The Need to Support Independent Student-Directed Learning

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Abstract As new educational paradigms, such as blended learning, flipped classrooms, and flexible learning, become mainstream, it is important to have the proper tools in place to support methods of student-initiated and student-directed learning. In this paper, we present a prototype of an online educational tool called the *Concept Navigator* that is designed to provide students with an explicit and visual representation of the core concepts and learning outcomes of a course. Unlike typical course websites where materials are structured linearly based on an academic calendar, course materials in the Concept Navigator are associated to a set of core concepts presented via a visual, pedagogical tool called the *concept map*. By digitizing a course concept map and integrating it with existing online functionality such as individualized learning paths, real-time performance and progress monitoring, and data analytics for course management, the Concept Navigator will improve the learning experience in new student-centric paradigms.

1. Introduction

One of the most important factors in course design is the overall picture of the relationship between the main course concepts and the lectures, exercises, assignments, tests, class discussions and expected learning outcomes. As educators, we are often concerned about how our students perform with respect to specific concepts, specific learning outcomes, or whether they understand the connections among the different components of the course. While we design assessments to help students achieve various learning outcomes, the interconnectedness of the concepts assessed in assignments, projects, and exams make it difficult for us to tease apart what students excel in and what they find difficult. This problem is even more challenging in large classes, where instructors need to keep in mind the average class performance as well as the performance of individual students. In order to better help the students, ideally, educators should be able to point to an assessment piece (e.g., an assignment question), see the corresponding perfor-

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mance 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 hope 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 navigation tool is needed to overcome these challenges by visually presenting course concepts and their connections to other course components (including assignment questions, exercises, lecture material, learning outcomes, and assessments). We call this tool the Concept Navigator. We believe the Concept Navigator will empower both students and educators with an explicit view of the students' progress and the relationship to expected learning outcomes.

As new educational paradigms, such as blended learning, flipped classrooms, and flexible learning, become mainstream, it is important to have the proper tools in place to support methods of student-initiated and student-directed learning. By giving students immediate feedback on where they stand with respect to the targeted concepts and learning outcomes in a course, students can take control of what they want to study and which outcomes to focus on. We envision integrating additional features in a simple interface that allows instructors to add practice exercises for each concept, participate in real-time question-answering forums, and monitor information sharing practices among students. The question-answering forum is of particular importance, especially for large classes, because most students feel embarrassed when they ask a question or if they answer a question incorrectly. Thus, by integrating this forum, students can benefit from peer learning and choose to learn at their own pace. Such a tool enables individualized learning from the student's perspective. At the same time, it gives instructors access to objective and immediate feedback about student progress and performance, both at the class level and at the individual level, allowing instructors to readily tailor course content according to student needs.

The objectives of this project are two-fold: (i) to provide instructors with immediate feedback on student progress that explicitly corresponds to course concepts and learning outcomes, and (ii) to enable independent, student-directed learning in a blended learning environment. The rest of this paper presents a literature review on the use of concept maps (Novak and Gowin 1984) in educational settings in Section 2 and prototype mockups of the Concept Navigator in Section 3. Our next steps of this project are provided in Section 4. In addition to controlled testing and evaluation in the classroom with student users, we hope to enhance the Concept Navigator with advanced features that improve the progress monitoring process and provide support for learning analytics so that instructors may easily adapt future course delivery based on the feedback from the analytics.

2. Concept Maps in Education

Concept mapping supports the self-directed, experimental, and networked learning that characterizes the flexible learning approach (Bates 2011; Davidson 2009). To encourage self-directed learning, educational institutions need to provide students with a safe opportunity to learn, without excessive judgment, before their knowledge is assessed. Students need to pair reflection on the theories and concepts to which they are exposed in the classroom with their experience. The experimental coupling of theory and experience is part of a process of self-discovery, a process that may be suppressed by high-stakes testing. Students learn best in a "tinker-centric" environment that allows them to experiment, iterating over the same set of problems, as they "document what changes from experiment to experiment" (Sayers 2011, p.285). This documentation can take the form of metrics, showing students their relative progress over time. Electronic concept maps that contain assignment profiles and self-diagnostic tests which students can take again and again to test their comprehension gives learners a safe place to test their own comprehension.

