

Chapter VIII

Games–Based Learning, Destination Feedback and Adaptation: A Case Study of an Educational Planning Simulation

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ABSTRACT

Serious games are suitable for learning. They are a good environment for improving the learning experience. As a key part of this setting, feedback becomes a useful support for decision making and can reinforce the learning process in order to achieve certain objectives. Destination feedback allows users to draw on strategies and improve skills. However, too much feedback can make the learner too dependant on external advice when taking the next action, resulting in a weaker strategy and a lower performance. In this chapter the authors introduce a conceptual approach to feedback in E-Learning with serious games; how useful or harmful it can be in a learning process. They describe a case study carried out with a simulation of an educational planning task. The authors studied the performance of 43 learners who had, or did not have, visual destination feedback in a problem solving task. They conclude that in this context, too much assistance can be counterproductive.

INTRODUCTION: AN APPROACH TO ADAPTATION, ELEARNING AND GAMES-BASED LEARNING

Serious games have become an important topic in the recent and not so recent history of education. Gaming itself is becoming a key issue in education and has been widely researched in the last 50 years (Caillois, 1958; Huizinga, 1971). In the mid 90's the Internet started to provide new perspectives for serious games. A range of new possibilities arose, such as collaborative worldwide extended multi-player sessions, instant messaging, instant updating of settings and multi-language support. The array of features is still growing, and is not only attractive for *regular* users, but also for learners and teachers (Bruckman, 1993; Prensky, 2001).

Generic games that can be used for learning can cover any kind of non-educational games; for instance, the well-known Sims, SimCity, Flight Simulator, Pac-Man, FIFA, SuperMario Bros, Civilization, Rayman and Diablo II. (Dickey, 2005; Squire & Barab, 2004; Jenkins & Squire, 2003). All of them belong to different categories (*genres*) of games. Following the taxonomy produced by Crawford (1984), which focused on objectives and nature of the game, we find several well-defined categories, such as skill-and-action, combat, maze, sports, paddle, race, strategy or any other kind which is in the list. Goldsmith (1999) also describes another taxonomy: Trick Taking Card, Collectible Card, Exploration, Trading, Auction, Solitaire, Word, etc. Prensky (2001) defines a similar taxonomy based on objectives and nature but follows a different categorization focused on pairs of opposite features (e.g. intrinsic versus extrinsic, reflective versus active, single-player versus multi-player). With a more theoretical perspective drawn before the digital era, we can resort to the first taxonomy on games ever made by Roger Caillois (1958), although it fits only partially with the aim of this text, as it concerns the pre-personal computers

and consoles era, and therefore, also pre-digital games-based learning.

With such a variety of available games and genres it is very easy to find several direct applications and consequences among them, as can also be found in learning. For instance, games allow players to experience, to try, to improve skills, to learn content and to practice strategy (Turkle, 1995; Piaget, 1962; Vigotsky, 1978; Arts, 2005a); they elicit emotional reactions in players, such as wonder, the feeling of power, or even aggression (Squire, 2002); they can also support rather accurate episodes of history (SEGA, 2005), real systems (Microsoft, 2006b), complex popular events (Interactive, 2004) or board games (Microsoft, 2006a), just to mention a few. In addition, with computer networks or network Serious Games on the Internet, they allow players to strengthen their social skills while using virtual communities alongside the games and the facilities of collective and shared games (Bruckman, 1993; Prensky, 2001; Arts, 2005b; Auralog, 2005).

In addition, there are several interactive learning techniques that can be used inside and/or around a game, i.e. learning by doing, learning from mistakes, goal-oriented learning, role playing, constructivist learning, adaptive learning and feedback (Prensky, 2001). Adaptive learning supports adaptivity (the ability to modify eLearning lessons using different parameters and a set of pre-defined rules) and adaptability (the possibility for learners to personalize an eLearning lesson by themselves). These two approaches go from machine-centered (adaptivity) to user-centered (adaptability) and can be used in combination (Burgos, Tattersall & Koper, 2007). Furthermore, we also define adaptation in eLearning as a method to create a learning experience for the student, as well as the tutor, based on the configuration of a set of elements in a specific period aiming to increase the performance of pre-defined criteria (Van Rosmalen, Vogten, Van Es, Van, Poelmans & Koper, 2006) (i.e. educational, user satisfaction-based). Elements to modify/adapt can be based

on content, time, order, assessment, feedback interface and so forth (Burgos, 2008).

