Information Systems Frontiers (2023) 25:161–182
https://doi.org/10.1007/s10796-022-10291-4

Artificial Intelligence (AI) Student Assistants in the Classroom: Designing Chatbots to Support Student Success

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Accepted: 4 May 2022 / Published online: 14 June 2022

Abstract
In higher education, low teacher-student ratios can make it difficult for students to receive immediate and interactive help. Chatbots, increasingly used in various scenarios such as customer service, work productivity, and healthcare, might be one way of helping instructors better meet student needs. However, few empirical studies in the field of Information Systems (IS) have investigated pedagogical chatbot efficacy in higher education and fewer still discuss their potential challenges and drawbacks. In this research we address this gap in the IS literature by exploring the opportunities, challenges, efficacy, and ethical concerns of using chatbots as pedagogical tools in business education. In this two study project, we conducted a chatbot-guided interview with 215 undergraduate students to understand student attitudes regarding the potential benefits and challenges of using chatbots as intelligent student assistants. Our findings revealed the potential for chatbots to help students learn basic content in a responsive, interactive, and confidential way. Findings also provided insights into student learning needs which we then used to design and develop a new, experimental chatbot assistant to teach basic AI concepts to 195 students. Results of this second study suggest chatbots can be engaging and responsive conversational learning tools for teaching basic concepts and for providing educational resources. Herein, we provide the results of both studies and discuss possible promising opportunities and ethical implications of using chatbots to support inclusive learning.

Keywords Conversational agents · Chatbots · Higher education · Inclusive learning

1 Introduction

Education research has shown that positive social interaction and rapport between students and teachers enhances student learning (Dobransky & Frymier, 2004). However, in current classroom settings, high student–teacher ratios make it difficult for every student to receive the one-on-one interaction and guidance needed to improve learning outcomes. Additionally, there has been a recent increase in students interested in self-paced learning opportunities. Online learning options, such as Coursera, Udemy, and Udacity, have grown in popularity, in part due to their ability to support different learning speeds and styles (Okonkwo & Ade-Ibijola, 2021). Blended learning experiences, with both student/teacher interactions and self-paced learning, may offer the best of both options but still present time challenges for instructors with many students. How then, as instructors, can we provide needed interactions without working overtime?

Artificial intelligence (AI) has provided promising opportunities for addressing important problems in education and society (Cowls et al., 2021; Tomašev et al., 2020) while also provoking considerations about the unintended consequences and risks of AI usage (Hagendorff, 2020; Peters et al., 2020; Atkins et al., 2021). As one type of AI technology, conversational agents (Luger & Sellen, 2016) such as chatbots (Schlesinger et al., 2018; Stieglitz et al., 2021), have been leveraged to assist student life in education

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(Goel & Polepeddi, 2016; Hwang & Chang, 2021; Kerly et al., 2007; Kerry et al., 2009; Okonkwo & Ade-Ibijola, 2020, 2021; Zhao et al., 2020). The term "chatbot" stems from "Chatter bot," coined by Michael Loren Mauldin fofr programs capable of text-based conversations with users. Chatbots were initially studied in the early 1980s, but did not receive much attention until recent developments in natural language processing, AI, and deep learning increased their usability (Chuah & Kabilan, 2021; Hwang & Chang, 2021; Okonkwo & Ade-Ibijola, 2021). Currently, chatbots are used on commercial websites for many applications, including answering frequently asked questions, product troubleshooting, marketing, and service inquiries (Avula et al., 2018; Jain et al., 2018; Tallyn et al., 2018; Winkler & Soellner, 2018; Behera et al., 2021; Kushwaha and Kar, 2021; Nguyen et al., 2021). Studies in the information systems field have mainly investigated the benefits of chatbots in facilitating interactive and timely support in business contexts (Behera et al., 2021; Kushwaha and Kar, 2021; Nguyen et al., 2021), such as facilitating collaboration (Stieglitz et al., 2021), enhancing work performance (Williams et al., 2018), collecting research data (Zhou et al., 2019), and fostering health and well-being (Schroeder et al., 2018; Fadhil, A., & Gabrielli, S. (2017); Lee et al., 2019; Fitzpatrick et al., 2017; Ahmad et al., 2022). Researchers have also begun to explore teaching and learning scenarios to determine where pedagogical chatbots may be most helpful (Chuah & Kabilan, 2021; Goel & Polepeddi, 2016; Gonda et al., 2018; Huang et al., 2022; Malik et al., 2021), with most focusing on chatbot support of language learning (Huang et al., 2022; Kohnke, 2022).

