Proposal Defense  
Doctor of Philosophy in Intelligent Systems

“Towards Continuous Estimation of Student Cognitive States: A Multimodal Approach”
by Deniz Sonmez Unal

Date:    July 25, 2024  
Time:    9:30 a.m. – 12:00 p.m.  
Place:   6106 Eli Lilly Conference Room/Sennott Square Building,  
         210 S Bouquet Street, Pittsburgh, PA 15260  
         https://pitt.co1.qualtrics.com/jfe/form/SV_8IGPicdkswj9VUa

Committee:

- Erin Walker, Associate Professor, Department of Computer Science, School of  
  Computing and Information  
- Peter Brusilovsky, Professor, Department of Informatics and Networked Systems,  
  School of Computing and Information  
- Michael Lewis, Professor, Department Informatics and Networked Systems, School of  
  Computing and Information  
- Erin Solovey, Associate Professor, Department of Computer Science, Worcester  
  Polytechnic Institute

Abstract:
Student models constitute a critical component within Intelligent Tutoring Systems (ITS) as they  
facilitate personalized instruction by reflecting students’ skills, knowledge, and emotional and  
motivational states. Despite the advancements achieved in modeling these aspects, the  
reliance on event-based interaction logs poses limitations, particularly in capturing cognitive  
states during pauses, potentially leading to incomplete representations of students’ learning  
experiences. Traditional modeling approaches may overlook crucial cognitive dynamics  
occurring during these pauses, impacting the accuracy and depth of the student models.

My dissertation aims to address the existing gaps in student modeling within ITSs by integrating  
multimodal data to capture students’ cognitive states, particularly during pauses in student  
interactions with educational technology. The central hypothesis suggests that leveraging  
various sources of data will facilitate a more continuous estimation of students’ cognitive states,  
and foster a deeper understanding of their learning processes. To achieve this, my research  
adopts a multifaceted approach.

The initial phase of my research focuses on understanding low-level cognitive mechanisms,  
such as cognitive control and rule learning. These mechanisms are fundamental to higher-level  
cognitive states typically examined in ITSs and AI in Education (AIED) systems. Through the  
development of a learning task aimed at eliciting behaviors associated with these mechanisms,  
we first establish robust behavioral indicators within a realistic educational context.  
Subsequently, we will collect verbal data in the form of think-alouds while students engage in a  
similar problem-solving task. We will investigate how students talk when they are in specific  
cognitive states. Additionally, in another study, students will engage in a similar learning task  
while wearing a neuroimaging device for the collection of brain data. Within this phase, we will  
investigate whether brain signals associated with the identified cognitive states can be captured  
during the learning task, providing insights into the neural correlates of cognitive processes.
Finally, we propose exploring the utility of the multimodal data, including verbal and neural data, in various predictive modeling approaches aiming to predict students’ cognitive states. Using the Learning Using Privileged Information (LUPI) paradigm, we will assess if models trained with multimodal data can generalize to realistic contexts where such data may not be available.

I expect that my research will provide methods to enhance the efficacy of student modeling in ITSs that will ultimately improve the adaptability and effectiveness of personalized instruction tailored to individual learners’ needs.