Chapter 2
Metis:
A Content Map-Based Recommender System for Digital Learning Activities

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ABSTRACT
Recommender systems in e-learning contexts typically try to “intelligently” recommend actions to a learner based on the actions of previous learners. One of the limitations of such systems is that a lot of data is needed in order to recommend meaningful activities. This chapter describes one approach for addressing this limitation in a framework that uses a structured map of mathematics concepts and processes to power a recommender system that will recommend to students digital learning activities for which they are ready. This recommender system is called Metis, for the Greek goddess of good advice, and is currently in the design phase. Metis takes seriously the idea that to build on the knowledge, skills, and abilities (KSAs) that a student has, it is essential to identify those KSAs. Trying to build on KSAs that a student does not have is misguided. Metis recommends activities linked to KSAs that students are ready to learn, and more standard recommender algorithms further refine the list of recommended activities. Taking this approach has the potential to make activities more engaging, which can lead learners to greater interest in the content area.

INTRODUCTION
“We are leaving the information age and entering the recommendation age.”--Chris Anderson, author of The Long Tail (p. 107)
As Mark Twain said about the weather, “Everybody talks about it but nobody does anything about it,” it is widely understood that people can most easily learn something that they almost know. But “doing something about it” requires finding out what each individual student is ready to learn and tailoring lessons appropriately. Only with great difficulty, and perhaps only in theory, can a teacher conduct this kind of assessment and instruction for 30 students simultaneously. Human tutors can help individual students learn, with varying approaches and levels of success, but they are expensive. Some intelligent tutoring systems have displayed impressive results in laboratory studies (Shute & Psotka, 1996), but their approach is to create a single software application as a solution to help all students learn. We posit that no single activity can be a solution for everyone since students have different background knowledge and take different approaches to learning. Some researchers are developing educational games (e.g., Plass, et al., 2010), and some practitioners have developed videos (e.g., http://khanacademy.org) that focus on singular concepts perhaps for the same reason. Multiple activities that take different approaches to learning single concepts and processes, structured in easily accessible ways, would help individuals learn in their own ways. Our approach will focus on singular concepts, which is the basis for allowing us to determine what people know and provide them with material they are ready for.

Some mathematics educational content portals (e.g., onlinemathlearning.com, exploremath.com, some textbook publishers) have activities that focus on individual content areas. A learner can browse the activities according to content area and sometimes genre (e.g., games, worksheets), but the activities are not structured to help students and teachers locate activities that are geared to their existing knowledge and learning preferences. Moreover, each content area typically has a single activity, that is, takes a single approach to learning; there are not multiple activities, where each would take a different approach to help students learn the material, in tune with different learning preferences. In addition, these sites do not provide descriptions for required prior knowledge for an activity, which would help guide learners to activities they are ready for.

This chapter describes a recommender system that will guide students to activities for which they are ready by using a framework for structuring digital learning activities in terms of knowledge, skills, and abilities (KSAs). This recommender system is called Metis, for the Greek goddess of good advice. The Metis approach provides a unique environment for underperforming learners in which their learning paths are individualized. Our explanation for underperforming students is that they are not given enough time to master material before they move on to more complex material. Metis will suggest to these students only activities they are ready for. For example, in mathematics, if a learner is having a lot of difficulty with an activity that uses ratios for comparison, Metis will recommend activities that focus on comparing and ordering numbers or understanding the concept of ratios and proportions, both of which are prerequisites for using ratios for comparison. If they are having some difficulty with this activity, they will be directed to an activity of a different genre that teaches the same KSA. Similarly, if the learner finds a ‘using ratios for comparison’ activity easy, suggestions will be made for activities that build on that concept. Such a prerequisite content map-based recommender system, where achievement is individually defined and measured, has the potential to strengthen overall attitudes toward and self-efficacy in math-related tasks (Schoenfeld, 2002), which in turn can bolster achievement.

After presenting reviews of research in support of the underlying cognitive pedagogical approach of Metis, we describe the modules of the recommender system and then expound on it via an example.
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