Catalyzing Python Learning: Assessing an LLM-based Conversational Agent

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Abstract: The rapid rise of digital learning platforms has ushered in an era of educational transformation. While these platforms offer the advantage of scalability, they often fall short in facilitating meaningful interaction, which is pivotal for effective learning. Addressing this concern, our study introduces PyGuru 2.0, an innovative online learning environment for Python programming that aligns with the ICAP framework with an advanced conversational agent. We further investigate the interactions between students and a chatbot, employing a qualitative approach to comprehensively explore the diverse ways in which students interact with the chatbot. The interaction categories encompass a wide spectrum, including code assistance, error resolution, and conceptual explanation. In future, we plan to further elaborate on this coding scheme and see its impact on students' learning outcomes.

Keywords: PyGuru, Chatbot, ICAP, ChatGPT, Python Programming.

1. Introduction

In recent years, there has been a steady growth in the use of digital learning environments to supplement classroom teaching. However, the design of these learning environments challenges educators' capacity to facilitate personalised and meaningful interactions with learners (Song, Oh, and Rice, 2017). Such interactions align with established learning theories that underscore the significance of social engagement and meaningful discourse in yielding fruitful learning outcomes (Kim, 2001).

There is a quest to create technology that can mimic personal and meaningful interactions to improve learning in these digital learning environments. This gap of unavailability of meaningful and personalised learner-educator is now being overcome by Conversational Agents (CA). A CA is a computer system intended to converse with a human. In the domain of education, plenty of initiatives were undertaken to employ CA for various reasons, including the exploration of their potential to foster active participation, drive knowledge construction, and enhance learning outcomes (Song, Oh, and Rice, 2017; VanLehn et al., 2007; Grossman et al., 2019). However, notwithstanding their promising prospects, traditional CAs bear certain limitations. Their knowledge scope can be confined, resulting in limited responses and incomplete guidance. Moreover, their ability to grasp conversation context may be constrained, leading to misinterpretations of learners' queries.

To fill this lacuna, our research endeavours to address these limitations by introducing PyGuru 2.0: an extension of PyGuru that seamlessly integrates an advanced conversational agent powered by "ChatGPT 3.5 turbo". Further, we seek to examine how students interact with this chatbot and how it impacts their learning outcomes. This exploration is grounded in the principles of Chi and Wylie's ICAP framework, which was extended by Raković et al., 2020 by proposing 10 rhetorical moves characteristic of the interactive mode of Chi and Wylie's ICAP framework (2014). An elementary analysis has revealed that students use the chatbot for error resolution support, conceptual explanations etc. In future, we plan to further elaborate on this coding scheme and see its impact on students' learning outcomes.

2. PyGuru 2.0: Learning Environment

The learning environment PyGuru 2.0 is a simple extension of PyGuru, which is a computer-based learning environment for learning Python (Singh et al., 2022). PyGuru has a book reader, video player, code editor, and discussion forum. The book reader contains textual information which can be highlighted and annotated. The video player offers an advanced interactive feature of embedding questions into the video. It also has a discussion forum to allow learners to put forth their queries. Further, PyGuru offers Integrated Development Environment (IDE) to practise coding.

