

# Towards an Authoring Coach for Adaptive Web-Based Instruction

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**Abstract.** A new approach to adaptive web-based instruction is outlined and advocated, which is based on models and principles that allow the course material to organize itself. This is particularly useful when course material originating from multiple authors is to be combined into a coherent whole.

## 1 Background

In previous research, an "artificial teacher" has been developed, which adapts instruction to the learner [1]. This artificial teacher needs an abstract description of the course material (often called metadata). Additionally, there needs to be sufficient variation in the course material to be able to reach a high level of adaptation. We are developing a system ('Authoring Coach') that coaches authors to provide both the metadata and the variation needed for the adaptation to be effective. It shall

- Provide an easy user-interface for entering course material and metadata.
- Stimulate authors to enter metadata by clarifying its purpose and consequences.
- Stimulate authors to provide variation by indicating the amount of adaptation possible with the current material and how this can be increased.
- Enable multiple authors to contribute without need for coordination. An essential aspect of the World Wide Web has been that it has organically grown: authors from around the world (without coordination) have contributed material. We use the same principle for the authoring of courseware.
- Generate personalized web-based lesson books from the material provided by the authors, which are easy to use, have a good narrative flow, and allow the artificial teacher to monitor and optimally support student learning.

## 2 Existing Systems

To model the teaching domain, both InterBook [2] and NetCoach [3] use concepts, which are organized in a network, with links reflecting different types of relationships between them. Concepts in InterBook are "elementary pieces of knowledge for the

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<sup>1</sup> The author is supported by Nuffield grant NAL/00258/G.

given domain". All examples mentioned are noun phrases, like "production rule". In NetCoach concepts are "internal representations of pages", like "Chapter-2-1-2". In InterBook, the author provides an electronic textbook that is hierarchically organized (chapters, sections, etc). Each page has a set of *outcome concepts* and a set of *prerequisite concepts* associated with it (analogous to pre- and post-conditions in programming). These are used to support adaptive navigation and hyperlink annotation. NetCoach also uses prerequisites, but as relations between concepts. In MetaLinks [4], authors provide the hierarchical relationship between pages.

### 3 Proposed Authoring Coach

We will describe here a number of aspects of our Authoring Coach that are vital for supporting authoring by multiple authors, in a self-organising way.

**1. Use of action verbs in outcomes and prerequisites.** The use of concepts to express outcomes, as in InterBook, is not enough to make the outcomes sufficiently precise and unambiguous. It can result in multiple pages in an electronic textbook that cover apparently the same outcome. In the pedagogical literature, outcomes are always described as containing an action verb, indicating what the student will be able to *do* [5]. We will express each outcome as a combination of an action verb with a concept. For instance, an outcome of a page will not be "search methods", but something like "explain search methods" or "implement search methods". This will allow authors to specify the content of a page more accurately.

Lists of recommended verbs exist, often classified into six levels of learning according to Bloom's taxonomy [5]. This allows the Authoring Coach to advice whether there is enough material at a suitable level. For example, in a third year module, the students should display higher levels of learning, like analysis and evaluation. The coach could give advice like "Please add pages that encourage critical thinking, using verbs like evaluate". The verbs will also inspire authors about which pages could still be added (comparable to the thematic links in MetaLinks). The Authoring Coach will coach the authors, by using requests like "Please write a page that covers outcome X", and "Please write a page that uses prerequisite X".

**2. Generation of page titles, exercises, etc.** Some aspects of the presentation of material can be *generated* automatically on the basis of underlying information, such as verbs and concepts (cf. [6]). A simple example relates to the generation of titles. Table 1 shows some example mappings between verbs and titles. Similarly exercises could also sometimes be generated. In both cases, an advantage of using generation is that it allows better support of narrative flow and consistency in terminology.