In keeping with contemporary research in teaching and learning, the Concept Navigator hails students as active agents in their own learning process. Hagemans and van der Meij's study of inquiry-based learning found that students who had access to a concept map were more likely to re-study for an assignment they had completed incorrectly than those in a control group with no map. On the whole, students who have access to a concept map that charts their progress outperform their peers and "learned even more when the concept map also included color codes that signaled progress and performance success" (Hagemans 2013).

While learning management systems, such as Blackboard and Moodle, are excellent courseware for recording grades, transmitting digital content (such as slides and videos), and storing student-generated content in blogs and wikis, they do not let students take control of their own learning process. Furthermore, Blackboard provides instructors with a detailed record of the students' most recent visit to the site, the modules they visited, and the length of time they spent, all largely unbeknownst to students. While this information gives instructors insight into whether students are likely to have the up-to-date information about the course, it does not offer any information about whether students understand the information that they have found in the course website.

In contrast, Concept Navigator lets students track their own comprehension of the concepts from course lectures, readings, assignments and exercises, and see where those concepts fit in the overall picture of the course as the students work toward the learning outcomes, allowing them to move from being dependent learners to independent learners. By offering students an overview of the course

concepts and letting them articulate their comprehension of those concepts through exercises, surveys, and assignments, both students and their instructors can track comprehension in an automated environment rather than simply measure the time spent using the software. The Concept Navigator will add transparency for both students and instructors, enabling students to access to their own metrics and to work with their instructors on setting learning goals for themselves. Students will have access to all the information that they need about how to get their desired grade in the course, and so can make informed decisions about their own learning.

Concept mapping is not simply a benefit to students; it helps instructors with course management. Significantly, the metrics collected through are a means to explain the effectiveness of course delivery as well as to predict student success. In large classes, data from the Concept Navigator acts as an early warning system that allows instructors to reach out and help students who are having trouble in the course. The benefits to instructors are immediate – instructors who had never used a concept map before benefited from using one in their course teaching just as much as experts do (Koc 2012). Online concept maps are an effective tool for students to engage in, allowing instructors to facilitate, self-directed, experimental, and networked learning through digital participation.

3. The Concept Navigator Prototype

There are two types of users of this system: an Instructor and a Student. In general, all the users will see the course material in the same way. However, because the Concept Navigator also provides student-specific information, a Student user can only view his/her own assessment outcomes, while an Instructor user can view both individual student performance results as well as aggregated results across an entire class. An Instructor user has additional responsibilities for setting up a course, such as defining the course concept map, outlining various assessment components, and uploading materials to each module. On the other hand, a Student user simply navigates the concepts, views associated course materials, completes assessments, and monitors his/her own performance.

The main interface of the Concept Navigator is a simple layout of course concepts and their relationships to each other. Each concept is represented as a node, and each relationship is represented as an arrow. An example is shown in Figure 1, where the main concept in this module is “Digital Participation”. As one can see, various concepts related to it are broken down further into smaller concepts. A course concept map is designed by the instructor; the choice of the concepts, as well as the emphasis on each topic is made purely by the instructor’s discretion.

