

## THEORETICAL ASSUMPTIONS FOR DESIGNING HYPERTEXT AS A CONSTRUCTIVIST LEARNING ENVIRONMENT

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**Abstract.** This discussion brings together three different perspectives, – from cognitive science, ergonomics and learning – that are crucial to consider in the process of designing hypertext as a constructivist environment for learning. The critical implications from all the perspectives are illustrated in several screen shots from one concrete hypertext application for learning of Pascal programming.

**Key words:** hypertext, learning theories, constructivism, nonlinearity, cognition, interactivity, ergonomics, usability.

**1. Introduction to educational hypertext.** For more than forty years technologists and educators have proclaimed the use of technology as the answer to the needs of education. Since the early days of computer the goals of technology in education have been defined broadly to include: Reaching those who are geographically constrained, providing tools for those that are handicapped, reducing the cost of education, increasing the effectiveness and efficiency of education (Krueger, 1993). The advent of new information technologies have not changed these goals: Computers are increasingly used in situations in which large amounts of information have to be stored and retrieved for some purpose. Especially the idea of hypertext has become the key to how we access and present information. The developers of educational software have especially been inspired by the possibilities to organize information, which is not limited to the linear presentation form typical to printed materials. Educational hypertext applications display data in multiple formats simultaneously (text, still images, animations, video, voices, sounds, music); this enables people with various learning styles (visual, auditory, symbolic) to initially examine material presented in their preferred mode of communication.

**2. Different types of educational hypertexts.** In recent years many stand-alone hypertext-based teaching applications were developed and are available on

CD ROM; also many educational hypertexts exist on WWW (e.g., The Victorian Web, developed by George Landow (1995), GEMBA – teaching business administration, StudioPhysics course, Variations music library, etc.).

The rapid development of hypertext systems has created research into how to design and use hypertexts. Most of current educational hypertexts tend to focus either on the *presentation of knowledge*, or on the *representation of knowledge*.

A common assumption used by hypertext proponents for using hypertext to present information is the belief that printed knowledge is inherently linear and often has ordering forced on it by the print medium. In contrast, hypertext systems eliminate such constraints in the presentation of knowledge; thus, they allow users to browse more freely through a data structure (Nielsen, 1995). In other words, knowledge presentation systems provide databases that can be browsed and searched in order to read or view information. Easy and fast access to the knowledge pieces needed by the student is a frequently used argument for the superiority of such of hypertext applications as learning environments. Designing hypertext as the presentation of knowledge many developers assume that readers know what sequence of information is best for them, that they can tell when they have read enough or judge whether what they are reading is important. A good example of knowledge presentation systems is that of electronic encyclopedias (see, for e.g., “Microsoft Encarta’97 Encyclopedia”; “Compton’s Interactive Multimedia Encyclopedia”; “The British Multimedia Encyclopedia”).

Other researchers investigate the challenges of representing knowledge in an advanced storage and retrieval system: According to this approach, in hypertext, links enable semantically and logically related information to be tied together in conceptual webs (Jonassen, 1993). Many assume that this representational architecture of hypertext systems allows to mirror some of the associational power of human memory. In other words, knowledge representation systems attempt to make explicit the relationships between the information contained in the nodes. It is often assumed that knowledge representation systems are designed to show expert knowledge. However, research shows that simply providing an advanced knowledge representation system does not guarantee that more effective or efficient learning will occur (Duffy and Knuth, 1990). Also, it was reported that the effectiveness of various features that can be used in hypertexts is determined by the domain, the goals and the experience of the reader (Rouet, 1992; Balčytienė, 1996; Shnotz, 1996).

Only recently some developers proposed a next generation of hypertext systems that will target the *construction of knowledge* (Dede and Palumbo, 1991; Jonassen, 1996). According to this approach, hypertext holds the potential for users to access tools by which they can construct personalized experience be-

tween the information to be accessed in the learning system and their own cognitive structure. It is accepted that this hypertext feature would *truly individualize* the information environment. In other words, **a more constructivist environment – where the learner not only browses the information base, but also has the ability to interact with the existing information holds more promise to promote meaningful learning** (Nelson and Palumbo, 1992; Jonassen, 1996).

