Efficient learning from multimedia web-based learning contents

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Web-Based Learning Contents (WBLCs) are becoming increasingly important learning sources. They should not be just transpositions of traditional learning materials into electronic formats. Constructivist theories of learning should be implemented to enhance learning and to ensure the student a meaningful learning experience. WBLCs should be interactive and appropriately designed. The intention of this article is to give advice on how to create efficient WBLCs, to examine students' learning behaviour and to present their opinion about certain design questions, such as the length of learning-pages, paragraphs, graphic-elements, communication and applied interactivity-elements.

Keywords: Multimedia; Web-Based Learning; Web-Based Learning Content

1. Introduction

Our research is based on the multimedia WBLCs used within the scope of the PHARE project "Improvement of computer literacy of unemployed adults". 3300 unemployed persons took part in the web training using the adapted Learning Management System eCampus that enables the use of web-based pedagogical tools as scaffolds for self regulated learning, such as collaborative and communication tools, content creation and delivery tools, administrative tools and assessment tools.
The WBLCs in question were developed considering recent findings in the field of web-based learning:

- Constructivist learning theories,
- appropriate graphic or audio content presentation and effective use of multimedia elements

2. Theoretical framework

2.1 Implementing constructivist learning theories

For creating WBLCs researchers suggest the implementation of constructivist and socio-constructivist theories of learning [1, 3]. According to the constructivist theory, articulated by Jean Piaget, learning is an active construction of knowledge. Individuals build knowledge on previously acquired knowledge and experiences through the processes of accommodation, assimilation and adaptation. Therefore it is very important to be aware of the learner's abilities as well as his previously acquired knowledge and to stimulate his activity [12]. On the Web active learning can be enforced by the use of interactivity, e.g. interactive questions, online tasks, online assessments, hyperlinks, and interactive multimedia elements such as simulations, interactive games, interactive video, etc. Elements of activity increase students' motivation and active learning [1, 3, 12].
According to Vygotsky, the process of learning and cognitive development is dependent on social interaction. Students should therefore collaborate with a teacher and among themselves.
On the web, learning can be enhanced with scaffolding and instructional scaffolding [3] where the teacher provides supports to facilitate the learner's development. Scaffolds encourage the student's ability to build on prior knowledge and internalize new information [13].
McKenzie [8] states the characteristics of scaffolded web-based learning:

- Providing clear directions, e.g. offering step-by-step instructions.
- Providing activity (e.g. keep students on tasks).

- Offering assessments to clarify expectations.
- Clarifying the purpose: "Why are we doing this?" Scaffolding keeps the idea and motivation in forefront. Built around essential questions scaffolding helps to keep the "big picture" central and in focus.
- Pointing students to valuable web sources and therefore helping them to save time.

Our research confirms that students like interactive questions and online assessments as they act as motivators, give instant feedback and strengthen gained knowledge.
Furthermore, there are some other advices an author of WBLCs should follow: Chickering & Gamson [2] believe that quality teaching and learning should encourage the student - teacher contact, encourage cooperation among students, active learning, give prompt feedback, emphasize time on task, communicate high expectations, and respect diverse talents and ways of learning.
Authors should use the first person plural to address students, making instructions not sound as commands. Addressing students in first or second person plural facilitates the cooperation between teacher and student. Mayer [6] called this a personalization effect in which students learn more intensively when words are presented in conversational rather than formal style. A good teacher communicates with his or her audience throughout the time in the classroom and this must be in some way (e.g. with the help of communication tools and through the style of writing WBLCs) transferred onto the web. Successful learning is easier to achieve when students receive fast feedback [1-3].
Course and content designers should pay considerable attention to scaffolding the student's self-regulated learning processes (e.g. goal setting, self-monitoring, self-evaluating, task strategies, help seeking, time planning and management) to ensure successful learning [3].
The style of writing or narration is also important: emphasis should be made on essential elements, rational expressions and composing short, clear, understandable sentences [9-10].

