# Course Generation as a Hierarchical Task Network Planning Problem

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**Course generation automatically assembles courseware adapted to the learner's competencies and learning goals. Previous course generators offered only a limited representation a pedagogical knowledge and did not take full advantage of service-oriented architectures. This dissertation proposes a course generation framework (called Paigos) that enables the formalization and application of complex and realistic pedagogical knowledge. Compared to previous course generation, this approach generates structured courses that are adapted to a variety of different learning goals and to the learners' competencies. Additionally, Paigos is service-oriented, thus allowing the integration of learning-support services into generated courses in a generic and pedagogically sensible way and enabling third-party learning environments access to its functionality using a Web-service interface. Paigos was evaluated by technical, formative and summative evaluations. The technical evaluation primarily investigated the performance to Paigos; the formative and summative evaluations targeted the users' acceptance of Paigos and of the generated courses.**

## 1 Introduction

Course generation uses information about educational resources, the learner and his learning goals to generate an adapted sequence of resources that supports the learner in achieving his goals.

However, previous course generators cannot handle *complex* learning goals. In most course generators, the learning goal consists of the target concepts the learner wants to learn about. But during learning, a user will have different objectives: when the content is unknown to him, he requires detailed, comprehensive information. Later, he might want to rehearse the content, which requires a different course. When preparing for an exam, he wants to use a workbook, which is yet another type of course.

Such complex learning goals require sophisticated pedagogical knowledge. While early, pre-Web work emphasizes this requirement [8], it is marginalized in recent work on course generation [2, 1]. In addition, the quality and coverage of the pedagogical knowledge in most of the recent work cannot be judged due to insufficient information. Schulmeister's [5] criticism on adaptive systems in general applies to course generation as well: a large percentage of existing work neither describes the characteristics of the learner used for adaptivity nor the methods and dimensions of adaptivity that are aimed at.

In addition, none of the previous course generators has a service-oriented architecture. They cannot perform federated search (i. e., combine courses from resources found in different repositories), nor make their functionality available as a service to other systems.

This thesis [7] uses many of the possibilities offered by today's (Semantic) Web, Artificial Intelligence and technology-enhanced learning techniques to overcome these and further problems. The work contributes to service-oriented course generation and modeling of pedagogical knowledge. Several evaluations served to assess the practical value of Paigos.

## 2 Modeling of Pedagogical Knowledge

Paigos implements realistic pedagogical knowledge developed jointly with pedagogical experts. The implementation is based on Hierarchical Task Network planning (HTN [4]). In HTN-planning, the goal of the planner is to achieve a list of tasks, where each task is a symbolic representation of an activity to be performed. The planner formulates a plan by using methods to decompose these top tasks into smaller subtasks until primitive tasks are reached that can be carried out directly using operators.

The formalized pedagogical knowledge encodes how to generate courses that help the learner to achieve his learning goals. Paigos's domain knowledge realizes a large set of learning goals, ranging from selecting single resources such as examples and exercises to complete courses.

The basic pedagogical axioms, operators and methods developed in this thesis are pedagogically neutral. Pedagogical neutrality is important since pedagogical researchers as well as practitioners disagree on the question which pedagogical principles to use for teaching. Hence, if a course generator aims at wide-spread applicability, it should not impose any specific learning theory.

The basic knowledge encompasses the following: 1) inserting resources in a course; 2) structuring courses by opening and closing sections and by inserting dynamically generated texts that inform the learner about the purpose of sections; 3) interacting with knowledge sources, i. e., querying content repositories and the learner model; 4) combining information from knowledge sources, e. g., removing all known educational resources from a given list; 5) inserting links to learning-support services.

These primitives are employed to build up complex collections of pedagogical knowledge, so-called *scenarios*. The scenarios are *discover* new content, *rehearse* weak points, establish *connections* between concepts, *train intensively*, *train competencies* and *exam simulation*. A scenario determines


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