one is *technological* and the other is *action-based*. The former refers to the technological instruments used in game-based learning and teaching, while the latter refers to human activities taking place during this process.

Technological layer

The technological layer is a crucial abstraction for understanding how to challenge the disbelief issue (C, Sec. 3). We divide the technological layer into two *environments*:

a) the *computer-enabled* environment, which includes all the digital technology,

b) the *classroom* environment, which entails everything else (e.g. chalk, chalkboards, and chairs in the classroom).

This division can be applied to most educational videogames. There is only one justifiable reason for going beyond the traditional classroom environment to use computer technology during education: it brings new possibilities for the experiencing of educational material by students, for the explanation of this material by educators and for the construction of learning environments by designers. Digital technology offers some innovations to the "good-old-fashioned" educational practice. For heuristic reasons, we unify these digital technology offers with the concept of *affordance*.

This term was coined by Gibson (1979) in the psychology of perception, and later became rearticulated by Norman (1988) in the field of design psychology. These two notions differ in one aspect that is important for our current purposes. For Gibson, affordances are relational, *objective* and *physical* properties of animal-environment systems that afford the execution of an action:

"...the *affordances* of the environment are what it *offers* the animal, what it *provides* or *furnishes*, either for good or ill."

"I mean by [affordance] something that refers both to the environment and the animal... It implies the complementarity of the animal and the environment." (Gibson, 1979, p. 127; emphasis in the original).

Thus, for Gibson, it is the relation between a) the shape of an object and b) the shape plus degrees of freedom of the joints in my hand that affords me the opportunity to grasp this object, no matter whether I can see the object or not – the affordance is out there. Norman departs from Gibson in that affordances become *perceived* and culturally dependent (Norman, 1988; Mateas, 2002)[7]. Norman's affordances also apply to technologies and media.

"...affordance refers to the perceived and actual properties of the thing, primary those fundamental properties that determine just how the thing could possibly be used. ... Affordances provide strong clues to the operations of things. Plates are for pushing. ... Slots are for inserting things into. ... no picture, label, or instruction [to the user] is required." (Norman, 1988, p. 9)

"Affordances also apply for technologies. Different technologies afford different operations. ... they make some things easy to do, others difficult or impossible." (Norman, 1993, p. 106)

From the design perspective, the important point is to make affordances visible. A possibility to act that one cannot see is not a good possibility to act. To stress the visibility feature, we will use the terms, *–affordances* and *+affordances*. Both terms refer to physical as well as culturally dependent possibilities, but while –affordances denote possibilities that the

[7] The term affordance is notoriously difficult to pin down. It is used ambiguously both in the design and perception psychology communities (e.g. McGrenere & Ho, 2000; Jones, 2003). We will disregard these intricacies here and use the term in its intuitive manner for its heuristic value.

perceiver is not aware of, +affordances denote visible ones. Whether an affordance is – or + depends on a particular person and a particular situation. For example, one may learn in a course on Internet that the blue underlined text allows the user to open a new web page.

Mateas suggests that it makes sense to conceive affordances from two different perspectives in the context of interactive software systems: from the standpoint of the system's author (authorial affordances) and the system's user (interpretative affordances).

"Interpretative affordances support the interpretations an audience makes about the operations of an AI [artificial intelligence] system."

"The authorial affordances of an AI architecture are the 'hooks' that an architecture provides for an artist to inscribe their authorial intention into the machine." (Mateas, 2002, p. 124-125)

This distinction is important for the DGBL paradigm. Similarly to Mateas, we have the standpoint of an author: the designer of the learning environment. The ALE framework conceives the technology as a set of affordances for constructing the educational environment: structuring forms of access to the educational material, creating mechanisms for engaging students and teachers, and designing possibilities for interaction between these two groups. Beyond Mateas, we have two kinds of users: students and teachers (Fig. 4). The technology affords them some means for how to teach and how to learn. Put differently, the designer's goal is to use authorial affordances to construct +affordances for the students and teachers. It makes no sense to design a complicated game unless teachers and students can perceive the possibilities it offers and are able to exploit them fully. For example, students should perceive that they can learn from the in-game encyclopedia of Europe 2045, because it is based on real data. They should also see that information in the encyclopedia can help them to play better. On the other hand, teachers should know that the process of students' searching within the encyclopedia was intentionally designed to encourage students to contextualise in-game knowledge into a real-world context and vice versa. Peculiarly, results of many studies indicate that designers often forget to make the affordances visible: especially for teachers, which later complicates integration of the educational application into the formal schooling system**.** For instance, recall the reported unintelligibility of commercial game interfaces and game rules for some teachers (Egenfeldt-Nielsen, 2005; Squire, 2004).