Despite the potential benefits of pedagogical chatbots, IS empirical studies of pedagogical chatbot efficacy in higher education are limited (Hobert, 2019; Hwang, G. J., & Chang, C. Y. (2021)) and fewer still discuss their potential challenges, drawbacks (Chocarro et al., 2021; Okonkwo & Ade-Ibijola, 2021), impacts on equity and accessibility, or threats to privacy, justice, and fairness (Goel & Polepeddi, 2016). We seek to address this gap in the literature through two sequential exploratory studies employing an experimental chatbot named "Sammy." The first study gathers feedback from 215 undergraduate business students at a large public university in the United States who completed an "interview" (i.e., a chat) with Sammy, answering open-ended questions regarding the main barriers to instructor-provided assistance as well as the potential opportunities, strengths, and challenges of using chatbots as intelligent student assistants in higher education *prior to* creating a pedagogical chatbot. Specifically, this study asks the following questions, RQ1: How can chatbot intelligent student assistants help students?, RQ2: What are the strengths of chatbots as intelligent student assistants?, and RQ3: What are the potential challenges with using chatbots as intelligent student assistants? The second study then builds upon the findings from Study 1 to design, develop, and then test the effectiveness of using the new Sammy chatbot to provide a guided learning experience that introduces AI and its applications to 195 undergraduate business students. The goal of Study 2 was to explore the following questions, RQ1: How effective are chatbot intelligent student assistants at teaching basic content?, RQ2: How effective are chatbot intelligent student assistants at encouraging students to explore additional resources?, RQ3: What are student perceptions of chatbot-guided learning experiences?

This research contributes to the IS field by empirically investigating the opportunities, benefits, and drawbacks of chatbots as intelligent student assistants in higher education and assessing the efficacy of these tools in educating non-technical students about technology. Our findings extend the IS literature by revealing previously unconsidered ways in which chatbots might be leveraged to support student success in higher education as well as how chatbot features, design, and interactions may positively influence both student behaviors during the learning process and learning outcomes (Hwang & Chang, 2021).

The rest of the paper is organized as follows. Section 2 discusses research related to chatbots in education, including relevant research on the ethical application of AI in education. Section 3 presents the research methodology and research design of the two sequential studies in this paper. Section 4 discusses the findings of both the first study, which examines student perceptions of chatbots as intelligent teaching assistants, and the findings of the second study that investigates the effectiveness of a learning chatbot we developed in this context. Next, Sect. 5 discusses the key findings and contributions of this research and discusses the limitations and implications for research and teaching. Finally, Sect. 6 concludes the paper.

2 Related Work

2.1 Chatbots in Education

As one application of AI, a chatbot interacts with users in the form of a conversation. It interprets users' natural language questions and responds with the most suitable answers (Nirala et al., 2022; Petrović & Jovanović, 2021). Depending on its functionalities, a chatbot may be enabled by a wide range of technologies such as natural language processing, machine learning, deep learning, artificial neural networks, etc. (Nirala et al., 2022). Chatbots' interactive, cost-effective nature has led to a growth in their popularity and applications in multiple industries, primarily for customer service (Xu et al., 2017; Johannsen & Leist, 2018; Behera

et al., 2021; Chuah & Kabilan, 2021; Kushwaha and Kar, 2021; Nguyen et al., 2021). Recently, researchers have also explored the use of chatbots in a variety of other areas, such as facilitating collaboration, enhancing work performance, conducting recruiting interviews, and promoting physical and mental health (Ahmad et al., 2022; Avula et al., 2018; Fadhil & Gabrielli, 2017; Fitzpatrick et al., 2017; Hwang & Chang, 2021; Lee et al., 2019; Schroeder et al., 2018; Stieglitz et al., 2021; Williams et al., 2018; Zhou et al., 2019). Chatbots have also been leveraged to deliver informal learning and services to underserved and vulnerable populations. Examples include FarmChat (Jain et al., 2018), which was designed to provide farmers in rural India with better access to information, and Consejero Automatico (Wong-Villacres et al., 2019), which supports the educational engagement of Latino parents.

