Can Learning Inform
Screen Design in E-Learning Settings?

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To date much of the courseware available in hypermedia learning settings follows the design tradition formerly used to produce print-based textbooks and workbooks. More recently, attention is being given to how the material to be learned is presented, and to the ways in which students might need to interact with and interpret this material. Learning theories are now being used to provide guidelines for designing a variety of presentation modes and student activities online. This is in contrast to an initial focus in web-based software on screen display. This shift in focus would seem to be part of the maturing of our understanding of hypermedia and its application to learning. This paper sets out to review recent commentary on this shift in focus. Finally, an attempt is made to map the cognitive aspects discussed in an effort to understand how they might inform e-learning screen design.

Background

Nearly twenty years ago Norman, Weldon, and Schneidermann (1986) identified that computer information is organised in three different "modes of representation". They described these as the: machine layout (which describes the internal data representation in the computer); the surface layout (which describes the physical organisation of objects on the screen); and the cognitive layout (which describes the mental mode of the information developed by the user). For educators, the latter two representations are of most interest as they represent the two aspects, which impact on learners. The surface layout is analogous to a more traditional view of screen design whilst the cognitive layout is analogous to the encoding and representation of knowledge in memory.

Berry (2001) argues that in order to understand the basis for much of the web page design that currently occurs stem from much earlier work in computer screen design. This early research was more concerned with the perceptual aspects of how users viewed and interacted with data on screens (Galitz, 1989). Most of the earlier studies were technology driven and more concerned with new screen display technology and were attempts to answer the question of "How can we most effectively display data on a screen". This research was exemplified by the work that led to the innovation of the Graphical User Interface (GUI), which now dominates computer interfaces (Herot, 1984). Other research into the perception of printed copy has contributed to the understanding of how text is perceived and interpreted on a computer screen (Gropper, 1991; Gillingham, 1988; Jonassen, 1989).
However, those aspects of computer screen design that are of most interest to educators are related to the way in which information displayed on a screen is perceived and encoded into memory by the learner, or in Norman et al terms the cognitive layout. Cognitive theory views the processing of this information as falling into two general areas; perception and pattern recognition of information, and processing and encoding of information into long term memory. Berry (2001) suggests that more recent studies on screen design have focussed on the latter.

Viewed historically then, it becomes apparent that little attention was given to the cognitive effects of screen design or the educational implications of such design. That situation has started to change. Leflore (2000) has identified three aspects of learning theory that are influencing the contemporary screen design of web-based instruction, Gestalt theory, Cognitive Theory and Constructivist theory. These theories and their influence to date are discussed next.

Gestalt theory
The main focus of Gestalt theorists was to explore perceptions and their relationship to learning. What is contained on a computer screen heavily influences the visual perception of the learner (Smith-Gratto & Fisher, 1999). Leflore (2000), argues that those Gestalt "laws of Perception" that ought to be considered in designing web-based instructional pages include; figure-ground contrast, simplicity, proximity, similarity and closure. How these laws might influence hypermedia screen displays is teased out further next.

Figure-ground contrast deals with the concept that the foreground needs to be distinct from the background. This aspect suggests that the text or graphics should have sufficient differences to make the information to be learned easily accessible to the learner. This would imply that many of the coloured backgrounds, half-toned graphical backgrounds and corporate watermarks often used in courseware whilst looking attractive, might in fact be counterproductive.

Simplicity deals with the concept that learners will simplify the visual into a form they can understand (Smith-Gratto & Fisher, 1999). Since learners do this it might be more efficient to simplify a graphic when it is introduced and then gradually add complexity as necessary. This would permit the viewer to build up to the complexity required. Through avoiding distracting and irrelevant visuals the content will be more easily interpreted by the learner.

Proximity is associated with the placing close together of elements that are related to one another. In screen displays it is easier for learners to understand that different text or graphic elements go together (e.g., labels for parts of graphics) if they are placed together. This lessens the chances of ambiguity and of learners perceiving unintended relationships.

