Interactive Nonlinear Learning Environments

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Abstract: E-learning materials often have a linear design where all learners are forced into a single-mode pedagogy, which is contrary to the interaction that occurs in face-to-face learning. Ideally, e-learning materials should be nonlinear, interactive, contain context-sensitive and active learning elements, and accommodate various learning levels and styles. This paper presents an educator's perspective on approaches to designing such e-learning materials, which are essential to enhancing the education of future generations of students.

Keywords: Interactive, nonlinear, e-learning environments, active learning

1. Introduction

1.1 Effective and intelligent use of information technology in e-learning

Modern tools of information technology provide excellent opportunities for creating engaging e-learning environments. In recent years, online learning via Internet has increased substantially. However, computer-based learning materials tend to have a linear or sequential design where all learners are forced into a single-mode pedagogy. This is in sharp contrast to the pedagogy and interaction that occurs in individualised face-to-face learning. Simulating the teaching and learning process between educator and learner is difficult in an electronic medium such as the Internet, which, in essence, replaces one page of information for another each time a link is selected. Presentation software also promotes a linear "next/previous" page pedagogical style. Ideally, computer-based learning materials should be nonlinear, interactive, contain context-sensitive and active learning elements, and accommodate various learning levels and styles (Lee et al. 2004, Swaak et al. 2004, Phelps 2003, Chen and Macredie 2002). Such e-learning environments, in which the educator's pedagogical approach and expertise are encoded into the design, represent an effective and intelligent use of information technology for learning environments where each student is guided during their independent study. This goal is extraordinarily difficult to achieve, especially since educators are often not adept at computer programming or using other tools required to achieve such a goal. While the technical aspects of e-learning are often performed by technical personnel and instructional designers, such personnel do not have the pedagogical expertise of an experienced educator. Therefore, the perspective of the educator in designing nonlinear interactive learning materials is essential.

During the past 15 years, I have researched and used various approaches to e-learning and explored many promising information technology tools that initially showed great promise and yet proved unsuccessful. Other tools and approaches ultimately proved to be very effective at enhancing learning. Rather than simply a matter of selecting the appropriate information technology tools, effective e-learning materials fundamentally stem from the educator's pedagogical expertise and close personal interaction with the learner. Still, linear learning designs – whether custom-designed or commercial learning systems – dominate e-learning education. In order to significantly enhance the e-learning educational experience for future generations of students, information technology must be effectively and intelligently used for learning materials that are: (1) interactive in the sense of context-sensitive responses to the learners actions, (2) nonlinear so that learners can determine their own learning path, and (3) actively engage learners of different levels of base knowledge.

1.2 e-Learning and the science curriculum

My primary field of expertise is in the science of ecology, which integrates all aspects of the biological and physical components of nature. Principles from disciplines such as chemistry, biochemistry, physics, geology, geography, botany, zoology, and biology are used for the understanding of how organisms respond and adapt to their environment. Students must be able to integrate biological levels that range from the molecular to the individual with ecological processes that include the physical environment (climate, temperature, wind, solar radiation, etc.), interactions among organisms (e.g., competition, herbivory, predation, and parasitism), and the structure and function of whole ecosystems. Thus, the integrative nature of ecology makes this science ideal as a model for nonlinear interactive learning environments.

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Understanding of ecological principles relies heavily on the visual elements of nature (photographs and video of plants and animals, sounds of animal communication, animations of processes, etc.). Thus, effective learning designs in ecology should include a blend of multimedia elements, e.g., digital audio, video, scientific and conceptual graphics, and animations. The inclusion of context-based audio clips and cues can significantly increase the rate of learning and retention of understanding (Mayer et al. 2005, Mareno and Mayer 2004, Mayer et al. 2003, Mayer and Anderson 1991). The latter appears to be applicable to a variety of subjects in e-learning.