Prior work has also explored the use of chatbots in higher education (Chuah & Kabilan, 2021; Hwang & Chang, 2021; Okonkwo & Ade-Ibijola, 2021). To date, the educational application of chatbots has been mainly in the areas of health and well-being, language learning, feedback facilitation, metacognitive thinking, and student queries (Chuah & Kabilan, 2021; Petrović & Jovanović, 2021; Winkler & Soellner, 2018) with most noting the educational benefits of chatbot interactions. For example, a study conducted by Bii (2013) revealed that the interactive nature of chatbots provides opportunities for social interaction, which plays a critical role in the development of cognition and contributes to the process of learning. Similarly, a 15-week study by Pereira and Juanan (2016) found @dawebot, an educational tool that generates practice tests, to be an engaging way for students to study for exams. One of the most well-known examples in higher education is the "Jill Watson" chatbot piloted by Georgia Institute of Technology as an automated teaching assistant designed to answer student questions in an online course (Goel & Polepeddi, 2016). More recently, studies have found that educators are generally positive about the potential for chatbots to increase student engagement and, perhaps unsurprisingly, that instructors are more likely to adopt these technologies when they are perceived to be useful and easy to use (Chocarro et al., 2021; Chuah & Kabilan, 2021; Hwang & Chang, 2021; Okonkwo & Ade-Ibijola, 2021). Malik et al. (2021) found that perceived ease of use and usefulness also positively influence student adoption intentions and their attitudes toward these technologies, and that perceived technology convenience influences these factors as well. Beyond applications in support of learning, a few universities have also deployed chatbots to support student life. Pounce (Peterson, 2016) helps first-time students transition to and enroll in Georgia State University. The chatbot can answer student questions regarding enrollment and financial aid, while also having the capability to remind students who haven't finished portions of the enrollment process. A more advanced application of this technology in education is INDIGO (Xiao et al., 2019), a chatbot developed as an intelligent agent to infer a student's personality and facilitate the process of forming teams and supporting teamwork among college students. In this application, the chatbot not only understands the content of a conversation, but also infers the personality of the users.

Recently, researchers have also proposed designs for career counseling chatbots. For example, Parab et al. (2017) modeled a chatbot career counseling system that suggests career options based on users' qualifications, interests, and hobbies. D'Silva et al. (2020) proposed a more comprehensive chatbot counselor that can conduct a series of psychometric tests to infer a user's personality and then present career options based on their personality traits. Once a user has decided to apply for a specific job, the chatbot would then learn about the user's emotions in order to understand their interest in the job application and mentor them to learn the skills required in the job description. Finally, the chatbot would build an e-portfolio for the user's own information and/or for job providers. The chatbot could also provide translation services throughout the job application process for users who face language barriers (D'Silva et al., 2020).

2.2 Ethical Considerations of Chatbots in Learning

In a recent literature review of 74 papers, Wollny et al. (2021) found that over 50% of chatbots in education were focused on teaching a new language. Only a few research projects have studied the value of chatbots in education for increasing equity and inclusion or investigated the ethical issues surrounding its use in educational settings. For example, the chatbot CiSA (Heo & Lee, 2019) was developed to support the communication, information accessibility, and social inclusion of international students. Eicher et al. (2018) examined ethical issues related to Jill Watson – the virtual teaching assistant at Georgia Tech that was discussed in Sect. 2.1 – particularly the inability of its natural language processing techniques to understand the specific needs of students from minority groups or those with physical conditions, especially in STEM (Science, Technology, Engineering, and Mathematics). An additional consideration is chatbot transparency to ensure users understand they are talking with a chatbot and not a human (Cheng, 2018). However, this is counter to a common AI goal of passing the Turing Test (conversing in a style indistinguishable from that of humans) (Okonkwo & Ade-Ibijola, 2021), and in the implementation of Jill Watson at Georgia Tech, most students were not aware that they were talking with a computer (Microsoft, 2019).