The law of similarity states that learners will group things together that have a similar appearance. Learners need to be aided in the recall of information by focussing their attention on the key concepts of a visual field (Kohler, 1947). On screen displays this can be achieved in a variety of ways through the use of contrasting colours, animation or any other technique that focuses attention on an item or highlights a differentiation. However, Leflore (2000) warns us that too many differences on one
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Screen of information might in fact produce an opposite effect. Therefore, these techniques do need to be used judiciously to emphasise key words, graphics or aspects of the learning.

The law of closure indicates that learners will try to interpret incomplete text or graphics based on past experience. Learners try to bring meaning to what is perceived and will force meaning on information perceived by them to be incomplete. Therefore, during instruction incomplete information could lead learners to misunderstand the information presented. It is crucial then that screen displays are checked to ensure the completeness of the learning point.

When learners engage with web-based instruction their underlying objective is firstly one of meaning making. As Kohler (1947) asserted, learners either obtain meaning directly from the information or they impose patterns on the information in order to give the information meaning. Web-based instructional designers overarching priority must therefore focus attention on how learners make meaning.

Modern cognitive theory is in some respects an outgrowth of Gestalt theory. There are some important differences that can be exploited to provide additional approaches to web-based instruction. These are discussed next.

Cognitive theory
There are several concepts from cognitive theory that can be used to help design what appears on a web-based instructional page. Cognitive mapping or webbing, concept attainment activities, activation of prior knowledge, and the use of motivational graphics, animation, and sounds are ways that cognitive theory can contribute to hypermedia screen design. A brief look at each of these follows.

Cognitive mapping or webbing
Webs, graphics and outlines are forms of cognitive mapping that assist the learner to build frameworks or schemas that help them understand the world (Piaget, 1954). While each learner's schema will be different, it is possible to provide some structure to help guide this schema formation. Taba (1962) argued that learners develop concepts by reorganising existing concepts as they interact with new experience. This would suggest that assisting with the development of some sort of cognitive map at the commencement of a web-based lesson is useful. Visual referents are another way of indicating to the learner relationships that exist between the various aspects of the content and what they might be expected to learn (Reiber, 1994). Thus, overviews of information and relationships amongst the elements of the content can easily be made explicit.

Concept attainment activities
Concept attainment is an interactive process (Bruner, Goodnow, & Austin, 1956). Learners can be presented with examples of a concept in order that the characteristics of the concept become evident. Learners initially hypothesise about their definition of a concept until a definition is reached (Bruner, Goodnow, & Austin, 1956; Hodges, 1986). Smith (1989) argues that concepts assist learners to classify things into different categories and that such categories assist the learner to remember and learn information. Therefore, by providing learners with various examples they are able to check and refine their concepts and learn the information. In web-based learning graphics, animation and
sound are also important devices that can augment text in the development of concepts and information. However, they do need to be employed in cognitively appropriate ways.

**Activation of previous knowledge**

Ausubel and Robinson (1969) stated that new materials should be related to the learner's existing cognitive structures. The learners existing schema, or pattern of information, is built from previous experience. Therefore, by activating previous knowledge new information ought to be more meaningful and therefore easier to learn. Several theorists suggest that learning is more effective when information is meaningful (Ausubel, Novak, & Hanesian, 1978; Bower & Clapper, 1989; Mayer, 1999). In web-based instruction knowing of the learners previous knowledge is much more problematic than in the classroom. Therefore, providing explicit hooks (links) to previous knowledge (in the materials) might be a way to stimulate the development of effective schema.

**The use of motivational graphics, animations and sounds**

The gaining of a learners' attention is an important part of any instructional sequence (Gagne et al., 1988). In web-based instruction graphics, animation and sound can be used for this purpose. Reiber (1994) argued that graphics could increase both extrinsic and intrinsic motivation in a learning event. However, Leflore (2000) cautions that whilst graphics, animation and sound can be very powerful motivators, they need to be employed with discretion and it is not necessary to use graphics and animations or sounds with each webpage or lesson.

