Interface design for digital courses

Chapter 7

Interface design for digital courses

Huib Tabbers, Liesbeth Kester, Hans Hummel and Rob Nadolski

1. Introduction

The most important delivery medium in integrated e-learning is the computer interface, not only because it is very suitable for presenting rich environments in which students can work collaboratively, but also because its multimedia capabilities make it possible to present educational content in any modality thinkable of. Therefore, it will not come as a surprise that instructional designers have greeted the opportunities of the networked multimedia computers with open arms. One problem often overseen in all the enthusiasm, however, is the lack of clear guidelines on what to put where on the screen and what the consequences of certain choices are on the learning processes of the student working with the computer (Park & Hannafin, 1994). Most existing ideas are based on designer's intuition and common sense rather than based on theories about how people learn from a computer screen. This can lead to some very satisfactory screen designs, but can also produce designs that make students despair rather than motivate them to learn.

The importance of good interface design might be illustrated by the use of so-called banners in web sites. No one likes a web site that is filled with ads that are noisy and flashy and attract the attention away from what one is looking for. Now imagine that a student has to learn something in this overcrowded environment, but does not know where to look and what information is relevant. Moreover imagine what it's like when he or she is simultaneously listening to a narration that does not seem to have any relationship at all to what is presented on screen. Although this search process might be a learning goal in itself, it will not always be the aim of the instructional designer to discourage most of the students by mentally

overloading them with information. Usually, the designer will strive for an environment in which students know their way and with which they can work effortlessly, so that all effort can be put to the task at hand and not to the peculiarities of the specific environment or to the search for disparate pieces of information.

Of course, a lot of research has been done on the relation between interface design and learning, especially in the field of Human-Computer Interaction and Educational Psychology. Two important areas of interest are the lay-out of the Graphical User Interface and the way in which multimedia content is presented. Recent research has provided some promising results that can be translated into guidelines for interface design to help designers increase the effectiveness of integrated e-learning. In this chapter we will present these guidelines for the design of Graphical User Interfaces and for the presentation of multimedia content, that are firmly based on both the Human-Computer Interaction and the Educational Psychology literature and that are illustrated with cases from our own experiences at the Open University of the Netherlands.

2. Graphical User Interfaces

The Graphical User Interface (GUI) acts as an intermediary between a computer program and the user. In other words, a GUI is a collection of techniques and mechanisms that allow the user to interact with the computer program. The main interaction mechanism in a GUI is a pointing device equivalent to the human hand. With the pointing device in the GUI, the user interacts with the elements in the computer program (i.e. objects) by pointing, selecting and manipulating them (Galitz, 1997). A *good* GUI distinguishes itself predominantly by 'invisibility'. The best GUI designs are the ones most users never notice (Lynch & Horton, 1999). The next sections will focus on principles of good GUI design, guidelines for GUI design in e-learning and an example of GUI design in actual practice.

2.1 Designing Graphical User Interfaces

Before the design of a GUI is even started it must be made clear what the characteristics of the future users, the task and the context are. In a process of investigation and collaboration with the future users it has to be determined *who* the intended users are and *what* their characteristics are, *what* the intended task domain is and *what* its characteristics are and finally, in *which* context the technology will be used (Johnson, 2000). Then, a thorough analysis has to be made of purpose, structure and function of the user interface. A conceptual model has to made in which a list of objects and actions, a lexicon and task scenarios are set down. When the user, task and context characteristics are made clear and the conceptual model is ready, the actual design process can start. During and after the design process tests are needed to find out whether a design is working or not. Usability tests (i.e. GUI try-outs on future users, see next chapter) have to be carried out early in and throughout the development phase (i.e. prototyping) to inform the developer about aspects of the GUI that cause difficulty and need adjustment.

