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The role of cognitive theory in human–computer interface

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Abstract

Many computer users have trouble learning and remembering information presented on a computer screen. Based on cognitive theories, part of the reason for lack of retention is hypothesized to be the user's inability to form a mental picture, or schema, of the information presented via a computer screen. In order to form a schema, users need to be able to understand where newly acquired knowledge fits into "the big picture". However, computers and the information on them are so infinite, users may have trouble thinking in terms of a big picture. When on a website, for example, how many times have you asked yourself, "Where am I?" or "Where was I?" or "Where am I going?" Likewise, for many learners, there may be little sense of place when learning with the assistance of a computer. It is proposed that these problems of the inability to form a schema and disorientation with the human–computer interface are worth researching, not only for better retention, but also for increased satisfaction among users. In addition to cognitive theories of learning, retention, organization, and individual differences, human–computer interface guidelines are also addressed. For this paper, the phrase *human–computer* interface is also called the "*user* interface" because of the emphasis on the end user, or the student. It may also be called simply the interface. Human–computer interface is defined as the point of contact between the computer and the computer user.

Keywords: Human–computer interaction; Human–computer interface; HCI; CHI; Human factors; Cognition; Cognitive theory; Interface design; Interface development; Software interface; Usability

1. Introduction

In 1951, Univac introduced the first commercial computer. In those early years, computers were used in only a few areas such as computation, data storage and data retrieval. However, computers have since been used in a myriad of fields including, but certainly not limited to, business, advertising, entertainment, engineering, law,

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medicine, training, and education. It is the last of these fields, the field of education, upon which this paper is focused.

Education with the assistance of technology, or educational technology, is becoming a booming industry, especially in the area of distance education. Learning institutions around the world are competing for their place in the endeavor to educate learners who may not be willing to or able to come to a campus for instruction. In addition to learning institutions, many other entities, medical organizations being one example, are in the business of educating the public via the World Wide Web, on topics ranging from abrasions to zygotes. Everyone seems to be eager to educate the public via computers. Indeed, computers may be the most convenient support to education our world has ever seen. However, the effectiveness of this type of education remains to be established.

Human–computer interface is defined as "the point of contact between the application and the end user" (Sheppard & Rouff, 1994, p. 1402). As such, in an *educational* setting, the human–computer interface is that which enables the learner to communicate with the computer, and is that which enables the computer to communicate with the learner.

This interactive communication is accomplished for both the learner and the computer via the computer *hardware* interface, by way of such features as the keyboard, function keys, the mouse, a touch screen, or a stylus. Interactive communication is *also* accomplished via the computer *software* interface. The computer software plays a role in interactive communication by way of the presentation layout or screen design, including, among other features, icons, menu bars, dialogue boxes, graphics, windows and split screens. This paper is focused on *software* interface.

1.1. The digital divide

One problem with educational technology is the difficulty many learners have working with computers, including computer software as well as computer hardware. This problem begs usability questions such as, "Is quality hardware and software equally usable to all learners?" This problem is so prevalent there is now a coined term, "the digital divide," to describe the situation of inaccessibility and lack of usability.

"If there is a digital divide, i.e. if computers and other technological advances are not equally accessible and usable to all learners, who are the people who do not have access to usable technology? In the United States, older adult learners, women, and less educated learners are three groups who have less accessibility according to Kerr (1996, p. 154).

In studying educational technology, we need to consider that women, older adult learners and those less educated, even if they had equal *access* to computers, could still be at a disadvantage because they experience the world differently, resulting in different ways of interacting with computers, thus making computers less usable.

1.2. Usability

With a growing number of organizations and researchers working on behalf of access for as many as possible, the future should be brighter for those on the other side of the digital divide. However, even among people who have *do* have access, many say, "I'm just not good at computers". These types of comments have spurred the growth of usability organizations such as the Human Factors and Ergonomics Society (HFES), the Usability Professionals' Association (UPA), the British Computer Society Specialist Group on Human–Computer Interaction (BCS-HCI), the Association for Computing Machinery (ACM) and its special interest group for improving computer–human interaction (SIGCHI). These organizations, and those like them, work toward usability for all computer users.