**3. Needs and aims.** According to modern learning theories, technology-based learning environments should support constructive learning processes and enhance more active learning strategies in passive learners (Glaser, 1991; Salomon, 1994). **The goal of instruction is no longer primarily to impart new knowledge in readily accessible form but to facilitate the student's own attempts to construct meaning.** Therefore, the main question in design of educational software should be “How can we create situations which facilitate learning?”. This question points to the issue that the process of designing a hypertext-based learning environment should not mean producing the knowledge to structure the students' learning processes, but rather *creating situations* and offering *tools* that help students to make use of their own cognitive potential (Salomon, 1994; Scardamalia *et al.*, 1989; Hakkinen, 1996; Jonassen, 1996). Therefore, the critical issues from the cognitive science (What reading strategies must come into play when students work with hypertext materials?), ergonomics (How to support physical use of the material?) and modern learning theories (How to create more “authentic experiences” in learning situations?) must be combined to produce the light into design of acceptable educational hypertext.

#### **4. An alternative approach on hypertext design: the perspectives of cognitive science, ergonomics and learning**

**4.1. Hypertext and cognition.** Simply speaking, hypertext assumes a world of multiple texts. Therefore, most important theoretically is how readers understand and use multiple texts. Although hypertext differs significantly from printed text in its arbitrary structure, it shares many similarities for the reader: Hypertexts are composed from paragraphs and links and there is no reason to believe that at least at paragraph level the user will read differently than from the traditional paper (McKnight *et al.*, 1993; Rouet and Levonen, 1996; Dillon, 1996). Thus, a cognitive model of reading hypertext may use some concepts of traditional text comprehension research. Research on reading comprehension reports that structural features of text (e.g., organizational structure, grammatical complexity, vocabulary) affect the ways in which they are read. Most importantly, the reading research indicates, that people conceive of text as a collection of ideas

that author has carefully selected, framed and organized into some sequence in hope of influencing a reader's *knowledge* and *actions* (Kintsch, 1986). Therefore, it is hypothesised that, **in hypertext-based learning environment, every learning situation should generate a content specific and goal-oriented activity to ensure that meaningful learning will occur.**

**4.2. Using hypertext to study: the perspectives of ergonomics and learning.** Both ergonomics (or human factors) and educational theory seek to understand what it is about the use of technology in educational contexts. The perspective of ergonomics deals with designing of usable technology. More specifically, it takes focus on developers of hypertext systems to produce a technology that supports user's learning tasks. In other words, **ergonomics emphasizes aspects of usability rather than increase in learning.** According to ergonomists (or human factors professionals), learning may be enhanced by certain technological inputs to the educational context, but only if the technological input (e.g., the search mechanism or nonlinearity) is usable and not solely a result of that technology's presence (Dillon, 1994).

The modern learning theory – constructivism – suggests that meaningful learning occurs when learners engage in personal, constructive processes of sense-making when they cope with new information (Resnick, 1989). Thus, **there can be no "true" representation of knowledge, only personal interpretations constructed through personal experience.** According to this perspective, the transfer and use of knowledge for real-world problems could be facilitated by hypertext systems which emphasize more "authentic experiences" (Spiro and Jehng, 1990; Jonassen, 1996).

Altogether, the ergonomic and educational issues are located at different levels of analysis but are intertwined when we seek to understand just what it is that hypertext may offer in pedagogical contexts.

**5. A case study: A combined approach to designing hypertext as a constructivist environment for learning.** On the basis of the above theoretical remarks three principles (perspectives from the cognitive science, ergonomics and learning) for designing a hypertext-based learning environment for a complex domain will be introduced. These three principles will be illustrated in screen copies depicting hypertext that was designed for learning basic programming concepts.

Educational hypertext "Informatika" was developed with Asymetrix Tool-Book version 3.0 program which is running under Windows. As a matter of fact, the textbook – Informatika (Dagienė and Grigas, 1995) – was converted and adapted for presentation as hypertext. Several technical requirements apply to this particular learning system. In particular, computer Pentium 100 or higher,

Windows'95 Operating System, 3.0 Mb or more HDD space, 16 Mb or more RAM, 256 colour and 640 × 480 resolution display. The hypertext reading consists of more than 150 information nodes (computer screens) and, in general, covers the following issues: Introduction to logic; Introduction to basic concepts of Informatics; Introduction to the theory of algorithms; Basic principles of Pascal programming language. Over 50 practical exercises on principles of logic and Pascal programming are included in the program. Also, two general restrictions apply to the hypertext database "Informatika". First restriction deals with type of information presented with hypertext: Domain of Pascal programming language was selected as the particular ill-structured domain which includes references to logic and Informatics. The second restriction is the type of hypertext structure: The combination of information from a complex domain and presentation with hypertext was chosen because assumptions exist about the possible advantages of presenting complex information with hypertext (see, for e.g., Spiro and Jehng, 1990). No attempts are made to make generalisations about other types of information or other types of hypertext structures.

It is not the goal of this paper to discuss the hypertext design process in detail. Rather, the attempt is made to indicate the particular theoretical issues that were taken into consideration in the process of developing hypertext as a system for knowledge construction.

### 5.1. Three basic principles of hypertext design.

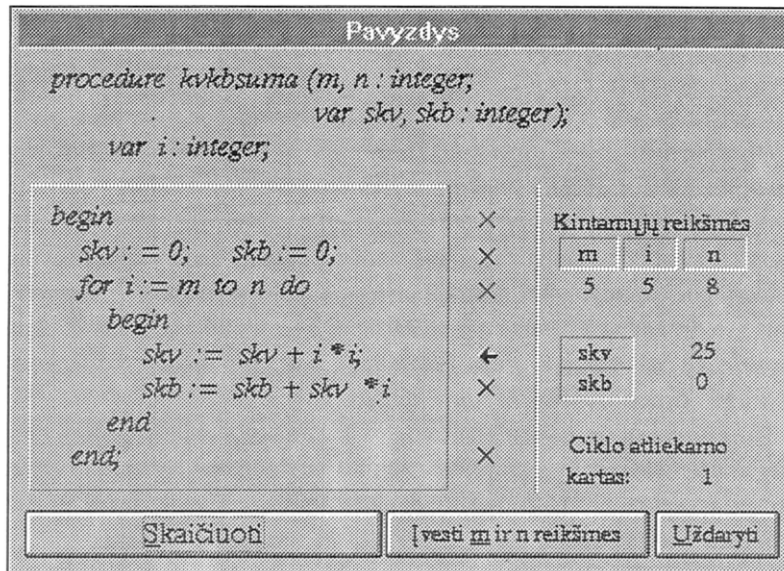
**5.1.1. The perspective of cognitive science.** It was mentioned earlier, that the hypertext-based learning environment should encourage hyperreaders (i.e., hypertext readers) towards a *goal-oriented activity* that is related to the essential topics of the domain to be learned. In other words, **in a learning context, hypertext should be considered as a cognitive tool that helps the planning, fulfilling and reflecting the activity.** For example, when entering the program "Informatika" the reader gets to the main menu – the Contents node where all the titles of the information items of the hypertext system are presented. The menu consists of two major issues – Information (with 5 smaller information items) and Algorithms (with 17 smaller information items) – and has a fully interactive "topic selection" capability that allows students to select one or several related information items and explore them in sequence.

Because constructive learning relates so closely to the creation of certain kinds of memory representations by learners themselves a very important role for the learner himself cannot be missed or denied. Only learners themselves can be active participants in the learning process. Under the particular hypertext design it is hypothesized that **the reader will not primarily start reading the**

**hypertext as such, but will begin to plan and fulfil a complex activity.** In other words, the system prompts the reader (depending on his or her previous experience, interests or the task of the moment) to select one or few research topics from all the information that is available in the application. According to the cognitive perspective, clearly defined learning goal – to select several related topics from the main menu – will activate in learners decision making strategies (i.e., metacognitive strategies) and, therefore, will stimulate active knowledge construction processes among people who may initially doubt their own ability to participate in independent thinking.

