Proceedings of I-KNOW '03
Graz, Austria, July 2-4, 2003

Aspects of Game-Based Learning

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Abstract: How to design effective learning opportunities? Why is learning by experience often more efficient than learning by studying? How to provide the learning experiences needed to respond to current challenges? Using computer games and games in general for educational purposes offers a variety of knowledge presentations and creates opportunities to apply the knowledge within a virtual world, thus supporting and facilitating the learning process. An innovative education paradigm like game-based learning suitable for this purpose is described in this article. The connection of the collaborative social context of education with game-based learning is discussed.

Keywords: education; collaborative learning; constructivism; game-based learning; game; motivation.
Categories: H.4.3, I.2.1, I.6.8, K.3.0, K.3.1, K.8.0

"The reason most kids don't like school is not that the work is too hard, but that it is utterly boring" (Dr. Seymour Papert, Prof. at the MIT)

"Computer-based training designers could learn a lot from the people who build computer games." (Bob Filipzak," Training Magazin")

1 Introduction

Despite decades of research we still experience a lack of appropriate and interesting contents that would engage learners and improve the learning process. That is the reason why we have to invent radically new ways of learning that mesh with the new world, style, and capabilities and Human-Computer Interactions (HCI) of new generations of so called computer "natives".

As early as the 80s and 90s, many scientists stated that computers and later hypermedia could be used as a cognitive tool for learning, and also outlined a number of other potential advantages that computer aided learning offers. Among the researchers of hypermedia applications for education, the following basic questions were proposed: How to design effective learning opportunities? Why is learning by

experience very often more efficient than learning by studying? How to provide the learning experiences needed to respond to current challenges?

David reported [David, 97] that there is an increasing demand for greater interactivity to be built into learning materials. There is a clear need to offer a variety of different knowledge presentations and to create opportunities to apply the knowledge within the virtual world, thus supporting and facilitating the learning process. To achieve that, it is necessary to provide a complex level of interactivity that stimulates users' engagement, apply different interactivity concepts as object, linear, construct or hyperlinked interactivity, and non-immersive contextual interactivity as well as immersive virtual interactivity.

When using computer games, and games in general, for educational purposes several aspects of the learning process are supported: learners are encouraged to combine knowledge from different areas to choose a solution or to make a decision at a certain point, learners can test how the outcome of the game changes based on their decisions and actions, learners are encouraged to contact other team members and discuss and negotiate subsequent steps, thus improving, among other things, their social skills. .

Recently there have also been several initiatives within the EU ([UniGame, 02], [GAMENET, 03], [GAMERESEARCH-NET, 03], [PROMETO-CG, 03]) that focus on facilitating and improving the learning process owing to the introduction of digital games into learning as well as fostering innovative learning paradigms like game-based learning.

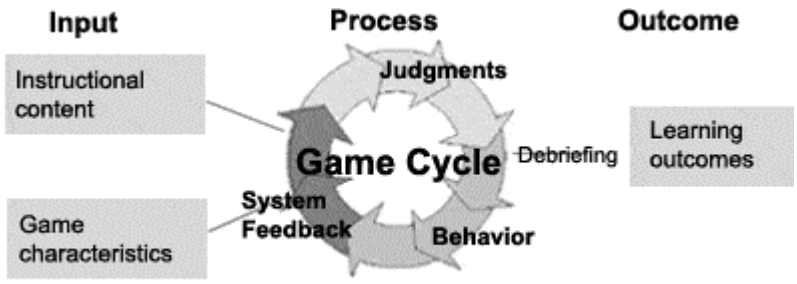

Figure 1: Model of game-based learning by [Garris et al.,02]

2 Games and Learning

Most researchers conceptualise learning as a multidimensional construct of learning skills, cognitive learning outcomes, such as procedural, declarative and strategic knowledge, and attitudes. The game based learning model is used in formal education very successfully, in particular, in military, medicine, physical, etc. training.

Let us consider, based on the Model of game-based learning Figure 1, how and when learning occurs when learners interact e.g. play a game. The main characteristic of an educational game is the fact that instructional content is blurred with game

characteristics (see the next paragraph on elements of computer games). The game should be motivating, so the learner repeats cycles within a game context. While repeating e.g. playing a game, the learner is expected to elicit desirable behaviours based on emotional or cognitive reactions which result from interaction with and feedback from game play.

In Figure 1, one can see the debriefing process between the game cycle and the achievement of the learning outcomes. Debriefing provides a link between simulation and the real world, draws a relationship between the game events and real-world events, connects game experience and learning. This part of the model corresponds, as [Kolb et al., 71] have written, to "doing, reflecting, understanding, and applying" process of study in a game.