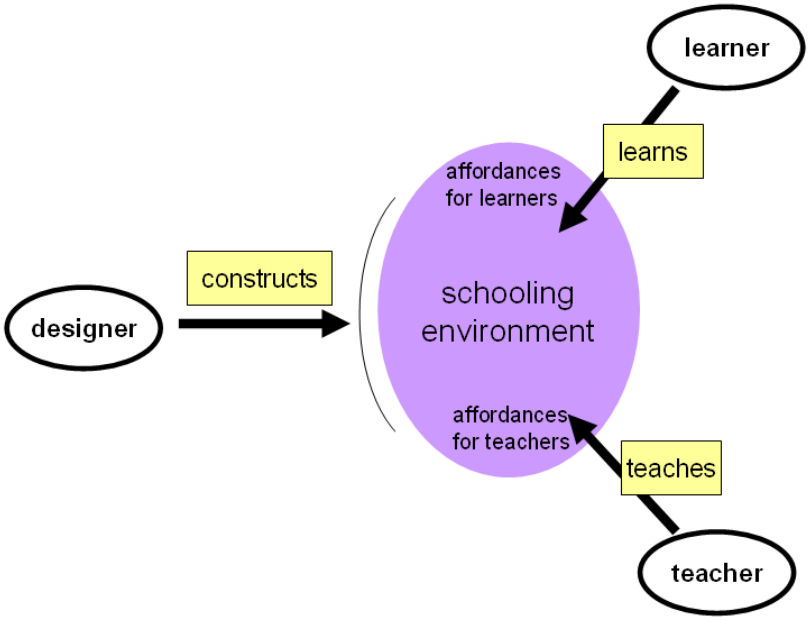

Fig. 4. The triad, designer – learner – teacher. The designer constructs a schooling environment, that is, +affordances for students and teachers.

The two environments of the ALE's technological layer – computer-enabled and classroom-enabled – offer different affordances. For instance, from the designer's standpoint, the possibility to simulate the EU's economy and to help students develop a mental model of it is computer-enabled, while the possibility to let students discuss their proposals is classroom-enabled. One of our main motivations for combining the MOVG with the SRPG was that the social environment offers teachers more opportunities than the videogame. Importantly, some affordances are only offered when these two environments are employed as an organic whole, as demonstrated later. This group of "joint" affordances is most important for tackling the transfer problem.

To summarize, the ALE framework makes one think about technologies in terms of affordances for designers, students, and teachers, and about turning –affordances into +affordances. This helps to construct games, whose educational objectives and means will be better understood by students and teachers.

Action-based layer

The action-based layer is a crucial abstraction for understanding how to tackle the tension issue (A, Sec. 2) and the context-dependency issue (B). The layer is organised around gaming, learning and teaching related activities that the environments of ALE afford. This layer combines four conceptually different *spaces* in which these activities take place.

a) the game space,

b) the information space,

c) the formal schooling space,

d) the everyday space.

Spaces refer to distinct contexts. The *game space* is defined by gaming objects with an internal state changing during the game, gaming roles (or actors) which players assume in the game world, goals that the players can/should achieve, and gaming rules transforming the states of objects and/or roles. Importantly, the game space offers an intrinsic motivation, curiosity, excitement and other gaming elements thanks to which players want to stay within this space or return to it (see Hopson, 2001). Additionally, gaming rules allow and force players to make decisions that influence the game and whose consequences will be mediated by the game. From an educational perspective, the game space alone allows for the development of game-specific knowledge; it provides many affordances for game-specific learning (but only a few for everyday-world learning and curricular teaching, which causes the tension issue (A) and its perception by the audience (C) and necessitates transfer between the knowledge gained in the game and the real-world context – Issue (B)).

The *schooling space* is most important from an educational perspective. It presents the formal learning environment controlled and organised by an instructor, i.e., it provides affordances for teaching and also some for learning. From the DGBL viewpoint, it is important that the latter affordances have to promote both learning of real-world knowledge as well acquiring knowledge that helps play the game (otherwise, the gaming/learning tension is caused).