In addition to Gestalt and Cognitive theory, constructivism might also be drawn upon to create web-based instructional activities that require students to approach learning in different ways.

**Constructivist theory**

Another theoretical base that can be drawn upon for the design of web-based instruction is Constructivist theory. Constructivist theory argues that each learner has a unique mental structure, which allows them to make meaning from their experiences. As a consequence we can help learners understand their structures and connect their experiences by making the process of connecting what they are learning a conscious one. Leflore (2000) argues that Constructivist theory has a number of characteristics that are easily adapted to web-based activities. These include, learner construction of meaning (Von Glasersfeld, 1989; Piaget, 1954), social interaction to assist learners learn (Vygotsky, 1981), and learner problem-solving in real world contexts (Gott, 1989; Duffy & Jonassen, 1991). Constructivist based activities require that the learner be given active and engaging tasks that require more than minimal intellectual involvement.

**Learner construction of meaning**

Given the uniqueness of learners it is important that they participate in a learning activity in a way that permits them to create an external structure that reflects their internal conceptualisation of the topic. This will provide them with the freedom (and responsibility) for organising their understanding of the content. This would suggest that on-line tools to effect this are important.
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Social interaction to assist learners learn

While learners perceive and understand what they are studying in different ways, commonalities in that understanding can be created through social interaction. Vygotsky (1981) argued that social interaction provides mediated interpretations of experiences and much of what is learned about the world is dependent upon communication among individuals. He further asserts that language is a primary tool for creating and mediating meaning for an individual and supports the idea that language is the key to problem solving. Whilst web-based instruction is not always conducted in a social setting (e.g., a learning centre), technological alternatives such as chat rooms, email, and threaded discussions are alternatives means of providing learner interactions.

Learner problem-solving in real world contexts

Duffy and Jonassen (1991) and Smith-Gratto and Leflore (1998) argue that in order for meaningful learning to occur, students must address "real-world" problems. Brown et al (1989) argue that such "real-world" or authentic problems help learners to construct highly developed schema that contribute to an increased ability to solve problems. Leflore (2000) believes that web-based instruction lends itself very well to involving learners in "real-world" problem-solving through mechanisms such as simulations. The use of graphics and sound is often useful in assisting with the simulating "real".

Berry (2001) suggests that screen layout and the relative salience of visual elements constitute the most relevant studies in screen design and the focus of educational researchers ought to be on the role of such elements in gaining and maintaining learner attention.

Discussion

Whilst it is possible to examine more learning theories in the same manner as has been undertaken above the constraints of this paper make that impossible. What I have attempted to do in this paper is to demonstrate how screen design for e-learning settings can be usefully informed by learning theory, and particularly cognitive theory. While many e-learning resources attempt to use standardised screen formats to present learning on the premise that this standardisation assists the learner to quickly assimilate with the resources, I would argue that the format might be more profitably driven by the learning intentions. It is hard to see how any standardised screen format could accommodate the multiple learning requirements of even a very basic unit of study.

Table 1 shows how the learning theory highlighted in this paper might usefully inform e-learning screen design practices. This is an initial attempt by me to use the literature in this way.

Many of the screen design features highlighted in this paper are commonly employed in e-learning screens. However, there use is usually driven by principles of good design or the need to present visual impact. Screens designed using these principles are more likely to be entertaining rather than engage a learner in the learning task at hand. It ought to be the requirements of the learning task that determines the screen design and layout features that are selected.
Table 1