Let us reflect upon this learning model based on an example of an adventure game. The purpose of an adventure game is entertainment or edutainment. In adventure games there are very complex environments i.e. microworlds, with no deterministic problem representation. Adventure games use intrinsic motivation. Intrinsically motivating games incorporate learning activity in a virtual world. Game characters have to solve a certain problem and can proceed further only after solving the problem. In this case the problem is part of the game and players are motivated to provide a solution in order to continue with the game. An example for intrinsic motivation is a game where players discover different rooms of the house. The access to the next room is possible only by solving a riddle that is actually a problem in the topic of, for example, logic. (In contrast to extrinsic motivation where a player is rewarded when a correct problem solution was provided) In the described game, enjoyment is strongly related to the learning activity, which can be viewed as a desirable outcome.

There are different opinions about what the game characteristics are. For example, [Thornton et al., 90] claim that **interactivity** is an essential aspect of a game. [Johnston et al., 93] suggested that the dynamic visuals**, rules, goal** and interaction are the essential features. [Baranauskas et al., 99] stated that the essence of playing is **challenge and risk**. According to [Malone, 81], four elements of computer games can be defined: **fantasy**, **curiosity**, **challenge** and **control**.

Fantasy stands for the scenario and the 'virtual' world in which the activity is embedded. Games involve imaginary worlds, activity inside this world has no impact on the real world, and nothing outside the game is relevant. The fantasy in the context of the game leads to greater interest on the part of the student as well as increased efficiency of learning.

Curiosity is sustained by the continual introduction of new information and non-deterministic outcomes. Although game activity takes place apart from the real world, it occurs in a fixed space and time period with rules**,** which govern the game for its duration. Different types of rules help players to reach a goal of the game. The system rules define the game world; procedural ones define actions (e.g., "When the time runs out, whatever's "on the screen" will be implemented as the decision"); imported rules are those that players import into the game from the real world and that allow the game to take place. Games create a second-order reality for their duration.

Challenge is provided within each appropriate level of difficulty. Using progressive difficulty levels (e.g., accelerating tempo or switching to the expert option in Chess), multiple goals that have to be meaningful for individuals, game developers design

challenge by participants activities. In the case where the activity level of difficulty is too low, players lose interest. The same occurs if the activity level is too high relative to the players' abilities.

Through opportunities to make choices that have direct consequences, players *control* the game development. There is the possibility to control a character within a game that has to solve different tasks and is confronted with problems. However, the players or learners have to be the ones making the decisions and choices. For example, what makes an adventure game fun to play is the satisfaction of advancing the story by solving riddles or puzzles. In an adventure game solutions to problems should be difficult to conceive but not difficult to execute.

Game-based learning is not the superior learning method per se. [Druckman, 95] states that games enhance motivation and increase students interest in subject matter ... yet the extent to which this translates into more effective learning is less clear. A number of studies were carried out that focused on retention of learning. Eight out of eleven studies showed that retention is better when using game-based learning, whereas the results of the three studies showed no significant difference. Researching students' preference, results of seven studies out of the eight were in favour of games. However, we are also aware of other studies where the results are not so clearly in favour of game-based learning.

There are specific educational domains where game-based learning concepts and approaches have a high learning value. These domains are interdisciplinary topics where skills such as critical thinking, group communication, debate and decision making are of high importance. Such subjects, if learned in isolation, often cannot be applied in real world contexts. These subjects are targeted by the research reported in this paper.

3 Educational game design

In this chapter we will present a theoretical framework for designing a game with an emphasis on the educational component. As collaborative learning has become so popular, we will present options for including collaboration by means of creating shared playgrounds where players can experiment with knowledge and where they can design common activities to achieve the goals of the game. The chapter concludes with a description of several different games that are applied for game-based learning.

3.1 Steps of educational-game design

[Cordova et al.,92] have shown that enhanced learning which is fun can be more effective. Using some simple educational tasks, they demonstrated that learning embedded in a motivating setting improved learning outcomes and that engagement can facilitate learning. Learning occurs when the learner is mentally involved and actively interacts within the game, where a balance of challenge and possible courses of action is provided. To support learning we have to create appropriate mapping of education and engagement.