After answering the questions of the digital divide and usability mentioned above, we are faced with the more specific question, "What is the solution to the above problems?" In other words, *how* can we make educational technology more accessible and more usable? Although the lack of accessibility and usability are intertwined, this paper addresses usability. It is hoped that better usability will yield better access to educational technology. In other words, as technology is made more *usable*, it may be more *accessible* to a larger portion of the population.

1.3. Disorientation with the interface

One problem with technology in general is the problem of disorientation. In fact, disorientation is one of many reasons for computer anxiety and computer related anxiety, which is estimated to affect 30% of the United States work force (Logan, 1994, as cited in Ramsay, 1997, p. 546). Ramsay also noted that computer related distress in the workplace yields increases in mistakes, debilitating thoughts, self-deprecating thoughts, irrational beliefs and absenteeism. These, in turn, are suggested to have an impact on decreases in performance, production, motivation, and morale. These problems may also extend to student computer users.

Designing a usable interface, however, is cumbersome and challenging, which makes it difficult to design good user interfaces for computer hardware and software. In fact, the code to implement the user interface typically takes up 40–90% of the code for an entire program (Sheppard & Rouff, 1994, p. 1402).

How easily users, or learners in the case of educational technology, become disoriented in a computerized text may be a function of the user interface. In fact, many computer users have such a difficult time with text on a computer screen they will simply print out a hard copy of whatever is on the screen, rather than orient themselves to the computer screen. This phenomenon can be related to problems with font type, font size, screen brightness, or simply the users' inability to adapt to text printed on a screen.

One area where disorientation can be a problem is in the use of links. Links may be a joy for some people but a means to disorientation for others. Links enable users to expand their knowledge to include thousands of related topics. Although links create the advantage of exploration, as with explorers through the ages, there is always the chance that the explorer may get lost. For example, explorers, or learners in the case of hyperlinked computer tutorial programs, may become so disoriented they do not know where they were, where they are going, or more importantly, where they are.

In summary, there are problems in general with human–computer interaction. Of these general problems, the one specific problem that will be addressed in this paper is disorientation, since it may be related to schema building.

2. Can we apply learning theory to user interface development?

When designing the software screens for education, we *can consider* incorporating traditional learning theories. Learning theories have traditionally been applied to venues of instruction such as textbook instruction, classroom instruction, and one-on-one tutoring. It cannot be assumed, however, that learning theories applied to the above venues can automatically be applied to learning with computers. On the other hand, it may be a good place to *start*. For example, we can assume that in order to use computer-based information, we must incorporate the knowledge into our cognition, or *learn* it, and we must *retain* information if we are to use it.

2.1. Schema theory

Schemas are generally thought of as ways of viewing the world and in a more specific sense, ways of incorporating instruction into our cognition. Schema theory is a cognitive learning theory that was introduced by Bartlett (1932). Piaget described schemas as the basic building blocks of knowledge and intellectual development. Schemas have further been described as "mental representations of general categories of objects, events, or people" (Bernstein, Roy, Skrull, & Wickens, 1991, p. 321). Satzinger (1998) more recently described schema theory to include knowledge structures that store concepts in human memory, including procedural knowledge of how to use the concepts. For example, the schema of "bottle feeding" is composed of the cognitive organization of: learning to seeing a shape, recognizing and categorizing it as a bottle, grasping the bottle, bringing the bottle to the mouth, and sucking on the nipple of the bottle. Likewise, the schema of "cleaning an art studio" may be composed of the cognitive organization of: learning the rationale for a clean studio, the cleaning and storing of paint supplies, as well as the cleaning and replacing of furniture.

Piaget proposed that learning is the result of forming new schemas and building upon previous schemas. He proposed that two processes guide learning: (1) the organization of schemas, and (2) adaptation of schemas. He further proposed that adaptation of schemas involves: (a) the assimilation of new information into existing schemas, or (b) the accommodation of schemas to new information, which may not fit into existing schemas.

Organizing a schema for a learner and providing the schema to the learner may be especially important for novice learners. Novice learners are those who have little or no knowledge of a topic. At the risk of the learner organizing an incorrect schema, it may be optimal to provide novice learners with an already organized schema.