In the literature, a lot of guidelines for good GUI design are given but they often have a different level of abstraction and are overlapping or even contradictory (Galitz, 1996; Johnson, 2000; Shneiderman, 1992; Van der Harst & Maijers, 1999). Moreover, the development of a GUI is always an optimalisation process in which more practical preconditions have to be met as well. In spite of the problems of overlap, contradiction and practical preconditions, a number of generic guidelines can be distinguished.

Guideline 1: Do not complicate the user's task.

The GUI should not make the task more difficult than necessary. A good GUI does not let the user perform unnatural acts, avoids computer jargon and visibility of the software's internal workings, finds an optimal balance between power, complexity and usability, makes common tasks easy by providing customisation support and wizards and, finally, minimises the need

for deductive reasoning in operating the software. This will only distract users from their own tasks and goals (Johnson, 2000; Van der Harst & Maijers, 1999).

Guideline 2: Promote mastering the GUI.

The user has to learn how the GUI works. The design of the GUI should facilitate this process. Therefore it is very important that a developer looks through the eyes of a lay person instead of through his or her own expert eyes while designing a GUI. Experts tend to think that users automatically perceive and understand all features of a GUI the way they have intended it. Needless to say that this is often not the case. Useless confusion at the user's side can be prevented by: avoidance of textual, typographical and graphical ambiguity, consistency, and by provision of a low-risk environment (Johnson, 2000; Van der Harst & Maijers, 1999).

Guideline 3: Deliver only relevant information

Instead of simply present all available information, *relevant* information should be displayed so that the user's attention is focused on *only* this information and not distracted from it. Careful display design, preferably by a professional, should facilitate this. Moreover, the software should not change (much) on its own initiative. A good GUI is based on direct manipulation of information by the user. Furthermore, the display changes that occur, because of manipulations by the user, should be minimal (Johnson, 2000).

Guideline 4: Design for responsiveness.

Responsiveness, the perceived speed of the software, is very important to users. To optimise the responsiveness it is important that software provides feedback on what it is doing, when it is busy and when not. Moreover, it should let the user know how much time a certain action will take. The software should enable the users to work in their own pace (Johnson, 2000; Van der Harst & Maijers, 1999).

The guidelines stated above are applicable to all GUI design regardless of software application. Nevertheless, they are usually meant for software that enables the learner to perform a certain task (e.g. text editors, graphical editors). In the next section it is considered in which way the design of a GUI for educational purposes, that is, the design of a GUI for e-learning software, is different from the GUI design of task performance software.

2.2 GUI design in e-learning

In GUI design in e-learning, great emphasis is put on the user's model, which is the set of concepts and expectations a user has of the e-learning software. Although complete overlap of the user's model and the developer's model is an utopia, the developers should at least aim at the closest approximation. The central role of the user in GUI design for e-learning software leads to three more specific guidelines.

Guideline 5: Do not neglect individual differences in ICT experience

A user judges a GUI based on earlier experiences with other computer programs or ICT experience in general. A GUI should take the differences in ICT experience between users into account. An inexperienced user will need more scaffolding than an experienced user and the GUI should provide this.

Guideline 6: Support different pedagogical scenarios equally

The goal of e-learning is to allow the user to learn as efficiently as possible. In order to reach this goal, different pedagogical scenarios can be provided. A pedagogical scenario is the range of activities carried out by the user in order to reach the learning goal. These scenarios are based on pedagogical models, in which theoretical principles and prescriptions from learning theories are stated. The user’s individual characteristics determine which scenario suits the learning goals best. So a good GUI provides optimal support for each of these pedagogical scenarios.

Guideline 7: Optimise individual freedom.

In e-learning it is important to facilitate active and independent learning. The users of educational software are responsible for their own learning process. A GUI should therefore respond optimally to the users' initiatives.

Guideline 8: Conform to the user's model.

This is one of the most important guidelines in GUI design for e-learning. A good GUI uses a metaphor that is known to the user, and that is also suitable for the specific didactic scenario used. Moreover, the metaphor should adhere to the user's expectations, and should be adaptive to the user's needs.

In the next section an example is given in which some of the guidelines stated above are applied.