The *information space* encompasses all information resources related to real-world learning topics and, importantly, also to the game: the information should help students to make game decisions better (otherwise, again, the gaming/learning tension increases) and teachers to prepare lectures and debates.

While these three spaces provide distinct social contexts in which students behave differently and have different expectations, they all have a common gist: they are organised around educational activities. There are many other contexts in which students can find themselves (a sports club, at home, at their job, etc.). We use the term *everyday space* to denote all of these contexts. Ultimately, the outcome of the lessons will be employed here, meaning the knowledge should be transferred to one of these everyday contexts.[8]

In our opinion, both Issue (A) and (B) emerge when the four spaces of the action-based layer are not mutually connected, which is the case in many modern-day educational games and e-learning software programmes.

Grounding and causal links of ALE

To explain how the four action-based spaces can be connected, we define two qualitatively distinct kinds of links: *grounding links* and *causal links*.

[8] In the ALE terminology, transfer in the context of general educational research often refers to the transfer of knowledge, acquired by a student within the schooling space, to the everyday space. Here, we are more interested in transfer from the game space.

Recall that Strategies I and II from Sec. 2 posit that the material from the game has to be presented in and made visibly relevant for the real-world context, in other words, *grounded*. In general, this can happen in two ways. First, when a student roams around the information space, some information can bring him/her to the everyday world. Second, when a teacher discusses the gaming issues and gives short lectures, he/she has the opportunity to decontextualise these gaming issues and make them relevant for the everyday world. To capture these two means, we define two kinds of grounding links: links connecting the information space with the everyday space and links connecting the schooling space with the everyday space (Fig. 5).

However, what motivates the student to leave the game space and to start roaming around the information space? Why should he/she listen to the teacher? Obviously, the student is searching for information. As Squire and Steinkuehler (2005) have demonstrated, research is a core component of game play. Many gamers regularly conduct research on the Internet and find and interpret data in order to determine the best strategy for particular game situations.

Thus, students search for information *because* they need this information for success in the game: to control their domestic policies, to persuade their fellow players about the merits of an EU policy or to find a solution to a simulated crisis. Importantly, they must be able to find this information, at least sufficiently often, and it must prove helpful to them. Humans tend to conceive events as effects, which have some causes, and students need to perceive that they have achieved success (to some extent) *because* they have found the information *because* they started to search for it. To represent this causal chain, we speak about *bidirectional* causal links between the game space and the information space, and between the game space and the schooling space (Fig. 6).

Thus, students can find information they need via causal links, and this information is grounded via grounding links. Through this mechanism, the system intrinsically encourages students to contextualise the gaming material into the everyday context, or everyday material into the gaming context (see Sec. 4, part 3 of the evaluation). Many educational software projects lack these grounding and bidirectional causal links. Consequently, the coherence and immersion of both the learning process and the gaming experience are fundamentally corrupted (recall the tension issue and Strategy I). Moreover, the possibility of elaborating on knowledge from the gaming and the real-world perspective at the same time is not afforded (context-dependency issue, Strategy II).

Additionally, we define causal links within spaces, so-called *intra-space* causal links: these capture standard causal relations within the spaces.

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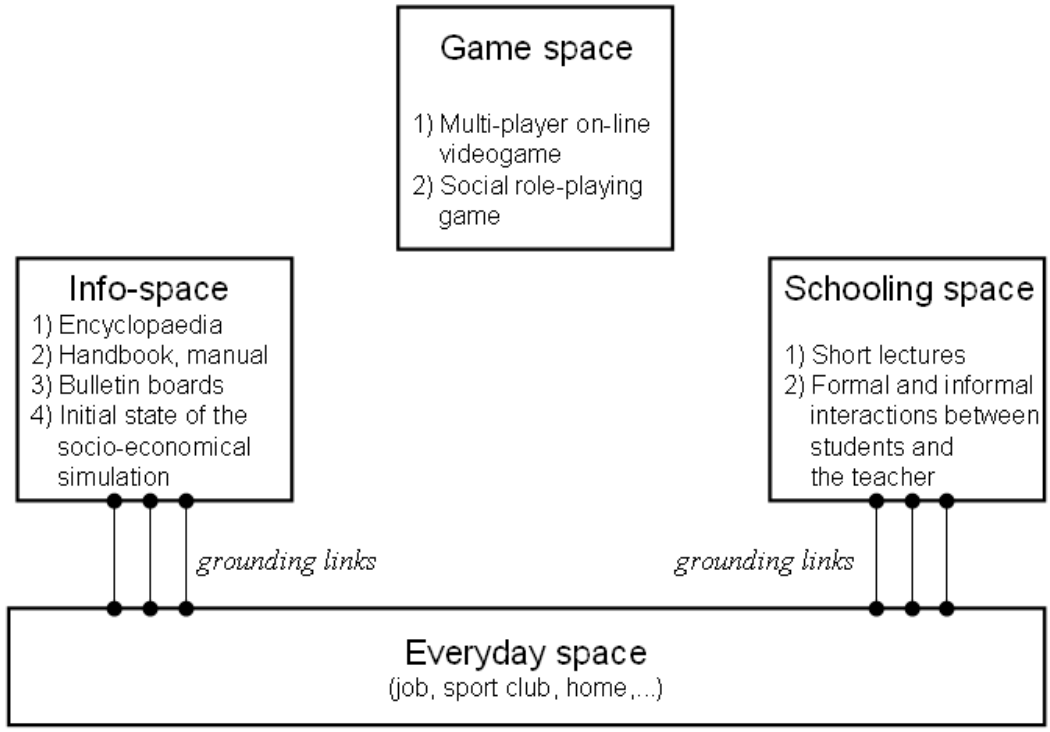

Fig. 5. Four action-based spaces of ALE and grounding links between the information space and everyday space and the schooling space and everyday space.

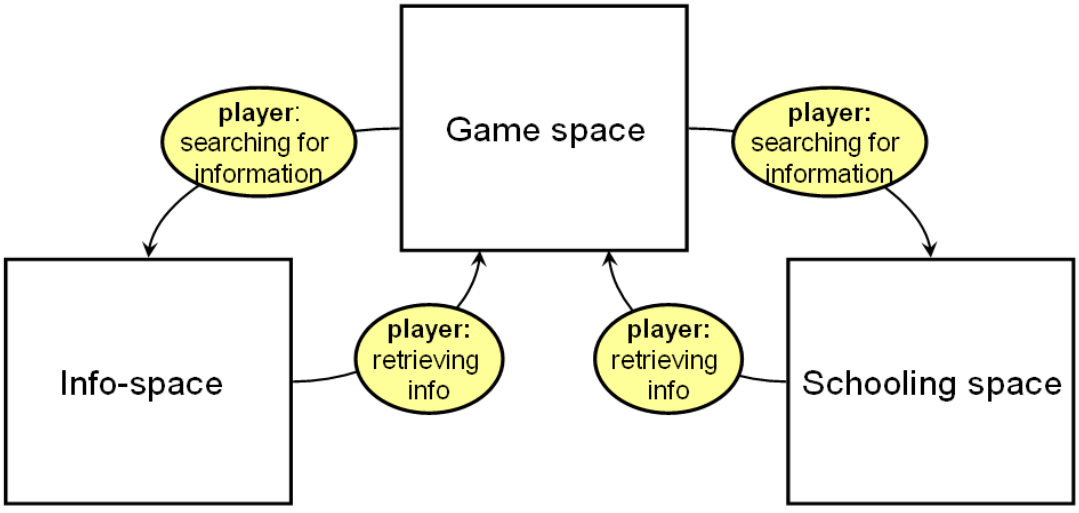

Fig. 6. Information-seeking bidirectional causal links of ALE.

ALE in Europe 2045: a practical example

This section presents components of ALE from the case of Europe 2045.

Game space and its intra-space causal links

The game space of Europe 2045 encompasses both the MOVG and SRPG. The reason for this amalgamation is twofold. First, as already said, both game genres possess their specific learning advantages. Second, this coupling has additional advantages from the standpoint of Strategy III from Sec. 2, as will be detailed below.

Both games are interconnected by causal links *between* the games (Fig. 7). Without them, the two gaming components would not constitute an organic whole. Additionally, each game, by definition, possesses inherent causal quality on its own.

The most important part of the MOVG is its economic simulation, which provides the player with immediate *feedback* on his or her domestic policies, which is both a feature facilitating learning (Prensky, 2001) and a manifestation of the game's internal causal coherency.

