# Adaptive Hypermedia for Online Dental Education


## Heiko Spallek, DMD, PhD; Titus Schleyer, DMD, PhD

Center for Dental Informatics, School of Dental Medicine, University of Pittsburgh


## Background

**Web-based online courses** and supplemental lecture material are widely used in dental education.

Online courses can reach a distant audience which is most likely more diverse than a local classroom audience. However, a compilation of static Web pages cannot take individual learner characteristics into account (1).

**Adaptive hypermedia (AH)** is an emerging research direction on the crossroads of hypermedia and user modeling that focuses on the design of educational software that adapts to the user. The goal of these systems is to match different learning styles and levels of pre-existing knowledge to make learning more efficient and effective.

**Definition: Adaptive Hypermedia (AH)**

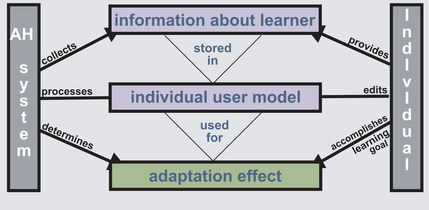
Adaptive hypermedia systems build a model of the goals, preferences and knowledge of each individual user, and use this model throughout the interaction with the user, in order to adapt to the needs of that user (2, 3).

**Definition: User Model**

A user model can also be called "mental state" of the user (4). The AH system keeps a model of the user to adapt the teaching sequence and the presentation of the material to a given user. For each knowledge item, an individual user model stores some value which is an estimation of the user's knowledge level of this concept (5).

**Definition: Knowledge Item (KI)**

A knowledge item is used to index the information resource, it can also be called information fragment or subtopic. A KI denotes a knowledge concept of the domain.




**Schematic overview of AH systems**

## Conceptual architecture

**Modifying an approach by Brusilovsky (2), we asked three questions:**

### 1. Where could an AH system be helpful in dental education?

The Dental Informatics course "Information Retrieval for Dental Professionals" was chosen for the following reasons:

A wide range of potential course participants was expected: e.g. pre-doctoral and postgraduate students; dental educators; dental professionals, fellows of the dental informatics training program. Various levels of computer literacy among these dental professionals could be expected.
A structuring of course material into KIs was possible.
The developer of the course shell could also act as the author, therefore eliminating initial training efforts for another author.

### 2. What features of the learner can be used as a source of the adaptation?

Using various adaptive learning elements allows the design of a highly individualized course. However, this goal can only be achieved by collecting enough information about the learner:

1. knowledge (pre-test results, completion of quizzes)
2. interests/goals (selection of a specific learning goal)
3. traits (learning style)

### 3. What is feasible to adapt?

In general, the adaptiveness is based on the system's estimation of the learner's knowledge level of each KI stored in the user model. The user model can be easily kept up-to-date during the course based on actions during the course, such as the pre-assessment test and quizzes throughout the course.
The particular KIs are compiled based on the user's learning goal (1).

1. adaptive text presentation (text adaptations: inserting/removing of fragments, altering fragments, stretch text)

2. adaptive navigation support (adaptive links: hiding, adaptive link annotation, sitemap adaptation)

Other approaches to increase individual adaptiveness:

- admission to final quiz only after mastering of all offered KIs

- forced repetition of KI in case a predefined knowledge level could not be accomplished by the learner

- example-based learning versus concept-based learning following the individual's learning style (Gilbert 1999).

**Definition: Learning Goal**

A learning goal is a set of KIs to be learned. Typically, the author assembles them from a large pool of KIs belonging to the domain.

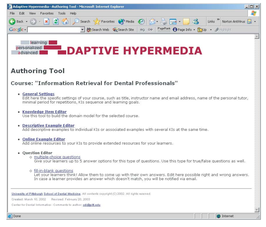
**Definition: Adaptive Presentation**

Adaptive presentation modifies the content of each KI based on the user's current knowledge.

## Technical implementation

### Authoring Tool

= Tool to build the domain model (6)




**short view of KI**
abbreviated version of the core explanation

**beginner view of KI**
for novice users

**main view of KI**
very detailed high-level textual explanation

**expert view of KI**
for graduate level knowledge

**multiple-choice questions**
- one correct answer out of 2 to 5 options
- including level of difficulty
- intended use, e.g. for pre-assessment test only
- explanation for wrong and right answers

**fill-in-the-blank questions**
- including level of difficulty
- intended use, e.g. for final quiz
- potential right and wrong answers
- explanation for wrong and right answers

**descriptive and online examples**
- mandatory examples for all users
- additional examples for learning style "by example"

**learning goals**
for this particular KI

**prerequisites**
KI which have to be mastered before getting access to this KI

**metadata**
Keywords, semantic information

### Learner Environment

An electronic personal tutor guides the learner sequentially through the necessary steps in order to start learning.