In research of the relationship between prior knowledge and interactive overviews (a method of organization) during hypermedia-aided learning, Shapiro (1999a, p. 143) noted that "novices may be uniquely challenged in that they have little or no prior knowledge to aid in the learning process.'' In addition, Shapiro found that novice learners benefited more from organization than did learners with prior knowledge of the subject matter. However, Shapiro noted that a pretest used in her study might have prompted prior knowledge and a ''redundancy effect'' which is described as the effect, which occurs when unnecessary information is presented, or when information is repeated (Yeung, 1999, p. 201). The redundancy effect has been described as a possible threat to schema organization (Bobis, Sweller, & Cooper, 1993; Chandler & Sweller, 1991; Sweller & Chandler, as cited in Yeung, 1999). As such, a redundancy effect may act as a confounding variable working against those with prior knowledge of subject matter.

Organizing a schema also brings up the question of who should organize the learner's schema, the learner, or the instructor. McNamara (1995) addressed this question. She used the term ''generation effect'' to describe the phenomenon that learners are usually better at retaining information which they *generate themselves* than they are at retaining information, which is *generated for them*. Examples of information generated for a learner include information read to the learner, and information presented in text form to the learner. In her study, McNamara compared math learners who simply read math problems and *read the solutions* with math learners who read math problems and *worked out, or generated, the solutions*. McNamara found that *low-prior-knowlege* and *average-prior-knowledge* students benefited more from the generation effect (generating the solutions, rather than simply reading the solutions) than *high-prior-knowledge* students.

The above findings may also have to do with a redundancy effect for the higher-prior-knowledge learners. That is, it is possible that the tutorial will prompt a redundancy effect if material is presented in text *and* in the form of an organizer.

Eylon and Reif (1984) found in their research the presentation of a well structured hierarchical organization was not as essential for *high ability* students as for *low ability* students. Further, they proposed, ''It would clearly be a major educational challenge contributing significantly to the good of making students better independent learners to develop methods for teaching students themselves to reorganize information into useful hierarchical forms'' (p. 41).

Larkin and Simon (1987, p. 57), on the other hand, proposed that *instructor generated* schema building would be better for learning in that it would make learning more efficient and less time consuming, which would expedite cognitive processing. This debate continues regarding organization and whether learners or instructors should generate schema building. The answer may lie in individual differences and in situational differences, with learner-generated schemas better in some cases, and instructor-generated schemas better in other cases.

Scaffolding is a term used to describe the process of forming and building upon a schema. *Interface scaffolding* refers to a schema support for computer-assisted learning. A key component of one kind of interface scaffolding is that it can be made fadeable. That is, interface scaffolding can be faded in or out as needed. This fading can be a function of the learner or the computer. In learner induced fading, learners decide whether of not to show the scaffold. The trouble with this idea is that learners may not make good decisions about which scaffolding to show and which scaffolding to hide. In computer induced fading, the computer decides whether or not to fade the scaffolding, based on a model of the learner's understanding. The main problem with this approach is that "an extensive model of the learner's knowledge may be hard to specify or evaluate in more open ended domains" (Jackson, Krajcik, & Soloway, 1998, p. 187). In their study, Jackson and her colleagues developed a software tool called "Theory Builder" based on guided learner-adaptable scaffolding. This system would offer the "best of both worlds" in that learners could control the fading of scaffolding *with the help of the system.*

2.2. Cognitive load

In addition to schemas, another closely related cognitive learning theory is that of cognitive load. Cognitive load is a term used to describe the amount of information processing expected of the learner. Intuitively, it makes sense that the less cognitive load a learner has to carry, the easier learning should be. In fact, researchers have proposed that working memory (similar to short-term memory) limitations can have an adverse effect on learning (Sweller, 1993; Sweller and Chandler, 1994; Yeung, 1999).

