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論文審査の要旨及び審査員

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論文審査の要旨（2000字程度）

This dissertation titled, *Personalized Online Adaptive Learning System*, describes a web-based system called POALS designed to help learners succeed in online learning environments. The learners must be trained to be autonomous by equipping them with metacognitive skills. Teaching metacognition inevitably introduces cognitive strain, which can vary among individuals. Thus, we introduce adaptive learning to personalize each learning experience. We tap into the teachers as learning facilitators by creating an analytics dashboard to give implicit feedback to teachers that they can use to provide interventions if necessary.

Chapter 1 Introduction provides a short historical overview to have a better understanding of views about an individual's learning and how these views have changed through time. In addition, this recall was used to discuss the motivation behind this research and introduce the methodologies to be used in answering the derived research questions.

Chapter 2 The Metacognitive Tutor first defines what metacognition is and describes how metacognition can be taught and measured. Metacognition, which is essential to succeed in online learning environments, spans three distinct phases: planning, monitoring, and evaluating. An existing metacognitive tutor targeting knowledge of cognition and regulation of cognition at different phases previously shown to be effective in an experimental setting was considered. This was adapted to be more optimized and usable for online use, which is now POALS' Metacognitive Tutor. This chapter answers the question: are open response prompts effective in developing metacognitive skills on an online learning platform? Indeed, POALS' Metacognitive Tutor was shown to be effective in improving learner metacognition to varying extents through a series of experiments. The tool is cognitive domain agnostic; thus, it can be a convenient means of tutoring metacognition in online learning environments.

Previous studies on metacognition indicate that metacognitive training on top of cognitive learning can strain learners' cognitive resources. Adaptive learning techniques such as knowledge tracing is an active research area for managing cognitive resources in online learning environments. Chapter 3 The Adaptive Engine investigates adaptive learning as a latent variable modeling problem that can be solved with machine learning. This chapter answers the question:

can we use innovative ways to improve knowledge tracing algorithms for adaptive learning? Various algorithms were used to train models using a synthetic dataset created from predetermined learner personas. The models using metacognitive inputs performed better than the standard models while still following learning intuitions. This indicates that combining knowledge tracing and metacognitive tutoring is a viable option for improving learning outcomes. This serves as the backbone for POALS' Adaptive Engine.

Chapter 4 The Analytics Dashboard introduces POALS' Analytics Dashboard which serves as the teacher's window to their learners' implicit feedback. The proof-of-concept shows an aggregate of tools the teacher can use to understand learner sentiment, diagnose possible misconceptions, and check learning retention. Because the Analytics Dashboard utilizes the metacognitive prompt responses, problems with other sources of feedback (e.g., discussion forums participated by only a few, course surveys which are very sparse) can be resolved by providing a private and consistent channel between learners and teachers.

Important results, POALS' limitations, its potential societal impact, and possible future work are laid out in Chapter 5 Conclusion. This includes exploring how technology can make education more equitable and checking that algorithms intended to foster learning are fair. Educational technology hype trend from 2018 to present and its consequences to online learning environments are presented. Metacognition is also viewed as part of self-regulation, a concept that contributes to learning and an individual's growth. This opens future work extending the current study of technology-enhanced learning to the related areas of motivation, self-efficacy, learner behaviors, and performance.