2.3 Ethical AI Frameworks

Although there has been limited research specifically on the ethics of AI related to chatbots, there have been calls by academia, industry, and nonprofits for research into the ethical and responsible use of AI technologies in general and several AI ethics frameworks and taxonomies have been proposed (Peters et al., 2020; Hagendorff, 2020; Atkins et al., 2021). For example, Barredo Arrieta et al. (2020) examined the importance of explainable AI in terms of fairness and privacy by design. Through their review of soft-law and non-legal norms issued by governmental organizations, industry giants, professional societies, and ethical institutes and centers, Jobin et al. (2019) identified the following 11 ethical AI principles: 1) transparency; 2) justice and fairness; 3) nonmaleficence; 4) responsibility; 5) privacy; 6) beneficence; 7) freedom and autonomy; 8) trust; 9) dignity; 10) sustainability; and 11) solidarity (in order of how often each principle was discussed). However, they found the definition of these principles varied widely, as did recommendations for the ethical application of AI, revealing a lack of consensus among practitioners. In related research, Ghallab (2019) addressed the ethical use of AI from the viewpoint of the risks it poses, including 1) the safety of AI applications in critical fields (e.g., healthcare, transportation, and surveillance and defense systems), 2) the security and privacy of individual users, and 3) social risks, including the long-term impact on future generations and their cultural and ethical values. Researchers have noted the complexity of providing a generalized AI ethics model given the many different contexts to which AI is applied, while also recognizing the need to bridge theory and practice (Wearn et al., 2019; Peters et al., 2020; Atkins et al., 2021). This has led to suggestions for domain-specific ethical AI guidelines that are easier to use and would yield more practical insights than domain-independent frameworks, as well as calls for measurable standards rather than high level principles (Atkins et al., 2021). Although multiple frameworks exist for AI ethics, Microsoft's guidelines for responsible bots (Cheng, 2018), while not domain-specific, is the only framework directly focused on chatbots as a class of applications.

One ethical dilemma raised by Jobin et al. (2019), but not directly addressed in the 11 ethical principles identified in their literature review, is the global imbalance in the discussion of AI ethics. They suggest that economically developed countries are shaping the debate on AI ethics and this can have a detrimental impact on cultural pluralism and global fairness. While Microsoft (2019) identified the potential for AI to reduce poverty in Sub-Saharan Africa and address a number of social problems (including education), Carman and Rosman (2020) note the ethical challenge of assuming universal norms, particularly for Africa given its history of externally imposed values. The authors also highlight the challenges in addressing the ethical goal of explainability with a diversity of languages, cultures, and norms, but that doing so may result in more ethical outcomes, and if done well, better AI technologies, without stifling innovation and development.

In sum, prior work has demonstrated the potential benefits and challenges of using AI in educational settings and highlighted potential ethical considerations. In particular, domain specific ethical implications for AI might be more important than general or domain-independent guidelines. As one application of AI technologies, chatbots have been used in various domains, including education. However, the potential benefits, challenges, and risks of using chatbot for learning in higher education are understudied.

3 Research Methodology

This research investigates how using chatbots as intelligent student assistants may support student success in higher education. We designed and then conducted two sequential studies, employing a user-centered design approach (Norman and Draper, 1986, Abras et al., 2004), in which users may influence the evolution of a system's design through their engagement in development steps, such as needs and requirements gathering and / or user experience testing.

3.1 Study 1 Design

In Study 1, we gathered student perceptions of their learning needs and explored their ideas on how chatbots might support student success by "interviewing" them with a chatbot named "Sammy." Chatbot-led interviews for data collection are similar to survey data collection methods but offer several additional benefits. First, chatbots serve as a convenient tool for gathering interview-style data from a large sample with minimal human involvement (Tallyn et al., 2018); second, chatbots provide a more interactive participant experience than standard survey methods (Tallyn et al., 2018; