Designing an Educational Game: Case Study of 'Europe 2045'

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Abstract. This paper presents a theoretical framework, which has been adopted in designing an on-line multi-player strategy game *Europe 2045*. *Europe 2045* is an educational tool for high school social science courses, aimed at familiarizing students with political, economic, and social issues in contemporary Europe. Apart from learning facts, players develop a range of key skills: discussion ability, negotiation, teamwork, and group decision-making. The presented theoretical framework is based on a critical analysis of crucial issues, which seem to determine the success or failure of development and implementation of an educational game in the formal school environment. It demonstrates key approaches the authors of *Europe 2045* have adopted in order to overcome already known problems related to game-based learning. On a general level this paper discusses issues related to formal fact learning in educational systems and the possible role of educational games in enhancing these systems.

Keywords: Educational games, serious games, game design, immersive environments, game-based learning.

1 Introduction

The earliest-developed computer games have already been used to support training and learning objectives [4]. Since then, the concept of game-based learning has undergone substantial changes. The high expectations of early edutainment and e-learning have not actually been met by particularly successful outcomes. The reasons mentioned in this regard are that such tools were poorly designed, simplistic, and repetitious, and did not allow players any active exploration [16]. On the other hand, many commercial computer games often place the user in very complex environments and require them to complete highly demanding tasks with difficult objectives. Therefore some authors argue that at least some commercial games are actually based on well developed and sound theories of learning in order to engage the player and instruct him how to play and win the game [12]. In this respect several recent works have explored of the potential for commercial strategy games in formal education and their supposed advantages over classical e-learning and edutainment tools, e.g. [8, 23, 26]. The results from these case studies are promising but also ambiguous in some aspects, pointing out the difficulties in linking games' educational content with the context of formal education.

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Hence, so called *serious games* – full-fledged games in which education (in its various forms) is the primary goal, rather than entertainment [6] – are starting to gain an increasing amount of attention. The fact that these games are, contrary to commercial games, intentionally developed as educational tools arguably makes their integration into formal education easier. Several of these games have been already evaluated with generally positive outcomes [7, 11, 32].

With the rapid development of the Internet a new form of gaming has emerged. Drawing upon the concept laid down by multi-user dungeons (MUDs) in the 1980s, multi-player on-line games construct complex virtual worlds, allowing non-linear interactions and exploration, as well as various forms of collaboration/competition among groups of players. The distinctive features of multi-player, on-line games – team collaboration, problem solving, and group decision-making – have already attracted the interest of educators and instructors, including the U.S. Army [32].

Learning and training via computer games and simulations can be regarded as a part of a more general process in what de Freitas calls *learning in immersive worlds* [6]. Minsky and Papert define immersive worlds as given environments which may be explored in a non-linear way by learners. They include artifacts and objects and allow users to learn through exploring the environment and its objects in a relatively open-ended way [19; cited from 6]. The fundamental question of learning in immersive worlds is how to transfer the acquired experience into relevant knowledge and skills and similarly how to design an immersive learning environment in order to facilitate such transfers [8, 23].

The primary goal of this paper is to present the theoretical framework used in designing a complex learning environment, which combines the advantages of serious games (i.e. easier integration into formal education) with those of multi-player, on-line games (i.e. intrinsic facilitation of collaboration). Within this framework we have developed a multi-player, on-line strategy game *Europe 2045* aimed at educating high school students in economics, politics and other social sciences as well as training them in a range of key skills. The theoretical framework stems from research conducted prior to embarking on the game's development. It has been evolving during the development process, having been shaped by preliminary case studies carried out during the game's testing and implementation. Basically, it presents the desired learning objectives of *Europe 2045* and the strategies our team has adopted in order to ensure fulfilment of these objectives. It also reviews our approach in light of the results from pilot evaluations of the game. Evaluations were conducted on two groups of 34 high-school students.

As far as we know, *Europe 2045* is most likely the first multi-player strategy game worldwide that has been designed specifically for use in secondary schools. Therefore the secondary goal of our paper is to set theoretical and case-study-based background for researchers and designers involved in similar future projects. Thus, on a more general level, this paper analyzes the crucial issues that seem to determine the success or failure of developing an educational game and its insertion into formal secondary education programs. Finally, this paper argues that successful and effective implementation of an educational game requires reconsidering the very way in which one learns, the desired outcomes of formal education, and how the learning context should be enhanced in this respect.

