

On-line educational games: an efficient learning tool

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Summary: The advent of the information super-highway is building up interest for the use of educational games in a learning context, whether initial or continuous. Studies show that games introduce favourable learning conditions, namely feedback, interaction, the active participation of learners, motivation and skill development and strengthening. To facilitate the use of the game, developmental research helped develop computerized generic educational game shells based on the frame game concept. These shells were tested in three training environments: school (from kindergarten to college), the community and the workplace. This presentation outlines the progress of the research, the methodology used and certain test results concerning the teacher's preparation before the game is introduced, the teacher's involvement while the game is in progress and finally, the pedagogical and technical quality of the games developed by the teachers.

Key words: Educational game, generic shell, frame game, pedagogical innovation, on-line training.

INTRODUCTION

The advent of the information super-highway is building up interest for the use of educational games in a learning context, whether initial or continuous (Johns, 2002). Studies show that games introduce favourable learning conditions, namely feedback, interaction, the active participation of learners, motivation and skill development and strengthening. In order to facilitate their use, developmental research helped develop computerized generic educational game shells based on the frame game concept.

What is meant by frame game is an educational opportunity endowed with a structure that generates learning activities to promote the use of various strategies, involving conflict and a set of rules governing the players' moves, and criteria allowing to close the game by declaring a winner. This structure is easily adapted to a wide range of pedagogical objectives and contents. (Stolovitch & Thiagarajan, 1980; Hourst & Thiagarajan, 2001; Sauvé & Chamberland, 2003) Any game can thus be broken down in two main parts:

- The structure determines the way the game is played: the rules, the stages of the game or the moves of the players, the challenge they face and the winning strategies they can deploy. As for the game itself, what we do is to "hollow out" its content and expose its underlying structure. Once this structure has been identified and analysed, it becomes a "frame".
- The content refers to the information conveyed during the game. In the case of games of a pedagogical nature this also involves the objectives sought and the skills that will be developed by playing the game. So, when the game is being worked out, you only need to slip in a new content

with predetermined objectives to generate a new game with an educational potential adapted to a special target audience.

This study involves the testing of four computerized frame game shells in three different training environments: school (from kindergarten to college), community and workplace. This presentation outlines the progress of the research, the methodology used and certain test results concerning the teacher's preparation before the game is introduced, the teacher's involvement while the game is in progress and finally, the pedagogical and technical quality of the games developed by the teachers.

RESEARCH PROGRESS

Several meta-analyses of research studies and results have described the effectiveness of the games and simulations for cognitive, affective and psychomotor learning (Jones, 1998, MCLI, 1999; Jubiebo & Durnford, 2000; Mumtaz, 2001; Reuss & Gardulski, 2001; Shapiro & Shapiro, 2001; Bartholomew et al., 2001; Sauvé et al., 2002; Garris et al., 2002; Baranowski et al., 2003). According to these studies, the game motivates the learner, offers immediate feedback, increases the learners' active participation, reinforces knowledge, contributes to the development and application of acquired skills and the transfer of learning and finally, influences behaviour and attitude changes.

St-Germain & Leveault (1998) and MCLI (1999) also explain that one of the success factors in learning with computer games is the degree of interaction between the user and the system; in other words, the degree of involvement of the learner in the environment. Kinsy et al. (1996) add that, to date, the Internet is one of the most efficient broadcasting media to offer a high degree of interaction and to increase the level of retention and satisfaction of learners with the games. Rieber & Matzko (2001) and MIT (2002) conclude that the games are powerful learning mediators for a person's entire life. Although the games apparently demonstrate a definite effectiveness, several authors mention certain pitfalls that should be looked into more thoroughly within a research framework. Alessi & Trollip (1991) claim that the educational games developed using information and communication technology (TIC) are often weak in their design, and the learning environment they provide is rarely effective. Thiagarajan (1998) and Hourst & Thiagi (2001) observe that the games are not tested as much as they should be in order to establish their technological performances, and their effectiveness and efficiency in relation to learning. Bartholomew et al. (2001) emphasize that the poor development of educational tools such as the games, is due to a lack of continuum between theory and practice, and operational strategies. Therefore, these analyses often reveal some disparity in the results, and in their research the authors wonder about the cause of that disparity. They note that certain factors have an impact on the game's effects:

- variables related to research: weakness of the studies' conceptual framework, deficient methodology, lack of continuum between theory and practice, etc.;
- variables related to the game's designer: the designer's ability in transferring a content in the game, the choice of game for the type of learning sought, the ease in drafting simple and easily understood rules for the learner, etc.;
- variables related to the individual characteristics of the learner, for example, the learner's school history, social and economical history, learning profile, etc.;
- procedure variables, that is, the manner in which the teacher/trainer prepares themselves to introduce the game, his/her involvement while the game is in progress (before, during, and at the end) and the

manner in which he/she leads the discussion around the synthesis review (in person or from a distance);

- variables related to the game itself: the pedagogical (feedback, motivation, interaction, etc.) and technical aspects (uniformity, presentation, simplicity, adaptability, etc.).

A developmental research that was initiated in July 2000 and was successively funded by *Francommunautés virtuelles* (Industry Canada), the Office of Learning Technologies (OLT) and the Inukshuk Fund (Industry Canada), allowed for the exploration of several variables. In this paper we will mostly dwell on the research data concerning the preparation of the teacher before the game is introduced, the presentation of the game by the teacher/trainer and, finally, the pedagogical and technical quality of the game.

METHODOLOGY

Our research strategy aims at using existing knowledge systematically, at substantially improving an already existing intervention (a more effective use of the on-line games in a teaching context) and at improving the computerized generic shells, an instrument that serves to create educational games adapted to the needs of the teaching environment (Contandriopoulos et al. 1990). In this developmental research context, we relied on the so-called collaborative approach, which is “aimed at (paving the way) between the world of research and the practical world within the specific framework of the teaching profession” (Desgagné, 1997: 372). Finally, we retained the case study technique because our objective was to document the introduction of educational games in various environments and to assess the results of such introduction (Leedy, 1995).

Sample

Two types of clientele are part of the case study:

- Eleven teachers/trainers who have designed at least one educational game and who are from three learning environments: public education (primary level to college), community environment and work environment.
- Two hundred and twenty-four learners, distributed as follows: 145 from the public education sector, 44 from the community environment and 35 from the work environment.

Aspects studied

For the purposes of this paper, we emphasize three aspects studied with target clientele within the framework of this research. Two of them involve trainers/teachers; namely:

- The teachers’ preparation before introducing the game, especially the following elements:
 - type of integration of the game in the teaching period: motivator, trigger, notional, text editor, evaluator;
 - search for activities or information (preceding or following) the game;
 - establishment of a game leadership scenario;
 - preliminary reading of game rules;
 - checking on-line material before use;
 - selection of the role played by the trainer during the game: facilitator, referee, observer.

- The teacher's involvement during the course of the game, especially these elements:
 - general presentation of the game;
 - presentation of the general theme or subject within which the game and objectives fall;
 - explanation of the game's operation;
 - presentation of the goal and special objectives of the game, its different possibilities and its limitations;
 - presentation of the instructions and rules of the game;
 - explanation of the game's end;
 - time allotted to the participants for them to read the rules following their presentation;
 - possibility of doing a trial run before starting the game;
 - time allotted at the beginning of the game to answer the questions of the participants and reassure those showing signs of anxiety or nervousness;
 - type of intervention during the course of the game;
 - use of synthesis report after the game is over.

Concerning the student clientele, we dwelled on the pedagogical and technical quality of the games, especially on the following elements:

- Does the game motivate the learner?
- Does the game allow for immediate feedback?
- Does the game offer a high degree of interaction between the user and the system, or between several users and the system, thereby contributing to successful learning?
- Does the game increase the learner's active participation?
- Does the game meet the following technical criteria: uniformity, informative presentation, appropriate language and legibility?

Case study assessment technique

The case study method involves the use of several data collection tools (Stenhouse, 1980). In our study we retained the following tools:

- For teachers: (1) an observation checklist to note the actions of the trainer during the field test, (2) a teaching diary that the teacher/trainer annotates during and after the field test; and, (3) an interview questionnaire submitted to teachers/trainers after the game has been tested in their environment.
- For learners: (1) a questionnaire concerning the learners' attitude towards the game and the pedagogical and technical qualities of the game (2) an account of the players' actions during learning using a computer trace tool; and, (3) an interview on the various aspects of the game: motivation, interaction, active participation, etc.

The quantitative data was processed using different descriptive analysis techniques (frequency, average, standard deviation, percentages, etc.). As for qualitative data, it was processed according to the different content analysis methods (L'Écuyer, 1990; Paillé, 1994).

ANALYSIS OF THE CASE STUDY RESULTS

The games developed by teachers were used for various pedagogical purposes: revision, training, test on knowledge following the learning of a new concept (formative assessment) or training. Out of the eleven games tested, four were developed for the primary level, two for the secondary level, two for the college level (including one in a context of distance learning), two in a community environment and one game in a work environment. In this presentation we will dwell on the procedure variables as well as on the variables related to the game itself.

Teachers' preparation before the game is introduced (procedure)

All teachers prepare themselves before the game is introduced in their learning environment. At the primary level, the teachers checked the on-line material on all the computers used by their students. On each of the stations used they typed the game's Web address in the address bar of the browser to facilitate access. At the secondary and college levels, the teachers played the game once before they introduced it in their classroom and they gave the address to their students. In the community and work environments, a single computer was available for the game; the two workers and the trainer checked the material every time it was used. All trainers/teachers printed the game rules for their clientele. Asked about this, they emphasized that in doing so they were able to answer the learners' questions more rapidly.

Only 55% of them (primary and secondary level teachers) wrote a few lines of a game story board in their teaching diary. When asked about this, they answered that the educational game provided all the necessary elements for the game's integration in the learning environment and that drafting a scenario would not be that useful.

The preparation of the learners varied according to the nature of the game: teachers who used the games as a revision tool all taught a course on that subject from two to seven days before using the game, which was not the case for teachers who used the game as a training or awareness tool. In these two last cases, the teachers used the game as the primary element of their teaching strategy.

At the primary level, the games were used as a motivational tool for learning to spell (25%), as a French language revision tool (50%) and as an evaluation tool following the learning of basic geometry (25 %). At the secondary level, the games (100%) were used to acquire basic knowledge in geography and history. At the college level, the games (100%) allowed the health and agri-food content to be revised. In the community environment, the games (100%) were used to raise awareness about job search among their clientele and, finally, in a work environment the game was used as a test on knowledge following training given the week before concerning the operation of a new machine and the preventive measures surrounding its use.

The teacher's involvement during the course of the game (procedure)

The teacher/trainer sometimes played the role of an animator and at other times of an observer, based on the three periods targeted in the case study.

- *Before starting to play*

In all teaching environments, the teachers/trainers presented the game (subject and context) and outlined the objectives. It should be noted that they did not explain the operation of the computer before having the game tested by their clientele.

At the primary level, the teachers also read the rules, determined the teams of players and fixed the game timetable for every team since the activity was to be part of a workshop. Before going ahead with the game they invited the children to ask questions. However, they noticed that, although they had been apprehensive about this, none of the children showed any signs of anxiety or nervousness. At the secondary level, at the college level, and in the community and work environments the teachers/trainers invited the students to test the game without giving them the rules.

None of the teachers/trainers, after presenting the game and the objectives, gave any time to the participants to read the rules of the game individually and for a trial run before starting. However, we noticed during our field observation that 63% of the learners had read the rules when they started to play or as the game progressed.

- ***During the course of the game***

During the course of the game, only primary grade teachers assumed the role of trouble shooters for students who needed help. They were surprised at the small number of requests (only two), which was different from other learning computer activities they had done with the students. At the secondary and college levels and in the community and work environments, the teachers/trainers did not provide this aid during the period set aside for this activity.

- ***At the end of the game***

None of the teachers explained how the game ended; they all considered that the kind of game played was known to their clientele. All learners had time to finish their game within the allotted period. Only 47% of the teachers asked their clientele to answer the synthesis report questions. When we questioned the teachers/trainers who had not used this feedback tool, 77% of them gave lack of time as the reason, and 13% could not see the usefulness of such a tool, especially in the community environment.

Pedagogical and technical qualities of educational games

Interesting information was gathered on the pedagogical and technical quality of the games through observation of the players, an interview and a questionnaire concerning the game they had played. All participants except one totally agree, or agree, that the game could be used as a learning aid by teachers/trainers.

Five pedagogical variables were taken into account in evaluating the pedagogical aspect of the games developed with generic shells: learners' attitude towards the game, feedback, interaction, the active participation of learners, motivation and knowledge consolidation. As for the technical aspect, it was assessed in relation to the rules concerning uniformity, informative presentation, adaptation of the environment to the users' language and legibility.

- ***Attitudes towards the use of the games for learning purposes***

Social cognitive theorists suggest that positive role models and opportunities for successful experiences help to develop self-efficacy and positive attitudes concurrently with knowledge and skills (Bandura, 1986; Kaufman et al., 2000; Benbassat & Baumal, 2002). Generally speaking, the attitude of the participants towards educational games is positive (92%), and this even though 48% of them say that they had never played educational games on the Web as a learning tool. We find it interesting that most of the primary level students had already used educational games on the Web, including: Adibou, TapTouch, Adi and Reader rabbit.

- ***Feedback***

Feedback is one of the characteristics most often mentioned by researchers in relation to educational games, especially in terms of speed and quality. Feedback can be defined as a “process induced automatically following a disruption to prompt remedial action in the opposite direction” (“Le Petit Larousse illustré”, 2002: 888-889). Computer games enable one to receive immediate feedback either from the system or from the other learners. (Hourst & Thiagi, 2001; Reuss & Gardulski, 2001).

The results of the study show that, regardless of the educational level and training environment, 96% of the learners are very satisfied with the type of feedback provided by the games, and 4% are satisfied. More specifically, the games that provide personalized feedback were better appreciated (100%) than the games that only provided feedback by default (61%). The respondents emphasized that personalized feedback towards the game (an option offered to the trainer) helps with learning: “[...] we remembered the subject better, because when we had wrong answers it (the system) gave the right answers”. “identifying the reason why we answered incorrectly allows us to understand better”.

- ***Interaction***

Literature shows that computer games offer a high degree of interaction between the user and the system, between several users and the system and between the users themselves. Hourst & Thiagi (2001) note that the games contribute to the development of interactions between learners, as well as better group cohesion. Shapiro & Shapiro (2001) conclude that the use of the game contributes to interaction between the learners, discussion and idea co-ordination. The game then becomes a means of communication and co-operation and promotes active learning. Kinsy et al. (1996) explain that, to date, the Internet constitutes one of the most effective broadcast media to offer a high interactivity level and increase the retention and satisfaction level of learners with the help of games. Educational research frequently stresses the use of new technologies to promote collaborative learning (Ritchie & Hoffman, 1996; Marton, 1994). It should be pointed out that this type of learning generally stirs up the motivation of a majority of students (Reuss & Gardulski, 2001).

Results show that 93 % of learners consider that the game allowed them to interact with other learners, and 7 % could not answer (namely, the primary level children). During our observations with the primary level children we noticed that the game fostered interaction and co-operation among learners. As a matter of fact, even though the students played against one another, they thought out loud and discussed among themselves about the choice of answer to give. A fourth-grade student even explained to his “opponent” what a parallel line was. However, we should point out that as the game draws to an end, this co-operation subsides.

- ***Active participation of learners***

The involvement of learners in the environment guarantees the success of their learning (St-Germain and Leveault, 1998; MCLI, 1999). The game promotes the active participation of the learners by “forcing” them to participate and put into practice the notions studied, and by demanding from them cognitive commitment and constant attention. (Ripp, 2001).

Through playing the game, 84% of the learners consider that they actively participated in their learning, 16 % of the participants, mostly from the college level, felt that they more or less related to the game they played. In all learning environments the results mostly bring to light the following points: a higher degree of retention relative to the subject matter, memorizing of information, acquisition of new knowledge, revision of subject matter and learning motivation. In this respect, here are a few comments by some participants: “Very helpful for learning and reviewing the subject matter”, “This game was fine to make us study”, “It helps get the subject matter into my head”, “It’s very good, it helps us learn”, “Before playing the game I didn’t know what was a perpendicular line, now I know”.

It is very interesting to note that 45% of the players would have liked the games to include more questions: “Add more questions”, “Vary the questions because they tend to always be the same”, “The only thing is that there were not enough questions, the same questions were always repeated”. When the games developed by the trainers were studied, all of them except one had used only a minimum number of questions at the time the game was created.

