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Adaptivity in e-learning

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Abstract

Materials for e-learning often have a linear pattern where all participants are compelled to one-sided teaching which is contrary to interaction which appears in face to face learning. Thus, it will be ideal that electronic materials for learning are non-linear and interactive. Electronic materials for learning should be incompliance with content and should consist of active elements of learning. Also, they should be adapted to different learning levels and styles.

Keywords: adaptive, non-linear, e-learning

Introduction

Classical education, although surviving for millions of years, has some significant faults. One of the biggest is the necessity of attending lectures. That fact forces a participant to pay the costs of accommodation, travelling and other telecommunication services. There are also indirect costs of time spent on the travelling. Another important problem is that teaching is adjusted to a so called average student, while others, who do not belong to this category, cannot be included, no matter if the process of learning is too slow or too fast for them. With the wide use of computers and the Internet, new techniques of learning have been developed that are called e-learning, and can help overcome the above mentioned problems.

From the aspect of contemporary education, Learning Management Systems (LMSs) have a great influence on many aspects of a learning process and on the transfer of knowledge. They enable interface implementation based on the Web, and support a large number of activities, including forums, electronic study material, tests for student assessment, surveys and other contents. In other words, these platforms enable knowledge acquisition by performing different activities in the applications implemented in LMS surroundings and they force a team work (Cheng, Basu & Goebel, 2009; Moreno & Mayer, 2007).

Electronic universities are being created by uniting a large number of courses, and they can be completely independent or they can serve as a support to the existing universities.

When one passes the exams from the syllabi, he/she gains the same title as in any of the `real` faculties. In the context of this work, the term “faculty” refers to schools or department. However, here is also the same rule as at the classical universities: the higher rating of the faculty, the graduates find jobs more easily and have a possibility to choose companies and jobs.

Currently, most courses are for higher education and some specific special needs for industry.It should not be expected in the near future that e-learning is going to push back present primary and secondary schools, but faculties should remain the object of interest of investors in this area. Electronic learning is applied even in some industrial branches: for example, the employers can inform themselves about new products, workers about new technologies, clients with the application of the delivered devices, etc. The common thread for all this is better efficacy of the economical systems by introducing new knowledge through technological processes.

The great flexibility of e-learning is a significant advantage in comparison to the classical forms of education. With the traditional form of education it is not possible to attend a course at a time suitable for you, but at a time set by the institution. Secondly, the student needs to be present at a certain place that can be a problem if the student does not live close to the classroom. Thirdly, the students have to work at a pace determined by the institution and which cannot be changed. Besides this, in traditional education, a student cannot choose the amount or the structure of the material used for gaining knowledge. For example, a student may need to continue to study a certain area necessary for his profession even 10 years after the graduation. `Distance` learning provides him that, and its great flexibility motivates the student and improves his work satisfaction, which shows the efficacy of this kind of learning.

Generally speaking, the researchers have concluded that there are no significant differences in the students` achievements between online learning and traditional learning, but some of the online methods can lead to better learning results. (Bernard, Abrami, Lou, Borokhovski, Wade, Wozney, Wallet, Fiest, Huang, 2004; Fortune, Shifflett, Sibley, 2006; Herman, Banister, 2007; Talent-Runnels, Lan, Cooper, Ahern, Shaw, Liu, 2006; Weber, Lennon, 2007).

Modern tools of information technology provide excellent opportunities for creating e-learning environments. In recent years online learning via the 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 a sharp contrast to the pedagogy of 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 materials, and accommodate various learning levels and styles (Lee, Cheng, Rai, Depickere, 2004). Such e-learning environments, in which the educator`s pedagogical approach and expertise are encoded into the design, represents an effective and intelligent use of information technology for learning environments where each student is guided during their independent study. This goal is very hard to achieve, especially since educators are often not adept at computer programming or using other tools required to achieve such a goal.

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 style, and
3. Actively engage learners of different levels of knowledge.

Learning models

Linear learning models

The dominant learning design in e-learning, whether in the form of a lecture or a course site on the Internet, employ a two-dimensional linear or sequential pedagogy.

All learners are forced to use a 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, 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. Beginners, 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 learners 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 learners can only proceed at the average pace of the class.

The three-dimensional linear learning design is a variation that includes additional information elements on each page. Each page may contain an additional set of information elements such as definitions, comments and images. Although this design may appear nonlinear, and learners, regardless of their initial knowledge and learning style, still follow the same main learning path from start to end pages as predetermined by the instructor.

These additional elements may be comments, side notes, definitions or images. Within each page, the learner 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.

For learners who require a high level of guidance in their learning, the linear designs can be very effective. Information is presented in a logical manner from the elementary level to 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-enrollment 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 e-learning designs are a familiar extension. However, e-learning via the Internet provides great potential to accommodate learners of various abilities and levels.