The implementation of adaptive learning within a game, along with other techniques, can improve the learning process as well as the user involvement. This involvement provides a *de facto* bi-directional communication flow, where the game stimulates the active role of the user, who in turn gives a feedback that provides some influence to the game itself. Therefore, we can use learning strategies to achieve some well-defined benefits to guide the user.

BACKGROUND: FEEDBACK AND SERIOUS GAMES

What is Feedback?

Mason and Bruning (1999) define *feedback* as “any message generated in response to the learner’s action”. There is an interactive flow between the learner and the system (Evans, Kersh & Kontianen, 2004). This information flow is seen as a series of frequent inputs and not as a single one, because it is a part of the full learning flow (Gherardi, 2006); and it can be based on a number of inputs (i.e. the learner’s performance, the learning history, the learning goals) (Prensky, 2001). Furthermore, it is fully supported by the learner’s interactions, and collects specific data from this user as an input, and, in turn, provides some analysis back to the same user as an output (Weber, 2003; Evans, Kersh, & Kontianen, 2004)

In the context of Human Computer Interaction (HCI), feedback can manifest itself in different ways, although it usually refers to some information presented to the user *after* something is done. This can be an indication that a certain action has been carried out (or been left behind) and it provides some qualitative and/or quantitative feedback about, for example, the user’s performance. Since the widespread introduction of Graphical User Interfaces, it was common to

adhere to guidelines; for instance, Apple started to provide this type of support from 1992 onwards (Computer, 1992). One of the guidelines is to keep users informed about what is actually happening by the provision of an appropriate communication flow between user and application through a bi-directional feedback. A few years after GUI’s and WYSIWIG’s interfaces became common, however, Gentner and Nielsen (1996) wrote an influential article that explored alternative approaches to computer interfaces. One of the issues was to consider bringing some flexibility into the feedback and dialogue provided by the system. They pondered how much feedback should be provided to the user to be most effective. For instance, the computer could initially provide detailed feedback to familiarize the user with operations and increase their self-confidence. Later, the feedback could be scaled back over time and restricted to unusual circumstances when the user requests more feedback and/or the system detects such need.

Types of Feedback

As mentioned above, in computer applications there are numerous ways to provide a user with feedback (e.g. visual, acoustic, or force feedback just to name a few and others will emerge in the future). In addition, feedback can be fully driven by the learner’s activity and data can be collected as input, and after analysis by the system, information can be returned back to the learner as output (Evans *et al.*, 2004; Weber, 2003).

Generally speaking, there are two main types of feedback (Mory, 1996): instructive (related to knowledge domain) and informative (related to the context where learning happens). While the instructive feedback leans on a corrective intervention on the learning process, the informative is focused on self-regulation. In addition, there are four complementary types of indicators in informative feedback: 1) related to performance, 2) related to process, 3) related to social interactions

and 4) related to environmental interactions. Performance feedback is the most common feedback in games-based learning, but not the only one.

Use of Feedback in Games-Based Learning

Significantly, games also provide outcomes and feedback in real-time (Rieber, 1996; Laurillard, 2002), which guide the next actions to be taken and help the user to focus his/her activity and decisions and the evolution of the story. They are attractive for the players but also for the teachers, as they engage and excite the students as well as provide a means of interaction and learning.

Feedback is also a key factor in educational games and simulations, as they constitute another resource while learning. Garries, Ahlers and Driskel (2002) define a cycle in games that involves several loops of repeated judgment, behaviour and feedback and she points out that feedback is a critical component to regulate the learner's motivation. Also, Csikszentmihalyi (1990) stresses the importance of feedback in his classical definition on flow theory. Kernan and Lord (1990) state that specific feedback based on commitment of goals increases the effort, the performance and the motivation of the learner. People are expecting some reaction on their actions and efforts and become disappointed when they do not receive it, resulting in a decrease in their motivation and performance (Beck & Wade, 2004).