Section 2 summarizes the key findings on game-based learning resulting from previous research and case studies. Essentially it is based on a study conducted in the initial phase of *Europe 2045*'s development. These findings were crucial for choosing the *Europe 2045* game platform and content, and for creating the methodology for its use in education. Section 3 describes the game *Europe 2045*, outlines in detail its fundamental learning features and theoretical approaches adopted in order to facilitate implementation. It also reflects upon which features and approaches proved to be/or not to be successful during the game's testing and pilot evaluation. Section 4 provides conclusions on the project assessment.

2 Key Findings on Game-Based Learning

As Piaget and Vygotsky have argued, play is a crucial method through which we test ideas, develop new skills, and participate in new social roles [20, 31]. In this respect early video games raised various expectations about their educational value. Given the fact that motivation is regarded to be a key aspect of effective learning, the popularity of games among younger generations inspired many educators. Indeed, early research on arcade-style games has demonstrated that games create intrinsic motivation through fantasy, control, challenge, curiosity, and competition [18, 5]. The high popularity and consumption of games even led some authors to suggest that children of the "videogame generation" do not respond to traditional instruction and developing educational games is thus a necessity [15, 21]. However, the facility with which one can transplant this intrinsic motivation from a leisure time activity into formal education structures is a different question that will be discussed in Section 3.

Commercial computer games construct oftentimes rich, complex environments that allow immersive exploration of numerous strategies for action and decision [10]. Many authors suggest that by situating players in immersive worlds, where they can freely move and act, these games can promote problem-solving, goal-related behavior, engagement and motivation, as well as social networking [13, 6, 28, 11, 23]. Other studies argue that games help develop strategic thinking, group decision-making, and higher cognitive skills [1, 6].

Several case studies have evaluated the implementation of commercial computer games in formal education – i.e. *The Sims 2*, *Civilization III*, and *Europe Universalis II* [23, 26, 8]. On a general level they have demonstrated that commercial games exhibit some of the positive learning effects mentioned above but have also revealed certain ambiguities and problems as discussed below. Egenfeldt-Nielsen conducted a case study on learning history with *Europe Universalis II* in Danish high schools and concluded that students using the game had, in the end, slightly worse factual knowledge than the control group (attending normal classes). But those test-group students exhibited better retention of the learned facts over the long-term and a greater willingness to search actively for additional information [8]. Similarly Gee and Steinkuehler argue that research is a core component of gameplay, and games stimulate an interest in topics related to a game's content, thus promoting various types of information literacy and developing information-seeking habits [29]. Another study has introduced *Civilization III* into secondary school history classes in the US. The study's author, Squire, argues that one group of students, in the end, exhibited a

deeper understanding of the broader geographical, social, and economic conditions determining historical processes. At the same time, another group of students refused to continue in the course, opting for a normal history class instead [26].

Despite some positive outcomes, these studies point out a significant incompatibility of most commercial games with school environments [8]. Conclusions from the studies also suggest that a more theoretically grounded approach is needed for the development of educational games and their implementation in formal schooling. As has been already mentioned, such games are often being developed in the emerging field of so-called serious games, e.g. *Tactical Iraqi*, *Revolution*, or *Global Conflicts: Palestine* [17, 11, 7]. For example the latter is a 3-D role-playing game that deals with the Israeli-Palestinian conflict and is based on real personal stories. According to the evaluation study of the game prototype, players demonstrated significantly better comprehension of the complexity in the conflict, the ability to consider problems from a broad perspective, and higher personal involvement in learning via the game [7]. The majority of studies concerning serious games also demonstrate that the latter are useful for stimulating debates and discussions between peer learners concerning the taught topic [6, 7, 32, 10].

Generally speaking, 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. As Gee puts it, a large body of facts that resist out-of-context memorization becomes easier to assimilate if learners are immersed in activities and experiences that use these facts for plans, goals, and purposes within a coherent knowledge domain [12].

On the other hand, there exist some substantial problems in using (even serious) games in formal education. These known pitfalls will now be reviewed, and in Section 3 we will present how we have incorporated our solutions to these problems into our framework.

First and most notably, there has been a dominant perception, among the majority of teachers, of gaming 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, the deeply-rooted experience with videogames as entertainment may mitigate the educators' willingness to use games as educational tools [6, 24]. To some extent this applies also to students who, even when playing complex games in their leisure time, are skeptical of the learning effects of games in the school environment [8]. Such perceptions are also strengthened by the fact that learning in immersive environments generally does not promote awareness of – and more specifically how – we are developing our skills and knowledge. In the case of *Europe 2045* we have tried to overcome this problem by defining clear, desired learning outcomes in accordance with national curricula guidelines and by explaining these outcomes to teachers and students as we will discuss in Section 3.6.