Based on the success of one's domestic policies, the student is awarded prestige points. These points can be invested into proposals for changes to EU policies, which is a MOVG→SRPG causal link.

The proposals are discussed in the classroom as a part of the SRPG element, and then they are voted through. The behaviour of a player during the discussion and the voting (e.g. whether he/she keeps his/her word) influences the attitude of other players towards him/her in subsequent rounds, which is an intra-game causal relation.

At the same time the MOVG features storytelling, which simulates various international affairs and crises. These have to be discussed as a part of the SRPG and the proposed solutions again voted through. This is a MOVG→SRPG causal link. The result of this voting and also the result of voting about EU policies influence economies of individual states, an SRPG→MOVG causal link.

We see that both of the games are connected bidirectionally. Now, we also need the whole game space to constitute a union with the schooling and the information spaces. For this, we need extra-space causal links.

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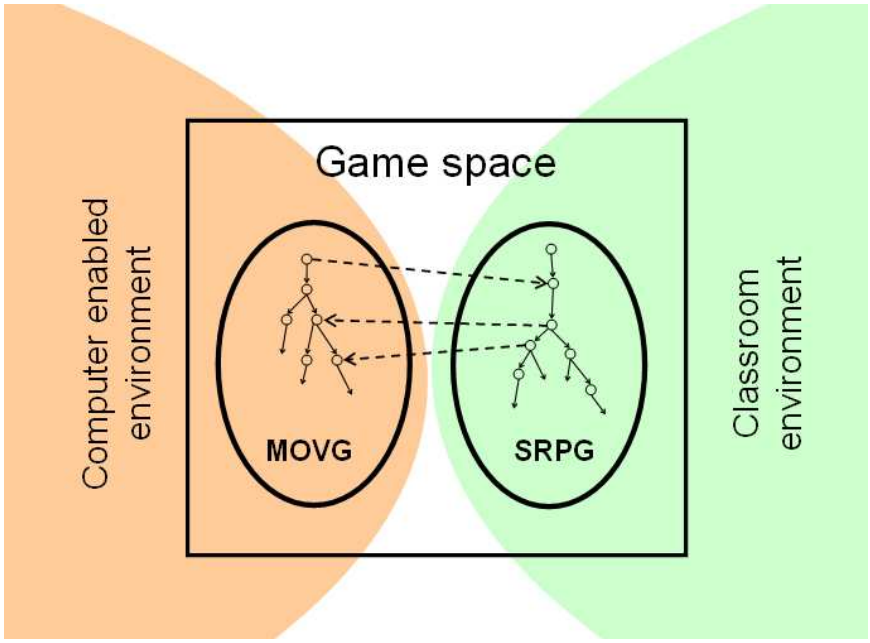

Fig. 7. Causal relations within the game space. Note both the causal relations within games (full lines) and causal links between the games (dashed lines).

The information space and its causal and grounding links

Europe 2045 provides players with both the "official" information space, i.e. the encyclopedia, the news and the initial state of the game, and an "unofficial" one, i.e. the discussion boards. As such it promotes individual, goal-oriented research as well as peer collaboration and information sharing. Students often conduct extensive research in order to gain a competitive advantage over others. They also use real-world information gained from the encyclopedia and the Internet to support their arguments (see Tab. 1, Lines C1-C3, E; see also Tab. 2, Lines C4-5; and Part 3 of Sec. 4).

This "information seeking" behaviour is only possible because the bidirectional causal links from the game space to the info-space were defined during the game's design phase. This definition entailed intentional structuring of the official part of the information space according to the needs of students as *players* (i.e. according to gaming objectives) and providing the materials in an intelligible form.

Causal links that influence player behaviour

One kind of causal link represents possibilities for information seeking and exploitation, but there is yet another kind of causal link: the one representing possibilities to influence players. The content of the information space is not fixed, it evolves. First, it can be commented by students and teachers. This not only allows for adaptation of the game content for different classes by teachers, but also influences students' behaviour by providing specific information during the course of a particular game. Second, the news generated by the MOVG in every round highlights some information from learning resources that is relevant for actual challenges in the game. This is a causal link through which the game space influences the information space, helping to focus a student's attention (Fig. 8).

