EXPERIMENTAL COMPARISON OF ADAPTIVE LINKS ANNOTATION TECHNIQUE WITH ADAPTIVE DIRECT GUIDANCE TECHNIQUE

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Abstract: The problematics of educational environment adaptation when using the adaptive hypermedia systems (AHS) not only includes the need to implement these systems, to develop the applicable adaptive problem solving structures but also the evaluation of e-learning, pedagogical-psychological aspects of creating materials supporting the education, scheming the subject matter, efficiency of the problematics presentation etc. Based on their knowledge of the given field, the authors of this article have executed an experiment aimed at the quantitative evaluation of results when searching for the options of AHS application in the informatics courses at the Department of Informatics, Faculty of Natural Sciences, Constantine the Philosopher University in Nitra. The gained experimental results have verified the didactical efficiency of e-learning courses built by using adaptive hypermedia systems, the time-effectiveness of these courses, as well as the choice of the best adaptation form. In the experiment, the adaptive annotation technique was compared with the direct guidance technique. An important discovery coming from the results of the executed experiment was that the direct guidance technique when compared with other techniques was the least time-effective, but its didactical efficiency was the highest.

1 INTRODUCTION

The hypermedia materials lack personalization, customizing and adapting of shown information to individual needs of the user very often. Nowadays, this disadvantage could be eliminated by application of adaptive hypermedia systems (AHS) into hypertext documents. This specific type of applications combines hypermedia, user modeling techniques and a certain type of artificial intelligence that adapts the structure and contents of hypermedia documents according to each user. The majority of today's AHS projects are aimed mostly at teaching and presentation of information in education.

2 ADAPTIVE NAVIGATION SUPPORT

Adaptive navigation support consists of influencing user's path in an information space. When using this technique, the system's adaptive core evaluates the applicability of each shown link for the given user and offers a result upon which it influences the user's path in the document system. This influence can be directive in such a way that the system disables the paths that aren't applicable for the given user and context or which are non-directive. In this case, the system presents recommended (or not-recommended) path in the information system to the user by using various instruments. When using the non-directive way, the system just sorts the links according to their relevance or distinguishes the important link differently (Brusilovsky, 2001).

To achieve the listed navigation methods in information content, if using the directive or the non-directive approach, the following techniques are used mostly: **direct guidance** (the AHS guides the user in an information space, which means it selects the most applicable concepts and fragments assigned to them), **sorting links** (links leading to other pages are sorted hierarchically according to their relevance (Kaplan, 1998)), **links annotation** (the adaptive system marks links that are advisable for the user (De Bra & Calvi, 1998)), **hiding links** (the links that

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guide to the non-recommended information are hidden (Paterno & Mancini, 1999)) etc.

3 THE RESEARCH METHODOLOGY

There is a question needed to ask. Does a university student need content and explanation-of-the-subject-taught personalization when studying and is it even appropriate to individualize the subject matter at a university? In our opinion, we see as questionable if it is effective to present the subject matter to university students by using AHS or the 'classical' e-learning method. Even the using AHS, it is needed to find the most effective technique of adaptation.

In our experiment, we have aimed at the thematic field of 'Programming Internet Applications' in a combined form of bachelor studies of Applied Informatics. We have asked the following research questions:

- Are e-learning courses built on the basis of adaptive hypermedia systems didactically effective?
- Are e-learning courses built on the basis of adaptive hypermedia systems effective in terms of the time needed to explain the given subject matter?
- Which adaptive technique is the most appropriate for students?

To prove the given questions, we have created the following solution steps:

1. Creating of control and experimental groups.
2. Creating of reliable and valid measuring procedures.
3. Realization of the experimental plan.
4. Understanding the data.
5. Checking validity of the used statistical methods.
6. Data analysis and interpreting the results.

4 TECHNOLOGY USED

LMS Moodle was chosen to be the experimental environment. This learning management system was not only chosen because of its implementation at our university as the university system dedicated for e-learning and electronical study support, but also because of its wide usage in the academic field when managing education.

Except of several available activities in the system that we have used to create the e-course, we would like to point out the Lecture module that we have used to create a lesson for direct student guidance and the iLMS module that we have implemented into LMS Moodle for the needs of our experiment. This module has been used as an adaptive system for link annotation.