Second, a substantial problem lies in transferring skills developed through game-based learning into a real environment. In educational research, this phenomenon is commonly referred to as the *transfer problem* [8, 23, 30]. It means that the players actually develop a number of skills and knowledge required to finish the game's objectives, but are not easily able to apply what they learned in different contexts and different social practices. The role of the teacher and his/her reflection upon and

moderation of the learning process seem to be of critical importance in dealing with the transfer problem as we will discuss in Section 3.7.

Finally more practical barriers to using games in schools were cited by a majority of researchers. For example, they mention a lack of access to equipment and limited availability of up-to-date video cards [6], or barriers posed by fixed lesson times (mainly 45 or 50 minutes) which seem insufficient for game-based learning [23]. Also, in several cases, the commercial computer games chosen for educational purposes appeared to be overwhelmingly complicated both for teachers and some students to handle [8, 26]. These limitations have been central to the development of *Europe 2045* and its educational methodology.

3 Designing Europe 2045

3.1 Game Description

As a part of the European-funded project "Integration of IT Tools into Education of Humanities" we have developed a multi-player, on-line strategy game *Europe 2045*, designed to be supporting educational material for social science courses, attempting to familiarize players with political, economic and social issues in a united Europe and the present-day world. Apart from learning facts, the player should develop a range of key skills: the ability to discuss, to negotiate, to think critically, and to work in a team. In the course of the game's development, which finished at the end of 2007, seven preliminary studies were carried out, each involving about 10 high school students. A pilot evaluation has been conducted on two groups of 34 high school students (19 females, 15 males) in Prague, Czech Republic in January 2008. They include both qualitative and quantitative outcomes (here, for reasons of brevity, only some of the qualitative data are presented). The game is intended to be fully applied in the spring 2008.

Europe 2045 features three layers of game-play. In the game, each student (1) represents one EU member state and defines its domestic policy (beginning with tax levels and environmental protection and graduating on to issues such as legalization of same sex marriage and privacy protection policies). Also, the player offers subsidies designed to persuade domestic and foreign investors to invest in his/her country. On a diplomatic level (2), the player has an opportunity to present drafts for policy changes to the EU. At the beginning of the match, the situation closely copies the real state of affairs in Europe today. The players are free to cancel current policies or to introduce new ones. Additionally (3) players face various simulated scenarios and crises addressing contemporary key issues faced by the unified Europe, including migration, population aging, international relations, and energy independence. The players must react to all these events and, in co-operation with fellow players, seek out appropriate solutions. During the course of the game, they typically witness the short- and long-term effects of their decisions.

Moreover, each player (or team of players) has his or her own project to try to push through at the European level. A project is basically a vision of how the EU should look like in the future (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). The final appearance of Europe at the

end of each match is thus a result of discussions, voting, and intense diplomatic negotiations in a given player group. The discussions take place in the classroom, where they are moderated by the teacher. Supplementary information, which is both relevant for success in the game and which summarizes the real world information, is provided by hints and the in-game encyclopedia (Fig. 4).

Technically, the game is a client-server application; the students play the game via the Internet (Fig. 1). The server part comprises PHP scripts generating the game interface, the story manager is written in PHP as well, and the social-economical simulation is written in Java. Almost all parts of the interface are programmed in Flash (Figs. 2, 3) in order to make the game suitable to technological equipment standards in Czech secondary schools (e.g. slower Internet connections, etc.) and make it ready to use without the need of special installations by end-users. These seemed have proven problematic in the past, according to many case studies [8, 26].

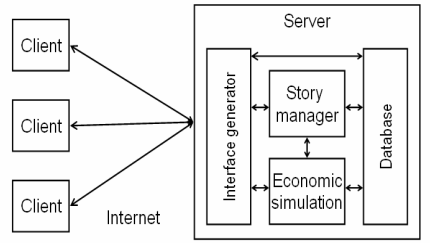

Fig. 1. Architecture of *Europe 2045*

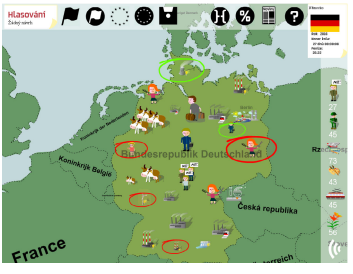

Fig. 2. Flash interface; state management

Fig. 3. Flash interface; EU policies

Fig. 4. In-game encyclopedia

3.2 Development Framework

The following sections (3.3–3.7) describe fundamental features of *Europe 2045*. Emphasis is placed on the aspects of technological solution, gameplay and usage methodology, which are relevant to achieving learning objectives and integration of the game into formal education structures. For better clarity we have summarized our framework in a simplified graphical representation (Fig. 5). In the left column we have listed key problems with and objectives for developing educational games, which stem from Section 2 of this paper. The second column consists of our solutions

to these problems, while the last column reviews the solutions in relation to testing and pilot evaluations. Detailed descriptions, including working hypotheses and case studies, are provided below.

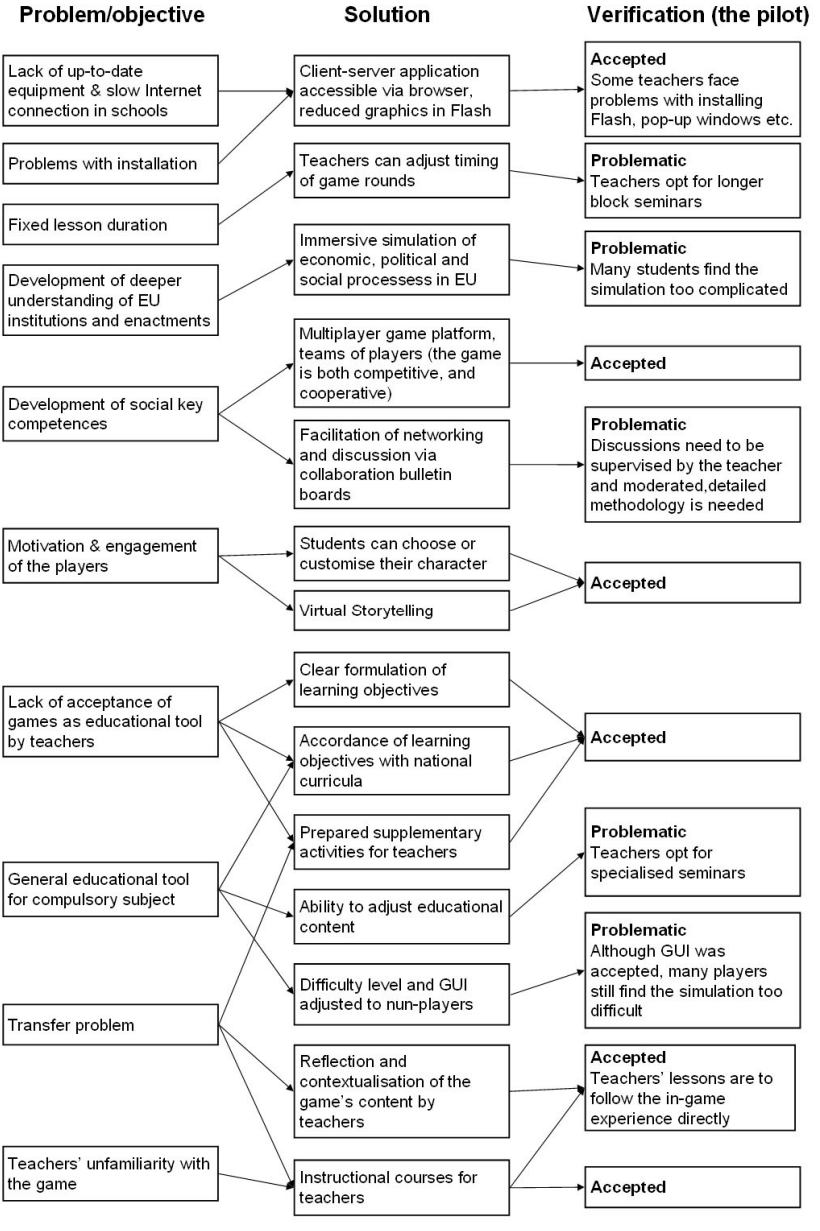

Fig. 5. *Europe 2045's* development framework

3.3 Collaboration and Multi-user Environment

As argued in [2, 27], multi-player, on-line games offer an ideal environment in which gamers can communicate with one another, accomplish shared goals, and participate in solving complex problems. In order to maintain the development of the above-mentioned social skills, the gameplay of *Europe 2045* was designed so that co-operation among the teammates (players sharing the same project) would be necessary in order to achieve the game's very objective, i.e. to put the project through at the European level. Changing particular EU policies is also not possible without careful diplomatic negotiations with other teams. Thus the learners are encouraged by gameplay to take an active part in the complex in-game diplomacy.

With regard to the development of social skills, several case studies suggest that cognitive tools, such as discussion forums and bulletin boards, play an important role in enhancing learning in multi-user environments through the mediation of social interaction and by encouraging discussion [6, 10]. *Europe 2045* is equipped with a multi-thread bulletin board, which enables communication on a variety of levels, from general message boards to peer-to-peer communication. Although it has been proven during the pilot evaluation that these supplementary tools actually play a vital role in enabling the players' collaboration, without proper teacher moderation discussions soon digressed into utter chaos. After several rounds the dominant players took over the discussion and the arguments started to be personal and irrelevant to the game's content. Similarly, the voting about EU policies was heavily influenced by the persuasive power of these dominant players. As a result we have developed a more detailed methodology for managing the players' discussions and voting processes. We will present this in Section 3.7.

Previous case studies also argue that students in multi-player environments need to have the opportunity to choose their roles or at least to customize their characters [6, 22]. During the testing of *Europe 2045* we applied various approaches, ranging from random distribution of the players' roles (i.e. the state and the project) to students' free selection from the roles available. It becomes evident that the identification with the player's virtual representation is crucial. When students had the opportunity to deliberately choose their roles and their motivation, then their level of engagement in the game and in the subsequent negotiations was significantly higher. On the other hand, when they have to represent states and projects without the possibility of choosing them, discussions soon became short, lacking in content and rather formal (i.e. most of the students were simply trading support for various laws or regulatory measures).

3.4 Simulation and Educational Content

From the findings demonstrated in Section 2 it seems that simulation is an essential feature of game-based learning [8, 12, 23, 26]. As argued in [10], simulation can respond to students' actions, provide rapid feedback, and gradually increase the degree to which they are challenged. *Europe 2045* puts students into an immersive simulation of the European Union, its economic and political dynamic, etc., where they can experience its processes in a complex way. Our hope was that this can assist students in better understanding the underlying logic for key issues addressed by the European Union. These are issues that are otherwise overwhelmingly complex and unfamiliar to most of them.

Conceptually, our model is a multi-agent simulation, where each agent is either a country, or an abstract representation of an EU industry. In a simplified fashion, at the end of each round, an agent-country computes the next state of the country, while an agent-industry carries out decisions which lead the country to build new factories, mines etc. based on particular variables related to the countries. Similarly, our model simulates a vast number of other variables, e.g. comfort, unemployment, crime levels, immigration, etc.

Essentially, the pilot evaluation has proved that students definitely appreciate a simulation based on real data and benefit from exploring its logic (see also [25]). At the same time some of the features of simulation-based learning turned out to be problematic.

First, although we intended for the model to be designed in a relatively simple way, and we have tried to explain it to students via introductory lectures, hints, and an in-game encyclopedia, a substantial number of students have found the simulation too complicated and have failed to successfully manage their states. This applies particularly to non-players, i.e. students who do not play computer games regularly in their leisure time (see also [8, 26]). As a result, it seems that educational games intended to be used in general education need to lower substantially the difficulty level set as a standard by the gaming culture for various game genres. In this respect it has to be noted that most commercial computer games are designed for relatively longer periods of use (e.g. weeks or months), which gives the player more time to explore, challenge and master the game's rule system.

Second, given that the simulation inherently provides a schematized picture of the world, some teachers have expressed concerns that by merely exploring the relationships between various phenomena in the game, students might develop naïve concepts of how the economies of the European Union work. Other researchers formulated a similar concern as well [25]. During the pilot evaluation it appeared that the role of reflection of the game's content through additional educational materials, active interpretation, classroom discussions, and teachers' explanations is of paramount importance. The methodology designed for this reflection will be detailed in Section 3.7.

3.5 Virtual Storytelling

Storytelling has played an important role in humanities education since the advent of formal schooling [6]. Our working hypothesis was that stories help to build a learning context. Through stories students can better understand certain issues. Stories increase their involvement and, consequently, their motivation.