Prensky (2001) supports the use of instant feedback to reinforce adaptive learning and games-based learning as a way to provide useful and immediate information to the learner about his performance. Baer (2005) underlines that immediate and contextual feedback improves learning and reduces uncertainty. Kirriemuir (2002) highlights that instant feedback invites and allows for exploration and experimentation, as well as stimulates curiosity. Kiili (2005) and Chen, Wigand, and Nilan (1999) state that games should provide instant and appropriate feedback in order to improve the performance.

However, not all authors agree on the positive effects of feedback. In their literature review on computer and video games for learning, Mitchell and Savill-Smith (2004) state that one and the same feedback mechanism can be perceived in different ways. They refer to a study by Halttunen and Sormunen (2000) that used an educational game to support learning of information retrieval. After an evaluation, the effectiveness feedback users received from the system were generally seen to promote learning significantly. Feedback concerning the performance of one's own query, the chance to reformulate the query, and to further evaluate the effect of changes on performance were seen as highly motivating and enhancing learning. However, there were also students reporting that their attention were fixed on performance and tried to improve on their results mechanically, without analysis and reflection of their preceding queries and results. Here, the feedback tempted searchers to pay attention to the performance measures achieved, rather than on analysis of the situation and strategy of the search task.

Educational games, and even more in simulations, are usually played in an unpredictable way by the players. This unpredictable behavior can provide some input based on performance on which a final analysis will be given back to the learner, although this feedback can be too complex or not specific enough to make it useful or even easy to understand or to apply (Fowlkes, Dwyer, Oser, & Salas, 1998). In addition, once some feedback is provided, its use by the learner is uncertain, possibly resulting in a reduction of the performance as well (Kluger & DeNisi, 1996).

Destination Feedback and Games-Based learning

There are other types of feedback, such as *destination feedback* (Computer, 1992). It refers to the issue of when the user drags an item from its place to a selected target, the application provides some information back that indicates whether the

item will match and/or be accepted. Destination feedback depends on the destination's ability to accept the nature of the information contained in the dragged item. This type of feedback informs the user about a range of possible actions to be taken. Furthermore, these possible actions in some ways constrain the free choice of the user, and results in an assisted election. In computer use, there are a number of examples where this principle is being applied, such as software installation wizards, extended help-options, access to restricted areas and greying-out menu-items that are blocked when a specific user should not make use of them. This last setting provides a context-sensitive feedback in the interface. Feedback by *greying-out* of items is one example of what is referred to as externalizing information. The *externalization* of information makes it available on the interface; however, there is no need for recognition but instead for recall, in order to carry out the associated task satisfactorily, and it relieves working memory (Zhang, 1997; Zhang & Norman, 1994). On the other hand, when no visual support is provided, the user has to *internalize* the information himself, and store this information in his memory. Depending on the type of information and task to be carried out, externalization or internalization are more suitable or can hinder the process of finding the right solution (Zhang, 1997).

In the context of games-based learning, the internalization-externalization approach provides guidance or assistance in complex situations. It relieves the working memory of students so that they can devote attention to development of more elaborate strategies. However, we can question the assumptions of the positive effects that this kind of feedback can have. Perhaps learning with a feedback-based interface is more volatile and difficult to transfer to other situations. This situation is not advisable when learning or gaining insight is the final aim. We pondered that having this kind of destination feedback might encourage users to be less proactive and lazier, and lean on

the trial-and-error technique instead of on a more solid strategy or thinking.

Research by O'Hara and Payne (1999) supports the notion that a too strong reliance on external information leads to negative effects regarding the planning and transfer of skills. They drew a distinction between plan-based and display-based problem solving, which can be seen as analogue to what happens during internalization vs. externalization. During plan-based problem solving one has to construct problem strategies and subsequently use detailed problem strategies from long-term memory. Display-based problem solving on the other hand makes little use of learned knowledge but instead relies on interface information. Plan-based activity leads to a shorter solution route, because steps are planned and no unnecessary steps are taken, while a display-based strategy involves more steps because of more searching and less planning. Also, Svendsen (1991), who used the Towers of Hanoi problem, showed that an interface yielded improved understanding of problems.

