

Adapting to Prior Knowledge of Learners

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Abstract. Prior knowledge is an important factor that influences the interaction with a hypertext and the learning gain. Our authoring system NetCoach provides a way to assess the users' prior knowledge and to adapt the course in different ways. We describe how the adaptation mechanism assesses the user's knowledge with test items, infers the user's current learning state from this information, and finally adapts accordingly. An evaluation study with an adaptive HTML course demonstrates that this kind of adaptation might reduce the completion time, but retains the learning gain.

1 Online Learning Courses and Prior Knowledge

Online learning courses are used by people that differ widely in prior knowledge of the domain. Especially in further education and learning on demand settings some learners will have a background of parts of the course while others are complete beginners. However, regardless of the prior knowledge, everybody should have the same knowledge after course completion. On the one hand users might get bored if they have to work on topics that they are already familiar with. On the other hand they are probably not able to estimate whether they do really know everything on a topic of a course without having seen the chapters. Thus, letting users decide on their own whether they have enough knowledge or not might result in incomplete knowledge acquisition. Moreover, prior knowledge has an impact on the learning gain. When constructing a hypertext authors should consider the users' prior knowledge [3]. It might be useful to adapt the hypertext's structure [2] or to provide different advisements [4].

In any case such adaptations require the assessment of prior knowledge. The authoring system NetCoach [6] provides a mechanism both to assess the user's prior knowledge and to adapt the course accordingly.

2 Adaptation Mechanism

NetCoach is designed to enable authors to build adaptive online courses without programming. While authors generate the content by filling in templates and forms, the course functionality including user management, adaptation, communication facilities, and tutoring is provided by NetCoach.

Each NetCoach course implements several adaptive features, that require an adequate assessment of the prior knowledge. Based on this information NetCoach infers the user's knowledge about each chapter and decides how to adapt.

2.1 Assessment of Prior Knowledge

Similar to a book, a NetCoach course is structured hierarchically with chapters and subchapters. The knowledge about a subchapter or a set of subchapters is assessed in so called test groups, i.e., a set of test items. Three types of test items are evaluated on the fly automatically: multiple choice tests, forced choice tests, and gap filling tests. Authors may define the difficulty of the test items and a critical value of points that are required for completing the test. After the learner has completed the chapter the items are presented in small groups (e.g., two in a row). Users achieve points for correct answers and loose points for false answers until they reach a critical value.

In the beginning of a chapter that has subchapters with test groups a link to a pretest is offered. In this case a random selection of the test groups' difficult items is presented.

In summary, the test items of test groups in subchapters which are usually presented after the chapter are aggregated and now serve as pretest for the superordinated chapter.

2.2 Inference of Current Learning State

Each item is evaluated as if it was answered in the test group. The only exception is that the result is weighted (default is 1.5). Afterwards, the current learning state is updated, i.e., NetCoach computes on the fly whether a chapter is *solved*, *inferred*, *ready* or *not ready*. See Weber, Kuhl and Weibelzahl [6] for a detailed description of the overlay model and the different states of chapters used in NetCoach. Such an inference mechanism requires information about relations between chapters which is stored in a so called knowledge base. NetCoach supports the two concept relations *prerequisite* and *inference* [6].

In summary, the inference of a user's current learning state is done in two steps. First, the items of the pretest are evaluated and points weighted by a factor are assigned to test groups accordingly. Second, if a test group has been solved because the critical value has been reached, this chapter is assumed to be learned and other chapters might be inferred to be learned in correspondence with the knowledge base.

2.3 Adaptation Decision

Finally, the learning state is used for two types of adaptations: adaptive annotation and curriculum sequencing. First, links to other chapters are annotated according to the state of this chapter (e.g., a green bullet indicates that the chapter is *ready to be visited*).

Second, NetCoach suggests which page to visit next and thus guides users to chapters that are *ready* and that are required to complete the course. Chapters that are assumed to be learned are skipped. Thus, the pretests provide an easy way to guide users to those chapters that they should learn. Other adaptation techniques that use the same information would be possible (e.g., link hiding [1] or changing the adaptation method [5]), but are not implemented in NetCoach.

3 Evaluation

The pretest mechanism of NetCoach has been evaluated with the so called *HTML-Tutor*. This online course introduces to publishing on the web and programming HTML. We

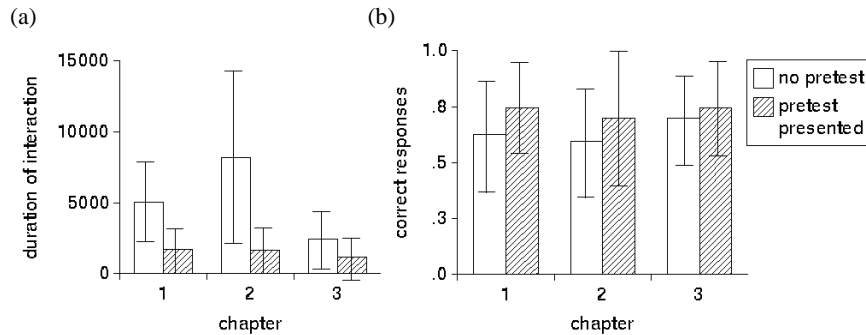


Fig. 1. (a) Duration of interaction (seconds). People who solved the pretest on one of the three chapters required less time to complete these chapters (including the time to complete the pretest). (b) Relative number of correct responses in the posttest. People who solved the pretest on one of the three chapters gave equally or more correct responses to test items in the post test. The standard deviations are indicated.

wanted to know whether the pretests can assess the prior knowledge correctly and how the learning gain is influenced by the adaptation.

We observed a total of 140 users who accessed the public course from all over the world. Two groups of users are distinguished: the first group (no pretest) ignored the pretest and completed the chapters as usual, while the second group (pretest presented) decided to answer the pretest. Consequently, most of them were advised to omit at least some subchapters. In the end of the course users completed a final test that included several test items on the pretest chapters. If the pretest assessment was successful the second group should know as much as the first group about the chapters, even though they did not read the contents.

We found that the pretest group completed the chapters much faster than the standard group. For all three pretest that have been included in this analysis the mean duration of interaction was lower (see Figure 1a). A 2-factor MANOVA yielded significant differences between these groups (see Table 1). However, the analysis of the posttest shows that the pretest group had at least as much knowledge on these chapters as the standard group. Their relative number of correct responses was even higher for chapter 1. The remaining chapters did not differ significantly (see Figure 1b).

In summary, the pretest group had at least as much knowledge about the chapters although they spent less time for browsing these chapters. Note that the users saved up to 80% of the interaction duration, but performed about 10% to 20% better in the posttest. Especially for learning on demand settings when people want to learn specific contents as efficiently as possible this could be an important benefit.

Table 1. (a) Statistical results of a 2-factor MANOVA (dependent variables duration and knowledge). (b) Statistical results of a 2-factor ANOVA (dependent variable duration). For each factor the F-value (F), the degrees of freedom ($df_{effect, error}$) and the statistical significance (α) are reported (sample size N=140).

(a)				(b)			
factor	F	df	α	factor	F	df	α
F1: presentation	15.84	2, 133	.000	F1: presentation	31.07	1, 134	.000
F2: chapter	3.15	4, 268	.015	F2: chapter	6.56	2, 134	.002
F1*F2	2.82	4, 268	.026	F1*F2	5.54	2, 134	.005

4 Conclusion

NetCoach offers easy creation of pretests by summarizing items from test groups. The assumed state of each chapter is computed in dependence of the answers in the pretest and the relations between chapters. Our results suggest that the HTML-Tutor assesses the prior knowledge correctly. Despite the fact that people were adaptively guided to omit those chapters that are assumed to be learned, they were able to answer test items on the chapter's contents even better than the standard group. Thus, assessing knowledge with test items facilitates interesting adaptation opportunities. Adapting to prior knowledge is an important approach to increase the effectiveness and efficiency of learning courses and might even increase the users' satisfaction.

References

1. P. De Bra and L. Calvi. AHA! An open adaptive hypermedia architecture. *The New Review of Hypermedia and Multimedia*, 4:115–139, 1998.
2. S. McDonald and R. J. Stevenson. Effects of text structure and prior knowledge of the learner on navigation in hypertext. *Human Factors*, 40(1):18–27, 1998.
3. I. Park and M. J. Hannafin. Empirically-based guidelines for the design of interactive multimedia. *Educational Technology Research & Development*, 41(3):63–85, 1993.
4. E. C. Shin, D. L. Schallert, and W. C. Savenye. Effects of learner control, advisement, and prior knowledge on young students' learning in a hypertext environment. *Educational Technology Research & Development*, 42(1):33–46, 1994.
5. M. Specht. Empirical evaluation of adaptive annotation in hypermedia. In T. Ottmann and I. Tomek, editors, *Proceedings of the 10th World Conference on Educational Telecommunications, ED-MEDIA & ED-Telecom '98, Freiburg, Germany*, pages 1327–1332, Charlottesville, VA, 1998. AACE.
6. G. Weber, H.-C. Kuhl, and S. Weibelzahl. Developing adaptive internet based courses with the authoring system NetCoach. In S. Reich, M. Tzagarakis, and P. de Bra, editors, *Hypermedia: Openness, Structural Awareness, and Adaptivity*, pages 226–238, Berlin, 2001. Springer.