4.1 The iLMS Module – A Link Annotation Module

The iLMS module has been used for link annotation which enables to recommend links to a user according to metadata and defining of dependencies. The system recommends the links by using four tags: recommended link tag, 'neutral' link tag, a tag when the system could not decide according to the metadata and the not recommended link tag. The iLMS module is an addition to the Moodle system. From the technical point of view, the module contains a new adaptive course format (the format complements the traditional course formats, the thematical and weekly ones) and some blocks for creating adaptive content in LMS Moodle.

The module has been developed by Gert Sauerstein as a part of his diploma thesis „KI-Ansätze zur Lerner-Adaption in Lern-Management-Systemen' at the Technische Universität Ilmenau (Ilmenau, Germany).

4.2 The Lesson Activity – A Module for Direct Student Guidance

A lesson is an activity type that opens up a study material in an interesting and flexible way. It consists of many text pages so-called tabs that can be extended by using pictures or hypertext links. Each tab is enclosed by asking a question and the student can choose from multiple possible answers. If the student has answered this question right, he can advance to the next page. If he has answered false, he is being redirected to the previous page to study the problematics again. The way of navigation in the Lesson activity depends on setting the parameters.

The Lesson is a universal module that can be customized by the creator of the course according to his ideas. He can decide to use a linear passing through each pages of the lesson and he can close each one by asking a check question. A more effective, but also a more demanding way is when the course creator decides to divide the pages of a

Lesson into more parallel paths and forces the student to study the described problematics by detail. (Švejda, 2006).

5 RESULTS

The experiment has taken place in the summer term of 2007/2008 at the Department of Informatics. All 75 students of the second year of the bachelor's studies in Applied Informatics have participated in this experiment.

5.1 Dividing into Groups

During the term, we have been monitoring four groups of students in the 'Programming Internet Applications' course that were created by regular dividing into groups. The students were divided into the following groups:

1. Without the LMS Moodle support (**Unsupported**) – a group where classical F2F teaching method was applied,
2. With 'standard' e-course support (**Non-Adaptation**) - a group that was supervised by using blended learning in LMS Moodle,
3. With direct guidance module support (**Direct Guidance**) – a group that was studying by using the direct guidance support,
4. With adaptive system for links annotation support (**Links Annotation**) – a group where the adaptive iLMS system was used.

Table 1: Experimental plan.

	n	Group	Pre-test	Effect	Post-test
Unsupported	21	control	✓	control	✓
Non-Adaptation	17	control	✓	control	✓
Direct Guidance	19	experimental	✓	intervention	✓
Links Annotation	18	experimental	✓	intervention	✓

We have decided to use this classification because the chosen groups had their virtual classes already created in the system. The students without the LMS support and studying with classical e-course support build monitoring groups and students with direct guidance module support and adaptive system for links annotation support build the experimental groups.

Courses in all three groups have had unified structure. The learning matter of the thematic field was divided into small parts, so that the part had had the maximum height of 1.5 times area shown when using typical display resolution. A test question was asked after each part. Despite these adaptive systems offer options for a much more interesting course structure, this simple course structure has been used intentionally to avoid distortion of results by enriching adaptive courses or to avoid penalizing the group with e-course support without adaptation.

5.2 Analysis of Pre-Test

The groups seem to be equivalent at first sight – all groups have attended the same courses together with the same teachers. Group allocation from the sex and age point of view is also equivalent. We have verified this fact statistically by using pre-test. The pre-test in a way of entry test checking the basic knowledge to pass the given problematics has been applied. In the entry test that consisted of 15 questions, we have checked score and the time in that the students were able to finish the test.

The following graph visualizes the MANOVA results. It shows the point and confidence interval estimates of pre-test score (*Pre-Test*) and the time needed for its completion (*Duration*).