The notion that too much feedback could be counterproductive while playing a game based on planning, led us to develop a case study with real learners. In the coming section we present the differences between having, and not having, destination feedback and the drawbacks of utilizing it while playing an educational simulation.

A CASE STUDY: THE PLANNING EDUCATIONAL TASK (PET)

The Planning Educational Task is an open source software application that simulates the planning of speakers with different demands at a conference venue with rooms of varying constraints. The software (implemented with Macromedia Flash MX ©) was developed by The Open University of The Netherlands and funded by the European UNFOLD Project (Burgos & van Nimwegen, 2005; Nimwegen, Osstendorp, Schijf & Burgos,

2005). The software presented a constraint-satisfaction scheduling task that involved planning speakers who give lectures at a 1-day conference. The problem solving situation was as follows (see Figure 1): There was a conference to be held in a facility, with a list of a number of speakers that would give a talk that day, displayed on the left. The conference facility had several auditoriums with differing features (listed on the right). Speakers, who as well had assigned specifications, had to be scheduled into a time grid over that day. Not all the timeslots in the grid were always available. Some of them were never available, indicated with light gray (e.g. the timeslots during lunchtime at 13:00), but there were also some arbitrary slots (e.g. 10:00, room “Maxima”). We designed the problems where a correct solution of fitting all of the speakers in the grid always existed. The empty available timeslots were shown in white, and the ones that were already occupied by a speaker would display their name.

A “feedback” interface (Figure 1) and a “no-feedback” interface were constructed (in the latter, the green feedback was simply absent). In the version where feedback was implemented, upon request (clicking on an object) users received feedback in the form of highlighted legal options where a speaker can be placed (the green timeslots look darker in Figure 1). Note that this did not show *the best* slot to place a speaker, but simply which slots are possible.

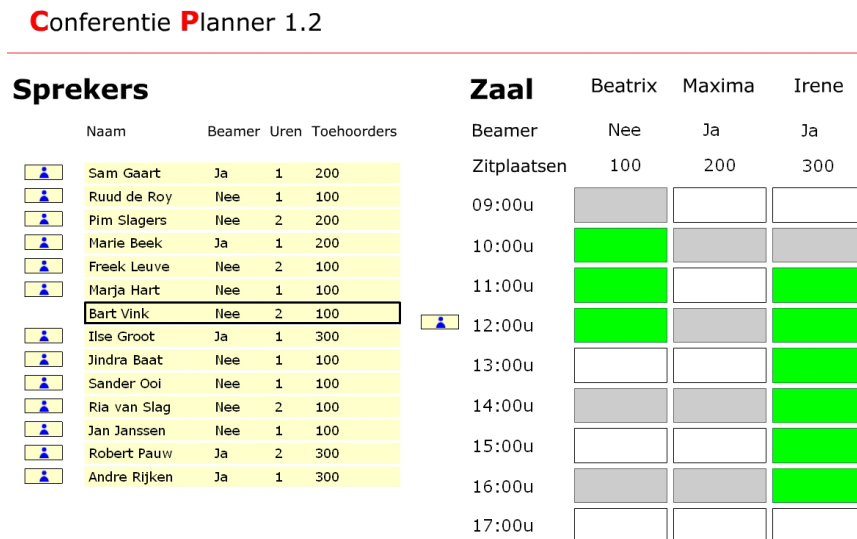
In situations such as the Planning Educational Task, students can first be expected to start to explore the application and in the meanwhile work towards the imposed goal: solving the problem. A routine or strategy will not be available in the beginning. Therefore, students will need to explore and discover in a most likely non-structured manner, which can be compared with Prensky’s (2001) statement that in games one of the most usual techniques is trial-and-error, defined as the absence of a systematic strategy when a learner plays (Dempsey, Haynes, Lucassen, & Casey, 2002). The Planning Educational Task focused on

the opposition between having the aforementioned destination feedback, or lack thereof. When the feedback is present, it might foster orientation on what to do next, and guide the player in the sense that it shows which choices are available, and serve as an orientation on what to do next. However, when moves are made, the player is at all times allowed to undo the taken action(s) and backtrack to establish a new strategy to follow. This strategy is partially based on trial-and-error movements, although the level of risk that a player takes in every movement can be different depending on the level of feedback provided, as we show in the coming sections.

