Developing Self-Regulated Learners Through an Intelligent Tutoring System

Kim Kelly
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609
508-461-6386
kkelly@wpi.edu

Neil Heffernan
Worcester Polytechnic Institute
100 Institute Road
Worcester, MA 01609
508-831-5569
nth@wpi.edu

1. ABSTRACT

Intelligent tutoring systems have been developed to help students learn independently. However, students who are poor self-regulated learners often struggle to use these systems because they lack the skills necessary to learn independently. The field of psychology has extensively studied self-regulated learning and can provide strategies to improve learning, however few of these include the use of technology. The present proposal reviews three elements of self-regulated learning (motivational beliefs, help-seeking behavior, and meta-cognitive self-monitoring) that are essential to intelligent tutoring systems. Future research is suggested, which address each element in order to develop self-regulated learning strategies in students while they are engaged in learning mathematics within an intelligent tutoring system.

2. KEYWORDS

Intelligent tutoring systems, self-regulated learning, meta-cognition

3. DEFINING THE PROBLEM

Intelligent tutoring systems (ITS) are designed to provide independent learning opportunities for students. Learning occurs through hints, tutoring, scaffolding and correctness feedback. A great body of research exists surrounding types and timing of feedback [6] and tutoring that have been found to improve student outcomes. As a classroom teacher I have used several different ITS with students to help them learn mathematics. Over the years, I have seen many students benefit from these systems. However, I have also witnessed students struggling to use the systems and who fail to learn, despite all of the assistance provided. Addressing this failure serves as the basis of my dissertation. For an ITS to achieve maximum results, the students using the system must be good self-regulated learners. My proposed research attempts to use an ITS to develop self-regulating strategies, while students are learning the desired content.

Zimmerman and Campillo [12], suggest that self-regulated learning is a three-phase process. During the *Forethought Phase*, students engage in a task analysis, which includes goal setting and strategic planning. Self-motivational beliefs, including self-efficacy [11, 4] outcome expectations, task value/interest [10], and goal orientation also play a significant role in this phase as they have been found to positively affect student learning. During the *Performance Phase*, students demonstrate self-control by employing various task strategies and help-seeking behaviors. Self-observation, which includes meta-cognitive self-monitoring, is also crucial. During the final phase, *Self-Reflection*, students engage in self-judgment and self-reaction.

2. PROPOSED SOLUTION

To help develop self-regulated learners, these components must be explicitly taught. However, some aspects are seemingly more relevant than others when interacting with an ITS. Specifically motivational beliefs, help-seeking behavior, and meta-cognitive self-monitoring can all be addressed within the structures of intelligent tutoring systems. The following sections discuss each of these components by presenting relevant literature, sharing results of my previously published studies, and proposing future research components of my dissertation.

2.1 Motivational Beliefs

One aspect of the first phase of self-regulated learning is motivation. Students who are strong self-regulated learners have high self-efficacy. Schunk [11] defines self-efficacy as "an individual's judgment of his or her capabilities to perform given actions." A student's belief that they are capable of learning can be influenced by a growth mindset [4]. Some of my earlier research, using teacher-created motivational videos, attempted to create a growth mindset in students while they were completing math homework inside of an intelligent tutoring system [7]. While the minimal intervention failed to show changes in student self-reports of mindset, there was a significant increase in the perception of task value and homework completion rates as a result of a video inspired by [10]. In addition to improving self-efficacy, increasing task value/interest is important to developing self-regulated learners. The protocol employed in my initial study is promising and a more sophisticated intervention will be explored to further increase motivation.

2.2 Help Seeking Behaviors

Intelligent tutoring systems provide many different structures to support student learning. One such structure that I have explored is correctness-only feedback. I found that this simple support provided by an ITS during a homework assignment was found to improve student learning significantly compared to traditional paper and pencil homework that did not provide immediate feedback [8]. Yet research has shown that many students do not effectively take advantage of these features. Aleven et al. [1] explores ineffective help use in interactive learning environments and suggests that there are system-related factors, student-related factors and interactions between these factors that impact help-seeking behaviors. In one of my recent studies, I found that there

are students who, despite access to the same instructional supports, do not successfully take advantage of them and therefore do not learn [9]. This has resulted in a phenomenon called wheel spinning [3], where students persist without making progress towards learning. I hypothesize that wheel spinning is a result of ineffective help-seeking behaviors. Therefore, I propose a study that would provide direct interventions to teach students the necessary help-seeking behaviors to become self-regulated learners.