Yeung (1999) devised a study in which the researchers presented learners with text that included unfamiliar words. Half of the learners had the definitions of the unfamiliar words in a *traditional glossary*. The other half of the learners had short definitions of the unfamiliar words *integrated* into the space above the line of text, based on a method of text writing used in classical Chinese literature. The integrated definitions in Yeung's study were in an 8-point font size directly above the defined word. The spacing between the lines of text was such that there was adequate room for short definitions above the defined words. The learners with the glossary were presumed to have a higher cognitive load than the learners with the integrated definitions. This was assumed because of the extra effort imposed on learners; that is, the effort and time it took learners to leave the text, look up the definition in the glossary, incorporate the definitions into their schema, remember the definitions, find their way back to the text, and, finally, incorporate the definitions into the text they were reading. Intuitively, this does seem to impose a great amount of cognitive effort on the part of the learner. Indeed, Yeung found that 5th and 8th grade students with the *integrated* definitions had better comprehension scores than the students with the *traditional glossary*. However, it was also found that university-age students with the integrated definitions had *lower* comprehension scores than the students with the glossary. It was proposed that the university students exhibited a redundancy effect, which interfered with the decreased cognitive load they may have experienced, had they been younger and less experienced readers. In addition, Yeung's 5th and 8th grade students learned to speak English after they learned to speak their native language (ESL), which could in itself, be a confounding variable.

Although his sample size was low, Yeung's study is important on which to build further research. Yeung did conclude that decreasing cognitive load (as measured by the time it takes to find a definition, hold the definition in memory, then incorporate it into the learning material) may or may not help comprehension, depending on such factors as grade level and ESL status.

Closely related to the idea of cognitive load is the effect of split attention. Split attention is described as that which occurs when learners have to split their attention between multiple sources of information (Yeung, 1999, p. 198). In the study described above, Yeung was not only studying the effects of cognitive load, but also the effects of split attention. The idea of learners having to split their attention between a glossary and text was one reason proposed to have affected learners in a negative way.

Redundancy also may have negatively influenced cognitive load in Yeung's study. For learners who are proficient in English, unneeded definitions above the text may simply create redundancy and unneeded split attention. A learner's use of definitions incorporated into text, may, therefore, show a positive *or* negative effect on learning.

In addition to Yeung's findings, Reinking and Rickman (1990) found that placing definitions close to unfamiliar words increased comprehension. Additionally, Hess, Detweiler, and Ellis (1999) found that learners took advantage of *physical information in software design interface* "to augment and strategically support their cognitive storage and control resources" when performing cognitively *demanding* tasks.

2.3. Retention theories

In addition to learning, students also need to retain information, if they are to use their knowledge beyond the learning situation. Retention refers to the amount of knowledge which can be remembered after a given amount of time. Retention can be subdivided into two types depending on the amount of time which has elapsed between the point of learning and the point of recall. These subdivisions are called short-term retention, or working memory, and long-term retention, or long-term memory. Working memory can be assessed during or immediately after material has been presented. Long-term memory, on the other hand, is assessed at least one week after material has been presented (Tennyson, 1996, as cited in Plomp & Ely, 1996, p. 54).

To enhance retention, a number of techniques have been suggested. One of these techniques is chunking. It has been shown that the average person can retain approximately seven (plus or minus two) items of information at a time (Miller, 1956, p. 97). What happens, however, when there are more than seven items of information to retain? One way to make retention easier is to "chunk" the information, that is, group the multiple pieces of information into chunks. In a computer-assisted learning situation, learners may be presented with, for example, 49 facts. The instructional designer can simplify the process of retaining all these facts by chunking the information into as many as nine topics with as many as nine subtopics.

3. How about software screen design theories?

In addition to learning theories, it is hypothesized that designers of computer-assisted instruction must also consider the importance of good screen design.

Heines (1984, p. 24) noted, "poorly designed computer screens can hinder communication". However, as Szabo and Kanuka (1998, p. 38) suggest, we cannot simply avoid poor designs, we must take an active role in producing good designs.

Szabo and Kanuka suggested that viewing a good screen design enables automatic processing, whereas viewing poor screen designs encourages a manual and, therefore, less efficient processing. In addition, these researchers found that good design leads to completing lessons in less time and with a higher completion rate. This, therefore, encourages instructional technologists and graphic designers to incorporate good design into educational technology, including attracting and holding the viewer's attention and communicating easily (understood information that aims to have the viewer remember the information'', p. 25).

3.1. Layout

Sheppard and Rouff (1994) described software layout to include, among other things, how objects are grouped. For example, menu choices can be grouped in a vertical arrangement, by a one-dimensional branching tree arrangement, or by a three-dimensional cone tree arrangement (p. 1403). Layout software also will determine object attributes such as font, font size, colors, and object placement. Finally, layout software also includes the objects, colors, movement, and sound used in the interface.