2.3 Casus: Developing a GUI for the Edubox-player

Edubox is used to deliver tailor-made education based on the functionalities of EML (Educational Modelling Language, see previous chapter). The educational potential of the GUI developed for the web-based Edubox-player comes from dynamically combining *roles, activities* and *resources* in order to enable personalisation of learning in a variety of didactical models (**guideline 6**).

Users carry out activities according to *role-parts* (either as students or staff members) in environments (available tools and resources), all according to the metaphor of a theatrical play (**guideline 8**). As in a theatrical play, an act includes one or more role-parts, which are 'on stage' at the same time. The activity description tells us what the role-part should do with tools and resources included in the environment. An environment may include both learning objects and services such as e-mail and conference facilities.

From the *activities* section, users start their personalised learning path (**guideline 7**). While users are online, interaction is captured, conditions are evaluated and personal dossiers are

constantly updated, triggering the web-player. Results can vary from displaying specific feedback to activating other users by sending announcements and/or assigning tasks.

Within the *tools & resources* section of the screen, resources become available, depending on activities, role-parts, or even personalised dossier elements. Data stored in personal dossiers allow tutors to monitor and support the learning process. Based on individual student profiles (preferences, prior knowledge, and learning results that are contained in student portfolios), the system can provide alternate feedback, content and interaction, as defined in the underlying educational model. For instance, students may want to receive either more theoretical (like definitions) or more practical information (like cases) about the subject matter, or may require more or less support in learning to work with the user interface and its tools, et cetera (**guideline 5**).

Figure 1 shows a screen example of a digital workbook produced with the Edubox™-player. It centres around a number of introductory psychological themes, each containing assignments for students. It shows an introductory section on 'What is psychology?' with learning content in the big window (pictures and information about famous psychologists), an activity-tree in the upper left window, and available tools and resources (the student's personal dossier, information about the study group) in the lower left window.

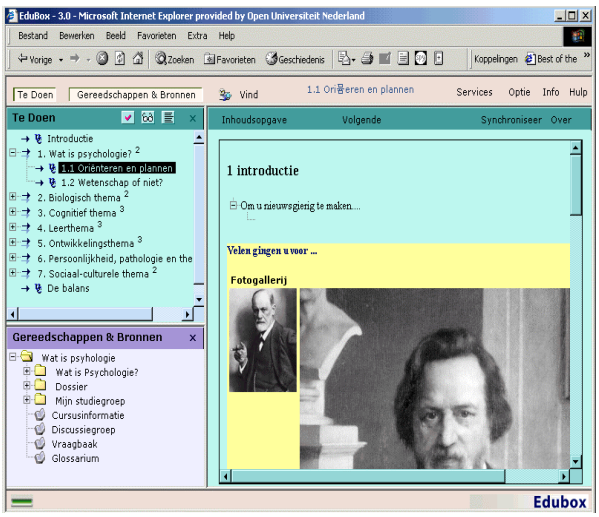

Figure 1: Screen example of a digital workbook in the domain of Psychology produced with Edubox 3.0 player.

3. Presenting multimedia content

An environment for e-learning is not only meant to navigate through or to provide the means for communicating with each other, but also to present educational content. One of the main advantages of multimedia computers is that they can present this content in any form, from written text to video, and that these presentation modalities can be used simultaneously. However, because the learner has a limited capacity for processing information, overload can be a serious threat in e-learning environments. How to deal with presenting multimedia content in instructions is an important concern in the work of Richard Mayer (2001) on multimedia learning and the work on cognitive load theory by John Sweller (1999). Both researchers try to base their design guidelines on the cognitive architecture of the learner's mind. This mind consists, roughly speaking, of both an unlimited long-term memory in which all prior knowledge is stored and a limited working memory in which new information is processed and linked to information in long-term memory. The capacity limitations of working memory have some important consequences for the presentation of multimedia content in e-learning environments. These guidelines that are discussed in the following sections on split-attention, multiple modalities, and redundancy effects.

