Personal informatics for self-regulated learning

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Abstract
We propose self-regulated learning, particularly with the use of web-based resources, as a new domain for personal informatics. We consider development in intelligent computer-based student modeling that can provide sophisticated data for reflection and describe a preliminary system for collecting and visualizing data from web resources for this purpose.

Author Keywords
Personal informatics, student modeling, self-regulated learning, web-based learning

ACM Classification Keywords
H.5.2. User Interfaces: User-Centered Design. K.3.1. Computer Uses in Education: Computer-assisted instruction.

Introduction
Many people use online resources for learning, whether to supplement learning in school, to learn new skills toward advancing a career, or to explore a personal interest in a subject. Advances in learning resources on the web have been heralded as a revolution in personalized and informal education [3]. However, the use of such resources, including locating them, organizing and comprehending their content, and

monitoring and self-assessing progress are usually left to the individual without support.

Given these features of learning online, it is essential that the learners can monitor and regulate their own learning processes to achieve better learning outcomes. To become a successful self-regulated learner, as defined by Zimmerman [9], people must develop or be taught how to monitor and self-assess their learning status, then use the results from self-assessment to reasonably allocate learning resources to the different content they are learning, as well as select appropriate learning strategies. We argue that online learning resources, to be truly effective, should be supported by personal informatics systems that scaffold a feedback loop for learners to self-assess and make decisions about their learning strategies.

Computer-supported learning allows new opportunities for automatic data collection and personal data reflection. The field of intelligent tutoring systems has developed fine-grained models of student learning, which keep track of students' behaviors and learning progress in the tutoring system. The student model enables adaptive instruction for individual students. For example, an intelligent tutor may select problems for the students based on their current mastery of different problem solving skills, while continuing to update their skill mastery levels in the student model as they progress in the tutor.

More recently, the idea of giving students access to their student models has been referred to as an open learner model (OLM). Researchers believe that OLMs can help support students' self-assessment, reflection and planning of their learning processes [2]. Bull [2] has described a variety of presentations and interactions that can be used for these models. By polling students, she found they were highly interested in accessing the potential open learner models that display information about their learning processes. However, effectively using information from the OLM to self-monitor is not automatic for all students, particularly low-achieving students [6].

Aligning open learner models with personal informatics

The stage-based model, describing the preparation, collection, integration, reflection, and action stages for personal informatics systems [4], is also applicable in the domain of learning.

The stages of preparation, collection, and integration depend greatly on what is being learned and the constraints of the environment in which it is being learned. A personal informatics system for learning may be built into an existing learning resource or used independently, accessed either at the direction of an instructor or on the learner's own accord.

The student models in intelligent tutoring systems are constructed based on cognitive theories of learning and allow learner data to be collected at a skill- or knowledge component-granularity rather than simply on a problem-by-problem basis. A benefit of such student models is that data could be integrated across multiple educational resources when they are structured on the same knowledge component basis. However, in some cases, a computer cannot perform assessment adequately, or knowledge components are not clearly defined for the domain, such as in writing quality or performance of a physical skill. Under such circumstances, the personal informatics system could support data entered manually as well, such as when work is assessed by a teacher or peer.

Reflection is a vital skill for learning. But to facilitate effective reflection, a personal informatics system must ensure the learners are able to understand how the information presented relates to what they are learning. In a previous study with a math tutor that uses an open learner model to display skill acquisition progress, students were not able to recall problems that were associated with a particular skill [5].

Different approaches to visualizing or timing the presentation of data may allow students to better relate the information to their learning processes. Arroyo et al. found that a visualization of progress that was periodically interjected between problems in a tutor had significantly positive effects on learning gains and improved students' attitudes toward the software [1].

Finally, at the action stage, a learner must understand how to apply the observed information to regulate his or her learning strategy. This may include the amount of time studying or what material to select for learning. Learners may have varying degrees of agency in learning: in intelligent tutoring systems, problems are often selected on behalf of the student, a feature that students appreciate [5,8]. Nevertheless, the dimensions of control on either the tutor or the student model are still to be explored [2].

A personal informatics platform for web-based learning

We plan to build a platform that enables collecting, synthesizing, and presenting online learning data to the learners, in order to enhance students' self-regulated learning from a variety of learning resources on the web. Specifically, we will synthesize the collected data to help build student models for individual learners, and then present selected information that could enhance students' self-regulation of learning using appropriately designed visualizations (similar to open learner models in intelligent tutoring systems).

The platform collects data made available through an API with participating web applications such as flashcard software, online intelligent tutors, or educational games. Even for websites that do not implement the API, learners can self-report access to resources like online lecture videos or Wikipedia entries. Each action performed by a user on the learning resource is logged and sent for analysis in a student model based on the characteristics of the domain of learning and learning theories. An example learning resource is Battleship Numberline, http://www.brainpop.com/games/battleshipnumberline, an online educational game for developing number sense. We have previously used Battleship Numberline to generate student models from its existing gameplay logs, but users are currently unable to access their own student model.

To present the information from student models to the learners, we can display their progress of each number sense skill – potentially aggregating progress across multiple learning resources – and correlate them to their actions in the game. The skills can also be displayed next to and compared with similar math skills.

The user can then use visualizations of the data to reflect on their learning strategies and take action for future learning. For Battleship Numberline, users may use the information about their progress to choose which types of numbers to study or to decide whether to continue playing at all. A student model can also incorporate forgetting curves [7] to remind the users to periodically play the game even after they have moved on to other topics that may rely on the previously mastered skills.

Personal informatics can play a strong role in supporting self-regulated learning from web resources. Early work on open learner models has shown challenges and opportunities in the application of feedback loops in learning. By applying the stage-based model of personal informatics, we describe a framework for approaching this problem in future work. With further lessons from personal informatics research, we can develop better ways of integrating data and visualizing it to facilitate self-regulated learning. We also believe the complexities of the learning domain will press at the limits of personal informatics research, particularly in representing data and putting reflective knowledge into action.

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