In an experiment, 43 subjects were divided into a *feedback* and *no-feedback* group. Both groups had to solve a series of combinations with the conference planning software. We studied whether time based measures and move based measures were influenced by having feedback or not. At first, it seemed that the time the participants needed did not differ between the two groups or players, but when analyzed further, it showed that this only counts for overall time. When looking more specifically at time needed for certain parts of the task, two interesting observations were made. Firstly, the players who had no feedback took significantly ($F(1,39)=4.34, p<0.05$) more time studying the situation before they started solving the problems than the ones that did have feedback ($M=18.9s, SD=1.5$ vs. $M=14.4s, SD=1.6$). The lack of feedback also resulted in more time between the individual moves, ($F(1,39)=4.82, p<0.05$) ($M=4.8s, SD=1.4$ vs. $M=3.9s, SD=1.3$). Both these findings, are thought to reflect planning and contemplation for the task, and thus aim at meaningful cognitive processes. Then, one might wonder why are there no overall time differences? This is explained by a more important finding.

It must be taken into account that the issue here was not “can they solve it?” but “how smartly or efficiently do they solve it?”, since in the end each problem had a solution, and these tasks are not extremely difficult given the limited number of

Figure 1. Conference planner in version with feedback



speakers. Results showed that having no feedback resulted in fewer superfluous moves than when having feedback, ($F(1,39)=4.17, p<0.05$) ($M=2.46, SD=0.61$ vs. $M=4.27, SD=0.63$). In other words, the lack of feedback led to doing the task in a more straightforward manner, thus with less deviation from the minimum amount of moves, resulting in greater efficiency. This finding is interesting, because it points at smarter strategies applied in the versions where no feedback was available. The players who had no feedback, thought longer before starting and between individual moves, but they needed significantly less moves and this, at the end, leveled out the time differences (all moves cost time).

With regards to the strategy that students chose, the results also indicated a more plan-based approach by students who worked with the no-feedback version. They filled the timetable by first scheduling speakers with the most constraints more often. This strategy again suggests planning, because students thought about whom they were going to schedule before starting with the task. Problem knowledge of the students was tested afterwards by means of questions in which they had to judge situations where rules (sometimes)

were violated. The effect of feedback on declarative knowledge was almost significant; having feedback resulted in less correct answers.

According to the results, feedback did not improve performance in any way. On the contrary, we found only positive effects of *no-feedback*: It led to more plan-based behavior, smarter solution paths and better declarative knowledge. *Feedback*, on the other hand led to a more display-based approach resulting in less economic solutions and shallower thinking. It seems that the option of deliberately leaving out certain types of guidance or assistance as was done in the no-feedback version can be fruitful. This would support Carroll's ideas (1990), who already two decades ago propagated minimalism in design and instructions.

FUTURE RESEARCH DIRECTIONS

Our findings show that computer-mediated tasks can take advantage of design considerations that run deeper than plain usability, even when they go against common sense (making the task harder). Depending on the specific goal and situation, it can be valuable to design software in such a way

that making inferences is provoked, and active learning takes place and users have better command of what it is they are doing.

There are various directions we are considering to extend our research. There are more ways to implement and vary feedback, and we are aware that “feedback” and “no feedback” by no means constitute a dichotomous variable, but can be positioned on a continuum. One could vary the amount of feedback by adaptively reducing or increasing feedback during the process, or to do this depending on the displayed behavior of the player. Another issue to mention is user expertise. We were aware that none of the subjects knew the task we used. Also, we did not focus on the more general level of computer experience, game playing experience or experience with office-like administration tasks. It might be worthwhile incorporating this in future research, since it might very well be that a person with almost no computer experience would display different behavior. Expertise in the sense of skill or knowledge in a particular domain also can be worthwhile to incorporate, especially in educational contexts. Regarding serious games, game based learning and training situations; we hope that our work partially paves the way for more research in that direction. Regarding Berlyne’s curiosity principle (1960), it might be too pretentious to claim that leaving out feedback as we did would arouse *an epistemic feeling of discontent not to know things*. Nevertheless, an information gap can play a part, albeit less drastically, and can be fruitful for these research areas. The more gaming moves towards educational realms, training and the like, the more interesting it can be to see how attention, mental effort and proactive behavior can be safeguarded. Likewise, the areas of educational systems and training can learn from principles that make games so successful.