2.3 Meta-Cognitive Self-Monitoring

Elements of meta-cognition, are evident in all three phases of self-regulated learning. For example, goal setting is prominent in phase one. Other elements, like self-monitoring, are evident in multiple phases. Self-monitoring involves students becoming aware of their performance and judging their knowledge. This is sometimes referred to as metacognitive knowledge monitoring [5]. In phase two, while students are participating in a learning task, they must monitor what they are learning. Students who are strong self-regulated learners will seek feedback to easily monitor their progress. I surveyed my students to better understand their perception of feedback. High performing students claimed that the immediate feedback provided by an ITS caused frustration, but was also beneficial to their learning [8]. They were able to identify their mistakes and learn from them. To help all students recognize the importance of monitoring their learning, I propose a study where students are provided feedback along with progress monitoring to show the benefits.

Self-monitoring continues into the third phase of self-regulated learning. During this reflection stage, students assess their success or failure. Strong self-regulated learners may challenge themselves in some way to confirm their success. A willingness to seek out challenges ties back into the growth mindset that is addressed in phase one. Students who believe that intelligence is fixed will often shy away from challenges for fear of failure, whereas students with a growth mindset view challenges as opportunities to learn more [4]. Therefore, to encourage all students to seek out challenges as a method to self-monitor, I propose a study where growth mindset messages are embedded in ITS and opportunities for students to choose challenging problems are provided.

3. CONTRIBUTION

Intelligent tutoring systems rely on independent learning practices to effectively teach students. For example, students must use available hints and tutoring to navigate new material. However not all students successfully learn when using an ITS. Some early research suggests that these students are those who struggle with self-regulated learning. The field of psychology has studied self-regulated learning for more than a decade, resulting in many ideas that can improve instruction. Some ITS have incorporated features to help students who lack self-regulated learning strategies, like automatically detecting when a student is frustrated [2] and providing additional assistance when a student is failing. However, little research has explored how technology can actually promote self-regulated learning. By integrating the capabilities of intelligent tutoring systems with the vast knowledge of self-regulated learning, the proposed research seeks to teach students how learn effectively. By addressing specific aspects of self-regulated learning, ITS can actually teach students how to learn while teaching them content.

This paper is part of my dissertation proposal and is being submitted as a doctoral consortium paper to the Artificial Intelligence In Education Conference (2015) and the Educational Data Mining Conference (2015).

4. REFERENCES

[1] Aleven, V., Stahl, E., Schworm, S., Fischer, F., & Wallace, R. (2003). Help Seeking and Help Design in Interactive Learning Environments. *Review of Educational Research*, 73(3), 277-320.

[2] Baker, R., Walonoski, J., Heffernan, N., Roll, I., Corbett, A., Koedinger, K. (2008) Why Students Engage in "Gaming the System" Behavior in Interactive Learning Environments. *Journal of Interactive Learning Research*, 19 (2), 185-224

[3] Beck, J., & Gong, Y. (2013). Wheel-Spinning: Students Who Fail to Master a Skill. In *Proceedings of the 16th Artificial Intelligence in Education*, Lane, H.C., Yacef, K., Mostow, J., & Pavlik, P. (Eds.) 431-440.

[4] Dweck, C. (2006). *Mindset*. New York: Random House.

[5] Isaacson, R. M., & Fujita, F. (2006). Metacognitive Knowledge Monitoring and Self-Regulated Learning: Academic Success and Reflections on Learning. *Journal of the Scholarship of Teaching and Learning*, 6(1), 39-55.

[6] Kehrer, P., Kelly, K. & Heffernan, N. (2013). Does Immediate Feedback While Doing Homework Improve Learning. In Boonthum-Denecke, Youngblood(Eds) *Proceedings of the Twenty-Sixth International Florida Artificial Intelligence Research Society Conference*, FLAIRS 2013, St. Pete Beach, Florida. May 22-24, 2013. AAAI Press 2013. p 542-545.

[7] Kelly, K., Heffernan, N., D'Mello, S., *Namias*, J., & Strain, A. (2013a). Adding Teacher-Created Motivational Video to an ITS. *Florida Artificial Intelligence Research Society* (FLAIRS 2013). 503-508.

[8] Kelly, K.. Heffernan, N., Heffernan, C., Goldman, S., Pellegrino, J., Soffer Goldstein, D., (2013b). Estimating the Effect of Web-Based Homework. In Lane, Yacef, Motow & Pavlik (Eds) *The Artificial Intelligence in Education Conference*. Springer-Verlag. pp. 824-827.

[9] Kelly, K., Wang, Y., Thompson, T., Heffernan, N. (2015). Defining Mastery: Knowledge Tracing Versus N-Consecutive

Correct Responses. Submitted to Educational Data Mining Conference: Madrid Spain (2015).

[10] Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review, 18*(4), 315-341.

[11] Schunk, D. H. (1996). Self-efficacy and academic motivation. *Educational Psychologist*, 26, 207-231.

[12] Zimmerman, B. J. & Campillo, M. (2002). Motivating self-regulated problem solvers. In J. E. Davidson & R. J. Sternberg (Eds.), *The nature of problem solving*. New York: Cambridge University Press.