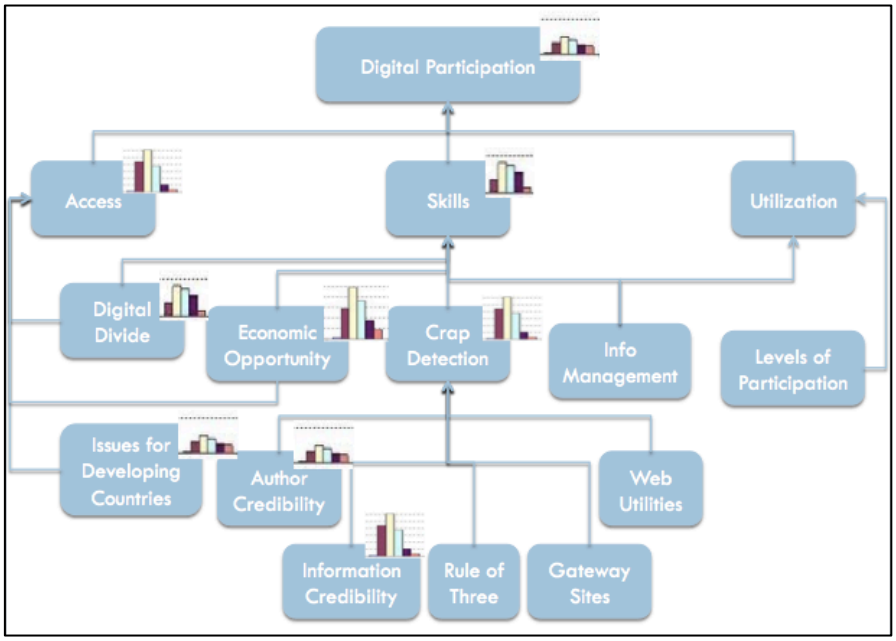

Figure 1: A partial concept map for the course Digital Citizenship, showing a graph of overall student performance for the concepts where data is available.

Note that some of the concepts in Figure 1 have small graphs shown on the top right-hand side. These graphs provide a summary view of overall student performance for those particular concepts. For an instructor, this view is available to access both overall performance as well as student-specific performance. Progress is implicitly shown in Figure 1 as well, since the lack of available data indicates a lack of attempted exercises or assessments associated with a concept.

From Figure 1, a user may click on a concept to view its details. An example of a detailed view of the concept "Crap Detection" is shown in Figure 2. The top of Figure 2 shows a brief overview about the concept. Generally, the left-hand side displays a hierarchy of concepts showing the parent concepts of the selected concept, while the right-hand side displays a graphical performance summary of the exercises and assessments relevant to the selected concept. The main portion of this figure lists the course materials associated to the selected concept, with "Key Concepts" and anticipated "Learning Outcomes" expanded.

In detail, we see from the top portion of Figure 2 that the selected concept "Crap Detection" is related to the concept "Skills", which in turn is related to the concept "Digital Participation". The top right-hand side also shows a visual summary of student performance based on the exercises or the assessments completed for the "Crap Detection" concept thus far. If the current user is an instructor, this

visual summary can reflect either the class average or individual performance, depending on which mode the instructor wishes to view. For student users, this summary view reflects their personal performance only.

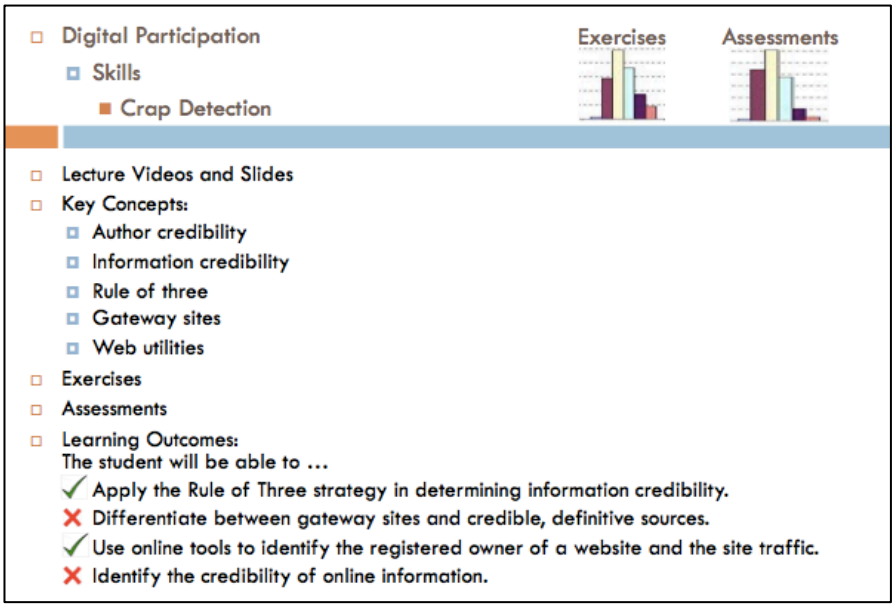

Figure 2: Detailed view of the "Crap Detection" concept, with the associated lecture material, lower-level concepts, exercises, assessments, and learning outcomes. Summary performance for exercises and assessments are displayed at the top. Individual learning outcomes that can be achieved based on the current performance levels are checked off.