The narrative structure of *Europe 2045* serves three purposes. First, it introduces new topics and agendas for students' discussions. Second, by tying new events to players' previous decisions, it serves as a global feedback mechanism for students and as a method for sharpening discussions. The third class of events provides individual players with feedback on the results of their previous actions concerning their own states.

The game proceeds in rounds, one round is one game year. An atomic "beat" of a scenario is called an *affair*. It is an event that takes place in one round and can be triggered by players' actions or results from the economic and social model or events from previous rounds. An event is communicated to the player via a textual description in the game newspaper (Fig. 7) or via a short animated clip on TV (Fig. 6). In some cases, an event also has an impact on the economic and social model, i.e. it influences state of one country or that of the whole EU.

Fig. 6. The TV News; Darfur conflict

Fig. 7. The Newsletter

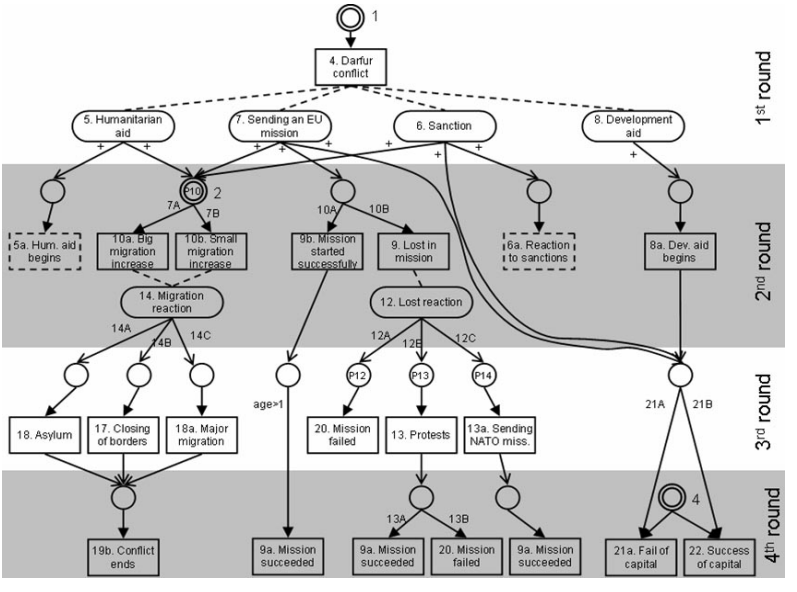

Fig. 8. Darfur scenario. The elements of the plot are organised in rounds for clarity's sake.

Some events introduce issues that require decisions to be taken by the players (e.g. accepting another state's proposal, sending a humanitarian mission to a conflict area, etc.). These decisions are intended to be taken during a discussion, typically in the class under the teacher's supervision (see Sec. 3.7), and voted on via ballot. One event often triggers more ballots, each containing a precisely-formulated question ("Do you support sending a European humanitarian mission to the Darfur Region?") with three possible answers (yes/no/abstain). The ballots chosen by the game designers aim to cover all the main possible solutions usually proposed by real policy-makers in similar cases. When the answers cannot be schematized to fit a yes or no option, the ballot contains a number (3-4) of more detailed solutions. The decision chosen by the players again influences the economic and social model and the events to be triggered in the next round.

We have adopted a modified version of Petri Nets for *Europe 2045's* plot specification [3]. Fig. 8 provides an example of specifications for the Darfur scenario: one of

the largest, and perhaps most informative, scenarios in the game. This scenario starts in the first round with an event communicating via TV that the crisis in Darfur has escalated and requiring four ballot proposals. Based on the results of the ballots (i.e. the actions of the students), the crises evolves further. The important point is that it can develop in several aspects at the same time. For example, if students agree both on a form of development aid (Ballot 8) and of humanitarian aid (Ballot 5), both the events "Development aid begins" (8a) as well as "Humanitarian aid begins" (5a) follow through to (or lead to a) the second round. Additionally, either Affair 10a "Big migration increase", or Affair 10b "Small migration increase" ensues. Which affair is started depends on conditions 7A and 7B. In a similar manner, the scenario then evolves further and provides the students with direct feedback on their actions. In the basic campaign of *Europe 2045*, there are two additional scenarios of similar size to the "Darfur" one and several dozens of small scenarios consisting of one to three actions.

During the pilot evaluation it became evident that well-designed virtual storytelling is a key element in *Europe 2045*. The students appreciated scenarios which provided them with more alternative solutions and evolved according to their own actions. At the same time, they were more skeptical about smaller and simpler scenarios, which they perceived as schematizing. Nevertheless, the narrative structure appeared to be an important factor for students' motivation. During various phases of testing *Europe 2045*, the game was played on several occasions without any events at all. In most of these cases the students' engagement in the game was significantly lower after several rounds.