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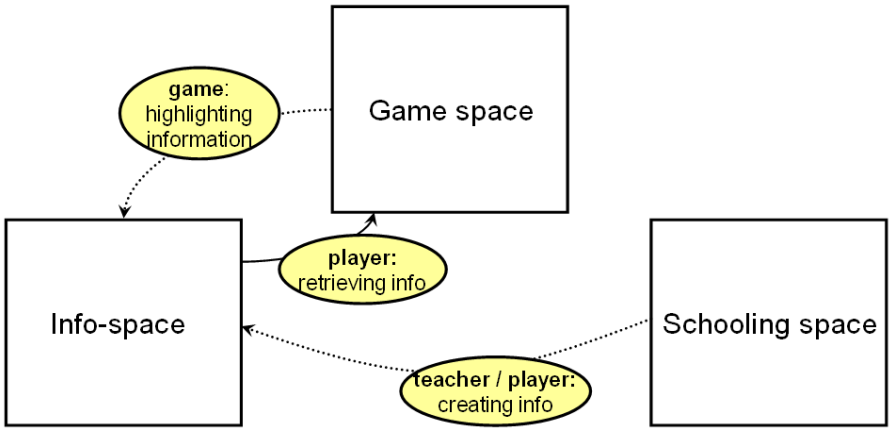

Fig. 8. Causal links shaping player behaviour (dotted lines). The mechanism works because the information is retrieved via information-seeking causal links (the full line and Fig. 6).

Intersection of the schooling space and game space

Perhaps the most important pedagogical feature of Europe 2045 is the intersection of the game space and the schooling space. They blend in the real environment in the classroom, unifying the gaming, learning, and teaching processes in the same time-space framework. Importantly, what does merge is not the game space of the MOVG, but that of the SRPG. From the standpoint of the technological layer of ALE, the SRPG redirects players' attention from the computer-enabled environment of the MOVG to the real environment, while preserving their immersion in the game. This is only possible because of the bidirectional causal links between the MOVG and the SRPG. At the same time, the teacher "feels at home" in SRPG which takes place in the real environment, mainly in the classroom. This blended space affords:

1. Formal and informal social interaction between students. Students are engaged in discussions moderated by the teacher, but they also have the opportunity for individual negotiations. They interact, because they are motivated; they want to persuade their peers to vote for their proposals and they want to resolve the crisis scenarios (see Tab. 2, D3). At the same time, they search for information from their fellow players. Discussions and searches can continue via on-line boards.
2. Short formal lectures given by the teacher. The teacher has the opportunity to comment on the in-game development, the proposals, and the events taking place in the virtual scenario and thus to contextualise them into the everyday space. Our opinion is that students are willing to listen a) because the talks are short and b) the talks offer them additional information to help them play better. Again, the students have to perceive that information really helps in the game. Here, the materials we have prepared for teachers play an important part.
3. Semi-formal discussions with the teacher. Students can interact with the teacher the same as with a game master, which is a different role than that of educator. This facilitates their information-seeking behaviour.

Tab. 1, Line C2 suggests that both the discussions with peers as well as the formal lectures by the teacher are valuable sources of information; the discussions are valued even more by the students. Consolidation of these three possibilities within an organic time-space frame is an aspect that is often missing in most educational games.

Tab. 2. Additional findings from the evaluation study. This table complements Table 1. Each cell contains three numbers in this order: total, girls, and boys.

C4. How often have you used the encyclopedia?

Very often	Often	Sometimes	Rarely	Never
6% (8% / 5%)	12% (13% / 10%)	52% (62% / 39%)	21% (12% / 33%)	9% (5% / 13%)

C5. Was the encyclopedia relevant to the game?

Yes	Probably yes	I don't know	Probably not	No
21% (25% / 16%)	44% (43% / 49%)	26% (26% / 24%)	7% (5% / 9%)	2% (1% / 2%)

D3. How intensely have you argued for your project?

Very intensely	Intensely	Mildly	Rarely	Never
22% (28% / 14%)	15% (17% / 14%)	28% (36% / 17%)	21% (10% / 34%)	14% (9% / 21%)

Discussion and practical implications

To summarize, the ALE framework organises the learning environment into two layers: technological and action-based. The former is organised around affordances, while the latter around distinct activities that students are involved in: gaming activities, information-seeking activities, formal learning activities, and other "everyday" activities. While the former three kinds of activities are educational, the last kind exploits the educational outcomes.