3.1 prevent split-attention

When learners have to integrate different information elements that cannot be understood on their own, such as a picture and an accompanying textual explanation, they have to switch from one element to the other. That means that they have to keep one information element active in working memory while searching for the other. Especially with multimedia, when people have to integrate verbal and pictorial information, like for example a graph and some on-screen explanation on how to read the graph, this can lead to a high working memory load

and sometimes even an overload that can hinder the learning process. This overload can be found in any situation in which learners have to split their attention between different sources of information. The main question is how to prevent this split-attention.

Guideline 9: Integrate information elements that refer to each other and cannot be understood separately

A very effective way of reducing split-attention is to physically integrate the separate information elements that refer to each other. For example by placing an explanatory text inside a picture instead of under it, or giving the meaning of a foreign word directly above it instead of after the whole text, the amount of search is reduced and mental integration of information elements will be much easier to accomplish. This way working memory load is reduced and more capacity becomes available for the actual learning process. The positive effect of integrating information elements on learning has been demonstrated several times (Chandler & Sweller, 1991; Chandler & Sweller, 1992; Moreno & Mayer, 1999; Sweller, Chandler, Tierney & Cooper, 1990; Tarmizi & Sweller, 1988; Yeung, Jin, & Sweller, 1998). It is interesting that the same effect has also been found when learners had to split their attention between a computer screen and a external source. Experiments showed that the use of either a written manual or an on-screen tutorial was superior to a mixed mode of learning, in which a combination of paper-based and on-screen information was used when learning a computer programming language (Cerpa, Chandler & Sweller, 1996; Chandler & Sweller, 1996; Sweller & Chandler, 1994). That implies that the designer of an integrated e-learning environment should take care that the learner who is working on a, relatively limited, task presented on the computer screen does not need any external sources like manuals to prevent working memory overload.

Not only do information elements on a computer screen have to be integrated physically in order to prevent mental overload, but also temporarily. Information elements that are

presented simultaneously can be integrated more easily which leads to better learning results than when they are presented sequentially (Mayer & Anderson, 1992; Mayer, Moreno, Boire, & Vagge 1999; Mayer & Sims, 1994).

3.2 use multiple modalities

Guideline 10: Present a text accompanying an animation as a narration

One alternative way of preventing learners from splitting their attention between a picture and a text on a computer screen is presenting the text as a narration. This way the learner can simultaneously look at the picture or animation and listen to the text so that working memory will not be overloaded. Moreover, as working memory has a separate subsystem for audio, its capacity is used more efficiently and overload is prevented. This 'modality effect' has been demonstrated in several experiments, in which better learning results were found when text was presented as audio compared to on-screen text (Jeung, Chandler & Sweller, 1997; Kalyuga, Chandler & Sweller, 1999, 2000; Mayer & Moreno, 1998; Moreno & Mayer, 1999; Mousavi, Low & Sweller, 1995; Tindall-Ford, Chandler & Sweller, 1997). However, it should be noted that this guideline to use audio only applies when time is limited and the instructions can only be studied once. With more time, or the possibility for the learner to set the pacing of the instruction, on-screen text are just as effective as audio. (Tabbers, Martens & Van Merriënboer, 2001).

3.3 prevent redundancy

So far, the guidelines for presenting multimedia content only apply to the situation in which two separate information sources like a picture and text cannot be understood separately. Sometimes, this will not be the case. For example, some designers will present pictures that are self-contained, like a picture that shows the flow of current through an electrical circuit with arrows, and add some explanatory text to it that gives the same information about the current, only this time in words. In a comparable situation text is presented on-screen and at

the same time as a narration. Most designers think that this redundant information has a neutral effect, and will not be harmful to the learning process so they decide to present the information twice, just to be sure. However, experiments have shown that presenting redundant information does have a negative impact on learning(Chandler and Sweller, 1991; Kalyuga, Chandler & Sweller, 1999; Sweller & Chandler, 1994), which leads to the following guidelines.

