Using Emerging AI Technologies to Enhance Student-Instructor Interaction in STEM Higher Education

Short Description

In this study we investigated instructor expectations and design considerations of the AI based Pedagogical Language Analysis tool, ExplainIt, which was designed to promote interactivity between instructors and students in large undergraduate STEM classes. The team interviewed three instructors in undergraduate STEM fields from two public universities in the US. We captured expectations, perceived benefits, and barriers of ExplainIt shared by instructors in order to identify expectations and design considerations for the system.

Keywords: Emerging Technologies; Instructional Designers in Higher Education

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Abstract

Introduction

Interactivity has positive impacts on students' learning outcomes (Chan et al., 2019). However, it is difficult for higher education instructors to create interactive courses since large class sizes often pose limitations on effective interactions between instructors and students (Caldwell, 2007; Hornsby & Osman, 2014). Lack of interactivity in lectures may lead to low grades in undergraduate STEM courses (Freeman et al., 2014).

Various studies have demonstrated that learning outcomes improved as interactivity increased through integrating technological tools such as audience response systems (Hunsu et al., 2016), or personal response systems (PRSs) (Chan et al., 2019). However, these systems may not help students develop deep conceptual understanding and achieve higher level cognitive outcomes in STEM courses (Hunsu et al., 2016; Shapiro et al., 2017), because these systems are limited to multiple choice answers, and do not allow students to construct their own responses, which is a critical part of active learning (Chi & Wylie, 2014).

Integration of Artificial Intelligent (AI) technologies in large courses showed promising results for achieving high-quality communication that created an interactive learning environment (ILE) (Chassignol et al., 2018). The most frequent AI application in education is intelligent tutoring systems (ITS), which can provide personalized interactions to students at scale to improve their learning outcomes (Cantu-Ortiz et. al., 2020; Hwang et al., 2021), especially in well-defined structured subjects such as mathematics or physics (Fadel et al., 2019). AI could be applied to simulate one-to-one personal tutoring by providing cognitive scaffolding and engaging students in dialogue (Zawachi-Richter et al., 2019).

AI technologies have the capability to create one-to-one interaction in courses covering complex problems (Roll & Wylie, 2016), and may offer opportunities for students to write self-explanations, which is a deeply constructive activity (Chiu & Chi, 2014), and then provide personalized feedback. Self-explanation — the process of expressing concepts in learners' own words, allowing learners to relate new knowledge to prior knowledge, to make inferences, integrate information, and monitor or correct misconceptions—has been found effective for learning (Fonseca & Chi, 2011; Johnson & Mayer, 2010). Furthermore, self-explanations were found to be effective for fostering student learning in undergraduate STEM subjects such as computer science (Sudol-DeLyser, 2015), biology (McNamara, 2017; Elme et al., 2022), and engineering (Vieira et al., 2017).

ExplainIt is an AI based Pedagogical Language Analysis tool developed using natural language process (NLP) to analyze students' timely self-explanations and provide timely feedback to instructors during large STEM courses. Specifically, for students, ExplainIt automatically analyzes their written responses to pose real-time questions to evaluate the quality or correctness of their explanations. For instructors, it provides real-time summaries of students' written explanations, their correctness, in aggregate classroom level so that they can adjust their instruction.

The current study is exploratory research to investigate expectations and perceptions of instructors teaching large STEM courses for embedding ExplainIt.

Research questions:

1. What are STEM instructors' expectations of an AI based Pedagogical Language Analysis tool (ExplainIt) embedded in their classrooms?
2. What do STEM instructors perceive are benefits of using ExplainIt embedded in their classrooms?
3. What do STEM instructors perceive are barriers to using ExplainIt embedded in their classrooms?

Method

Participants

Participants were three instructors teaching large computer science and biology courses. Instructor A, a professor in Computer Science (CS), has taught an introduction to AI course for both undergraduate- and graduate-level (75 and 100 students respectively) for three years. Instructor B, also a CS professor, has been teaching this course for three years (100) for undergraduate students. Instructor C, a Biology professor, has been teaching an undergraduate-level foundational biology course (250) for more than four years.

Data Collection Procedures and Analysis

The researchers developed a semi-structured interview protocol and then recruited instructors who have been teaching large STEM courses. Upon IRB approval, researchers sent an email to the instructors, and asked them to participate in an-hour interview. On the interview day, two researchers conducted the interview on Zoom. All interviews were recorded for later analysis.

Researchers later transcribed interview recordings to conduct thematic analysis. Thematic analysis was used for identifying and reporting themes within data

(Terry et al., 2017), and identifying common themes across (Riger & Sigurvinsdottir, 2016).

Results

Instructors emphasized various expectations of ExplainIt related to system accommodations such as class size; numbers of questions they would pose; teaching mode (online or face-to-face); beneficial topics; types of feedback; integration of ExplainIt with an existing Learning Management System (LMS). Instructor A expected ExplainIt to analyze students' "just-in-time" responses much quicker than Google sheets, and present an overview "snapshot" of students' understanding. Instructor B hoped ExplainIt could inspire students' to express deeper explanations of concepts and encourage higher engagement with laptops or smartphones. Instructor C wanted the system to provide accurate feedback to students and also provide feedback instead of grades to students. Technically, he expected ExplainIt to boot up and function with a high speed in the devices such as laptop.

In terms of the perceived benefits of ExplainIt, instructor A stated that the system could easily provide a picture of students' understanding from the response analysis (e.g., percentages of correct responses), allowing her to adapt her instruction immediately. Instructor B mentioned that using such a system can increase student engagement and push students' thinking further. Instructor C stated that using such a system may benefit low achieving students in the content area.

When asked about potential barriers, one common theme amongst the instructors was the question of AI technologies' accuracy of the automated assessment of students' self-written explanations. Other potential barriers included the time commitment for instructor to author questions and answer in the system and AI training (instructors A and C), limitations of NLP for analyzing long student explanations correctly (instructor B), and students being critical of AI systems used in courses generally (Instructor A).

Discussion

This initial study showed that instructors have various expectations and identified multiple barriers for integrating an AI-based system to provide feedback to their students' self-explanation responses. Results will be further discussed and detailed discussion will be provided in the full paper and session.

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