**Table 1.** Example mappings between verbs and titles

Verb	Title
implement CONCEPT	How to implement CONCEPT
advocate CONCEPT	Why use CONCEPT
explain CONCEPT	What are CONCEPT
compare CONCEPT1 CONCEPT2	How do CONCEPT1 and CONCEPT2 compare?

**3. Generation of a hierarchy.** In authoring tools like InterBook, MetaLinks, and NetCoach, authors explicitly provide the textbook hierarchy (like page1 has subsection page1-1). In contrast, Authoring Coach will *generate* the hierarchy on the basis of the concept network and the prerequisites and outcomes associated with pages (and some additional information, see below). The concept network provides information about which concepts are 'children' of which other concepts. Note that there are (at least) two different kinds of parent-child relationships: in AI, "Blind search" is a special case of "Search Methods" (an aggregation relationship), while "Criteria for evaluation" is a subtopic within "Search Methods" (a 'uses' relationship).

A concept will be included in the hierarchy if it has either (1) at least two children that are included in the hierarchy, (2) two pages that use it in their outcomes, or (3) one page that uses it in its outcome and one child that is included in the hierarchy. The included children of an included concept and the pages that use it in their outcomes will be shown as subsections or pages below that concept.

A concept can be a child of multiple other concepts. Additionally, a page can use multiple concepts in its outcomes. In those cases, the generated hierarchy may contain multiple instances of a concept (as section title) or page. This will allow the student to more easily find material, and to follow different paths through the course.

**4. Making a custom book.** Books can be generated that are tailored to individual needs. Authors, teachers and students can choose the outcomes to be covered by a book. The system will only include pages that are related to achieving those outcomes, either directly or indirectly (needed for prerequisite).

**5. Dealing with alternatives.** Different authors may have different views on how a specific outcome should be taught. So, different pages can exist with the same outcomes. We call these pages *alternatives*. As alternatives have the same outcomes, they will share the same generated titles (see above). The decision on which page out of a set of alternatives to include in the textbook can be postponed till the moment that the student (or artificial teacher) clicks on the title for the first time. Several strategies can be used. A page can be chosen on the basis of:

- Author: written by the same author as the previous page in the section (if exists), or by the same author as the last visited page. This may support narrative flow. Students (or teachers) may also provide an ordered list of their favorite authors.
- Its learning style. This would require the author to annotate learning style related characteristics of a page. Alternatively, deductions could be made based upon the page content, like use of images, formulas, words like "example".
- A quality measure. Experts could review (alternative) pages and indicate a quality rating. Students could also rate pages seen. Alternatively, deductions could be made based upon the time spend on the page (not very reliable), links clicks, and the students performance on exercises after having visited the page.
- Its prerequisites being most closely met. Different authors may have different views on the relative order in which outcomes need to be addressed. This can lead to pages sharing the same outcomes, but having a different set of prerequisites. When links are annotated, like in [7], the annotation should be the

most favorable one, i.e., if there is a page with the outcome whose prerequisites have been met, then the "ready to be learned" indication ought to be given. The student can select an alternative, via links available from the page.

**6. Ordering siblings.** Pages can have outcomes that use different verbs on the same concept. For instance, a page with outcome "implement loops", and another page with outcome "explain loops". We call such pages siblings. When generating the hierarchy, siblings are ordered in such a way that a page with outcome X will precede all siblings with prerequisite X. Within this constraint, different strategies can be used to support narrative flow.

- A page with outcome X is followed immediately (or as soon as possible) by a page with prerequisite X.
- A page is followed by another page by the same author.

The relative level of verbs in Bloom's taxonomy can also aid the ordering process. For instance, "explain" precedes "design", which in its turn precedes "evaluate".

## 4 Conclusions

This paper describes an alternative approach to authoring adaptive web-based instruction systems. Though this work is only in its starting phases, it is clear that the choice to generate hierarchies automatically poses interesting problems and opportunities. If we want web-based instruction systems to grow organically, while maintaining narrative flow and user guidance then this seems a way forward.

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