**1. Overview**
background, concept of AH, introduction to personal tutor, acknowledgments

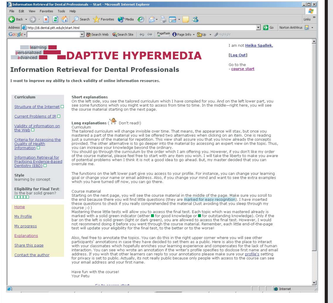
**2. Enrollment**
login name & password, demographic data, privacy restriction, access rights

**3. Learning goal**
learner specifies learning goal

**4. Pre-assessment test**
individually compiled test based on stated learning goal

**5. Learning style**
evaluation of pre-assessment test, user selects learning style

**6. Start page**
explanations aboutthe individually compiled curriculum, table of content




**7. Profile page**
display and option to change all previously made choices

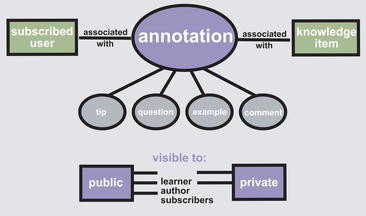
**8. Progress page**
enrollment data, test result, current expertise for all Kis, printable certificate

The user model is continuously revised based on the results of quizzes throughout the course and the final test which can be taken multiple times (repetition only after one week). But, it is not based on the content reviewed (no tracking of what was clicked on). Several works on AH emphasize that just watching what the learner is doing in hypermedia provides insufficient information for user modeling (6, 7, 8, 9).

The design follows the Guidelines of the Design of Educational Software, an ANSI standard (10).

## Annotations

Feedback is encouraged and can only enhance the course material as well as the knowledge of the author. Furthermore, the annotations are valued as an informal continuous formative evaluation. Therefore, all KIs can be annotated by learners (6). See schematic overview of user annotations below.




## Technology

| Purpose | Technology |
|---|---|
| Web server for hosting | IIS on MS-Windows 2000 Server |
| Programming language | Scripting language:<br>PHP version 4 and Perl-compatible regular expression |
| Database (highly granular storage) | MySQL version 3.23.47 on Linux |
| Validation of user input | JavaScript |
| Authentication | Cookies |

## Evaluation

**1. Initial Review: Task-oriented Cognitive Walkthroughs**

The goal was to solve anticipated problems before bringing the course to users for testing. Four independent walk-throughs were performed under observation of the developer. We tried to envision the users' route on their way to complete the task of enrolling into the course and mastering the KIs up to the eligibility of the final test.

Results: The users encountered several obstacles which allowed to identify and fix problems, such as confusing labels, confusing options during enrollment, missing guidance on start page, repetition of test questions and inadequate feedback for wrong answers.

**2. Formative Evaluation: Heuristic Evaluation**

We solicited a systematic inspection of the user interface design for usability based on a protocol specifically developed for this evaluation process. The goal of a heuristic evaluation is to find the usability problems in the design. Our heuristic evaluation involved a set of 8 expert evaluators who examined the interface and judged its compliance with two recognized usability principles (the "heuristics").

A: Ten Usability Heuristics by Jakob Nielsen (11) as general-purpose heuristic

B: Guidelines for the Design of Educational Software (10) as specialized heuristic

Results: The general feedback was positive from all experts. It was repeatedly pointed out that the use of the personal tutor concept was beneficial: The personal tutor helped to guide the learners through the course, explained answers, and provided navigational instructions and suggestions. All recognized problems were rated by severity which was judged by a combination of 3 factors: frequency with which the problem occurs, impact of the problem and persistence of the problem. All problems were addressed during the iterative design process.

**3. Summative Evaluation: End-user testing**

A summative evaluation is planned for the fall of 2003.

## Conclusions

Applying principles of recent AH research, we were able to create our own course shell for an Adaptive Hypermedia system for dental professionals using a state-of-the-art programming environment. After completion of the evaluation process, it can be used for in-house training (faculty and students) and continuing dental education. Furthermore, it is intended to serve as a template course for courses in clinical dentistry.

For the first time, a dental educational delivery system adapts itself dynamically using curriculum sequencing and adaptive presentation. While not formally evaluated, it can be assumed that it increases efficiency of learning and user satisfaction.

Evidence from the authoring of the prototype course suggests that what is more efficient for the learner is more time consuming for the course author. The authoring of different views on one topic in order to achieve the adaptiveness is more difficult and more time consuming than we had anticipated; other studies experienced the authoring process as well as challenge (1, 4). The developers cannot envision how this problem can be solved.

The results of the expert reviews indicate that the use of AH concepts is feasible for the development of online dental education courses. Therefore, the next step of research should compare the effectiveness and the efficiency of the prototype system in a real-world environment.

After completion of the evaluation process the further development will concentrate on

- further separation of conceptual representation from the content of the actual Website, the separation of content from adaptation issues,

- refinement of the structure and granularity of user models,

- improved communication between different adaptive Website "engines".

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University of Pittsburgh