Nonlinear learning models

The 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-enrollment 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 educational experience.

In contrast to the linear learning models where all learners follow a rigid path, 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-centered 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. 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 additional information that is necessary for learning (definition, images, audio, video, etc.) can be accessed directly. This design can accommodate linear and nonlinear learning styles, beginners 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 moving to the next 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 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 additional information through sub-windows.

Integration of multimedia elements for enhanced learning

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 & Jackson, 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. This is particularly the case for the sciences. 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 beginners may be shown visual elements in more elementary form, while more advanced learners may be shown more complex visual elements. Since this 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, Hegarty, Mayer, & Campbell, 2005).

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. 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 player`s actions. In this manner, interactive animations can be highly effective because they are immediate consequences and feedback to the learner`s actions.

The emerging field of visualisation represents an advanced form of animation. The goal of visualisation is to stimulate 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 extraordinary powerful tool, the technology is still relatively difficult for educators to use it 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.

Audio and video

The main 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 (Reynolds, Isaacs-Duvall, & Haddox, 2002). 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 a consequence, the main 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 lectures (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 extraordinary 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 lectures 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). 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, Svensk, & Johansson, 2004).

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 is reading, studying and interacting with the text and visual course content.

Accommodation of different learning levels and styles

An important aspect of engaging and interactive learning environments is context-sensitive feedback to the learner`s actions. Authoring systems provide built-in features that allow educators to easily design question elements with context-sensitive feedback and immediate evaluation (e.g., scoring questions or tests). Moreover, authoring systems allow the educator to design learning materials that emphasize 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. 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 the learner`s achievement and performance is also automatic, i.e., a customized evaluation for each learner is provided without additional input by the instructor. Since the feedback and evaluation are automatic, the learning environment is independent of the number of learners. That means that scaling from small to large numbers of learners is possible without increased instructor`s time and effort.

The personalized instructions that occur between instructor and learner are 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 instructed in the same manner, regardless of differences in base knowledge, learning abilities and learning styles. Interactive nonlinear learning models have the potential to resolve this issue of scaling by context-sensitive branching patterns. 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. Furthermore, since the learning design is nonlinear, each learner can determine his or her own learning style and pace. Such designs simulate the individual learning that would occur between an instructor and learner.

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, beginners may require the presentation of content at a more elementary level than 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. By continuously alternating between content, examination, evaluation and review, all learners will achieve mastery of the subject matter.

The nonlinear learning model combined with multimedia elements, context-sensitive feedback and branching has culminated in a comprehensive e-learning environment that is called guided independent learning. This pedagogical approach is learner-centered (Felder, 2005), and the learner is primarily responsible for his or her learning toward mastery.

Learning materials that incorporate the interactive nonlinear designs provide a powerful pedagogical approach that simulates highly individualized instructions for mass education. That is, individualized instructions do not represent a function of scaling in regard to the number of learners. The key pedagogical elements of guided independent learning are the following: (1) the learning materials are learner-centered 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.

Adaptive learning environment

The term adaptive is associated with a large range of diverse system characteristics and capabilities in the e-learning industry. A learning environment is considered adaptive if it is capable of: monitoring the activities of its users; interpreting them on the basis of domain-specific models; concluding user requirements and preferences out of the interpreted activities, representing them properly in associated models, and, finally, acting upon the available knowledge on its user and the subject matter to dynamically facilitate the learning process. The previous informal definition should differentiate the concept of adaptivity from those regarding reliability/configurability, flexibility/extensibility, or the mere support for intelligently mapping between the available media/formats and the characteristics of access devices (Paramythis & Stephanidis, 2004).

Categories of adaptation in learning environments

The first category, Adaptive interaction, refers to the adaptation that takes place at the system`s interface, and it is intended to facilitate or support the user`s interaction with the system, without modifying in any way the learning content. Examples of adaptations at this level include: the employment of alternative graphical or colour schemes, font sizes, etc., to accommodate users preferences, requirements or (dis)abilities at the lexical (or physical) level of interaction; the reorganization or restructuring of interactive tasks at the syntactic level of interaction; or the adoption of alternative interaction metaphors at the semantic level of interaction. Although interface adaptation can be thought of as generally independent from the material or content delivered through a learning environment, this is not usually the case with learning activities – the main differentiating factor is the emphasis on supporting a process in the case of activities. The dependency of learning activities on interface adaptation is a natural consequence of the fact that the interface encapsulates the tools for carrying out activities, whether they are interpersonal communication, collaboration towards problem-solving, etc.