3.6 Educational Framing: Learning Context

From the findings demonstrated in Section 2 [1, 25, 28] and our pilot evaluations outlined in Section 3.1 it essentially seems that when a game is supposed to be used in a formal school environment, the context of game-based learning is probably more important than the specific features and/or content of the game itself. By context here we mean both the contemporary educational practice, i.e. the national curricula, and the learning activities and discourse surrounding the particular educational game (e.g. supportive educational materials, students' presentations, teachers' lectures following the in-game experience, etc.). These last two sections of our paper (3.6 and 3.7) discuss the necessity of articulating clear learning outcomes, the role of the teacher in explaining the game's content, and our methodology for using *Europe 2045* in formal classes.

In the Czech Republic, the Education Ministry recently adopted a the new *General Educational Program*, which is a fundamental framework for secondary school education. It is aimed at enhancing the traditional form of face-to-face education by promoting development of key skills and a broader and multidisciplinary approach towards traditional subjects [14]. At the beginning of *Europe 2045*'s development, we defined its learning objectives as described in Section 3.1 in accordance with this new *General Education Program*. During our evaluations, it appeared that this step simplified our collaboration with Czech secondary school teachers. Ultimately, teachers demonstrated greater interest in the game and were more likely to integrate it into learning plans, when it was presented within the framework of the new national curricula.

However, we do not suggest that educational game designers should try to incorporate into a game the same scope of factual information prescribed by the national curriculum for particular subjects. More precisely they should construct the game's

environment such that it can draw upon students' already existing knowledge and understanding [9]. What we have found essential is that specific knowledge and skills developed through a game need to be clearly explained to teachers and students and integrated into accepted teaching formats in order to ensure effective learning (see also [6]).

3.7 Role of the Teacher

As Facer et al. state the role of the teacher in the game-based learning process should be one of translation – between immersion and reflection, between implicit and explicit knowledge, between the game world and the world of formal, summative assessment [10]. This role is by no means a simple task; yet it fundamentally determines the learning outcomes. From the testing of *Europe 2045* it is clear that the teacher has to be very familiar with the learning environment and has to experience the whole game-based learning process related to a particular game. In some cases during the pilot evaluation the teacher's lack of familiarity and preparation substantially corrupted the results of the implementation (see also [6]).

During the development of the *Europe 2045* game, we designed a teachers' preparation program that included seminars on how to use the game in various settings, model lectures, handouts, and suggested additional activities for students. After the first pilot evaluation, it became clear that a more detailed methodology document for helping to facilitate student discussions would be needed (see Section 3.3). Basically, it was obvious that discussions and subsequent negotiations are more productive when managed within a specified timeframe (i.e. between managing players' own states and voting about EU policies during each round), space (e.g. normal classroom instead of computer room), and moderated by the teacher. Fig. 9 outlines the model structure of a lesson based on this methodology.

The teacher's reflection on the development of the simulation and his or her lecture introduction to the corresponding real-world issues proved to be critical in reaching the desired learning outcomes of *Europe 2045*. The results of the pilot evaluation also suggest that this lecture has to follow directly the students' in-game experience and has to be clearly linked to the actual game's content. See also [7].

In order to use *Europe 2045* in of the general teaching of compulsory subjects we have designed the instructor's interface in a way that allows him or her to change the in-game scenario of events and thus adjust it to a particular curriculum (e.g. stressing environmental issues, economics, international relations, internal affairs of the European Union, or specific regional issues). Although teachers generally appreciated this feature, in most cases they opted for using *Europe 2045* in specialized, elective seminars. When they expressed willingness to use the game for compulsory subjects, it was mostly motivated by the above-mentioned need for compliance of learning objectives in *Europe 2045* with the new national curricula (especially development of key competencies and European Union issues). During the instructional seminars it also became clear that computer games, as an educational tool, do not appeal to every teacher. As such it seems such games will remain a supplementary – rather than mainstream – educational tool in the near future: at least in Czech Republic.

