

Adaptive eLearning based on individual learning styles – Performance and emotional factors

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Abstract

Adaptive eLearning systems are able to adjust to a user's learning needs, usually by user modeling or tracking progress. Such learner-adaptive behavior has rapidly become a hot topic for eLearning. This contribution presents original research on using differences in individual learning styles. Factors related to performance, motivation, satisfaction, and previous knowledge were targeted and used to assess the effectiveness of the approach.

1 Introduction

Compared to traditional, classroom-based learning, eLearning is e.g. characterized by a dramatically decreased instructor/student ratio and an increased variation in the student population and in contexts and patterns of use. In brief, there exists less option for the instructor to adapt and mediate a course's content to the individual student, and more need to do so. This is a gap that eLearning systems need to increasingly fill. We believe that a promising approach to filling the gap lies in tailoring or mediating the standard content of online courses such that it will adequately fit and adapt to students' individual backgrounds and learning styles. The goal is to maintain efficiency and effectiveness of the individual learning experience. A number of important learner variables to which a system can adapt address cognitive factors. Mayer and Massa (2003) differentiate between *cognitive abilities* (what people are capable of doing), *cognitive styles* (ways in which people process and represent information), and *learning preferences* (ways in which people like information to be presented to them). We will employ this categorization, while referring to Mayer and Massa's *learning preferences* as *learning styles*.

This paper presents original research on whether an adaptation of eLearning material to inter-individual differences in learning styles can increase learning effectiveness and efficiency,

learner motivation, and learner satisfaction. We will present a behavioral study and analyze and discuss resulting data. The paper will conclude with a discussion and future work.

2 Methodology and Method

For modeling learning styles on an individual basis, we chose to employ the *Felder-Silverman Learning Style Model (FSLSM; Felder & Silverman 1988)*. On the *visual/verbal* dimension of the *FSLSM* a predominantly visual learner remembers best what she sees e.g. as pictures whereas a predominantly verbal learner prefers words in written or spoken form to learn. Within this study, we chose to focus on adapting eLearning material along this style, because the dimension is well-investigated, also in cognitive style research, and because an adaptation of the presentation format of our learning material could be achieved with limited resources. Few previous studies have employed the *visual/verbal* dimension in the context of adaptive eLearning (e.g. Brown et al. 2006). While these usually focused on measuring performance-related outcomes, we chose to take a step further and also focused on emotional factors related to learner satisfaction and motivation. We deem learner's motivation to be essential for learning outcome, and believe high motivation levels to be an important precondition for sustained engagement in learning. Our main research questions were as follows: (Q1) Is there a positive influence of a good fit between the format of the learning material and the learning style on learning performance? (Q2) Does a good fit increase learner motivation and satisfaction?

To answer these questions, we designed a study. 53 participants (26♀, 27♂), with a mean age of 25.3 years [20-34 years], participated voluntarily. There was no reward in terms of money or credits. The study was conducted under laboratory conditions at Bauhaus-Universität Weimar to control and minimize effects of distraction and disruption. Participants were mostly students of *Computer Science and Media* degree programs. They learned at PCs with our *Moodle* system and were told that they would be given a quiz about the learning material. Participants were also provided with a questionnaire on their intrinsic motivation and satisfaction. The learning material was taken from an established eLearning course intended for future civil engineers on the theory of oscillations. The chosen chapters were comprehensible with secondary school knowledge. And the material was reproduced in two versions: one centered mostly on using illustrative diagrams, the other on using textual descriptions. The lecturer of the original course acted as an expert evaluator and ensured that both versions contained the same information and that expected learning times were each at 20 minutes.

The study was of mixed design. As between-subject component, two groups (A & B) were formed, which received the same learning units, however in different display formats (*visual* or *verbal*). One half of all units were presented according to the individual learning style, the other half were presented in the opposite format. The within-subject component contained the questions of the quiz, and all participants were given the same set of questions. Based on the research questions, the independent variable was the display format. As dependent variables, study time, test performance as well as learner motivation, and satisfaction with the learning material were used. In addition, participants' previous relevant knowledge were established.

3 Results

As it turns out, $\frac{3}{4}$ of our participants had a visual learning style. This corresponds with findings of other studies that about 74% of natural science study program students ($N > 2800$) have visual learning styles (Felder & Spurlin 2005). A correlation analysis and a set of ANCOVAs showed that previous knowledge had no influence on learning outcomes, nor did it influence motivation, satisfaction, or study times. The main focus of the analysis lies on the group of moderate to strong visual learners, as they constituted the largest learning style group of our subjects. The two key findings of the study are that (1) there was no significant influence of a good or bad fit between the material format and individual learning style on study time and learning outcomes, but that (2) there was an influence on learner satisfaction and motivation.

Visual participants who received pictorial material in lesson 1 were significantly more motivated than visual participants who started with the text material. Interestingly, such high motivation levels did not decline after the second lesson, which was presented as a mismatch (i.e., in text form). In group B, participants started with text; for the visual participants, motivation increased significantly after lesson 2 in which material was presented as pictures. One interpretation of our data is that high motivation levels caused by style-matched material declines slowly during a mismatch, and that it rises more quickly when mismatched material is followed by matched material. Visual learners were thus highly significantly more pleased with pictorial material. They did not like to learn with text only. For detailed results see Table 1, interestingly, none of these tests remain significant when aggregating data from all visual learners (including balanced visual learners). This shows that the effects reported here are really related to an expressed visual learning style, and that learners' individual strengths of style expressions may be just as important for designing effective adaptive behavior in eLearning systems as a sorting into dichotomous visual/verbal categories.

subject of investigation	group A <i>N=13</i> 11: pictures 12: text	group B <i>N=10</i> 11: text 12: pictures	test results (Mann-Whitney-U, due to the non-normal distribution of data)
study time			
lesson 1	<i>M=13.63 min</i>	<i>M=10.52 min</i>	<i>U=40.00, Z=1,550, ns, r=-.32</i>
lesson 2	<i>M=10.10 min</i>	<i>M=9.23 min</i>	<i>U=56.00, Z=-0.558, ns, r=-.12</i>
learning outcome			
lesson 1	<i>M=79.86%</i>	<i>M=75%</i>	<i>U=43.50, Z=-1,340, ns, r=-.28</i>
lesson 2	<i>M=71.87%</i>	<i>M=72.29%</i>	<i>U=64.50, Z=-.031, ns, r=-.01</i>
intrinsic motivation			
lesson 1	<i>M=12.54</i>	<i>M=8.70</i>	<i>U=26.50, Z=-2.409, p<.05, r=-.50</i>
lesson 2	<i>M=12.23</i>	<i>M=10.60</i>	<i>U=51.00, Z=-0,873, ns, r=-.18</i>
satisfaction			
lesson 1	<i>M=9.23</i>	<i>M=6.0</i>	<i>U=23.00, Z=-2.654, p<.01, r=-.55</i>
lesson 2	<i>M=3.54</i>	<i>M=10.00</i>	<i>U=2.00, Z=-4.002, p<.001, r=-.83</i>

Table 1: Overview over the test results

4 Conclusion, Discussion and Future Work

The aim of this contribution was to see how adaptive behavior can be infused into an existing eLearning platform by categorizing learners into subpopulations according to their individual learning styles, and by then presenting learning material in different matched and mismatched versions for each subpopulation. In our study we found no significant influences of a style-matched presentation of learning material on study time and learning outcome. This finding is in line with former research on this topic. However, we equally focused learner motivation and satisfaction. For scores of these factors, a presentation of learning material that is well matched to the individual's style of learning turned out to be highly important.

Emotional factors should not be underestimated for eLearning, as they play a substantial role for self-regulated learning. As Schiefele and Schreyer (1994) demonstrated, intrinsic learning motivation is significantly positively correlated with measures of learning success. In addition, Levy (2007) identified learner satisfaction as a major factor drop out quotes of eLearning courses. Even though the study on which we reported here did not show a direct influence of style-matched material onto learning success, one could argue that via the discovered strong influence of style-matched learning material on intrinsic motivation, as well as via the influence of intrinsic motivation on learning success widely established elsewhere, an indirect effect of learning style on learning success likely exists. This point clearly requires further and more systematic research. Further work is also needed to investigate the long-term impacts of style-matched courses on the performance-related factors, either directly, or indirectly via emotional factors. We thus suggest to conduct a long-term study, and to employ a suitable test-retest procedure that would have to be developed. Moreover, there is a need to conduct such study with a larger sample to verify the results obtained here also for the verbal learners.

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