The lesson learned from the technological layer is twofold. First, there are at least three kinds of affordances: for designers, students, and teachers. Second, in effect, affordances must be visible (that is, +affordances instead of –affordances). While it is possible to turn some – affordances into +affordances during an instructional seminar - and this is actually desirable - both for students and teachers, designers should also work with affordances that are *already* visible to avoid frustration from the lack of understanding of a new technology.

In our context, one of the largest advantages of the combination of MOVG with SRPG, with respect to affordances, is that teachers are more familiar with the classroom environment of the SRPG than the computer-enabled environment of the MOVG. That is to say, the former possess more +affordances than the latter. In Europe 2045, direct interaction of teachers with the MOVG is minimal; instead, students' attention is redirected from the MOVG to the classroom environment via the SRPG. Teachers play Europe 2045, both the MOVG and the SRPG parts, in the instructional course, but they need not worry about forgetting a detail from the MOVG element. Instead, they explore the possibilities of the SPRG part and realise that

they already knew about most of them. The SRPG only organises these +affordances into a coherent whole. At the same time, teachers need to be familiarised with new affordances that have been constructed by providing educational materials in the information space, as well as other methodological materials. These materials allow teachers, for example, to assign students readings and tasks that capitalise on the information space.

Now, let us return to the three issues detailed in Sec. 2. Our data indicates that the tension issue (A) is diminished because there is no abrupt switch between the learning and gaming parts and because the game is about reality. Students are encouraged to solve "nearly real-world problems." Conceptually, this connection with reality is permitted by grounding links. Because there are no grounding links from the game space, only from the schooling space and the info-space, the second key property is bidirectional causal links. These enable students to "travel" between the spaces and they motivate them to do so. The important point is that chances for acceptance of the game increase when these mechanisms are +afforded; that is, made perceptible, thereby helping the teachers and students to suspend their disbelief (Issue C). This ultimately implements Strategy I (Sec. 2). The practical implication is that when designing a serious game, it is beneficial to write down all affordances and causal and grounding links during the design phase.

At this moment, besides anecdotal evidence, we have no data that would support the claim that our approach really resolves the context-dependency issue (B). However, in this respect, ALE presents a testable hypothesis, which posits that Issue (B) is tackled by two mechanisms. First, students can perceive educational material from two different perspectives, a gaming one and a real world one. This happens both during their search for information and preparations of arguments, as well as during the discussions in the "joint" gaming-schooling space. Again, the grounding links and causal links are key features. This is actually Strategy II for tackling the transfer problem: elaborate on material from several perspectives. Our data actually indicate that students and teachers perceive that this indeed happens, even though we cannot yet evaluate the real learning effect.

Second, the causal links can redirect students' attention from the world of the videogame, that is from the computer-enabled environment, to the classroom environment of the SRPG. This brings students from the context of the MOVG, which is far from the every-day context, closer to it: to the "intermediate" context of the SRPG, enabling transfer between two near contexts (Fig. 9), i.e. Strategy III.