3.2. Consistency

Shneiderman (1998) lists consistency as the first of his ''Eight golden rules of interface design,'' Shneiderman's eight golden rules include: (1) strive for consistency, (2) enable frequent users to use shortcuts, (3) offer informative feedback, (4) design dialogs to yield closure, (5) offer error prevention and simple error handling, (6) permit easy reversal of actions, (7) support internal locus of control, and (8) reduce short-term memory load; although he added the caveat that these golden rules should be ''interpreted, refined, and extended for each environment'' (Shneiderman, 1998, p. 75). In addition, Jones, Farquhar, and Surry (1995) proposed using a consistent format in the form of keeping similar information in the same part of each screen.

However, Satzinger (1998, p. 3) tested the effects of conceptual consistency on user knowledge, performance, and satisfaction when two integrated work applications were learned and used by student participants and found *no* effect. Thus, there is confusion about how, when and where to use consistency in interface design.

3.3. Color

In addition to layout and consistency, color is another factor in software screen design. The use of color can involve a delicate balance between interest and distraction. In educational technology, the use of color should be used to maintain interest, but not at the expense of distraction. In addition, certain colors should be avoided because some users may be colorblind. Because the colors red and green are the most common colors to be confused with each other, these should not be used on the same screen. An exception may be made if users are familiar with an object, for example, the American stoplight. That is, if you were to insert a stop light into the computer graphics of a computer tutorial, users may know that the top color is red and the bottom color is green, not because they can distinguish these colors, but because they are familiar with the color placement.

The use of familiar colors may also be helpful. For example, when highlighting a word or phase, yellow may be used for the highlighting because that is a familiar highlighting color for many learners.

In addition, the use of a single familiar color may be less distracting, would not be confused with other colors, and would be easily recognized and familiar.

3.4. Spatial display

Regarding placement of objects on a computer screen, Szabo and Kanuka (1998, p. 33) described object placement *unity* as that which occurs when the "sum total of the square inches between the objects is less than the total of the square inches around the objects as a group" and also when the objects are farther from the edge than they are to each other. In their study, Szabo and Kanuka used the design principles of unity and proposed a focal point to decrease boredom via isolation and contrast.

3.5. Organizational methods and techniques

The use of organization in text presentations has had its proponents for a very long time. MacGregor (1999, p. 203) proposed that *organized* text enables learners to construct a coherent mental representation of what they learn and can make the difference between deep and superficial understanding of results. In addition, Shapiro (1999a, p. 143) noted that text organizers work because they prompt previous knowledge and give the learner an "elaborative tool for new information". Robinson and Skinner (1996) found delayed review facilitated performance for students who viewed text plus graphic organizers, which will be discussed below. They likened the brain to an organized library versus a library in which books are either scattered or in the wrong places. These ideas regarding organization of text hark back to schema theory and cognitive scaffolding discussed earlier.

Following is a discussion of organizational strategies. These strategies include advance organizers, outline organizers, post organizers, graphic organizers, and knowledge maps. Also included is the "continuous organizer", a potential improvement in screen organization.

3.5.1. Advance organizers

The presentation of a structure of what is to be learned was the thrust of much research by Ausubel (1960, 1968; Asubel & Youssef, 1963).

Ausubel (1963) as cited in Hall, Hall, and Saling (1999, p. 103) believed that the nature of a learner's pre-existing knowledge structure, or schema, was a critical factor in retention. An example of giving a learner an "advance organizer" may be an introduction to a chapter in a book or an introduction to a class lecture. Another example is a list of topics on a chapter title page, giving the main topic of the chapter with a list of all subtopics to be discussed. Ausubel proposed using the advance organizer to give learners a structure of pre-existing knowledge. In related research, McEneany (1990, p. 93) found that those learners who exhibit unfamiliarity with subject matter have more to gain from advance organizers than those learners who are familiar with subject matter.

Even though advance organizers have been researched heavily with regard to hard copy and in class presentations, there has been little published research on the effects of advance organizers with computer-assisted instruction (Jones et al., 1995; Shapiro, 1999a, 1999b). It could be assumed that the results of hard copy research would be transferable to computer-assisted learning. However, that assumed generalization may or may not hold true. Diaz, Gomes, and Correia, (1999, p. 107) note, quite understandably, "the very flexibility of reading on screen is disorienting for a user who cannot conceptualize an overview of the structure".

