Title:

Towards AI-Enhanced Classroom Response System Eliciting Self-Explanations in Computer Science Courses

Short Description

This study investigates implementation of a natural language-based classroom response system in STEM education within a higher education context. Data were collected from 36 students using four instruments to capture demographic information, self-efficacy, engagement, and system evaluation. The results showed that students reported a positive learning experience and demonstrated evidence of increased self-efficacy in STEM content, along with high perceptions of user engagement following their use of the ExplainIt classroom response system.

Keywords: emerging technologies, technology integration

Abstract/Proposal Body

Introduction

In recent years, AI-powered educational technologies have been increasingly applied to support instructional activities and provide scaffolding (Darvishi et al., 2024). Particularly there has been an increasing number of publications related to automated feedback systems within STEM domains in higher education (Deeva et al., 2021). Notably, intelligent tutoring systems can provide adaptive feedback to assist students during problem solving (Kochmar et al., 2022), offer guidance on practice items (Yilmaz et al., 2022), and facilitate learning specific topics, such as computer programming (Huang et al., 2023).

Feedback can improve learning (Carless, 2015) and plays a pivotal role in motivating students in higher education settings (Dawson, et al. 2019). In the feedback process, students' engagement is critical for the reception of feedback (Winstone & Carless, 2019), and engagement with the feedback can improve learning (Zhang & Hyland, 2018). Additionally, feedback can have positive effects on learners' self-efficacy (Ozogul, Olina & Sullivan, 2008, Asghar, 2010) and improve learning outcomes (Ozogul & Sullivan, 2009; Schunk & Ertmer, 2000).

Classroom response systems, such as audience response systems with clickers (Hunsu et al., 2016) and personal response systems with mobile apps (Teo & Chew, 2015), are among the most notable solutions for providing feedback in large classes. Although students may receive instant feedback from these systems, multiple-choice questions do not allow students to construct their own responses and engage in active learning (Chi & Wylie, 2014), so these systems may fall short in fostering deep conceptual understanding and achieving high-level outcomes in STEM courses (Hunsu et al., 2016; Shapiro et al., 2017). Emerging AI technologies present potential solutions to address limitations of these response systems (Roll & Wylie, 2016), as they can provide effective, timely, and personalized feedback on students' free-text responses (Li & De Luca, 2014).

One way to improve student engagement and learning in the classroom is by allowing students to write self-explanations. Self-explanation is a cognitive process by which students actively engage in processing new information and acquiring skills by articulating responses in their own words (Bisra et al., 2018; Fonseca & Chi, 2011; Johnson & Mayer, 2010). It has been shown to be effective for student learning in STEM domains, especially in Computer Science (CS) (SudolDeLyser, 2015).

ExplainIt is a web-based classroom response system that elicits student self-explanations and provides feedback. Instructors pose questions prompting self-explanations in the Instructor app, then students submit their self-explanations via the Student app. The system is evolving to automatically assess student responses using large language model (LLM) models like GPT-4 and FLAN-T5, and shows promise for efficient evaluation in large classes. It also provides summaries of student responses, assisting instructors in gauging class comprehension and adjusting instruction.

Research Questions

1. Are there any changes in students' self-efficacy in Computer Science before and after using the ExplainIt classroom response system?
2. How engaged were the students while using the ExplainIt system?
3. What are students' usability perceptions of the ExplainIt system?

Method

In this paper, we present a case study that took place at a public university. Researchers investigated the effects of the ExplainIt system on students' self-efficacy, engagement and potential usability perceptions.

Participants

Participants were 36 undergraduate students in a face-to-face CS course, among which 32 completed the survey. Students' reported ages ranged between 18 and 28 years old. The gender distribution was 8 (25%) female and 23 (72%) male, and 1 (3%) did not report gender.

Instruments

Researchers used four instruments to collect data: demographic information, self-efficacy, engagement, and system evaluation surveys. The latter three were adapted from previously developed surveys. All instruments except demographic survey used a five-point Likert Scale complemented by additional open-ended questions which capture students' perspectives on the ExplainIt system's usability and capture their expectations of ExplainIt.

Data Collection and Analysis

The demographic and self-efficacy surveys were distributed to students before the implementation in their CS course. After the implementation, self-efficacy survey, engagement and system evaluation surveys were distributed. Once all surveys were completed, researchers downloaded the data, conducted descriptive statistical analysis on Likert questions, and thematic analysis on open-ended question responses.

Results

The completion rates for the instruments varied. For self-efficacy, 16 students completed both pre- and post-surveys. Responses included five levels of agreement: strongly disagree (coded as 1), disagree (2), neutral (3), agree (4), and strongly agree (5). The average agreement level for each question across all participants was 3.69 in the pre-survey and 3.80 in the post-survey. The question with the highest gains in mean scores from pre- to post-survey was: "I am knowledgeable about the concepts covered in the course," which increased from 3.23 to 3.89.

Regarding engagement, 18 students completed the post-survey. Using the same data analysis method above, the average agreement level for each question across all participants was calculated as 3.48, indicating an overall engagement level above "Neutral" (3 points). This suggests that most students indicated that they felt well-engaged.

For the system evaluation, data were collected from 17 participants. As for ease of use, students rated the system 3.94 and the item regarding the ease of using the system to complete tasks received a score of 3.47, on a scale where "1" was coded as "very hard" and "5" as "very easy". This shows that the majority of the participants perceived the ExplainIt system as relatively easy to use, including submitting self-explanations. The general system evaluation yielded an average agreement level of 3.85, suggesting a positive reception among students.

The thematic analysis of the open-ended questions uncovered several themes. For example, most students indicated that ExplainIt was helpful for their learning and understanding the concepts covered in the CS course. In terms of disliked aspects, a few students mentioned software bugs, such as a timeout issue that necessitates reloading the ExplainIt student app. Additionally, students suggested additional features for ExplainIt, such as the ability to display a history log of their submitted answers, view instructor posed questions with graphs, differentiate between graded and non-graded questions from the instructor, and view a summary of all answered questions.

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