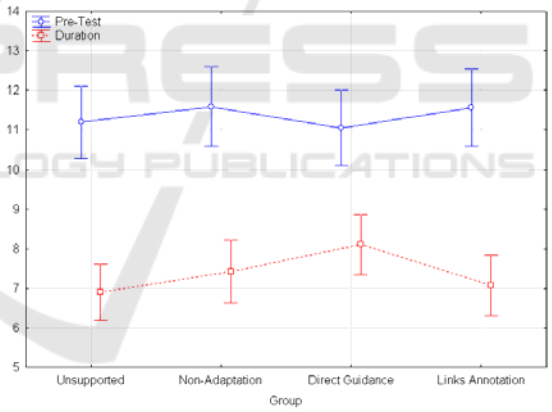

Figure 1: Means with Error Plot for Pre-Test.

Based on the MANOVA results, we do not reject the null hypothesis stating that the difference among the groups in pre-test score and the time needed to process it is statistically insignificant, that means that the vector of dependant variables (*Pre-Test*, *Duration*) is independent from the *Group* factor. This has confirmed the group equality presumption and randomization wasn't needed.

5.3 Analysis of Post-Test

After finishing their study we have evaluated the knowledge of students by using an end-of-course

test. The end-of-course test consisted of seven tasks. These were ai med on proving the mastering of each thematical area of the course.

Table 2: MANOVA, Multivariate Tests of Significance for Post-Test.

	Test	Value	F	Effect df	Error df	p
Intercept	Wilks	0,01530	2252,214	2	70	0,000000
	Pillai's	0,98470	2252,214	2	70	0,000000
	Hotellng	64,34898	2252,214	2	70	0,000000
	Roy's	64,34898	2252,214	2	70	0,000000
Group	Wilks	0,75439	3,531	6	140	0,002762
	Pillai's	0,25999	3,536	6	142	0,002715
	Hotellng	0,30652	3,525	6	138	0,002817
	Roy's	0,21985	5,203	3	71	0,002637

Based on the MANOVA (Table 2) results, we reject the null hypothesis with a 99% degree of confidence, which means the vector of dependant variables (*Post-Test*, *Duration*) is dependent on the *Group* factor.

Table 3: ANOVA, Univariate Results for Post-Test.

	Degr. of Freedom	Post-Test SS	Post-Test MS	Post-Test F	Post-Test p
Intercept	1	2105,347	2105,347	2121,571	0,000000
Group	3	15,490	5,163	5,203	0,002637
Error	71	70,457	0,992		
Total	74	85,947			

From the univariate results of the analysis of variance (Table 3) we reject the null hypothesis with a 99% degree of confidence in case of a post-test score, which means the *Post-Test* dependant variable depends on the *Group* factor. Vice versa, the differences in case of time needed to process the post-test haven't been proven. The following graph visualizes the results of ANOVA/MANOVA.

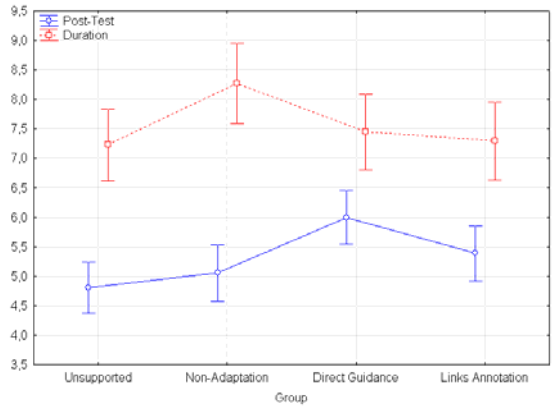

Figure 2: Means with Error Plot for Post-Test.

After rejecting the null hypothesis in case of a post-test, we ask what pairs are significantly different.

Table 4: Tukey HSD test (Unequal N) for Post-Test.

	Group	{1} 4,8095	{2} 5,0588	{3} 6	{4} 5,3889
1	Unsupported		0,884979	0,002562	0,308703
2	Non-Adaptation	0,884979		0,036747	0,769176
3	Direct Guidance	0,002562	0,036747		0,263381
4	Links Annotation	0,308703	0,769176	0,263381	

Statistically significant differences have been proven between *Direct Guidance* and *Unsupported* ($p<0,01$) and between *Direct Guidance* and *Non-Adaptation* ($p<0,05$) in favour of *Direct Guidance*. Vice versa, an interesting discovery is that there haven't been detected any statistically significant differences between *Links Annotation* and the other *Group* factor levels.

Except of statistically significant differences, based on the descriptive statistics (Figure 2), it can be seen that the final test with better results have passed those groups where AHS, this means *Direct Guidance* a *Links Annotation* groups had been used.