To create a successful game-based learning opportunity, the following steps of game design, elements of learning and engagement outlined below should be taken into consideration:

- Determine Pedagogical Approach (how you believe learning takes place)
- Situate the Task in a Model World
- Elaborate the Details
- Incorporate Underlying Pedagogical Support
- Map Learning Activities to Interface Actions
- Map Learning Concepts to Interface Objects

When designing an example of an educational game we have to reflect upon didactical approach and related topics. We have to create the situation asking "What do we want that learners learn?" Before defining the activities we should reconsider the saying *failure opens the gate to learning* and we should try to provide an answer to the question "Why?". There are many interactive learning techniques that have already been used in game based learning. According to [Prensky, 00], one of those techniques is "learning from mistakes", where failure is considered a point where user gets some feedback. In game based learning making a mistake - or trial and error - is a primary way to learn and is considered the motivation for players to keep on trying. In games failure consequence i.e. feedback is provided in the form of action (as opposed to feedback in the form of the text explanation that is provided in instructional material).

We then have to define clear goals for the activities, keeping in mind that challenge should match the skill level higher than mean. Students should also be able to asses their own activities to see how they are doing and to be able to evaluate their decisions / actions. There must be a close link between action and feedback. With the unexpected and repeated introduction of novel events students should be additionally motivated to play the game i.e. interact with the learning material. Successful learning opportunities could be created when following the constructivist learning theory, where 'constructivist' means an exploratory approach to learning. Major characteristics of the constructivist approach are, among others, interaction, coping with problems, understanding of the whole, etc. From the constructivist point of view learners are active participants in knowledge acquisition, and engaged in restructuring, manipulating, re-inventing, and experimenting with knowledge to make it meaningful, organized, and permanent.

The constructivist method of design is different from the linear task-oriented method of an instructional system design approach. Designers who use a constructivist method to create learning environments are less focused on a how-to or process approach but emphasise elements that facilitate a learning process. Designers applying this method take into account seven pedagogical goals: 1) to provide an experience with the knowledge-construction process, 2) to provide experiences encouraging appreciation of multiple perspectives, 3) to embed learning in realistic and relevant contexts, 4) to encourage ownership in the learning process, 5) to embed learning in social experience, 6) to encourage the use of multiple modes of representation, and 7) to encourage self-awareness of the knowledge construction process ([Robinson, 98]; based on works of: [Honebein, 96]; [Cunninham et al, 93]).

3.2 Collaborative Learning

Most researchers agree that an important role in current learning structures is played by "collaborative learning", which allows participants to exchange information as well as to produce ideas, simplify problems, and resolve the tasks. In this model the teacher is the active partner, moderator and advisor of the educational process, not just a repository of the information importing his or her own knowledge to a passive student as in traditional education.

This methodology called "constructivism" guides the design of the effective learning environments. Students bring their prior skills and knowledge to the classcommunity. The trainer structures learning situations in which each learner can interact with other students to develop new knowledge and fashion their own needs and capacities [Vygotsky, 78, 86], [Newman et al., 89]. Knowledge is generated from experience with complex tasks rather than from isolated activities like learning and practicing separately. Skills and knowledge are best acquired within the context. According to Vygotsky's theory, problem solving skills of tasks can be graded on (1) those performed independently by a student; (2) those which can be performed with help from others and (3) those that cannot be performed even with help. The second situation occurs in the classroom collaborative environment. So that it helps the students easily to transfer learning from classroom to "real life" and back, or information from one subject to another. Therefore this method requires that the trainer and students play nontraditional roles such as interaction and collaboration with each other within the educational process. The classroom becomes a community of learning.

In online distance education Internet plays the role of the classroom. In her theory [Salmon, 02] proposed the design of a collaborative e-learning process that includes a five-stage framework, which is helpful and useful for an e-moderator that builds online courses. In the first stage an e-trainer designs (1) access and motivation of the participants. Online socialization of the learners (2) is then reached. By using the results of these two steps the e-moderator organizes the next processes: (3) the information exchange, then (4) knowledge construction and as a benefit - the development of knowledge (5). An important note is that without successful processes in the first two stages there is no possibility for successful development in the last stages.

3.3 Several cases of Game-based Learning

Analysis of the current situation in the field of the game industry shows that at the same time, new multiplayer environments give opportunities for interaction for thousands of simultaneous players. In January 2003 a record number of 120,000 users simultaneously played EverQuest an online role-playing game. Its producer SONY "celebrated" a huge success when 430,000 subscribers joined the game last year [Rowan, 03]. EverQuest has a Command Central at their San Diego office where their 150 full-time customer service staff wander about the virtual game world assisting players, creating scenarios, conflicts, etc. It means that there is a huge interest of people in "collaborative" playing.

[TopSIM, 02] by TERTIA Edusoft provides different business games which have been used in business education and advanced training. A business game provides a model of the enterprise or of parts of the enterprise. The participants learn through experience the connections within the organization and the internal and external factors that influence the profit of the enterprise. They learn to implement business methods and means of information and to deal with uncertainty during decision making. The target groups are as follows: senior and junior managers in business, administration and authority, employees in technical and scientific areas, who need business knowledge for their activities, students of business administration and industrial engineering and trainees.