Guideline 11:Remove any information that is already presented in a way that can be understood at its own

The explanation is that all information has to be processed in working memory which has a limited capacity. Processing redundant information will only overload the system and will not be productive to learning.

Guideline 12 :Remove any information that is irrelevant to what has to be learned

Not only information that is presented in more than one way can have a negative effect, also adding 'nice' extra information elements, like illustrations or music or irrelevant sounds can lead to less learning (Harp & Mayer, 1998; Moreno & Mayer, 2000). Although the designer might think that decorating the interface with unnecessary extras will have a motivating effect on the learner, he or she should bear in mind that the learning process will be deteriorated, especially for novice learners.

Guideline 13 :Remove any information that the user already knows

Information that the user already knows can also be redundant, for example an on-screen explanation to a picture that the user is already familiar with. An expert in a certain area will not need the information that is essential to a novice. Having to process this unnecessary information increases the working memory load and also has a negative influence on learning (Kalyuga, Chandler & Sweller, 1998, 1999, 2000). This adds an interesting twist to the design of an e-learning environment, because the learner will gain expertise by studying the

multimedia content. That implies that information will become redundant while working on a task. One way to deal with this is by scaffolding the multimedia content in that all explanatory texts are gradually removed from the instructions. That leads to a final guideline for the presentation of multimedia content in integrated e-learning;

Guideline 14 :Build up the instructions by removing information that has become redundant as a result of increasing expertise

4. Discussion

So far, fourteen guidelines have been discussed that should be applied when designing the computer interface in an integrated e-learning environment.

The first eight are all related to the design of a Graphical User Interface (GUI):

1. Do not complicate the user's task;
2. Promote mastering the GUI;
3. Deliver only relevant information;
4. Design for responsiveness;
5. Do not neglect individual differences in ICT experience;
6. Support different didactical scenarios;
7. Optimise individual freedom.
8. Conform to the user’s model

And the next six are related to presenting multimedia content:

9. Integrate information elements that refer to each other and cannot be understood separately;
10. Present text accompanying an animation or movie as a narration;
11. Remove any information that is already presented in a way that can be understood at its own;
12. Remove any information that is irrelevant to what has to be learned;

13. Remove any information that the user already knows;
14. Build up the instructions by removing information that has become redundant as a result of increasing expertise;

All of these guidelines have an empirical basis, either in the Human-Computer Interaction literature or in Educational Psychology. The two sets of guidelines are supplementary, as they are aimed at different elements of screen design. The main difference however between the guidelines for Graphical User Interfaces and the guidelines for the presentation of multimedia content is that the first are more aimed at adapting to the individual needs of the user, while the latter give us generic rules that can be applied to all users. On the other hand, the common theme in all guidelines is not to overload the learner with elements that can disrupt the learning process. Learning in an integrated e-learning environment should be enabled and not be hindered by what is presented on screen.

5. Literature

Cerpa, N., Chandler, P., & Sweller, J. (1996). Some conditions under which integrated computer-based training software can facilitate learning. *Journal of Educational Computing Research, 15*, 345-367.

Chandler, P., & Sweller, J. (1991). Cognitive load theory and the format of instruction. *Cognition and Instruction, 8*, 293-332.

Chandler, P., & Sweller, J. (1992). The split-attention effect as a factor in the design of instruction. *British Journal of Educational Psychology, 62*, 233-246.

Chandler, P., & Sweller, J. (1996). Cognitive load while learning to use a computer program. *Applied Cognitive Psychology, 10*, 151-170.

Galitz, W.O. (1997). *The essential guide to user interface design: An introduction to GUI design principles and techniques*. New York: John Wiley.

Harp, S. F., & Mayer, R. E. (1998). How seductive details do their damage: A theory of cognitive interest in science learning. *Journal of Educational Psychology, 90*, 414-434.