Computer-based presentation software, Internet editors for creating online learning sites, and many commercial courseware systems tend to emphasise a linear and sequential pedagogical approach. This is particularly the case if default templates are used to create the learning materials. Although the linear or sequential designs are certainly the most straight forward and easiest to develop, I have found these of limited value in simulating the teaching-learning process between educator and learner. Because I believe the future of computer-based learning will require a very different and sophisticated pedagogy, my research on enhancing the science curriculum with information technology has focused on authoring systems that allow educators to encode their pedagogical approaches and expertise into learning materials. Using such authoring systems, I have developed a comprehensive suite of interactive nonlinear learning modules in the science of ecology for a learning audience that ranges from the non-scientist to undergraduate to graduate level learners in ecology. Learners via course sites on Internet access these learning materials. Although I have not conducted a formal evaluation study on the use of electronic learning materials in my courses, these learning materials have been used and evaluated by hundreds of students over the past decade. The interface for my learning materials has been developed and refined with the input of students. Student performance on examinations for on-campus students and online students is comparable. Also, students and instructor are able to have a more flexible learning schedule with this type of e-learning.

Although my scholarly work has focused on the use of information technology for enhancing the science curriculum, my work can serve as a model for a variety of disciplines with relevance in several areas: (1) significant potential for scaling to large enrolments without additional human resources or time commitments, (2) the ability to accommodate a variety of learning levels, styles, and paces from the same learning module, and (3) a student-centred learning model that is considerably more flexible than the fixed class and semester schedule.

2. Learning models

2.1 Linear learning models

The dominant learning design in e-learning, whether in the form of lecture presentations or course sites on Internet, employ a two-dimensional linear or sequential pedagogy (Figure 1).

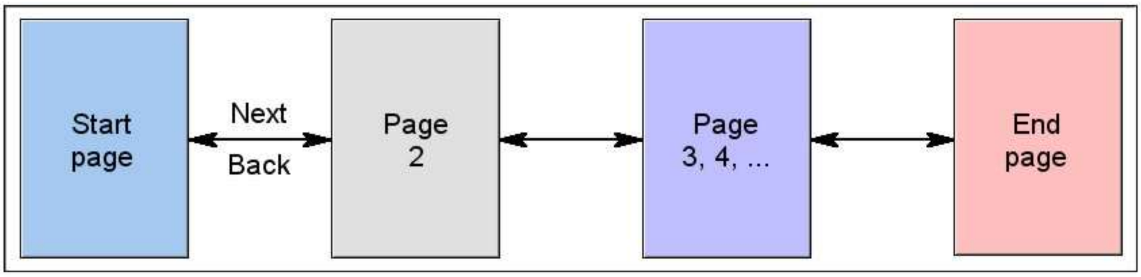

Figure 1: Two-dimensional linear learning model.

All learners are forced into this single-mode pedagogy, which has a specific starting and ending page. The instructor predetermines the flow of information between the starting and ending pages. Such designs follow a very logical flow of information from elementary to more complex topics, very much in the mode of the traditional printed textbook – chapter 1, 2, 3, etc. In contrast to the traditional printed textbook, however, the e-learning material can only be used in the predetermined linear manner. A learner can open a printed book to any page and turn to any other page, but there is no connection or logic between randomly opened pages in the book. Since all learners have to follow the single-mode design, the linear design does not accommodate various different learning levels and styles. Novice, intermediate, and advanced learners all begin at the same point, and proceed through the learning material in the same path. Only the pace of learning may differ because the more advanced learner may proceed through the learning materials at a faster pace than less advanced learners. This, however, is only the case if the pedagogical design allows learners to actually proceed at their own pace. If the instructor designs the e-learning course so that the entire class must advance together, the advanced learner can only proceed at the average pace of the class.

The three-dimensional linear learning design is a variation that includes ancillary information elements on each page (Figure 2). Each page may contain an ancillary set of information elements such as definitions, comments, and images. Although this design may appear somewhat nonlinear, all learners, regardless of their initial knowledge base and learning style, still follow the same main learning path from start to end pages as predetermined by the instructor. As in the two-dimensional learning model in Figure 1, the simple "next/back" pedagogical approach does not allow the learner to skip among pages at will – only back and forth between two adjacent pages.

These additional elements may be comments, side notes, definitions, or images. Within each page, the learner thus has access to an increased set of information that is related to the main page of information. However, the learning path is fundamentally still linear as described above for Figure 1.