From the adaptation methods it was naturally the direct guidance group, of which the significant differences we have proven. This fact is also exponentiated by the statement that this particular group had had the worst results in the entry test (Figure 1).

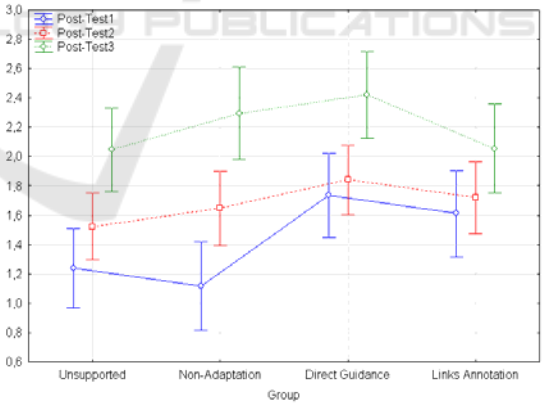

Figure 3: Means with Error Plot for Post-Test.

We present the graph (Figure 3), in which the end-of-course test results for each thematical field are shown (*Post-Test*1, *Post-Test*2, *Post-Test*3), because of data completeness, Also from the partial point of view, the better post-test results score can be seen in favour of the direct guidance method.

5.4 Study Time Analysis

The next field of experiment was to discover the time needed to study the given problematics.

The Moodle system where the adaptive systems were implemented contains a log file-creating mechanism. The following graph shows an overview of how much time the students in each group needed to study the given problematics. From the available time information, only the 'pure' study time values were chosen, this means the intervals of signing onto the system, 'random' course viewing or clicking on activities like the forum, dictionary etc. have not been included. There are only the values included when the student has been working with each chapter aimed at the particular thematic area in the time values. The group without support is naturally missing from the graphs; there has not been any mechanism to monitor the relevant time data.

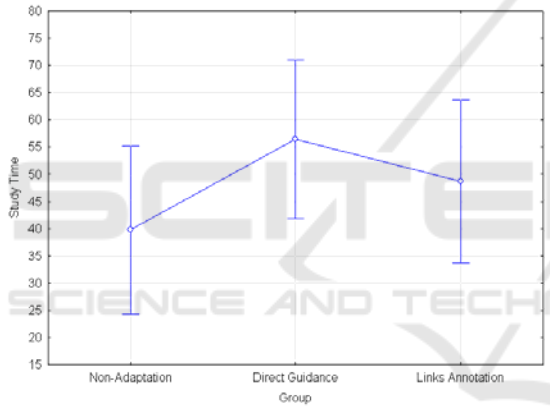

Figure 4: Means with Error Plot for Study Time.

Based on the ANOVA results, we do not reject the null hypothesis stating that the study time score difference among the groups is not statistically significant, which means the *Study Time* dependant variable does not depend from the *Group* factor.

Despite the fact that the statistically significant differences have not been proven, the results when taking study time into account are surprising. Originally, we wanted to prove that using AHS is not only didactically efficient, but also more time effective than the classical e-course. But surprisingly, in our conditions, we can state that the students have spent more time studying when using AHS than they would have spent with a classical e-course. Even the didactically most efficient adaptation method – direct guidance (the *Direct Guidance* group) has been the least effective in terms of study time. We explain this by the fact that a course that leads a student by using direct guidance can impress and motivate him in his next studies.

To complete the results, we show the graph (Figure 5), where the time needed to study a thematical field (*Study Time*1, *Study Time*2, *Study Time*3) in terms of the watched groups is shown. From these partial values of study time, we can see even more differences in using each guidance method.

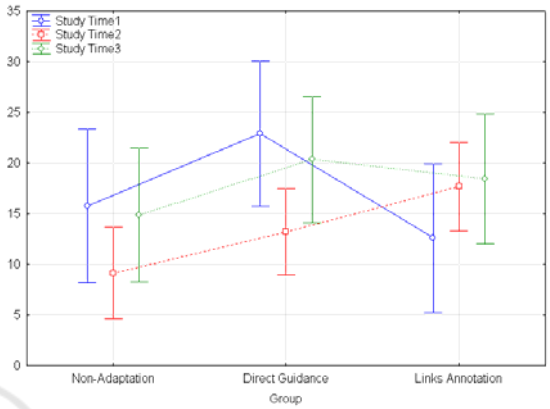

Figure 5: Means with Error Plot for Study Time.