Jeung, H., Chandler, P., & Sweller, J. (1997). The role of visual indicators in dual sensory mode instruction. *Educational Psychology, 17*, 329-343.

Johnson, J. (2000). *GUI bloopers: Don'ts and do's for software developers and web designers.* San Francisco: Morgan Kaufmann.

Kalyuga, S., Chandler, P., & Sweller, J. (1998). Levels of expertise and instructional design. Human Factors, *40*, 1-17.

Kalyuga, S., Chandler, P., & Sweller, J. (1999). Managing split-attention and redundancy in multimedia instruction. *Applied Cognitive Psychology, 13*, 351-371.

Kalyuga, S., Chandler, P., & Sweller, J. (2000). Incorporating learner experience into the design of multimedia instruction. *Journal of Educational Psychology, 92*, 126-136.

Lynch, P. J., & Horton, S. (1999). *Web style guide. Basic design principles for creating web sites.* New haven and London: Yale University Press.

Mayer, R. E. (2001). *Multimedia learning*. New York: Cambridge University Press.

Mayer, R. E., & Anderson, R. B. (1992). The instructive animation: Helping students build connections between words and pictures in multimedia learning. *Journal of Educational Psychology, 84*, 444-452.

Mayer, R. E., & Moreno, R. (1998). A split-attention effect in multimedia learning: Evidence for dual processing systems in working memory. *Journal of Educational Psychology, 90*, 312-320.

Mayer, R. E., Moreno, R., Boire, M., & Vagge, S. (1999). Maximizing constructivist learning from multimedia communications by minimizing cognitive load. *Journal of Educational Psychology, 91*, 638-643.

Mayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual-coding theory of multimedia learning. *Journal of Educational Psychology, 86*, 389-401.

Moreno, R., & Mayer, R. E. (1999). Cognitive principles of multimedia learning. *Journal of Educational Psychology, 91*, 358-368.

Moreno, R., & Mayer, R. E. (2000). A coherence effect in multimedia learning: The case for minimizing irrelevant sounds in the design of multimedia instructional messages. *Journal of Educational Psychology, 92*, 117-125.

Mousavi, S. Y., Low, R., & Sweller, J. (1995). Reducing cognitive load by mixing auditory and visual presentation modes. *Journal of Educational Psychology, 87*, 319-334.

Park, I., & Hannafin, M. J. (1994). Empirically-based guidelines for the design of interactive multimedia. *Educational Technology, Research & Development, 41*, 66-85.

Shneiderman, B. (1992). *Designing the user interface: Strategies for effective human-computer interaction* (2nd ed.). Reading, MA: Addison Wesley.

Sweller, J. (1999). *Instructional design in technical areas.* Camberwell, Victoria, Australia: ACER Press.

Sweller, J., & Chandler, P. (1994). Why some material is difficult to learn. *Cognition and Instruction, 12*, 185-233.

Sweller, J., Chandler, P., Tierney, P., & Cooper, M. (1990). Cognitive load as a factor in the structuring of technical material. *Journal of experimental psychology, 119*(2), 176-192.

Tabbers, H. K., Martens, R. L., & Van Merriënboer, J. J. G. (2001). The modality effect in multimedia instructions. *Proceedings of the 23rd annual conference of the Cognitive Science Society*. 1024-1029.

Tarmizi, R. A., & Sweller, J. (1988). Guidance during mathematical problem solving. *Journal of experimental psychology*, *80*(4), 424-436.

Tindall-Ford, S., Chandler, P., & Sweller, J. (1997). When two sensory modes are better than one. *Journal of Experimental Psychology: Applied*, 3, 257-287.

Van der Harst & Maijers (1999). *Effectief GUI ontwerp. Een praktische ontwerpaanpak voor browser- en Windows interfaces.* Schoonhoven: Academic Service.

Yeung, A. S., Jin, P. & Sweller, J. (1997). Cognitive load and learner expertise: Split-attention and redundancy effects in reading with explanatory notes. *Contemporary educational psychology*, *23*, 1-21.