- **Motivation**

Motivation to learn and to participate actively in learning communities is influenced by both the relevance and utility of the learning, and by learner enjoyment (D'Alessandro & Kingsley, 2002). Motivation is an important learning ingredient. In this study we define motivation as follows: “[...] the effort or energy a person is prepared to spend to perform a given learning assignment”. (Viau et al., 2003) The learner’s motivation to perform a given learning assignment depends on the importance attached by this learner to the final goal, on the learner’s interest in the assignment and on their perception of the extent of such task. Brien (1997) mentions that individuals are attracted by the performance of tasks that are likely to bring them positive emotions in the short-to-medium term. Among teaching situations that are likely to arouse the interest of the learner we find learning activities that trigger emotions related to the need for belonging and for seeking new challenges, especially peer tutoring, educational games, tournaments, simulations, etc. Games in one form or another therefore constitute a most interesting motivational element. They help sustain the students’ interest and increase their learning satisfaction (Wlodkowski 1985, Hourst & Thiagi, 2001; Reuss & Gardulski, 2001; D'Alessandro & Kingsley, 2002). Moreover, because of the nature of the game itself the learner reacts not only intellectually but also emotionally. This form of learning, with a positive emotional involvement, is very effective.

The results of the case study reveal that the participants considered that the game gave them a motivation to learn (81%), 12% were not very motivated, 2% were not motivated and 5% could not answer (mostly primary grade students). On that subject, here are a few comments made by learners: “I never would have thought I could learn so much by playing a game”. “I played at home with my friends, usually I don’t like to do homework, I could hardly believe it”. « “Before I played I felt I could not calculate, but now I feel I can”.

- **Knowledge reinforcement**

Generally speaking, the games speed up and reinforce learning (Reuss & Gardulski, 2001; Fonseca et al., 2000). They have an impact on the development of various skills according to the format and content conveyed. For example, they contribute to the development of interpersonal skills such as negotiation and co-operation. (Ripp, 2001); of cognitive skills such as memory retention, procedural learning (Hourst & Thiagi, 2001), mathematical co-ordination and problem solving ability (Bricker *et al.*, 1995).

In all learning environments, 86% of the participants consider that they experienced and learned new things, “I learned some things that I had not remembered very well”; “This allowed me to review the subject matter”; “Seeing the same questions during the game helps increase the retention level with regard to the subject matter.” In a work environment, some learners had misunderstood the procedure that had to be done. The game allowed them to realize their mistake.

- **Technical quality**

When the generic shells of the game were created, several parameters were weighed and tested in order to assess the technical quality of the games developed by the teachers/instructors, namely:

- the introduction of *signalling* and *layout standards* making browsing easier for learners during the game: permanent display of a scroll bar at the top of the screen, development of a series of “cuecons” common to the different game elements, quick retrieval of the rules, instructions, learning contents, etc.;
- the use of *objects and controls* that the game players are familiar with, especially: dice, pawns, cut and paste, cancel and aid functions, so that users do not have to learn a new environment and a new learning content at the same time;
- *the display of information on the screen* which takes into account, on the one hand, the information users need to perform their activities and, on the other hand, the manner in which the users perceive and understand these elements of the system. Therefore, in the games, the most important information appears at the forefront. For additional information the user has to click on a help bubble to learn more about the subject. The path must be the shortest possible between two elements. Kristof & Satran (1995) stress the importance of having direct access to information to minimize the use of mouse “clicks” and make browsing easier;
- the available option, *adapting the game to the language of users*, allows teachers/trainers, on the one hand, to review the wording of the instructions and rules and, on the other hand, to formulate questions and feedback adapted to the target audience;
- the *emphasis given to the key-elements* (bold type, colour, character size) of the content displayed on the screen, and the fact that these elements actually help users perform the tasks and get their bearings in the game;
- the use of *guides, references and markers* to guide users in their approach of the game as needed and let them experience learning, including permanent access to the game rules and the instructions displayed according to the moves of the players, etc.

Overall, the participants assessed as very satisfactory (84%), satisfactory (9%) and not particularly satisfactory (7%) the various technical parameters of the games developed using generic shells.

CONCLUSION

Despite the limits inherent to this case study (small sample, use of games with various learning contents), the first results are consistent with the findings of several studies, namely that information highway educational games provide conditions conducive to effective learning (Viau et al., 2003), in a way that is significant to learners and easily integrated into other activities, that represents a challenge and requires a cognitive commitment, that allows learners to interact and co-operate with one another, that involves clear instructions and takes place over a sufficiently long period.

Acting as a pioneer in the development of generic shells for educational games on the Internet, this developmental research allows trainers in the work environment, workers in the job search community environment and teachers of various professional bodies to rapidly develop educational games while helping establish a game bank supplied by experts and teachers. This bank will be accessible to the entire community of teachers and learners in Canada and all over the world. It is up to you to be part of it by enrolling in the Carrefour virtuel de jeux éducatifs at the following Web address: <http://carrefour-jeux.savie.qc.ca>.

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