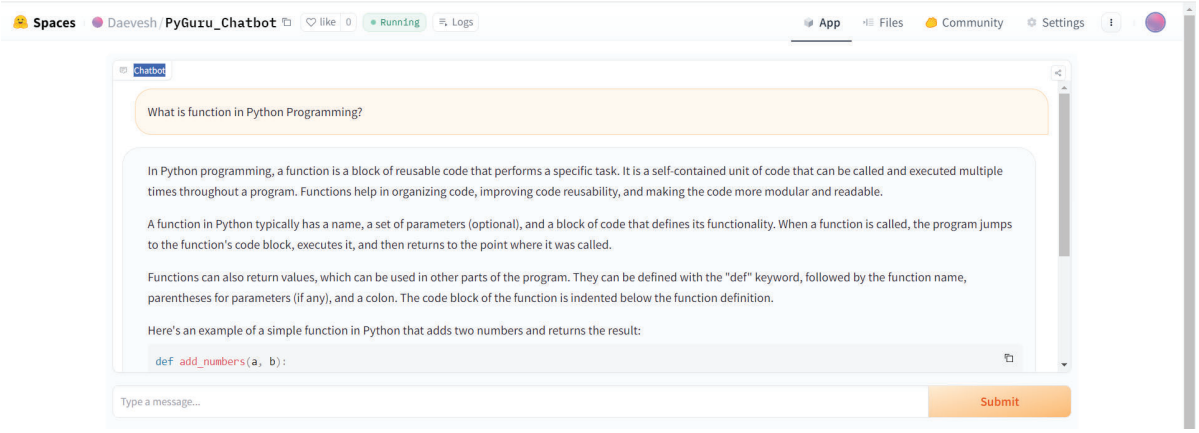

Figure 1. User interaction with the chatbot integrated with PyGuru 2.0.

In PyGuru 2.0, we have layered a chatbot on top of the existing learning environment PyGuru. This chatbot is powered by "ChatGPT 3.5 turbo". This chatbot provides students with real-time assistance, guidance, and feedback on their programming inquiries and challenges. PyGuru 2.0 aligns with the ICAP framework by promoting interactive conversations, where learners actively engage in discussions with the conversational agent.

3. Methods

3.1 ICAP Framework

ICAP is a hierarchical engagement framework classifying student behaviours into four modes: interactive, constructive, active, and passive (Chi & Wylie, 2014). Passive mode involves receiving information without active learning actions, leading to episodic storage (Chi & Wylie, 2014). Active engagement includes physical actions like note-taking and aiding learning with prior knowledge integration. Constructive engagement entails creating artefacts using prior knowledge and available information, fostering deeper understanding (Chi & Wylie, 2014). Interactive engagement happens during interactions between the partners (here chatbot and learner) and requires constructive engagement from both partners involved as well as sufficient turn-taking (Chi & Wylie, 2014). We intend to leverage the ICAP modes to analyse the learner interactions with the chatbot.

3.2 Study Design and Data Collection

This research aims to explore and analyse the interactions between students and a chatbot in the context of Python programming education. The study adopts a qualitative approach to investigate the diverse ways in which students engage with the chatbot during their learning process. The data for this study will be collected from PyGuru 2.0. The study involves undergraduate students enrolled in Python programming courses. Data will be collected for six sessions, each lasting 90 to 120 minutes, allowing for a comprehensive analysis of student-chatbot interactions.

3.3 Coding Interaction Categories

To analyse student-chatbot interactions, a set of interaction categories will be established based on the nature of communication observed during interactions. Some of the possible categories and their description is mentioned in Table 1.

Table 1. *The table presents interaction categories for analysing student-chatbot interactions*

Codes	Explanation
Error Resolution	Assistance in resolving programming errors.
Conceptual Explanation	Seeking conceptual explanations or theory.
Exploratory Discussion	Engaging in open-ended discussions to explore concepts

3.4 Data Analysis

Student-chatbot interactions will be categorised by multiple coders to ensure the consistency and reliability of the interaction categories. Inter-rater reliability will be assessed using Cohen's Kappa. The coded interactions will be subjected to qualitative content analysis. The identified interaction categories will be examined in terms of frequency, patterns, and nuances, providing insights into how students engage with the chatbot and how this impacts their learning outcome.

4. Conclusion

By embedding an advanced conversational agent within PyGuru's existing framework, we enhance the quality of interactions between learners and the platform, addressing the limitations of traditional digital learning methods. Our research is rooted in the ICAP framework's principles, advocating for interactive, constructive, and active cognitive engagement to optimise learning outcomes.

The integration of PyGuru 2.0 and its chatbot component aims to provide a comprehensive learning experience, promoting real-time assistance, guidance, and feedback. By employing a qualitative approach to analyse student-chatbot interactions, we seek to unravel the diverse engagement patterns occurring during programming education. This analysis can potentially offer valuable insights into how learners benefit from interactive discussions, error resolution support, and conceptual explanations facilitated by the chatbot.

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