A Framework for Self-Regulated Learning of Domain-Specific Concepts

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Abstract. Research in self-regulated learning environments has focused on student motivation, development of metacognitive skills, learning strategies, and individual differences. Equally important is the modeling of domain-specific concepts and the ability for students to learn them under their preferred environment. In this paper, we present a general framework for modeling domain-specific concepts that support self-regulated learning across different domains. Our framework is motivated by a well-established pedagogical tool called the *concept map*.

Keywords: Concept map, self-regulated learning, individualized learning paths, performance monitoring, relevance perception

1 Introduction

One of the most important factors in course design is the development of a *concept map* [1], which is the overall picture of the relationship between the course concepts and the learning elements. As educators, we are often concerned with student performance regarding specific concepts and learning outcomes, and whether they understand the connections among the various course components. While we design assessments to help students achieve various learning outcomes, the interconnectedness of the concepts assessed in course activities make it hard for us to tease apart what students excel in and what they find difficult. In order to better help the students, ideally, educators should be able to point to an assessment piece, see the corresponding performance level, and know immediately which concepts students have trouble with and which learning outcomes may be in jeopardy. Likewise, students should have access to metrics about their own progress so that they can monitor and shape their own learning process. Much like the benefits that project management software offer to managers and employees, we wish to deliver analogous information in the context of a course that lets students and instructors manage the learning process. As such, we argue that an online course tool is needed to overcome these challenges by visually presenting key concepts and their connections to other elements. We present a general framework called the *Concept Navigator* for just this purpose. While its design is motivated by the needs of educators, this framework also supports students in a self-regulated learning environment. We believe that the

Concept Navigator will empower both students and educators by providing them with an explicit view of student progress with respect to a course concept map and the expected learning outcomes.

2 The Concept Navigator Framework

As new educational paradigms, such as flexible learning and flipped classrooms, become mainstream, there is a growing need to have the proper tools in place to support methods of student-initiated and student-directed learning [2]. The Concept Navigator is a general framework for visualizing course concepts, their relationships to each other, as well as their relationships to other course elements such as learning outcomes and assessment pieces. The backbone of this framework is driven by a course concept map, as concept mapping has been shown to support self-directed, experimental, and networked learning (see [2] for details). Although the concept map has long been available to educators for course design purposes, in our experience, most instructors do not use it in designing courses or in articulating the roadmap of a course to students. From a pedagogical standpoint, we believe that the development of a concept map is crucial to the successful delivery of a course. For this reason, our framework is designed to have instructor-defined concept maps of courses, rather than data-driven [3] or editable concept maps of learners [4] as proposed by alternative approaches.

The concept map alone is simply a set of concepts and their relationships. In our framework, we model additional entities and relationships as depicted in Figure 1. For example, a concept is associated with many learning outcomes, and can be included in an activity (e.g., reading) or exercised in a question (which belongs to either an assignment or a quiz). Also, note that a learning

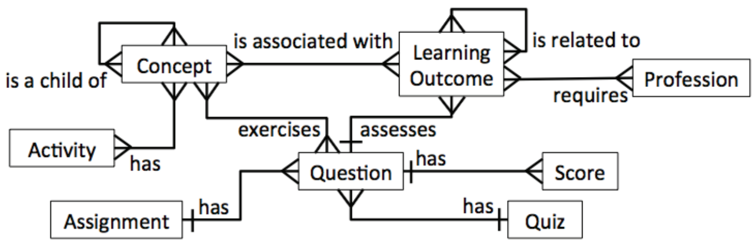

Fig. 1. The entity-relationship diagram for the Concept Navigator.

outcome is related to other learning outcomes because some outcomes may serve as prerequisite skills. Finally, a profession (e.g., Programmer, System Analyst, Project Manager) may require the mastery of different sets of learning outcomes. This relationship is of particular importance because it helps students see real-world relevance of what they are learning in class.

Overall, this model defines the structural content of a course from an the instructor's perspective. As such, one of our goals is to promote the use of concept maps in the process of course design. Since instructional content and style can vary, our framework is limited to supporting specific course development efforts rather than larger efforts such as degree program design (e.g., [5]). Unlike existing work in open learner models [6], we focus on the explicit communication of concepts and their interdependencies, as well as their relationships to learning outcomes and relevance to professions. Students with a good grasp of this knowledge will be able to personalize their learning experience by setting real-world driven goals and choosing their own paths based on what they want to achieve. Moreover, this framework is a concept navigation tool, without adaptive features and requiring minimal student configuration (see [7] for an alternative approach). In contrast to learning management systems such as Blackboard [8] and Moodle [9] that simply deliver course content digitally and perform simple software usage tracking, the Concept Navigator enables students to take control of their own learning process. Currently, Moodle also lets users tag course elements to learning outcomes, which is a step toward our overall design objectives.

3 A Course Prototype in the Concept Navigator

To illustrate our framework, we present a partial concept map of the course "Digital Citizenship" in Figure 2, where concepts are represented as nodes and relationships are represented as arrows. The small graphs shown on the top of the nodes indicate summary metrics of student performance, which we envision can be viewed per student or for a whole class. Student progress is implicitly shown in Figure 2 by a lack of available data in the remaining nodes.

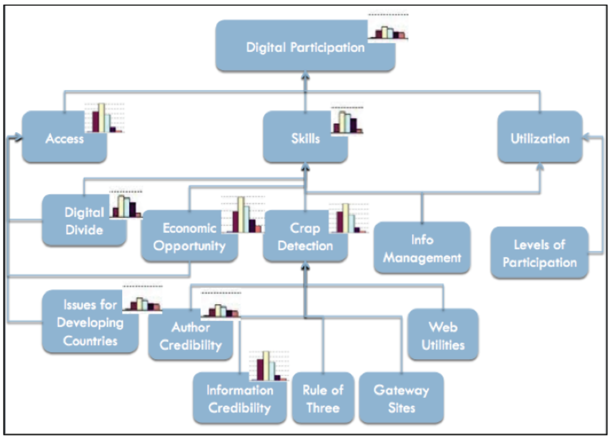

Fig. 2. A partial concept map for Digital Citizenship with summary metrics.

When a concept is selected, such as “Crap Detection”, a detailed view as in Figure 3 will be shown. Parent concepts based on Figure 2 and summary metrics are shown at the top, while related learning elements such as activities (e.g., readings, videos), questions (as part of exercises or assessments), and learning outcomes are displayed in the center. Details may be hidden or expanded.

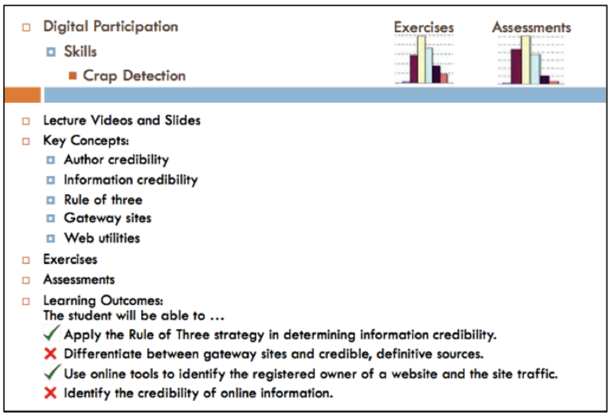

Fig. 3. Detailed view of Crap Detection, showing related concepts and summary metrics at the top and hidden and expanded learning elements in the center.

Of particular interest is the display of learning outcomes which serves as a constant reminder of why certain concepts are taught as part of the course and the expectations in applying them. Moreover, Figure 3 shows a visual status for each learning outcome to indicate how likely the student has achieved a learning outcome based on the current performance levels. These statuses can be determined based on predefined thresholds or automatically learned via a history of performance data. Usability feedback will be conducted to test whether a more fine-grained visual status (e.g., a percentage) will be more appropriate than a binary status (i.e., ✓ or ✗). These metrics are helpful in providing a formative assessment so that instructors may adapt learning activities accordingly.

4 Support for Self-Regulated Learning

The Concept Navigator is designed to support students in a self-regulated learning environment. A key aspect of the concept map interface (e.g., Figure 2) is the ability for students to pursue a course in a non-linear fashion. Given a visual map of the concepts and their dependencies, students may select the concepts of interest and acquire the relevant material via an individualized learning path. The ability to see the direct connections between concepts, learning outcomes, and professions not only enables students to set goals for themselves, but it also helps to foster a positive attitude in students by knowing the importance of each learning element at hand. With the metrics associated to each concept and learning outcome, students can monitoring their own progress and, thus, increase awareness of their own educational successes and needs.

Currently, our framework assumes students take full responsibility of their own learning. Opportunities to add social and intelligent features are left for future development, such as peer information sharing forums, monitoring alerts that trigger self-reflection, and adaptive assistance to support scaffolding.

5 Future Work

We presented a framework called the Concept Navigator which supports self-regulated learning of domain-specific concepts. This framework hails students as active agents in their own learning process. We instantiated this framework with a course prototype and discussed ways to support individualized learning, goal setting, performance monitoring, reflection, and relevance perception. Our immediate next step is to design the interface for visualizing the relationships among learning outcomes and between learning outcomes and professions. Thereafter, we will create a full instance of the Concept Navigator for a specific course and test it with student users. Controlled testing to debug usability issues will be conducted prior to assessing the utility of the system by testing it in the classroom. Finally, testing in different courses will be done to validate the feasibility of this framework across multiple domains.

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