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Usability Criteria for Interactive Educational Media: Bending and Breaking the Rules

Michael Herczeg
Institute for Multimedia and Interactive Systems (IMIS)
University of Luebeck
Luebeck, Germany
herczeg@imis.uni-luebeck.de

Abstract: Usability has a long tradition in the area of work systems. System models, criteria and processes have been developed to analyze and design human-centered computer-based work applications. However, human factors criteria like self-descriptiveness or error tolerance are not useful in the area of interactive educational media in the same sense as in work systems. While the basic principles of usability engineering still hold for educational systems, many interaction design criteria and recommendations have to be questioned and need to be changed basically. This contribution discusses criteria systems for interactive educational media questioning and transforming well known rules from working to learning environments.

1. Introduction

Since the late 1970s and the early 1980s to focus on *human centered system design* has been proposed by many researchers (Norman, 1986; Shneiderman, 1987). The main emphasis in these days had been laid on the transparency and robustness of human-computer interactions with VDT/PC-like computer systems. As a basic design principle it has been proposed by these researchers to foster the compatibility of the mental models of the user and the system designer and the conceptual model of the interactive system. Using development processes ensuring that the development is done in a reflective and systematic way in respect to human factors led into the next generation of software engineering, namely *usability engineering*. Following the basic human-computer interaction research, criteria systems have been developed, which resulted in international standards, like the ISO 9241 with interactive software product criteria systems for VDT-based applications and the ISO 13407 with frameworks for human-centered development processes. The criteria and the process frameworks have been applied to interactive systems since then with some success. Interactive work system became better adapted to the tasks to be performed by their users and they became more transparent, easier to be learned and more efficient for their users.

Interactive educational media are interactive systems in the sense of human factors as well. So the criteria defined generally for interactive systems might be applicable for these educational systems as well. This is certainly true to some extent, especially when it comes to the questions of robust and anticipated interaction methods, but this approach can totally be wrong when it comes to the question of criteria like self-descriptiveness or error tolerance. In a motivating and challenging learning environment it is important to keep the learner curious and searching. If we implement a system successfully according to the human factors guidelines and rules everything is quite clear, functions as well as information will not be hidden and the system will tolerate different types of user errors without being noticed by the users as long as these errors can be fixed in an obvious and unique way.

A motivating learning environment on the other hand has to make sure that the system looks interesting, stimuli and cues are given instead of solutions, and errors will not be corrected and will sometimes even result in dead ends. Efficiency has to give place to experience for the users. Sometimes solution paths need to be long and stony in the beginning until the users find and understand the shortest path. Effects like these are currently discussed in the area of experience design (Shedroff, 1995; Herczeg, 2003), where in many respects the road itself is the destination. Other criteria for learning processes stem from design. A motivating learning environment might apply an interface design model, where it is more important to play with a complex and dynamic interactive structure than to be able to activate the right function and clear a task. This draws the user’s attention and creates understanding as well as sensomotorical skills that will not emerge in a well designed ergonomic user interface according to the “laws” of human factors.

2. Criteria Systems for Interactive Educational Media

What can be applicable criteria sets for interactive educational media? While there is still neither a standard nor a list of generally accepted recommendation there are at least valuable observations that can serve as prototypes for criteria to set up a motivating and effective, not necessarily efficient learning environment. Efficiency in the sense of work systems is not a meaningful term in educational systems since learning processes need to take their time and cannot be measured in effort per unit learned or by similar constructs.

2.1 Ergonomic Criteria

It would be the wrong approach for the development of educational media to ignore all usability criteria resulting from many years of human factors especially in software ergonomics since this would just result in an even larger chaos of unusable or frustrating systems than we have already. So it is more a question which of the rules shall be bent or broken in certain situations in a meaningful way to create a well defined challenge for the users of the learning system. The following examples shall provide basic ideas what bending and breaking the rules might be. To illustrate this approach the five first well known dialogue criteria of ISO 9241 Part 10 (Dialogue Principles) are used as examples.

Suitability for the Task

While software ergonomics teaches that interaction methods have to be appropriate for the task to be fulfilled, it might be necessary to use less efficient interaction methods to gain a better understanding what is going on in the problem domain. This is for example the case with well known direct manipulation interfaces (Shneiderman, 1983/2005; Herczeg, 2005/2006), where the user has to select single or a few screen objects to manipulate them. The more efficient alternative of having an appropriate command interface that allows manipulating an arbitrary number of objects by a command language and scripts would prevent the users from understanding which single steps are necessary and how they have to be sequenced and timed correctly. This is one important reason why occasional users of an application system need direct manipulation interfaces in the first place to learn a system, its objects and the functions to manipulate them.

Self-Descriptiveness

In well designed human-computer systems a user will always understand how an interaction method will work and what will happen through the interaction. In a learning situation is might not even be obvious that there is an interaction element available. It might just be invisible and only be detected by approaching or hovering over some screen area. This method has been widely and successfully used in computer games, where the player has to explore an environment searching for activities that can be done.