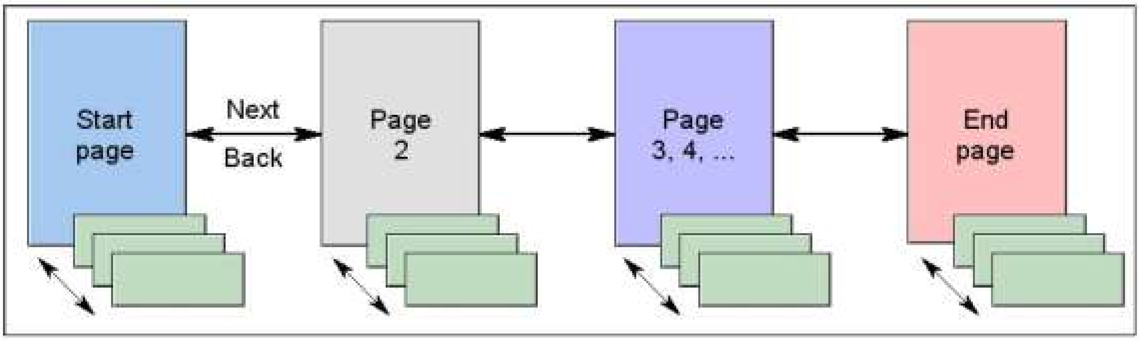

Figure 2: Three-dimensional linear learning model.

For learners who require a high level of guidance in their learning, the linear designs shown in Figures 1 and 2 can be highly effective. Information is presented in a logical manner from the elementary level to increasingly more complex levels. In some cases, it may be advantageous for the entire class to advance at a particular pace. Also, in many cases, this type of pedagogy occurs in large-enrolment classes where the instructor leads all learners through the material in the same way and pace. Learners at all levels of education are accustomed to this format and thus linear e-learning designs are a familiar extension. However, e-learning via the Internet provides great potential to accommodate learners of various abilities and levels.

2.2 Nonlinear learning models

As an educator, I believe that a fundamental goal in education is to provide each learner a personalised learning experience that accommodates learners of different abilities, initial knowledge base, and learning styles. With traditional teaching styles in the traditional classroom, such personalised teaching is often not possible. This is especially the case in large-enrolment courses. Ideally, education should have a pedagogical approach that approximates the personalised relationship between tutor and learner. If used intelligently, the emergent tools of information technology have the potential to realise this ideal education experience.

In contrast to the linear learning models where all learners follow a rigid path (see Figures 1 and 2), nonlinear or nonsequential learning designs shift the responsibility for mastering a particular subject to the learner. The instructor may provide guidance to the learner and determines the level of mastery. However, the learner is responsible for mastering the subject through a self-determined path and rate. Such a learner-centred pedagogy will ultimately be more effective than the instructor-centred pedagogy (Felder 2005).

The design of nonlinear learning environments is inherently difficult and complex. In such designs, learners should be able to select any entry point in the subject (similar to opening a book to any page), and directly move to any other point in the subject at will (Figure 3). Ideally, learning is individualised because each learner designs their own learning path and pace by the choices the learner makes. Information is divided into packets instead of sequential pages. Although this learning model may contain some "next/back" navigation, the learner can navigate in any direction among information packets. The information packets are connected in a coherent manner so that ancillary information that is necessary for learning (definition, images, audio, video, etc.) can be accessed directly. This design can accommodate linear and nonlinear learning styles, novice to advanced learners, and a path and pace set by the learner – not as predetermined by the instructor.

This is similar to randomly selecting any page in a printed textbook and then moving directly to any other page in the book. However, with interactive computer-based learning materials, the information on nonsequential "pages" is connected in a rational manner so that the learner has a coherent learning experience. That is, each information packet has extensive connections to other information packets. This is also known as hypertext or hyperlinks. However, rather than simply resulting in the navigation to a subsequent page (i.e., the "next/back" navigation model), a selection of a hyperlink may initiate a variety of actions: (1) display a definition or other related information on a layered or "pop-up" subwindow, (2) play context-relevant audio or video, (3) display an image, or (4) display additional context-relevant information in text form. In this three-dimensional design, the learner's attention remains focused on the main subject while having direct access to ancillary information through subwindows.