Relationships between learning theory and screen design for educational purpose

<table>
<thead>
<tr>
<th>LEARNING THEORIES</th>
<th>APPLICATION TO SCREEN DESIGN</th>
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<tbody>
<tr>
<td>Gestalt Theory</td>
<td></td>
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<tr>
<td>- Figure ground contrast</td>
<td>Effective distinctions between text and graphics.</td>
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<tr>
<td>- Simplicity</td>
<td>Eliminating unnecessary complexity in text and graphics.</td>
</tr>
<tr>
<td>- Proximity</td>
<td>Paying attention to the placement of related elements.</td>
</tr>
<tr>
<td>- Similarity</td>
<td>Grouping things together to focus learner attention.</td>
</tr>
<tr>
<td>- Closure</td>
<td>Ensuring the completeness of the learning point.</td>
</tr>
<tr>
<td>Cognitive Theory</td>
<td></td>
</tr>
<tr>
<td>- Cognitive mapping</td>
<td>Focus on structure to guide the learning.</td>
</tr>
<tr>
<td>- Concept attainment</td>
<td>Assisting learners to remember and learn.</td>
</tr>
<tr>
<td>- Activation of previous knowledge</td>
<td>Providing specific links to previous knowledge.</td>
</tr>
<tr>
<td>- Motivational aids</td>
<td>Using graphic and sound to motivate learning in appropriate ways.</td>
</tr>
<tr>
<td>Constructivism</td>
<td></td>
</tr>
<tr>
<td>- Learner constructing meaning</td>
<td>Providing access to tools to accomplish this.</td>
</tr>
<tr>
<td>- Social interactions</td>
<td>Providing links to learners.</td>
</tr>
<tr>
<td>- Problem-solving 'real world'</td>
<td>Providing links to authentic or simulated settings.</td>
</tr>
</tbody>
</table>

The application to screen design of the Gestalt theories discussed above would seem to have more general application across learning tasks. That is, they would seem to be equally applicable to a drill and practice learning unit as to one in which a learner may be engaging with a complex simulation. In contrast, the application to screen design of the cognitive and constructivist theories discussed above would be driven more by the nature of the learning task to which they were being applied.

An example in practice

An example of how I recently used this framework to assist a student with a project concludes this paper. The student worked a language teacher and was teaching the conversational Chinese to a group of students who were mainly businessmen doing business in mainland China. She had a student retention problem caused by the fact that many of the students were required to travel to China during the course. A key factor in language development is the need for the learners to maintain a constant immersion. However, when they took time off to travel the learning became interrupted and on returning from their travels many chose not to return to class as they had missed a number of lessons. She had provided her class with a set of text-based resources in an effort to provide continuity of learning whilst they were away but found that this had little impact on retention. She decided that, as all of her students were users of laptop computers for their work and overseas travel she would try to use an e-learning approach to the supporting resources. So as an initial step I asked her to consider how she successfully engaged learners in her classroom.
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She identified that from a cognitive perspective she used two primary methods, concept attainment and activation of previous knowledge as the essential drivers of her lessons. That is, in her language lessons she built student vocabularies by getting them to associate new words with the context (similar concept) in which they were being used (e.g., meeting and greeting people). What was also important was that at the concept level the learning was multi-modal. That is the learner needed to recognise both the Chinese characters that made up the word and associate this with the spoken word or its correct pronunciation. A major strategy she employed to assist her learners to develop the current concept was to relate it back to previous knowledge; that is the characters and sounds they had previously learned and continually practiced.

Armed with a clear understanding of what were her successful learning strategies she then set about developing an e-learning resource using Microsoft PowerPoint. Interestingly, PowerPoint was chosen because it was able to accommodate the learning strategies she had identified as important, rather than the other way round. On a PowerPoint slide she was able to provide the learner with The Chinese text, as well as a series of buttons that permitted the learner view additional learning resources (Figure 1).

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**Figure 1.**
Learning strategies as Microsoft PowerPoint ® screen elements.
On this representation of her slide are embedded the e-learning equivalents of the strategies she adopts when teaching face-to-face. That is, she presents the learners with the sentence they are to interpret. She often provides visual clues that assist learners understanding, provides the sentence in English, and finally says the sentence in Chinese.

Conclusion
In this paper I have discussed a learning theory based approach to screen design for e-learning products. Some examples of learning theory have been used to see how they might inform screen design. Finally, a recent example of this approach has been reviewed to demonstrate the approach in action. I would argue that this would prove to be a much more effective and educationally robust way of designing the screens used in e-learning resources.

References
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