Course materials listed as part of a given concept include a set of lecture videos and slides, key concepts related to it, exercises to practice the concept, assessments such as quizzes and assignments, and anticipated learning outcomes of this concept. While the top portion of Figure 2 shows the parent concepts of "Crap Detection", the concepts listed under "Key Concepts" enumerate its children concepts. This structure is taken from the course concept map (i.e., Figure 1) and repeated here to reinforce the concepts' interrelatedness.

In designing assignments and tests, instructors often come up with questions that assess student understanding of certain concepts. If an assessment piece (e.g., assignment question) is relevant to more than one concept, it can be tagged in the database so that it appears under the "Assessments" section of all the relevant concepts. Likewise, any detailed piece, such as key concepts, learning outcomes, etc., may be cross-listed in the same way.

Of particular importance is the set of learning outcomes for a given course module. For students, displaying learning outcomes gives them a constant reminder of why certain concepts are taught as part of the course and their real-world expectations in applying those concepts. Moreover, the mockup in Figure 2 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. If a student is successful in completing all the exercises and performs well in all the assessments, we would expect that the student have achieved all the associated learning outcomes. Rather than performing well on a concept from the start, it is more common that students improve on their skills over time. At the moment, Figure 2 shows a simple binary status (via a check or a cross). However, a more fine-grained visual status such as a percentage may be more appropriate in this case. Usability feedback will help determine the appropriate design for this feature.

While the main interface is the course concept map, we recognize the need that some students are more goal-driven and may wish to view courses based on learning outcomes. Since concepts and learning outcomes are associated with each other in the Concept Navigator, an alternate view of the course will be provided in the system. Navigation by learning outcomes will be designed so that students can choose a learning outcome of interest and study the relevant concepts. This type of individualized student-directed learning enables students to choose what they want to be able to do – by choosing a learning outcome of interest – and then working backwards to learn the necessary concepts to achieve the desired goal.

4. Summary and Future Work

In this paper, we have outlined a novel course tool called the Concept Navigator that supports student-directed learning. While the software is still in its preliminary stages, we have provided evidence from the literature that illustrates the benefits of concept map use in educational settings. We believe the availability of the Concept Navigator will enable students to better appreciate the content and relationships that underlie the concepts in their course undertakings. By giving students immediate feedback on where they stand with respect to the targeted concepts and learning outcomes in a course, students can take control of what they want to study and which outcomes to focus on. Moreover, we expect that knowing the explicit association between learning outcomes and concepts will increase student motivation levels and overall understanding of the materials.

There are many features we wish to develop in the Concept Navigator. For example, advanced features to support progress and performance monitoring are crucial, such as automatic “alarms” set to notify the student or instructor users that a certain progress level might be in danger. Another important feature is to create

an instructor dashboard of the metrics collected within the system so to provide instructors with information that assesses the effectiveness and engagement of different course materials used. Such a feature would enable instructors to adapt the course or its future delivery. At the moment, our immediate next step is to fully develop the Concept Navigator and test it with users. Ideally, testing will be done in the classroom by introducing the Concept Navigator as a supplementary tool designed to improve student learning. In this way, students will have the option to use this software during the course, and may use the software as much or as little as they wish. Passive observations about software usage, such as time spent each component of the software, as well as questionnaire responses will be collected to provide feedback on the utility and usability of the Concept Navigator. We will also collect subjective measures from students' self-reported questionnaires and feedback from instructors for improving the software in future iterations.

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