[Myzel, 02] is an online community game. The rules of the game are created by the players themselves. Players define what is allowed and what is not allowed and see firsthand the complex interconnections of economy, politics, and society. The players have to select a role and try to survive in the virtual world of Myzel with its various planets and complex social and political life. Myzel is not a commercial product, and has been largely supported through public funding. Nevertheless, a game world is available with all the important features in place, so anyone interested can register and download the client and have a look around the Myzel world.

The **[Monkey Wrench Conspiracy, 99]** videogame tutorial puts players into the role of an intergalactic secret agent dispatched to deep space to rescue the Copernicus station from alien hijackers. It is a complete tutorial for a complex technical product, designed to teach industrial engineers how to use new 3-D design. Videogame tutorials are a natural for engaging a younger, technology-oriented public. They employ a "Discovery Learning" approach that can include any combination of questions and performance tasks, with backup to reference manuals and videos as needed. They also include non-game alternatives to accommodate learners who do not like games or do not want to play at a particular time.

[Environmental Detectives, 02] was developed by MIT (Massachusetts Institute of Technology) and Microsoft within the Games-to-Teach project where conceptual prototypes for the next generation of interactive educational entertainment are developed. Environmental Detectives is a handheld PC game where players role play as scientists investigating a rash of health problems in their city stemming from point-source pollution problems. Players learn the science behind contaminants such as mercuric chloride, the properties of chemical cycles, and inquiry skills. Environmental Detectives is designed to be used in any environmental education context e.g. environmental science classes at the high school level. Students learn basic investigative skills (observation, hypothesis testing, data gathering, data analysis, and data reporting) that are a part of any environmental education curriculum.

4 Conclusions and Further Research

Game-based learning has been widely adopted for children's learning. Pedagogically highly valued products are on the market and have a proven success in the

improvement of learning as well as in children's acceptance. Recently, game based learning has also been proposed for adult education. Gaming is becoming a new form of interactive content, worthy of exploration for learning purposes. Universities are also looking for a new positioning in the changing setting of lifelong learning. Universities need to develop innovative forms of learning in order to provide concepts for lifelong learning to their prime customers, students. Modern technology needs employees proficient in effective communication, teamwork, project management and other soft skills such as responsibility, creativity, micro-entrepreneurship, corporate culture, etc. Game-base learning is an approach to tackle the above issues.

Games fascinate people. By using this circumstance and elements of collaborative learning, researchers of the FH JOANNEUM Graz in the framework of the EU project UniGame created a new game concept. Searching for information, selecting the appropriate and necessary information, development of discussion strategies, "conflict" of the arguments, decision-making process and negotiation are the important central aspects of the game. But the target and the culmination of the game is reaching a consensus in a problem solution. Players learn to understand and to combine different points of view, such as: individual/corporate interests versus team/societies interests; their own standpoint versus understanding the standpoints and opinions of others; from single aspects versus integrating of multiple aspects, from confrontation to cooperation. By playing different roles students learn and obtain both basic knowledge and practical experience and soft skills that are needed for the organizations of the modern industrial manufactures. The developed game concept can be seen as a template where different instructors can introduce different knowledge and contexts to apply game-based learning for their particular topics and specific learning goals.

Future work within the UniGame will be carried out in the form of development of the technical realisation of the proposed game concept. First pilot trials are scheduled for the WS 2003/2004, where the concept will be evaluated within different cultural settings. More details on the project goals, educational games research and related theoretical framework and proposed game model can be seen at the UniGame web page http://www.unigame.net.

References

[Al-Ubaidi, 00] Al-Ubaidi, Dietinger, T., Maurer, H., Pivec, M.: Situation Learning or what do adventure games and hypermedia have in common. Campus 2000: Lernen in neuen Organisationsformen (Ed.: F. Scheuermann), Waxman Verlag, Germany, 2000, ISBN 3-89325-925-2, p. 83 - 96.

[Baranauskas, 99] Baranauskas, M., Neto, N., & Borges, M. Learning at work through a multi-user synchronous simulation game. Proceeding of the PEG'99 Conference, Exeter, 1999, UK(137-144). Exeter, UK: University of Exeter

[Cordova, 96] Cordova, D.I. & Lepper, M.R. Intrinsic motivation and the process of learning: Beneficial effects of contextualization, personalization, and choice. Journal of Educational Psychology, 1996, 88, 715-730

[David, 97] David *et al.*: Integrated Development and production Tools for Building Hypermedia Courseware and Interactive Scenarios. Proc. Of ED-MEDIA'97.