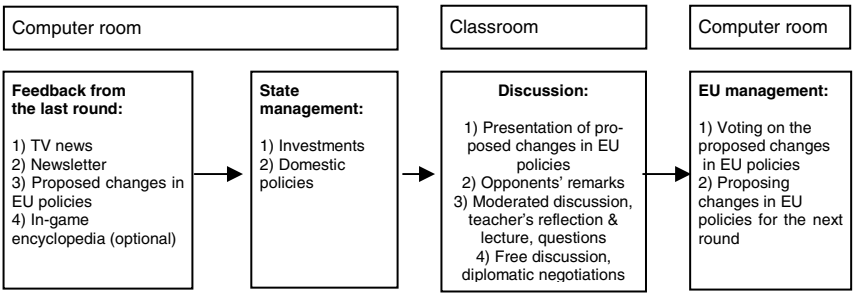

Fig. 9. Methodology for using *Europe 2045* in classes; model lecture

4 Conclusions

In this paper we have discussed key findings on game-based learning with emphasis placed on already known problems related to using computer games in formal education processes. Drawing upon these previous findings and case studies we have put together a theoretical framework, which has been adopted in designing the multi-player educational game, *Europe 2045*. The main purpose of this framework was to ease the development of *Europe 2045* and facilitate its implementation in Czech secondary formal education structures. On a general level this framework is intended to provide theoretical and case-study-based background information for similar projects.

The case studies conducted during testing *Europe 2045* underscored findings already come across in several earlier studies [1, 6, 28] that the context of game-based learning (i.e. national curricula and educational practices surrounding the game) is more important then the actual content of the game. Finally, we had started to formulate the theoretical framework for designing an educational game combining the features of serious games and multi-player on-line games prior to the development of *Europe 2045*. This framework has been further refined in the course of the game's development and has grown to include the following items:

1) Learning objectives must be clearly formulated and set out in accordance with accepted educational practice (e.g. national curricula) before development starts (i.e. accepted at least by teachers that are willing to use the product). See Sec. 3.6 and also [6, 7, 25, 27].

2) Supplementary collaborative activities, educational materials, and teaching methodologies need to be prepared in advance, but in co-operation with end-users. Further improvements in the course of development by means of evaluative studies is vital. See Sec. 3.7 and also [1, 6, 28].

3) The teacher has to be able to provide the students with reflection and contextualization of the learned skills and knowledge into meaningful real-world scenarios. We also suggest that teachers' lectures directly follow the in-game experience and are clearly linked to the game's content. See Sec. 3.7 and also [7].

4) It follows from (2) and (3) that the instructional courses for teachers are essential. The teachers have to be very familiar with both the game's interface and the whole game-based learning process (concept). See Sec. 3.7 and also [6, 25].

5) Multi-player games proved to be an ideal platform for student collaboration and for developing their key social skills. At the same time, a well-designed methodology for the teachers' moderation of student discussions and negotiations is crucial. See Sec. 3.3 and also [24].

6) If role-playing is part of the learning process in multi-user environments students need to have the opportunity to choose or customize their character. See Sec. 3.3 and also [6, 22, 24].

7) Educational games need to be adjusted to non-players in terms of complexity, difficulty level, and graphic user interface (GUI). See Sec. 3.4 and also [8, 10, 26].

8) Well-developed virtual storytelling which provides students with alternative solutions and evolves according to their actions has proven to be an important factor affecting their motivation and engagement. See Sec. 3.5.

9) Educational games need to be designed in accordance with the technological and personal limitations of individual educational institutions. Client-server applications that remove the need for end-user installations proved successful.

10) Fixed lesson times (i.e. 45 minutes) need to be adjusted for the implementation of game-based learning programmes. Most teachers opted for longer block seminars.

This list is, by no means, intended to provide a full and comprehensive or fixed framework for game-learning; rather, we recommend that it be taken as a set of working hypotheses. And of course, there are open questions. First, given the fact that games are often aimed at the development of key skills and broader and cross-disciplinary learning objectives, new ways for assessment of students' progress must be developed. This requires substantial re-thinking on how and what we learn, which is a long-term process that will require rather broad changes in formal educational systems.

Second, from the instructional seminars, that we have already conducted, it also seems that computer games as a learning tool do not appeal to every teacher. Similarly, several authors have suggested that some learners do not like using simulations or games for learning [6]. If an educational game is intended to be used as a general tool for compulsory subjects, educators should definitely have additional choices for presentation of learning materials and more differentiated activities planned [6].

Last but not least, as the field of game-based learning matures, it is probably time to start calculating the per student cost of development for educational games: in terms of money and time spent on development and instructing teachers how to use these specific tools.

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