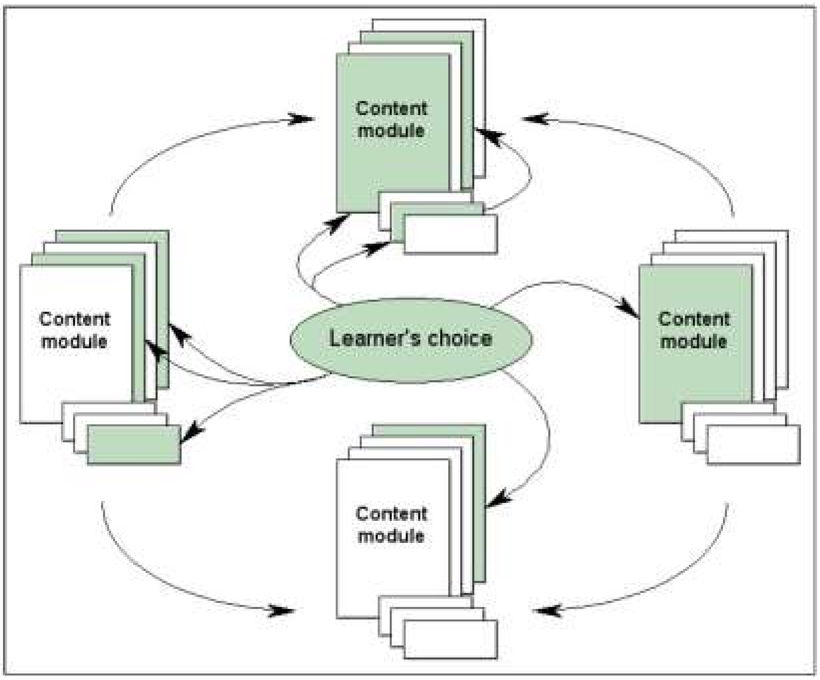

Figure 3: Three-dimensional nonlinear learning model.

2.3 Authoring systems for developing three-dimensional learning environments

Authoring systems such as Toolbook Instructor 2004 by SumTotal Systems and Macromedia Director are sophisticated computer software programs that allow educators to design three-dimensional learning models. Although linear learning designs can easily be developed with these authoring systems, these programs are highly suited for designing nonlinear learning materials with sophisticate feedback to the learner. While the learning curve for authoring systems is relatively high as compared to presentation software or Internet page editors, the most time and effort will be devoted to the planning phase. Imagine an interactive nonlinear learning environment that truly accommodates a variety of learning styles and levels, and where learners determine their own path and pace toward mastery. Such a learning environment requires a relatively large investment of time in the planning phase.

3. Integration of multimedia elements for enhanced learning

3.1 Static elements

In addition to the interactive nonlinear design of the learning environment, the use of visual elements is very important for understanding complex information and concepts (Mayer and Jackson 2005, Mayer et al. 2005). However, the key to the effective use of visual elements is the integration of these elements in a context-sensitive manner. For example, scientific and conceptual graphs that occur in isolation (e.g., on a separate page or “pop-up” window of an Internet browser) are not as effective as when such visual elements are fully integrated with text and/or other multimedia elements (see below). This is particularly the case for the sciences. Many processes and relationships in ecology, e.g., rely heavily on the graphical display of data. In print media, the context of the visual elements is primarily based on the position of elements on a page of text. Computer-based learning materials provide more precise positioning so that visual elements can be displayed in context to the learner’s actions. Furthermore, the visual elements that are displayed in response to the learner’s actions can be individualised for that learner so that novice learners may be shown visual elements in more elementary form, while more advanced learners may be shown more complex visual elements. As is the case for any e-learning design, the expertise of the educator for the design and use of visual elements is a significant factor in their effectiveness (Mayer et al. 2005).

3.2 Animations and visualisation

The ability to animate visual elements, whether two- or three-dimensional animations, adds a significant learning dimension that is not possible in print media. Scientific and conceptual illustrations that move can be highly effective for understanding dynamic processes. In biology and ecology, e.g., blood flow, molecular actions, nutrient cycling, energy flow in the environment, and the structure and function of ecosystems are some examples where animations can be particularly effective. However, simple animations with “start/pause/stop” controls are not as effective as interactive animations with audio that respond to the learner’s actions. Such interactive animations are similar to computer games, which are essentially continuous animations that respond to the game player’s actions. In this manner, interactive animations can be highly effective because there are immediate consequences and feedback to the learner’s actions. For example, in an interactive animation on the ecology of a rainforest, a consequence of the learner’s actions may include extinction of a species or other changes in the rainforest. Such context-sensitive feedback provides opportunities for learning that do not exist in static print media or static visual elements in e-learning.

The emerging field of visualisation represents an advanced form of animation. The goal of visualisation is to simulate a process in a three-dimensional, photorealistic, quantitative, and interactive manner. Visualisation is also known as virtual reality, in which the learning is positioned within the simulated process or scene. Visualisation models are commonly used to model various processes in physics, aerospace, medicine, and the military to understand complex interactions and systems. While visualisation is an extraordinarily powerful tool, the technology is still relatively difficult for educators to use routinely. The required high-powered computer systems are expensive and the software is relatively complex. However, this emergent field has great potential for e-learning in the future.

3.3 Audio and video

The principal communication component of face-to-face learning that is largely absent from e-learning is audio. When audio is fully integrated and interlaced with text-based and visual information, it can add an important dynamic dimension to e-learning environments. Thus, audio can significantly enhance static and animated visual elements. An extensive body of literature in educational psychology indicates that the predominantly text-based learning environment of online courses is in direct opposition to the way humans learn most effectively: audio narratives reinforced with visual elements (e.g., Mayer et al. 2005, Mayer et al. 2003, Reynolds et al. 2002, Moreno and Mayer 2000, Mayer and Anderson 1991). This research demonstrates significantly increased learning rates and knowledge retention occurs when audio is added to visual elements. However, high quality audio cues and narratives are largely absent from online education. This is largely due to three fundamental obstacles: production time, cost, and poor voice training of instructors. As consequence, the principal components of even the most comprehensive course Internet sites remain largely text-based with some multimedia elements. Courses with “chat” or discussion groups are entirely text-based and require intensive reading of text on a computer screen.

Using current technology and methods to produce high quality audio lecture (e.g., similar to professional radio broadcasts with no errors, extensive pauses, ”uhs”, or ”ums”) for online learning may involve many hours of production time for each one hour of completed audio lecture. With few exceptions, the audio is recorded impromptu with no editing or refinement. This is primarily due to the extraordinarily high production costs and limited expertise among faculty members for creating high quality voice recordings up to the standard of broadcast radio. Thus, an entire semester-long course online can amount to a considerable investment of time for the instructor. Revisions of audio lecture involve the same amount of time and effort in order to maintain recording quality and consistency. Even highly edited audio recordings will reflect the deficiencies of the instructor (poor voice quality, diction, and tonal quality); instructors with speech impediments or non-native English speakers are at a particular disadvantage for producing high quality audio narratives for online learning materials. A new technology with extraordinary potential to resolve these fundamental obstacles is enhanced synthetic speech, which is remarkably human-like in voice quality and expressiveness. Although many businesses (e.g., telephone companies, airlines, and corporations dealing with international clientele) are rapidly adopting synthetic speech technology, such technology is lacking in e-learning for the general learner and especially for learners that are reading and vision disabled (Harrysson et al. 2004).

A key advantage of synthetic speech is the substantial reduction in production time for the original recording and for any subsequent revisions. Producing audio with this technology for online learning materials is a straight forward procedure of digitally recording the audio that is produced as the synthetic voice software reads and speaks written text. A variety of voices are commercially available: variations of male and female voices, various English accents, and various international languages. The voices are highly expressive and human-like; pronunciation can be fine-tuned for special terms within a discipline. This completely eliminates the inherently poor quality of instructors' voices in audio recordings. The appropriate selection of a synthetic voice – or a combination of several different voices – can result in a high quality audio lecture for any instructor. In fact, one instructor could create multiple dialogs and discussions among virtual instructors or students, even with a mixture of female and male voices. Students could even select a particular voice for their learning environment. This approach to integrating synthetic speech is also highly relevant to emergent technologies such as "pod casting," where audio narratives are transmitted to personal audio players. Thus, integration of synthetic speech into online learning materials presents extraordinary possibilities for enhancement of teaching and learning.

Short video clips and streaming video lectures can also be very effective in e-learning. However, high quality video clips also have relatively high production time and costs; revisions over time can lead to inconsistencies in the presentation. High quality streaming video requires relatively high Internet transmission speeds. In contrast to video, audio can be more precisely integrated into learning materials for context-sensitive feedback that can range from short cues, pronunciation, and definitions, to extensive explanations to the learner while the learner reads, studies, and interacts with the text and visual course content.

4. Accommodation of different learning levels and styles

4.1 Context-sensitive responses

An important aspect of engaging and interactive learning environments is context-sensitive feedback to the learner's actions. Authoring systems (see above) provide built-in features that allow educators to easily design question elements with context-sensitive feedback and immediate evaluation (e.g., scoring of a question or an examination). Moreover, authoring systems allow the educator to design learning materials that emphasise active learning. For example, the inclusion of simple true/false and multiple-choice questions – whether inserted as context-sensitive elements within course content or provided as part of an examination – result in a passive learning style. The learner simply responds to the question by clicking the appropriate answer. In active learning, question elements can be designed so that the learner must move question elements in a particular manner in order to achieve the correct answer. For example, the learner may be asked to construct the molecular structure of a chemical from a set of chemical components. Or, in the field of ecology, the learner may be asked to construct the appropriate sequence of events (environmental factors, plant and animal species, etc.) that occur in the development of a forest from bare ground. In these examples, the learner is actively engaged in developing the solution to the question. At any point during the solution process, the learning environment can be programmed to automatically provide feedback to the learner in a manner that is relevant to the actions of the learner. Evaluation of learner's achievement and performance is also automatic, i.e., a customised evaluation for each learner is provided without additional input by the instructor. Because the feedback and evaluation are context-sensitive and automatic, the learning environment is independent of the number of learners. That is, scaling from small to large numbers of learners is possible without increased instructor time and effort.

There are a variety of ways to design and use context-sensitive elements in a learning environment. My approach has been to create discrete packets that combine a question that the learner answers and a response that evaluates the learner's answer (Figure 4). This packet combines a question to the learner, the learner's answer, and the response to the learner from the professor into a discrete unit. These packets can be inserted anywhere in a lesson to evaluate the learner's comprehension of the subject matter. Also, control codes can be used to easily branch various learners among novice, intermediate, and advanced learning levels.

A control element is added to the packet to control the type of branching that occurs through the lesson. Rather than the conventional pedagogical method of placing study questions at a particular point in the lesson (typically at the end of a section), context-sensitive control packets can be placed anywhere in the lesson. These packets can be actively presented to the learner based on what the learner is doing, or passively, where the learner has the option to initiate the question or not. This approach allows fine control over the flow of the lesson and evaluation of each learner's progress toward mastery of the subject matter.

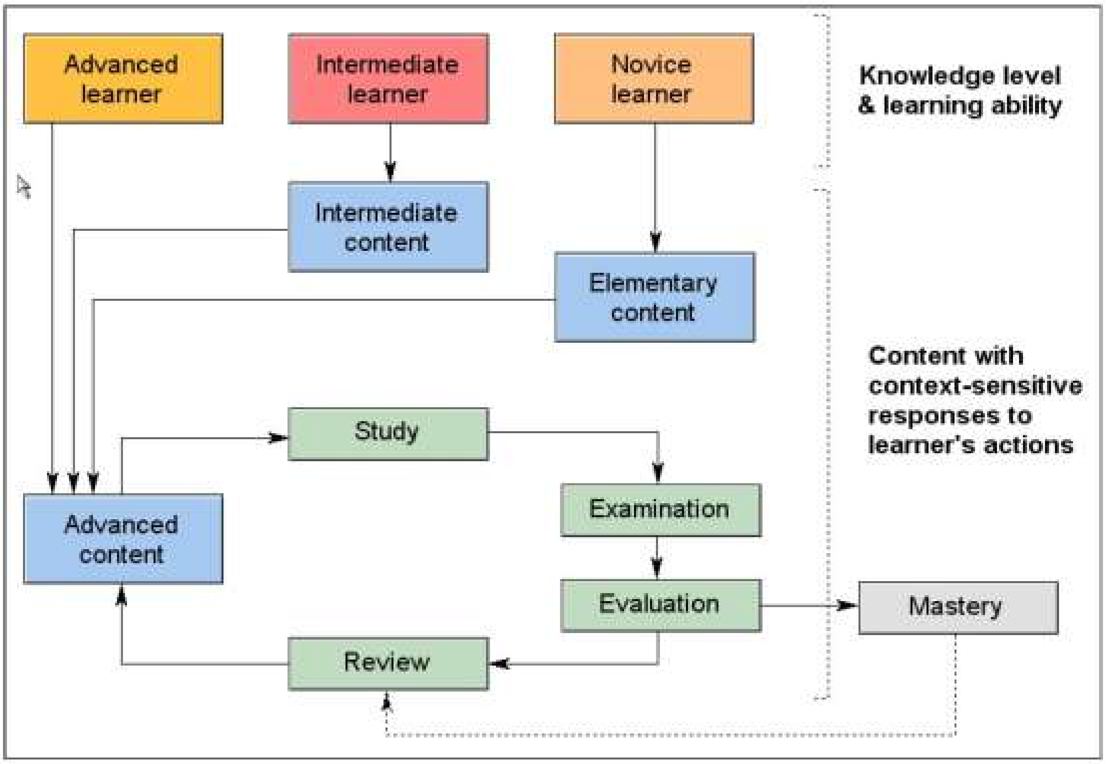

Figure 4. An example of a context-sensitive branching control packet.

Furthermore, the control aspects of the context-sensitive control packets can be used for complex branching patterns to dynamically shift learners among various learning levels, e.g., novice, intermediate, and advanced (see Section 4.2 below). Each learner's performance in a particular part of a lesson would determine the material that is subsequently presented to the learner. In this way, a learner who consistently exhibits a high level of mastery is continually presented with learning materials at the highest level and difficulty. In contrast, learners at the novice and intermediate levels would be presented learning materials at a level suitable for their learning style and pace. The various paths these learners take would continually progress toward the advanced level and on to mastery. The appropriate placement and number of control packets would influence the level of correspondence between the learner's interaction with the context-sensitive control packets and progress toward mastery. All learners could eventually master the subject matter.

4.2 Branching patterns in e-learning designs

The personalised instruction that occurs between instructor and learner is lost as the number of learners per instructor increases from one to many. In the case of the typical classroom or online course, all learners are essentially instructed in the same manner, regardless of differences in base knowledge, learning ability, and learning styles. Interactive nonlinear learning models have the potential to resolve this issue of scale by context-sensitive branching patterns (Figure 5). Such designs can automatically detect a learner's base level of knowledge and subsequently branch each learner to the appropriate level of subject content, testing, and evaluation. Also, because the learning design is nonlinear, each learner can determine his or her own learning style and pace. Such designs thereby simulate the individualised learning that would occur between an instructor and learner.

Figure 5: Model for simulating an individualised learning experience.

The learning design automatically detects the base level of knowledge of each learner and branches him or her to the appropriate level of subject matter. For example, novice learners may require the presentation of content at a more elementary level than for intermediate or advanced learners. All learners eventually reach the advanced level of content, which leads to mastery of the subject matter.

The primary goal of this branching model is for all learners to achieve the level of mastery of the subject matter set by the instructor. Regardless of their starting base of knowledge, all learners will eventually – at their own pace – achieve sufficient understanding to learn at the advanced level of subject content. Although Figure 5 illustrates only one learning cycle toward mastery, such a learning cycle can exist for each and every level of learning. By continuously alternating between content, examination, evaluation, and review, all learners will achieve mastery of the subject matter.

5. The third dimension in learning environments

Printed learning environments, e.g., textbooks and articles, typically present materials in a segmented manner in an order determined by the author (e.g., table of contents, chapter one, two, three, etc., and index). Computer-based non-linear learning environments (see Section 2 above) allow significantly greater flexibility for accommodating a variety of learning levels and paces. Typically, the designs are composed of a series of bifurcated pathways through which the learner navigates (e.g., Figure 3 above). By extending this to a three-dimensional design, I envision a learning environment as a sphere containing an entire set of information on a topic – including all appropriate multimedia elements (photographs, graphs, text, audio, video, and numerical data, etc.). A key difference from bifurcated pathways is that learners are free to select the starting point of their learning session anywhere on the sphere, rather than at a point determined by the instructor. In addition to selecting the starting topic on the sphere for a learning session, the information can be designed to be increasingly more detailed and complex as the learner probes deeper into the sphere. Thus, one learning sphere can accommodate the spectrum of novice to advanced learners.

Figure 6. The concept of a three-dimensional learning sphere that represents a complete set of information on a topic.

The topic could be narrowly focused (e.g., analogous to a book chapter) or very broad (e.g., analogous to a complete book). All appropriate multimedia elements are included. The learner can select any entry point into the learning sphere and navigate directly to any other subtopic.

With more comprehensive learning environments that address a variety of topics, many learning spheres can be integrated into a lattice framework (Figure 7). A variety of learning spheres are positioned onto the lattice by the instructor. Each learning sphere represents a complete topic that includes all information and appropriate multimedia. Even though the possible pathways in the lattice are predetermined by the instructor, learners can develop their own unique pathway among the learning spheres for an individualised learning experience. Fundamentally, the learning lattice represents the universe of knowledge determined by the instructor; the connections in the lattice are rigid and represent the possible navigation pathways. The instructor positions any number of learning spheres on the lattice, thereby increasing the knowledge base integrated into the lattice. Even though the lattice has rigid navigation pathways, learners can develop their own unique pathway among the learning spheres for an individualised learning experience. The instructor can continually add more learning spheres as well as increase the size of the lattice to increase the universe of knowledge available to the learner

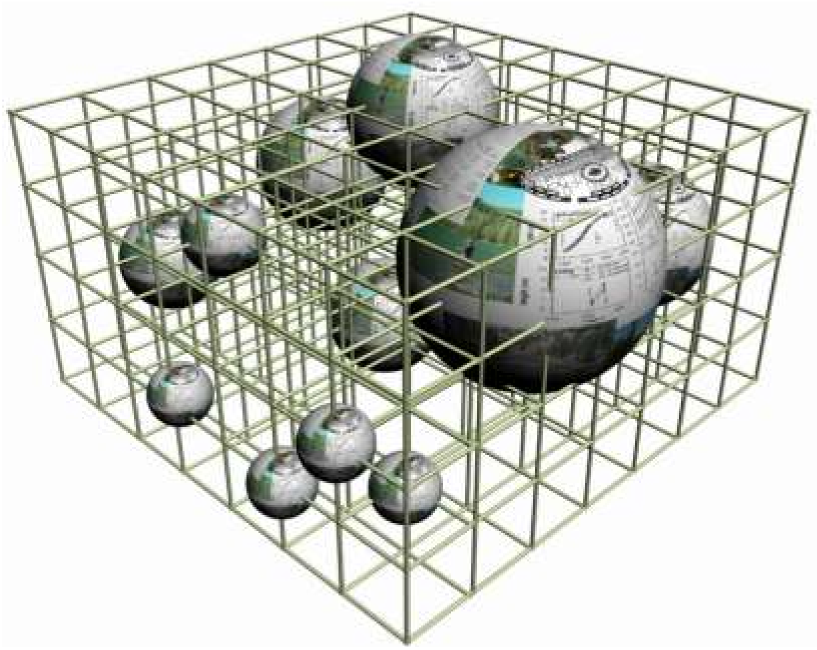

Figure 7. A rigid lattice that represents the universe of knowledge on a particular broad topic.

6. The total interactive learning environment: Guided independent learning

The nonlinear learning model combined with multimedia elements, context-sensitive feedback, and branching, has culminated in a comprehensive e-learning environment that I call guided independent learning. This pedagogical approach is learner-centred (Felder 2005), where the learner is primarily responsible for their learning toward mastery. Also, because my pedagogical approach and expertise are encoded into learning materials, learners are guided during their independent study. The learning materials that I have developed combined all the attributes described in the above sections and are available for review at: EcologyOnline.net. The learning materials I have developed are primarily for the science of ecology. However, these learning materials can serve as a model for e-learning in other subjects.

Learning materials that incorporate the interactive nonlinear designs I have discussed above provide a powerful pedagogical approach that simulates a highly individualised instruction for mass education. That is, individualised instruction is not a function of scale in regard to numbers of learners. The key pedagogical elements of guided independent learning are that: (1) the learning materials are learner-centred so that the learner is primarily responsible for mastering the subject material, (2) the instructor's pedagogical approach and expertise are encoded into the e-learning materials, and (3) the learning design is interactive, nonlinear, integrates multimedia elements, and contains context-sensitive feedback.

7. Conclusions

Although modern tools of information technology provide excellent opportunities for creating engaging e-learning environments, the dominant pedagogical approach for e-learning involves a linear or sequential design where the instructor determines a single-mode pedagogy for all learners. The emergent tools of information technology provide great potential for designing computer-based learning materials that are nonlinear, interactive, contain context-sensitive and active learning elements, and accommodate various learning levels and styles. When the educator's pedagogical approach and expertise are encoded into such learning designs, each learner can be individually guided in their independent study toward mastery. Even though the technical aspects of designing e-learning materials can be difficult for educators, it is essential to master the various tools of information technology in order to appropriately provide the educator's perspective in effective e-learning materials.

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