

Motivating Learning in the Age of the Adaptive Tutor

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Abstract. My research is rooted in improving K-12 education through novel approaches to motivation and individualization via adaptive tutoring systems. In an attempt to isolate best practices within the science of learning, I conduct randomized controlled trials within ASSISTments, an online adaptive tutoring system that provides students with immediate feedback and teachers with powerful assessment. This paper examines two facets of my research: the optimization of feedback delivery and the provision of student autonomy. For each tenet, the basis for research is examined, contributions thus far are presented, and directions for future work are outlined.



Keywords: Motivation · Learning · Feedback · Choice · Adaptive tutoring

1 Research Focus

The U.S. Department of Education's National Educational Technology Plan supported the idea that technology will play a key role in delivering personalized educational interventions [10]. Adaptive tutoring systems are beginning to foot that bill in classrooms around the nation, providing interactive learning environments in which students can excel while teachers can maintain organized, data-driven classrooms. Yet there remains a severe lack of research regarding the effectiveness of online learning systems for K-12 education [11]. My research acts on this deficit, by conducting randomized controlled trials within ASSISTments, an online adaptive tutoring system, to identify best practices while striving to enhance educational content, its delivery, and the overall user experience.

Specifically, my work employs diverse and novel approaches to improve student motivation and performance within the context of adaptive tutoring. This paper examines two of the primary tenets of my research: optimizing feedback delivery and providing students with the perception of autonomy. In the following sections, I present reasoning for each focus, discussing problems inherent to the state of the art. I then propose my research goals as solutions, noting my contributions thus far and outlining future directions.

2 Enhancing Motivation and Performance Within ASSISTments

2.1 Optimizing Feedback

Problem: Disengagement With (and Maladaptive Usage of) Feedback.

One of the most compelling aspects of adaptive tutoring systems is their ability to provide students with feedback at critical moments to optimize learning gains. Within the ASSISTments platform, both questions and feedback have traditionally been presented using rich text. A variety of tutoring strategies allow for the provision of feedback on demand (i.e., hints), automatically upon the student's incorrect response (i.e., scaffolding problems), or tailored to a common wrong answer (i.e., bug messages). Across most problems in the system, the final piece of feedback provides the correct answer, allowing the student to move forward in their assignment. Regardless of how or when feedback is provided, students frequently disengage from the content. In some cases, the feedback is too dense, too simplistic, or otherwise boring. In other cases, students are deterred from the appropriate use of feedback because the system records binary correctness on their first attempt or action when solving a problem. This can create an environment in which students avoid feedback due to the potential for penalization, or instead, overuse feedback if they have already lost credit (i.e., jumping to the answer rather than reading through a series of hints). Disengaging feedback and maladaptive practices surrounding the use of feedback reduce the likelihood of robust learning.

Proposed Solution: Enhancing Feedback through Video and Partial Credit.

To conquer stale feedback, the power of adaptive tutoring platforms should be harnessed to present feedback in a more engaging manner. According to Mayer's multimedia principles for the optimal design of e-Learning environments, it is possible to use hypermedia elements (i.e., video) to promote active learning while reducing cognitive load [1]. Still, systems that make use of video tend to do so in a manner that resembles lecturing (i.e., Khan Academy) rather than content specific feedback. Within my work, a novel approach is taken to embed brief (15-30 second) video snippets as feedback within the ASSISTments platform. Further, data mining has revealed that partial credit scoring would help to alleviate the maladaptive usage of feedback, serving to motivate student performance while simultaneously offering teachers a more robust view of student knowledge.

Contributions & Plan for Advancement.

My early work presented a randomized controlled trial comparing video and text feedback within the realm of middle school mathematics [5]. Results suggested a significant effect of video feedback, showing enhanced performance on questions following adaptive video tutoring, as well as increased efficiency in problem solving. Further, the majority of students self-reported video as a positive addition to their assignment. This study was the first of its kind to explore the potential for replacing text feedback within ASSISTments. Additional research has since investigated the specific elements of feedback delivery (i.e., audio, graphical, textual) using motivational feedback delivered via a

pedagogical agent [7]. To investigate realigning maladaptive feedback usage, my work has incorporated data mining approaches to develop and refine multiple models of partial credit scoring [3, 4].

Results promoting the effectiveness of video have inspired an influx of video content into the ASSISTments platform, providing endless opportunities for additional research. A group of studies are currently underway, examining research questions including, “What aspects of feedback delivery make the medium most engaging?”, “Do older students with stronger reading ability react negatively to video feedback?”, and “Does the effect of video differ across content domains?”. Further, this work inspired investigations into the potential for crowd-sourcing feedback from teachers and students through simple screen capture technology via tablets or smartphones. Students will be able to record messages to help their peers, and teachers will be able to reach multiple students through focused feedback simultaneously. Next steps for the ASSISTments platform include the development of a contextual K-armed bandit algorithm that will learn how and when to provide optimal feedback for each student.

2.2 Promoting Student Autonomy

Problem: Tutoring Systems Fail to Consider Student Preference.

While adaptive tutoring systems offer a variety of features for personalization and individualization, few allow students to invest in their learning process. ASSISTments is built largely around assessment, putting teachers in control of assignments and leaving students with little say (a traditional approach to education). However, the platform offers untapped opportunities to examine the motivational effect of choice.

Proposed Solution: Instill the Perception of Autonomy.

Choice is an intrinsically motivating force [8] that has the potential to boost subjective control, or a student’s perception of their causal influence over their learning outcomes [9]. By providing students with simple choices at the start of an assignment, it may be possible to enhance expectancies regarding performance and thereby enhance achievement emotions and motivation [9]. Considering the control-value theory within the realm of adaptive tutoring systems for math and science content, instilling autonomy may also help to ameliorate female dropout in STEM fields [2].

Contributions & Plan for Advancement.

A pilot study was conducted to investigate allowing student choice within ASSISTments [6]. In a 2x2 factorial design, students were randomly assigned to experience ‘choice’ or ‘no choice’ crossed with feedback medium (video or text). Results suggested that even if feedback was not ultimately utilized, students who were prompted to choose their feedback medium significantly outperformed those who were not. These findings inspired a significant infrastructure addition to the ASSISTments platform: If-Then path navigation. This feature will allow for the vast expansion of research in this area, allowing for investigations of how and when it is most appropriate to instill autonomy.

The If-Then structure is currently being used to conduct scaled-up replications of this work in additional content domains. If previous results are replicated, these findings may prove groundbreaking for the adaptive tutoring community by promoting a

simple approach to enhancing student motivation and performance. The future of this work will also consider more persistent user variables through a feature that is currently in production for the ASSISTments platform. Essentially, researchers and teachers will be able to base assignments adaptively around student characteristics, preferences, or past performance, allowing for powerful levels of personalization.

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