Based on results, we have decided to include another factor into the model – *Study time*. By the following analysis, we test if the adjusted group means are different. The means are adjusted as if there was the same (average) *Study time* factor value in all groups.

Table 5: ANCOVA, Univariate Tests of Significance for Post-Test.

	SS	Degr. of Freedom	MS	F	p
Intercept	416,0901	1	416,0901	423,4300	0,000000
Study Time	2,0857	1	2,0857	2,1225	0,151404
Group	6,2916	2	3,1458	3,2013	0,049179
Error	49,1333	50	0,9827		

We can see in the table (Table 5) that the dependence between *Post-Test* and *Study Time* is statistically insignificant (p>0,05), this means the study time length needed has not affected the post-test results. We reject the null hypothesis with a 95% degree of confidence. The null hypothesis states that the post-test score difference among groups are not statistically significant, which means the *Post-Test* dependant value depends from the *Group* factor.

The following graph visualizes the ANCOVA results.

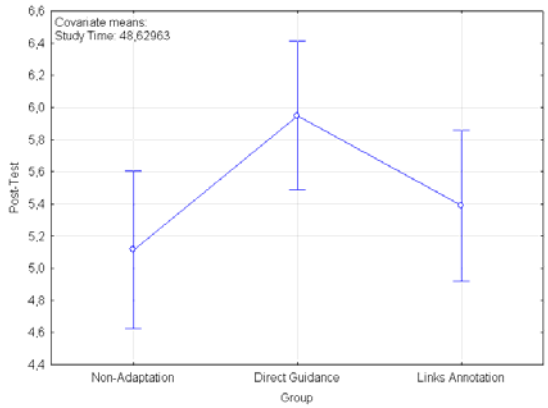

Figure 6: Means with Error Plot for Post-Test.

After rejecting the null hypothesis, our question is what pairs are significally different.

Table 6: Tukey HSD test (Unequal N) for posttest.

	Group	{1} 5,0588	{2} 6,0000	{3} 5,3889
1	Non-Adaptation		0,021271	0,598655
2	Direct Guidance	0,021271		0,164350
3	Links Annotation	0,598655	0,164350	

Statistically significant differences have been proven between *Direct Guidance* and *Non-Adaptation* ($p<0,05$) in favour of *Direct Guidance*.

6 DISCUSSION

Not to deemphasize the strength of statistical tests, we have proven their validity. To gain data, we have chosen to use reliable and valid measuring procedures. To solve our research problem, we have used two methods, the analysis of variance and the analysis of covariance. Where the analysis of variance is easier and does not require equation regression premise in each group. On the other hand, the interpretation is less valid if there exist differences among groups in the inspected variable. Similarly as in other situations, it is recommended to execute both ways of analysis and to compare their results. In our case, the results are identical and we have a reason to consider them as sturdy.

By executing the previous analysis listed in chapter 5, we have validated the didactical efficiency of using adaptive hypermedia systems in university education. We have proven statistically that implementing a direct guidance system had had positive impact on the end-of-course test results among students studying with this support. Also when using the adaptive links annotation, better end-of-course test results can be seen according to descriptive statistics (Figure 2), despite the fact that a statistically significant difference hasn't been proven. Among the adaptive techniques, the most advisable one seems to be the direct guidance technique.

Interesting were the results when examining the time-effectiveness where we haven't proven that any technique would be more time-demanding, but from the results of descriptive statistics, we have discovered time differences in favor of the non-adaptive methods. The most time-demanding is the direct guidance technique. In our opinion, this was caused not only by the attractive form of presenting the current problematics, but also by the technique itself that avoids studying the problematics improperly, which means it asks the student mandatory questions that need to be answered correctly in order to study further.

To approve the experimental results, we would like to execute the described experiment again in the winter term of 2008/2009 based on a bigger sample of students. In this experiment, we plan to use adaptive techniques only: the direct guidance technique, links annotation and a new AHS with the links sorting technique.

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