[Druckman, 95] Druckman, D.: The Educational Effectiveness of Interactive Games. Simulation and gaming across disciplines and cultures: ISAGA at a watershed, Thousand Oaks: Sage , 1995, S. 178 - 187

[Environmental Detectives, 02] Environmental Detectives (by MIT and Microsoft) http://cms.mit.edu/games/education/Handheld/Intro.htm

[GAMENET, 03] GAMENET; http://eoi.cordis.lu/dsp_details.cfm?ID=35825

[GAMERESEARCH-NET, 03] GAMERESEARCH-NET; http://eoi.cordis.lu/dsp_details.cfm?ID=32633

[Garris, 02] Garris,R., Ahlers,R., and Driskell,.J.E.: Games, motivation and learning, Simulation & gaming; An Interdisciplinary Journal of Theory, Practice and Research. Vol33, No.4 Dec. 2002

[Ferry, 99] Ferry, B., Kiggins, J.: Making Use of a Knowledge Building Community to Develop Professional Socialisation, ultiBASE, august 99, http://ultibase.rmit.edu.au/Articles/aug99/ferry1.htm

[Johnston, 93] Johnston,R.T. , de Felix, W. Learning from video games. Computer in the Schools, 1993, 9, 199-233

[Kolb, 71] Kolb, D.A., Rubin, I.M., & McInTyre,.J.(Eds) Organizational psychology: An experimental approach. Englewood Cliffs, 1971, NJ: Prentice Hall

[Malone, 81]Malone, T.W.: What makes computer games fun? Byte, 6(12), 258-277, 1981

[MacCormick, 01] MacCormick, R., Scrimshaw, P.: Information and Communications Technology, Knowledge and Pedagogy Education, Communication & Information, 1 (1) 2001, pp. 37 - 57, ISSN 1463-631X

[Myzel ,02] Myzel: online community game (by Institut für Gestaltungs- und Wirkungsforschung Technische Univeristät Wien) http://www.myzel.org

[Pivec, 00] Pivec, M.: Knowledge Transfer in On-line Learning Environments; Knowledge Mediation and Knowledge Glows for Authoring, Teaching and Learning. Doctoral dissertation at the TU Graz, 2000.

[Pivec, 01] Pivec, M., Maurer, H.: A New Approach - Situation Learning (SL). Proc. of SITE 2001, AACE

[Prensky, 00] Prensky, M.: Digital Game-based Learning. McGraw-Hill 2000

[PROMETO-CG , 03] PROMETO-CG; http://eoi.cordis.lu/dsp_details.cfm?ID=36954

[Quinn, 99] Quinn, C.N.: The Play's the Thing: Enhancing Learning Design Through Game Elements. Tutorial at the AI-ED99, LeMans, France, 1999.

[Ricci, 96] Ricci, K., Salas, E., & Cannon-Bowers, J.A. Do computer-based games facilitate knowledge acquisition and retention? Military Psychology, 8(4), 295-307, 1996

[Robinson, 98] Robinson, P.: Strategies for Designing Instruction in Web-based Computer Conferencing Environments, http://www.inform.umd.edu/About/.IIT/probinso/epiphany/strategies.html

[Rowan, 03] Rowan, D.: Getting hooked on an internet role-play fantasy, TIMESONLINE, February 01, 2003, http://www.timesonline.co.uk

[Salmon, 02] Salmon, G. (2002) E-tivities: the key to active online learning, Kogan page, London. Suits, B. American Philosophy of Science, XXXIV, 148-156, 1967

[Tanguay, 99] Tanguay, D.A.: What is an ideal adventure? (Part I-III) A guide to create the ideal adventure game, 9.,14.,26. of July 1999.

[Tornton,, 90] Tornton, G.C. & Cleveland, J.N. Developing managerial talent through simulation. American Psychologist, 45, 190-199, 1990

[TOPSIM , 02] TOPSIM – Planspiele (by TERTIA Edusoft) www.topsim.com

[Monkey Wrench Conspiracy , 99] The Monkey Wrench Conspiracy (how to get engineers to learn and to like it), http://monkeywrench.think3.com/

[UniGame , 02] UniGame: Game-based Learning in Universities and Lifelong Learning. Minerva Project: 101288-CP-1-2002-1-AT-MINERVA-M

[Vygotsky, 78] Vygotsky, L.: Mind in Society: The development of higher psychological processes. Harvard University Press. Cambridge, 1978.

[Vygotsky, 86] Vygotsky,L.S. Thought and Language. The MIT Press, Cambridge, MA, 1986