We used this method of exploring possibilities for interaction in a learning environment for medical computer science (Herczeg et al., 2004). Animations of physiological and medical mechanisms had to be explored. Flash interfaces have been programmed to activate certain areas of the animation while approaching certain screen areas with the mouse cursor. It could be observed that users worked and learned intensively with the animations to find out everything that could be done with them.

Controllability

Controllability means that the user is always able to manage an interaction by having full control over the interactive system. This rule needs to broken in many situations in learning systems. To demonstrate how something has to be used it might be necessary to instruct the user by a short tutorial, where the control of the user interface will be for several seconds completely with the computer system. To enable the user to stop the system presenting a short procedure will prevent users from experiencing the whole and correct sequence of activities. It is like interrupting a teacher at an arbitrary moment during some teaching discourse. It is of course an important question how long the control shall be with the system, but to be able interrupt even very short presentations will be of no value at all, even not for those who activated a sequence by mistake.

Conformity with User Expectations

According to ergonomic standards a user shall not be surprised by the system's behavior. If the system did something in a certain way yesterday, it shall do it in the same way today. This will be quite boring in a learning environment. If a teacher would answer or react to some student's questions or behavior always in the same way, the learner's problems and misconceptions could in many cases not be detected and solved. In learning situations the learners need multiple stimuli and system reactions to get a concise and multi-perspective understanding of the situation at hand. A learner expects a dynamic, changing environment that creates new challenges over time.

Error Tolerance

It can be very comfortable to automatically correct user errors. Let's take the example of a word processor which is able to correct misspelled words. This is helpful for users who have for example to write large volumes of technical documentations within a short period. In a case like this it is very helpful to provide automatic spelling or even syntax correction as long as the correction is unique within the domain. A school child being taught to use a word processor is still learning to write. Automatic corrections would prevent from learning the correct spelling. In other cases automatic correction and completion leads to an insufficient understanding of activities and of the properties of work objects. Therefore an educational system should not be very tolerant to learners when you expect them to acquire in the first place a deep understanding of a problem domain.

There are many more examples where ergonomic rules stemming from work systems have to be bent or broken and systems have to be designed less transparent and less comfortable in learning applications. In many cases it is the effort and the work load which triggers and creates the relevant learning effects.

2.2 Design Criteria

In the early days of usability engineering experts believed that there will be rules and methods to derive a user interface more or less automatically out of a description or specification. This worked in some way for VDT-based systems like simple menu- and form-based business applications where mainly data management had to be done. The method of automatic generation of user interfaces did not work with more complex form-based dialogues since the forms turned out to look just ugly. Questions like this were not answered properly until the field of interaction design emerged (Cooper & Reimann, 2003; Herczeg, 2005). Interaction design means to craft user interfaces with the full mental and sometimes even physical power of a creative person who understands users, their tasks, preferences and sometimes even emotions and cultural background. As a result the world of ergonomics changed quite a bit. It was not only accepted that there will be creative and experienced people around, called interaction designers, when complex user interfaces had to be build. It was much more than that, since these designers were capable and willing to bend and break the existing rules for user interface design. This resulted in user interfaces as we have them today on gadgets like MP3-players, electronically controlled bodybuilding machines or web-based and often animated business applications like e-commerce systems.

Aesthetics

One important lesson learned has been that there is more about user interfaces than structure, content and consistency. It is about something that can be collectively called aesthetics, meaning that the human perceptual system is not only seeking for the problem solution but as well for interesting perceptual complexities and patterns which are more bound to the culture and emotions of their users than to their physiology or cognitive structures. The human mind likes to experience anti-conformity within a set of well ordered elements and sometimes it even likes chaotic structures. These methods have not found their way to much of the interactive educational media until now, since the developers are in most cases not able to design in meaningful, attractive and effective way by bending and breaking the rules. They seek their fortune in applying style guides with the goal of 100% conformity without noticing, that one of the chances of conformity is to break it to create attention and experience, which are two of the most important prerequisites for learning processes.

Experience

The field of experience design (Shedroff, 1995; Herczeg, 2003) tries to go a step further than just bending and breaking the rules in respect to aesthetics. It tries to engage the users into an environment, let them explore it and be part of it. It is about gathering and fostering knowledge by takings risks and going for endeavors in physical as well as in digital environments. For e-commerce systems some reasons to use this method of experience design have been described the new field of attention economy, i.e. being aesthetic and different and, as a result, catching and binding customers. For e-learning systems it might mean to draw the attention to a certain display area in space and time, getting high levels of attention and creating a learning effect by guiding the users through a well-defined sequence of activities and states.