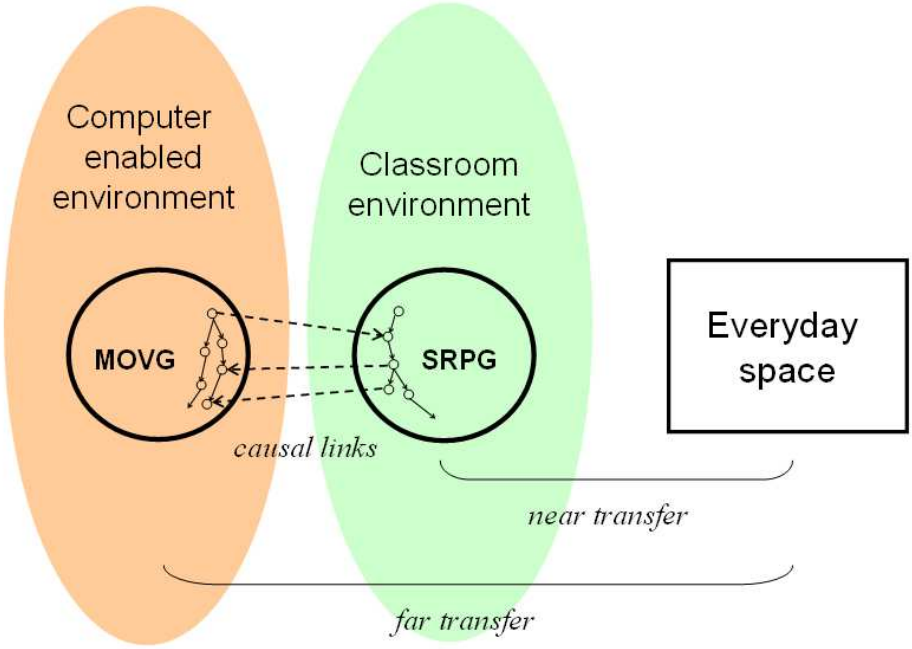

Fig. 9. Near transfer and far transfer in Europe 2045.

The most straightforward way of finding evidence supporting/refuting ALE would be to corrupt some of the causal or grounding links in Europe 2045 and compare a group of students playing this altered game with a control group playing the normal game (bearing in mind ethical issues).[9] Another possibility would be to cripple either the information space or the schooling space. It is also possible to apply this principle in another game. In either case, a methodology of longitudinal studies assessing students' development of high-level skills and mental models and their retention would be needed.

What kinds of games is the ALE framework applicable to? The answer has two parts: one relates to affordances, the other to action-based spaces. Our opinion is that the concept of affordances can be used broadly for any technology for learning, including physical/social games and any computer-based learning. This concept "only" tells us that we have to focus our attention on possibilities the technology offers and on making these possibilities visible both for students and teachers (and, on the meta-level, for designers).

The concepts of action-based spaces, grounding and causal links are more specific. We believe that it is worthwhile to think in terms of these entities when designing a team-based game focused on a complex topic: primarily facilitating learning multiple mental models and high-level skills. We do not think the concept is useful for classical "drill and practice" e-learning software, simulators (e.g. a driving simulator), and simple virtual laboratories.

From the design point of view, it is important that the ALE framework does not demand the SRPG element. However, the hypothesis of ALE is that without a real-world based gaming element, the near transfer strategy will not be available. Similarly, ALE would work without a digital game; however, many affordances provided by digital technology will become unavailable.

[9] We would like to thank to Arthur Greasser for pointing this fact out to us.

Finally, it should be noted that the ALE framework is not a fixed entity. Many new kinds of causal and grounding links, or perhaps even spaces, can be added, if needed.

Conclusion

In this paper, we have presented the full-fledged, serious game, *Europe 2045*, and demonstrated how it was firstly accepted by students and teachers as a learning tool and, secondly, successfully integrated into a formal schooling environment. The evaluation strongly implies the game's success. Most importantly, the game seems to have tackled two crucial problems relating to DGBL: namely the tension issue (A, Sec. 2), i.e. the tension between learning objectives and gaming objectives, and the disbelief issue (C), i.e. the perception of games as a leisure time activity and the unawareness of how they develop real-world related skills and knowledge.

We have abstracted the key features of Europe 2045 into the conceptual framework of the Augmented Learning Environment (ALE), introducing a novel paradigm in the field of educational games. Besides solving the two above-mentioned problems, ALE presents a testable hypothesis and it also puts forward a solution to the context-dependency issue (B), i.e. the dissimilarity of a videogame's context to the real-world context, which makes it difficult for students to transfer knowledge. The fundamental distinguishing features of ALE include the following aspects:

1) Grounding the game content in everyday context, which helps with formulating learning objectives and offers students options for solving "nearly real-world problems."

2) Integration of appealing game-play directly into formal lectures without compromising the learning or gaming aspects of the game; debriefing and classroom lectures are directly relevant to the game and partially take place in the game.

3) Exploiting information-seeking behaviour, helping students to contextualise gaming materials with a real-word context and vice versa, enabling the transfer of knowledge.

4) Creating supplementary materials and courses for teachers.

5) Describing the learning environment in terms of what it visibly offers students and students: that is, in terms of affordances.

Our opinion is that ALE can be used as a methodological framework for the development of similar, large-scale educational projects. Even though we have not yet tested whether students gained from the game when compared to a control group being taught in a traditional manner, let alone conducted longitudinal retention tests, ALE still presents a significant improvement in the field of DGBL. Essentially, ALE makes tests of learning effects possible, because it articulates how to develop educational games that can be accepted by the target audience and used in the formal schooling system. This was not the case for many previous DGBL projects.

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