CONCLUSION AND DISCUSSION

The idea of feedback, and what it can cause us to do, is reminiscent of research by Kiili (2005), in which he emphasized the importance of distinguishing between activities related to solving the tasks, and the use of the controls (the interface, which he calls “artifact”) of an educational game. He stated that “*all possible resources should be available for relevant processing (the main task) rather than for game control issues*”. Less of these artifacts being available leaves more resources for smarter processes, such as economically solving the task at hand as in our case study.

Interface-related events influenced behavior in approaching a task, especially concerning the motivation and effort involved. As an extra thought on motivation, central to many games is that curiosity is being fostered and that there is something to discover or to achieve, and not everything is given away too easily. Players are constantly triggered by *not knowing* things, and having to uncover them is a reason why the game is so intrinsically motivating. Regarding curiosity and motivation, there is research in which cognitive and information-processing factors have been used to explain curiosity. Regarding the discrepancy between what one knows, and what there is to know (which information is possibly available), an interesting perspective to look at in motivation is the notion of knowledge gaps, also referred to as information gaps (Loewenstein, 1994). A knowledge gap refers to the difference between what a person knows and what is presented to a person. When one becomes aware of the knowledge gap, curiosity arises (Berlyne, 1954, 1960). Then, the awareness of the information gap produces an aversive feeling of deprivation or discomfort that can be alleviated only by obtaining the information needed to close the gap, which consequently produces an intense desire to modify the existing knowledge structure (Berlyne, 1960). This fits well with the general notion that learning is more

effective when people experiment and discover for themselves. In the context of “not knowing things”, as in information gaps, and “wanting to know” there is an interesting experiment by Wishart (1990), who used a simulation to teach children what to do in case of a domestic fire. It showed that the amount of learning from an educational computer game increased by making it more challenging (among other mechanisms). Subjects learned more from a simulation that had a combination of challenge and complexity. She concluded that educational software could be improved by providing a greater variety of challenge and complexity with less emphasis on reinforcement. Information gaps are used as a technique to “move students out of their seats”, allowing critical thinking and opinion formation.

Electronic educational games and simulations are a powerful platform for learning. They are developed with game technology and game design principles but for a primary purpose other than pure entertainment. Serious games are seen as similar to educational games, but are often intended for an audience outside of primary or secondary education. Games are famous for their motivational or “fun” aspects, but also have the potential to facilitate cognitive processes such as making inferences and deeper thinking, which can be beneficial in an educational context

In our case study we explored the influence of providing versus leaving out visual destination feedback. We saw that the feedback as it was implemented was not beneficial in any way. In our two versions, students solved all the planning problems and, more importantly, in the same amount of time, so there was no advantage there. The version that provided *no feedback* resulted in longer thinking times *before* starting to solve the problem and to more time between moves. We take it as an indication that more contemplation was provoked and the students pondered longer before acting, so they studied the planning problem with more effort, also in between the initial actions and the subsequent ones. The *no-feedback*

version also resulted in more time between moves, which we also take as indicators of planning. This is in line with results of O’Hara and Payne (1999), who reported a longer inter-move latency for subjects in effortful conditions, indicating a more plan-based approach. Students who worked with the *feedback* version made more superfluous moves, thus they solved the problems with lower economy. We infer that this is caused by less planning, which resulted in worse solution paths. Similar results were also found by O’Hara and Payne (1999) who found that a more display-based approach resulted in more moves than a plan-based approach, and that *backtracking* (undo a move and return to the previous situation) occurs more during display-based behavior.

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