2.2 Efficient design

Efficient WBLCs are interactive and well designed: graphic design and the appropriate use of multimedia can enhance the learning-process, increase motivation and ensure valuable learning experiences [1, 5-7].
Research shows that students dislike reading long texts from the web, long paragraphs and narrations. Nielsen [10] believes that people rarely read web pages word by word. Nielsen & Morkes [9] claim that 79 % of users scan the page, picking out individual words and sentences and only 16 % of users read word-by-word. Our study shows that students probably read educational web pages more carefully but they are nevertheless particularly inclined towards specially formatted and added comments, such as interesting points, hints and warnings.
Visual presentation of learning material is highly important as it can enhance learning or impede it with counterproductive overload of sensory channels [5-7]. Multimedia goes beyond visual presentation - as it is an extremely important and essential element of efficient WBLCs it requires special attention. Different presentation modes are used to cater to students' different learning styles, cognitive abilities and to ensure efficient learning.
Research over the past two decades has produced mixed results about the effects of multimedia on learning. The inconsistencies are most likely due to the fact that there are multiple factors operating, as has been proposed in the integrated model of multimedia learning [4]. The use of multimedia tools must be carefully planned in order to avoid a counterproductive overload of sensory channels. In recent times cognitive psychology has progressed and many of the major findings in this field have been of use in instructional design of multimedia educational materials. Mayer presents a cognitive theory of multimedia learning which draws on dual coding theory, cognitive load theory and constructivist learning theory [5-7]. Mayer [5] considers that human working memory is limited and that people process visual and verbal information (e.g. narrated and online text) in separate cognitive channels, which work simultaneously. Considering this theories Mayer suggests the set of design principles.
The used WBLCs were created considering following cognitive key principles or effects [5]:

- *Redundancy*: Use animation and narration rather than animation, narration and on-screen text.

- *Coherence*: Exclude extraneous words, pictures and sounds.
- *Spatial contiguity*: Present corresponding words and pictures near rather than far from each other.
- *Temporal contiguity*: Present corresponding words and pictures simultaneously rather than successively.

Following principles were not strictly implemented.

- *Modality*: Present animation and audio narration rather than animation and on-screen text.
- *Multimedia*: Present words and pictures rather than words alone. Words can be narrated or printed.

Mayer claims that design effects are stronger for low-knowledge learners than for high-knowledge learners, and for high-spatial learners rather than for low-spatial learners [5]. Mayer agrees that learners with higher prior knowledge seem to be able to construct a mental model of the described content also only from the text. Some researchers claim that dual coding theory is not sufficient to explain multimedia principle. Schnotz & Bannert [11] indicate that presenting graphics is not always beneficial for the acquisition of knowledge. Their study suggests that pictures facilitate learning if individuals have low prior knowledge and if the subject matter is visualized in a task-appropriate way [11].
Furthermore, Mayer's principles were established in the context of numerous experimental studies where students had to learn about simple mechanical systems such as brakes and pumps. However, it can be assumed that some subjects can hardly be presented depictive.
When considering the implications of the modality principle it is important to be aware of circumstances that may impact its application. These circumstances can include the capability of student's hardware to support audio, his hearing ability and whether the physical environment is appropriate for audio.
Therefore the multimedia principle should be implemented considering learners' prior knowledge and whether the subject matter is visualized in a task-appropriate way. The modality principle should be implemented considering the learning environment and cognitive abilities of the learners.
Nevertheless we can assume that pictures related to the subject variegate the content representation and therefore influence learners' motivation. Our research shows that students are fond of pictures and animations.

3. Research

3.1 Methods

Research design

We carried out research using the e-Campus LMS system as the learning environment. The entire group of students who participated in the e-learning course on MS Excel in September 2006 had been chosen as an experimental group. The results were captured by means of an online questionnaire and by means of analysis of LMS logs.
Students studied at home or in libraries and schools on PCs with public internet access and with the help of WBLCs for the MS Excel module "Formulas and functions" that had been created considering the above described theory. The designed WBLCs are meant for self-directed learning. The following table shows technical data of WBLCs.

Number of pages with						Total number of pages
pictures	animations	pictures or animations	interactive questions	online tasks	assessments	
15 35,7 %	13 31 %	28 66,7 %	14 33,3 %	9 21,4 %	4 with 6 questions each	42

The length of learning pages varied between 771 and 2374 pixels (screen-length 1-4, resolution 1024x768), with an average of 1071 pixels. Students could choose between two types of animations:

animation with online text or animation with audio narration. Interactive questions for formative assessment were located at the bottom of certain learning pages, a randomly chosen assessment appeared after each paragraph with a final, summative assessment at the end of the WBLC. At the top and bottom of each learning page were two navigation buttons for moving back or forward.