Complexity

A basis principle of design is to cope with complexity by reducing or minimizing it. This might be a good strategy for work systems and the like. In the case of educational and entertainment systems complexity needs to reach a certain level to provide a challenging situation. It might even be motivating to increase complexity artificially to provide a system where the learners receive sufficient stimuli to be motivated to conquer the complexity of the problem at hand. We know since many decades with technical gadgets and software systems which have been used because they had been conquered and mastered in some way by their users. So even objectively badly designed systems found their way to large and serious communities.

2.3 Pedagogical Criteria

Where is the pedagogy left in these observations about designing the user interface of educational media? So far it seems to be just a question of using rules for interfacing and bending or breaking them at the right time and at the right place. Exactly this is where pedagogy comes in. Ergonomics and design are able to catch, bind and lead the users through a learning content by using narrative didactic structures (Schön, Hoffmann & Herczeg, 2003). Pedagogy must provide the content and activity structure in respect to the educational goals and purposes. This is not the place to repeat the learning methods developed through the many decades but it might be the place to discuss what is special for future interactive educational media.

Knowledge Modules

The far most applied methods of teaching in interactive media is providing *knowledge modules* (often called *learning objects*) by putting learning contents in form of mostly text and graphics into a web site. This is usually meant when people are talking about *web-based learning (WBT)*. Knowledge modules in their purest form are boring since they are basically lacking the experience of flow (Csikszentmihalyi, 1990). Users do not want do learn isolated knowledge modules and concatenate them by themselves. They want and need to learn in contexts and problem solving situations. So while from a technological point of view a learning space with well structured knowledge modules is an interesting concepts, from user's point of view situated and experience-based sequences of learning steps is more effective, even if the abstraction of what has been learned has to be taught or discovered by the users when needed.

Simulations

An often repeated demand in the view of pedagogues and instruction designers is providing *simulation environments* to teach dynamic systems. To simulate dynamic behavior is generally viewed as an important teaching method and often developers spent factors of 100 in effort to produce a simulation instead of writing down some formulas or descriptions. Despite this fact and the question how far the human mind is capable to simulate mentally many pedagogues just repeat the unproven and economically questionable rule to provide interactive simulations. While it is important to provide a flight simulator for pilots since the formulas describing the dynamic behavior of an airplane are far to complex for the human mind, it is questionable whether it is useful to build a simulator to teach the basic laws of mechanics. It might be better to climb a chair and drop a feather and a piece of metal in evacuated glass cylinder to see, feel and believe Newton's laws of gravity.

Tangible Media and Mixed Reality

Despite the fact that simulators might be a good or bad decision to spend the production money for, it has to be noticed that interactive media have a potential that goes far beyond this. Their major value is that they can be used as an *interface to the physical world*. This implies that computer-based interactive media are capable to affect body and cognition at the same time. We used this method in teaching children through all ages and school curricula enabling them to build interactive media by themselves to deal with very different fields like arts, mathematics, geography or history. They build environments in the sense of tangible media

(Ishii & Ullmer, 1997) and mixed reality systems (Milgram & Kishino, 1994; Winkler et al., 2002/ 2004/2005; Reimann et al., 2003) as well as a mobile applications (Winkler & Herczeg, 2005) enabling them to leave the school for learning. In this sense learning is brought back to the place where it should take place. Biology is done in nature and history at historic places and museums in town. Learning again is an experience-based activity where body and mind are stimulated and incorporated. So the rule, meanwhile we can even call it an ideology, of putting and mapping everything to cyberspace, has to be questioned basically. According to our findings which correspond to many media theories it will be much more effective, efficient and satisfying to enrich the physical world with digital attributes and artifacts instead of replacing it.

Media pedagogy started with a sensible understanding of the importance of the concrete physical world and the importance of abstractions like the world of mathematics and computation (Papert, 1980). In many current developments the only goal seems to be to get rid of the rich physical world and replace it by flat and boring digital media. So we need different criteria sets for media pedagogy like those emerging slowly with Tangible Media and Mixed Reality which make use of the high potentials in both world and tying them together. It is necessary to overcome the misconception that there is something before and something behind the screen. Actually the screen is not the divide between the physical and the digital world. The VDT or PC of the general form is just an accident which prevents us from rethinking the world of education with the help of interactive digital media which are tightly connected to our bodies, minds, and environments.

3. Conclusions

Building successful interactive learning systems cannot be done by just following the rules of human factors and by mapping everything to the digital domain. To catch the learner’s attention and create motivation and experience for effective learning processes it is often necessary to bend or even break the well known and proven rules coming from the world of work systems with VDT/PC-like computer systems. This has to done in a sensible way in the area of ergonomic dialog criteria to keep the system usable. In the area of design guidelines this reaches into design decisions triggering attention, emotions or providing cultural patterns. In pedagogical dimensions the instruction designer has to decide together with interactions designers how the content to be provided can be woven into an interactive media playing thoughtfully with rules and anti-rules. This approach leads to experience-based learning environments that can be strongly enhanced by connecting the digital world of interaction to the physical world of interaction like done in the areas of tangible media and mixed realities.

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