Although results from hard copy research do not necessarily generalize to computer-assisted instruction, it is a reasonable point from which to start research. It is at least intuitive and reasonable to assume that some of the knowledge we have gained from hard copy research or lecture-setting research (in other words, traditional teaching methods research) *may* transfer to computer-assisted instruction.

Jones et al. (1995, p. 19) took the idea of an advance organizer one step further than the traditional use in textbooks. They suggested not only using advance organizers in hardcopy text but in softcopy text as well, to help learners "conceptualize the organization of the information in the program".

Shapiro (1999a, p. 143) noted that advance organizers have been seen as successful in traditional text-based learning as well as hypermedia-assisted learning. This was especially noted for novice learners (Shapiro, 1999a, p. 150 in Mannes & Kintsch, 1987). However, she found that advance organizers did not have an effect on subjects with prior knowledge of presented material (p. 143).

On the other hand, McEneany (1990, p. 89) found on review of advance organizer research that the literature was "equivocal" at best. Possible reasons follow.

Advance organizers in the form of chapter outlines, with sub lists of topics to be covered in the chapter, may not help much if the information in the organizer is unfamiliar. If an unfamiliar *word* is used in the advance organizer, the learner may ignore the word, leading to incomplete understanding. Alternatively, the learner may make a false impression of what the word means, and the learner's understanding may be skewed. Likewise, if unfamiliar *concepts* are used in the advance organizer, the same results may occur.

The split attention theory noted previously might also come into play. In this case, the learner must leave the text, go back to the advance organizer, and then return to the text and attempt to fit the text into the schema of the advance organizer.

3.5.2. Outline organizers

Outline organizers may be presented in the form of an "agenda" *before* a tutorial or lecture. The presenter may also *refer back* to the agenda before each main topic is presented. In textbooks, outline organizers often appear in the form of a chapter outline. These outlines are usually presented for each chapter and *before* the chapter text. They may appear off to the side, below, or after the chapter title page.

Ausubel (1968) noted that an outline is helpful because it shows how present knowledge relates to prior knowledge. Westera (1999, p. 94) noted that an important reason for outlines is that they show how separate details of text relate to a broader body of knowledge.

3.5.3. Post organizers

Another type of organizer is the post organizer. Post organizers are used to help learners summarize information. They can appear in the form of a summary at the end of a chapter or a lecture. Researchers Hall et al. (1999) following in the footsteps of Ausubel found that post organizers were quite effective for learning (p. 103) and recall (p. 107).

3.5.4. Graphic organizers

Graphic organizers are organizers of information in a graphic format. Graphic organizers have been described as "spatial displays of text information that can be provided to students as study aids (i.e. adjunct displays) that accompany text" (Robinson, Katayama, Dubois, & Devaney, 1998, p. 17). If instructors are to present a lesson on fish, for example, they may show pictures of each fish presented in a row on the top of a graphic organizer (although *pictures* are not necessary for a graphic organizer), then show different characteristics of each fish in column-form beneath each fish. Robinson and Kiewra (1995) found an advantage to using text plus a *graphic organizer* over text plus *outlines* when students were asked compare-and-contrast questions.

However, even though a graphic organizer may be a great way to present taxonomic information, it may not lend itself that easily to other types of information such as concept knowledge. That is, not all information can be presented in columns and rows. Another potential problem with the graphic organizer is that it may take some creativity to construct. Not all instructors may have the creativity, not to mention the time, to construct graphic organizers.

Robinson, Katayama, Dubois, and Devaney (1998) compared text *alone*, to text *with outlines* and to text *with graphic organizers*. This study showed positive effects with graphic organizers but only when subjects were allowed a chance for delayed review immediately or two days later. In other words, graphic organizers were most useful when delayed review was possible.

3.5.5. Continuous organizers

Tweedie (1997, p. 381) has suggested that an organizer that includes "both historical *and* potential information would be an invaluable way to keep up a dialogue with the user, but such representations have not been fully exploited.

A continuous organizer is an organizer that is continuously updated and context sensitive. For example, in a text, on a blackboard, or on a computer screen, a continuous organizer appears continuously, contains present information as well as references to past and future information, and changes according to the material presented.