Participants

A randomly chosen group of 55 participants (e.g. unemployed persons) was examined and 51 of them filled in the questionnaire. The results showed that 65 % of the participants had finished secondary school and the remaining 35 % high school or higher.

The procedure

All participants followed the same procedure in the learning process. They started with a conventional lesson in classroom where they met the teacher and continued the learning-process using the WBLCs on the specially designed learning portal that enabled them to collaborate and communicate with each other and the teacher. The teacher guided students and motivated them to take part in the assessments. The e-course on MS Excel consisted of seven modules and ended with the ECDL examination.

In our research we used the inspection method and user testing. We studied user inputs such as clicking of navigation buttons, scroll buttons and other interactive items such as hyperlinks, interactive questions and animations that were recorded in a log. We also observed what kind of animations students prefer, if they made personal notes in WBLCs and if they contacted teachers on their own initiative. Finally we analyzed log files and compared results with the learners' responses obtained from questionnaires.

3.2 Results and discussion

Results

After studying with the help of WBLCs, 46 students (83,6 %) participated in the ECDL examination and 45 of them passed the exam successfully.

The inspection shows that

- students visited each learning page 2,13 times in average,
- 60,3 % of the visits on pages that were longer than 1 screen ended with clicking the bottom navigation buttons while at least 12,6 % did not,
- 83,6 % of the participants answered all interactive questions at least once,
- 20 % of the students took actively part in the forum,
- 3,6 % of the students made personal notes in the WBLC,
- 1,8 % of the students sent questions to the teacher,
- the results from the final knowledge assessments correlate to the results of the ECDL exams.

The results of the questionnaire are presented in the next tables.

How should the content be designed to act as a learning motivation?	**Agree**	**Undecided**	**Disagree**
The length of the learning page should be less than 2 screens.	70,6 %	2,0 %	27,5 %
The paragraphs should include less than 5 lines.	64,7 %	27,5 %	7,8 %
All learning pages should be of nearly equal length.	52,9 %	37,3 %	9,8 %
Each learning page should have interactive question for knowledge evaluation.	74,5 %	21,6 %	3,9 %
Specially formatted comments or important explanations enhance learning.	76,5 %	11,8 %	11,8 %
The learning page should indicate the amount of already learned pages.	84,3 %	5,9 %	9,8 %
The learning page should include verbal and pictorial information.	92,2 %	2,0 %	5,9 %
The learning page should include animations.	39,2 %	7,8 %	52,9 %

In the questionnaire we also asked students what kind of verbal presentation of information they preferred in animations: 27,5 %, preferred audio narration, 33,3 % online text, 37,7 % found audio narration plus online text to be better.

We also asked students why teachers were posed so few questions. 42,9 % of students answered that questions were not necessary, 26, 5% rather asked other students or friends, 30,6% were afraid to ask.

Discussion

Learning pages that most effectively motivate students to study should be less than 2 screens long, of approximately equal length and should have verbal and pictorial information. They should include specially formatted comments or important explanations, interactive question for knowledge evaluation, paragraphs with less than 5 lines and the indicated amount of already studied learning material or pages.

According to the constructivist learning theory, communication, collaboration, and activity enhance learning. However, students rarely make personal notes in web-learning material, ask questions or contribute in forums. Teachers should therefore encourage them to communicate and collaborate.

According to the results we can conclude that students read learning pages more carefully as ordinary web pages. They do not prefer narration in animation (e.g. implementation of modality effect) over online text. This it is not surprising as people in Slovenia are used to read subtitles when watching foreign movies. Therefore, students should have the possibility to choose the way verbal information appears in animation (audio narration; online text; audio narration and added online text after narration). As we did not assure an identical environment and all three types of animations to choose from, this subject should be further investigated. Nevertheless, we can suggest that students should have the possibility to choose the type of animation according to their desires, cognitive capabilities, technical equipment and learning environment. The better option would be WBLC adaptive to learners' choices.

Conclusion

Elements that enhance student's activity, enable online assessments and provide instant feedback are highly recommended for the use in WBLC-design. Each learning page should have interactive question for immediate knowledge evaluation. Students should be able to choose between animations according to their preferences. Essentials should be emphasized and learning pages should have verbal and pictorial information. Furthermore, they should be short, with less than 2 screens in length, and with paragraphs that do not exceed 5 lines. As students do not communicate spontaneously, the tutor should encourage the communication and collaboration.

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