**5.1.2. The perspective of ergonomics.** The perspective of ergonomics fosters the user-centred design of technology and basically leans on the *usability* aspects rather than on any assumptions from learning theories. In particular, ergonomic analysis conceptualizes the technology only as a support element of the learning environment and places emphasis on ensuring usability from the learner's perspective. In other words, the usability aspects focus on questions such as *how* and *why* the application will be used: It deals with manipulation skills and facilities that support physical use of the material. For example, one solution for a particular problem solving situation (i.e., of how to present an additional information) can be illustrated from the program "Informatika": The program opens an extra window every moment the user decides to explore the execution of a Pascal code example. The code's text color and style are selected to indicate example's double meaning – firstly, to show the example procedure and, secondly, to open another program window with interactive exercise whenever the user "double-clicks" on it. In other words, the particular example acts as a hotword (or hyperlink) and can be activated (by double-clicking) to open an extra program window (see Fig 1.).

**5.1.3. The perspective of learning.** A basic claim of hypertext proponents is that these systems are effective as a learning medium: Users can access a large knowledge base and seek out information that meets their particular needs, in terms of both their prior knowledge and their preferred approach to learning. Therefore, to develop hypertext as a constructivist learning environment means to define the level of *interactivity* promoted by the learning system (Nelson and Palumbo, 1992). A learning system that provides the user with a choice of direction in terms of information presentation does promote some level of user-control. True interactivity, however, refers to "the possibility of an audience actively participating in the control of an artwork or representation" (Cameron, 1995). Therefore, there might be different levels of interactivity – ranging from the interactivity which is based on merely selecting concepts from the Contents



**Fig. 1.** This example window (called Pavyzdys) opens under the highlighted hotword. The user can change the input values of variables  $m$ ,  $i$  and  $n$  and explore all the steps of loop execution (see how the values of variables  $skv$  and  $skb$  vary)

list towards true interactivity which allows the reader to intervene in a meaningful way within the representation itself (i.e., not just to read it differently).

The particular form of interactivity we can experience in "Informatika". Fig. 1 illustrates the reader's interaction with the domain information (the reader is expected to change the input values and explore the result of such an activity). This form of interactivity can be located somewhere between the two previously mentioned levels.

**6. Summary and conclusion.** Hypertext offers a framework for the storage, rapid retrieval and easy manipulation of information, therefore, it has a potential role to play in many learning situations. My aim in this paper was not to predict the future of educational hypertext. Rather, I attempted to highlight three issues in hypertext design in which the development would seem desirable.

In this paper I have presented some of the cognitive, ergonomic and educational issues that are essential to consider when designing hypertext as a constructivist environment for learning. In particular, these issues are: The *goal-oriented activity* (to activate the reader's prior knowledge and to promote the development

of metacognitive reading strategies); the *usability* of a hypertext system (to support physical use of the material); the level of *interactivity* offered by a learning system (to engage the reader into learning not *from* technology, but *with* technology).

The message – “Hypertext-based learning should not be equated with the simple processes of reading from the screen” – is the main message of this paper. More specifically, it is suggested that a combined approach which takes both the task (goal-oriented activity) and the learner (usability and interactivity) characteristics into account holds promise in designing hypertext as a constructivist learning environment. **Hypertext-based learning is viewed as an active process of knowledge construction where technology is used to facilitate information access and ensure usability and interactivity.**

The success of the educational system “Informatika” will be judged on the ability to help learners to achieve their aims. Therefore, the direction for further hypertext research will be to investigate how students actually learn with this particular hypertext design.

**Acknowledgements.** This work was partly supported by a grant from the Lithuanian State Science and Education Foundation under contract Nr. 96–117/4D. I want to express my thanks to Evaldas Bačiulis who developed the hypertext system “Informatika”. I’m also extremely grateful to Professor Valentina Dagienė for her valuable advice.

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## **KONSTRUKTYVIOS HIPERTEKSTINĖS MOKYMOŠI APLINKOS PROJEKTAVIMO TEORINĖS PRIELAIDOS**

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Šiame straipsnyje į mokymosi aplinkos kūrimą yra žiūrima trimis skirtingais požiūriais: kognityvinės psichologijos, ergonomikos ir šiuolaikinės mokymosi teorijos – konstruktyvizmo. Aprašoma ir iliustruojama praktinė visų trijų požiūrių visumos realizacija – hipertekstine programa Paskalio programavimo kalbos mokymuisi.