The second category, Adaptive course delivery, consists of the usual and widely used collection of adaptation techniques applied in learning environments today. In particular, the term is used to refer to the adaptation that is used to tailor a course (or, in some cases, a series of courses) to the individual learner. The intention is to optimize the fit between course contents and user characteristics/requirements in order to obtain the optimal learning result, while in join work, the use of time and interaction are brought to a minimum. In addition to time and effort economy, major factors behind the adoption of adaptive techniques in this context include: compensation for the lack of a human tutor (who is capable of assessing learner`s capacity, goals, etc. and advise on individual curricula), improvement of subjective evaluation of courses by learners, etc. The most typical examples of adaptations in this category are: (re)structuring of dynamic courses; adaptive navigation support and adaptive selection of alternatives (fragments of) course material (Brusilovsky, 2001).

The third category, Content discovery and assembly, refers to the application of adaptive techniques in the discovery and assembly of learning material/content from potentially distributed sources/repositories. The adaptive components of this process lie in the utilization of adaptation-oriented models and knowledge about users typically derived from monitoring, both of which are not available to non-adaptive systems that engage in the same process. There is a distinction between the perspective of the individual learner wishing to locate relevant material within a (possibly constrained) corpus and the perspective of the author or aggregator who undertakes the task of putting together a course from existing materials and targeting a specific audience – or, seen differently, collecting and tailoring material for accommodating specific user/context characteristics.

The fourth category, Adaptive collaboration support is intended to capture adaptive support in learning process that involves communication between more persons (and, therefore, social interaction), and potentially, collaboration towards common objectives. This is an important dimension to be considered as we are moving away from isolationist approaches to learning, which are different from what a modern learning theory increasingly emphasizes: the importance of collaboration, societies of learners, social negotiation and apprenticeship in learning (Wiley, 2003). Adaptive techniques can be used in this direction to facilitate the communication/collaboration processes, ensure a good match between collaborators, etc.

Models in adaptive learning environment

All the above mentioned categories of adaptation in learning environment are based on a well-established set of models and processes (Paramythis, & Stephanidis, 2004)

- The domain model: Since the current adaptive learning environment is focused on adaptive course delivery, domain-, or application-model is usually a representation of the course that is being offered. However, in those cases where general learning activities are supported, the domain model may additionally contain information about workflows, participants, roles, etc. The most important aspect of adaptive-course models is that they are usually based on the identification of relationship between course elements, which are subsequently used to decide upon adaptations (Brusilovsky, 2003).

- The learner model: The term learner model refers to a special case of user models, created for the domain of learning. The specific approach to modelling may vary between adaptive learning environments. Yet, there is at least one characteristic that is shared by all systems: the model can be updated at interaction time to incorporate elements or traces of the user`s interaction history. In other words, the learning model in adaptive learning environment, not only encapsulates general information about the user (e.g., demographics, previous achievements, etc.), but also maintains a live account of the user`s actions within the system.
- Group models: Similarly to the user model, group models capture the characteristics of groups of users. The main differentiating factors between the two are: (a) group models are typically assembled, and not filled dynamically, and (b) group models are based on the identification of groups of learners that share common characteristics, behaviour, etc. As such, group models are used to determine and describe what makes learners similar, or not, as well as whether any two learners can belong to the same group. This dynamic approach to identifying groups and user participation in them is already used widely in collaborative filtering and product recommenders, and promises a lot in the context of e-learning.
- The adaptation model: This model incorporates the adaptive theory of an adaptive learning environment at different levels of abstraction. The adaptation model defines what can be adapted, as well as when and how it is to be adapted. The levels of abstraction at which adaptation may be defined, range from specific programmatic rules that govern the run-time behaviour, all the way to general specifications of logical relationships between the adaptive learning environment's entities that are automatically applied at run-time.

Conclusion

In recent years, we have been witnesses to the growing awareness of the potential benefits of adaptivity in e-learning. This has been reinforced with the understanding that the ideal of personalized learning (i.e. learning coordinated with user`s specific demands and affinities) cannot be obtained, particularly not with the mass use of traditional approaches. The factors that contribute to the move in this direction include: the differences in the population that is a part of the education process (intensified by the gradual accomplishment of lifelong education); different approaches to the media, and the manner in which a person can efficiently use them, in order to approach, manipulate or take part in the work on educational content or learning, and at the same time with different uses of such technologies; the expected multiplication of free educational contents necessary to fit the learning subjects, space and activities, etc.

Adaptive systems are not so flexible for integration in existing LMS and it is one of their main disadvantages. Moreover, the content of the course cannot be reused. This paper represents a theoretical overview of adaptive e-learning and it is not based on specific research. Future research could develop the concept for providing and integration of adaptive courses, which are based on learning styles, in system for e-learning. This concept could be implemented as an addition to Moodle and its efficiency in students' process of learning could be evaluated.

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