3.5.6. Concept maps

A note of interest in the research on organizers is the use of concept mapping. Advance organizers, outline organizers, post organizers, graphic organizers, and continuous organizers differ from concept maps in that concept maps contain nodes and linkages to identify interrelationships between pieces of knowledge. The learner generates concept maps.

Diaz et al. (1999, p. 102) cautioned however, that maps may not always work in educational technology since the maps often take up much room and may appear overloaded and confusing to novice learners.

3.6. *Should we consider individual differences in computer users?*

3.6.1. *Age*

The age of a computer user may be less important than the years of computer experience of the user. Of course, there are exceptions. Many older adult users may compute quite easily. In addition, many younger adult learners may not even know how to use a mouse. However, since most older adults have not been exposed to as many learning years with computers, it would seem to follow that they would need more experience in order to compete with younger users. Indeed, prior computer experience has been ''identified as a key antecedent for success or failure at a computer-related task'' (Rozell & Gardner, 2000).

3.6.2. *Gender*

There is some evidence that men and women respond differently to computers. In general, women in the United States have been found to engage in more word processing and collaborative computer learning, and males engage in more computer games and competitive work (Kerr, as cited in Jonassen, 1996). The role of gender in computer use is an important one, and one to consider when designing the user interface for computer-assisted instruction. There appears to be considerable evidence to conclude that women tend to approach computers with less confidence and more anxiety than men (Colley et al., 1994; Corston & Colman, 1996; Dyck & Smither, 1996; and Hemby, 1998 in Rozell & Gardner, 2000, pp. 199–222). However, it may be the case, as above with age, that *gender* is not as important as computer *experience*. Nonetheless, the question of how genders differ in their use of computers will continue to be an important area of computer-assisted learning research.

3.6.3. *Level of education*

Level of education may be a factor in computer use, although more and more technical and vocational skills require a complete spectrum of abilities, from basic computer literacy to extensively advanced computer experience. When researching computer use, it is important to tap into the levels of education of potential users when designing interface screens. It is important that screens be simple enough for the novice learner and complex enough to sustain the interest of the expert learner.

3.6.4. *Affect*

Affect is another consideration when designing the interface. Rozell and Gardner (2000), in a study of 600 undergraduate management information systems students, found that ''one's mood will influence the level of effort expended on a computer-related task'' (p. 207). Norman (2002) notes, that Alice Isen (1993) and Ashby, Isen, and Turken (1999) showed that if people were given small unexpected gifts, afterwards they were able to solve problems that required creative thought better than people who were not given gifts. This assumes, of course, that gift giving leads to a positive affect. In addition, Norman notes that the gift giving may have "the side effect of making people more distracted". Regardless of which way you look at it, designing for the desired affect should be considered when researching and developing user interfaces for computer-assisted instruction.

3.6.5. Motivation

In addition to affect, Rozell and Gardner (2000) further noted that researchers have found that motivation, or level of effort, is one of the primary variables affecting individual performance in general (Kanfer, 1991; Martin et al., 1989) and computer-related performance in particular (Waern, 1989). Thus, motivation is also important individual difference to consider when researching and developing user interfaces for computer-assisted instruction.

4. Summary

In summary, the literature suggests that problems of disorientation persist, at least for some computer users. If we are to orient learners during computer-assisted instruction, it will be important to determine if long-held theories of hard copy text learning and auditory learning also apply to computer-assisted learning. Retention theories will also be important to consider, as well as software screen design principles. Organizational methods and techniques are beginning to be researched with computers and may have an impact on retention and ease of navigation in computer-assisted instruction. Individual differences such as age, gender, level of education, affect, and effort also need to be considered when developing useful interfaces for computer-assisted learning.

That said, it should be remembered that the code to implement the user interface typically takes up 40–90% of the code for an entire program. Therefore, before developing software user interfaces, it makes sense to research the effect of learning theories, retention theories, organizational theories, and individual difference theories in computer assisted instruction. This will help determine if these theories and principles of traditional *text instruction* and *auditory instruction* also hold true for *computer assisted instruction*, under what circumstances, and for which individuals. In addition, software screen design principles need to be validated. Then we can design usable computer-assisted instruction according to our findings.

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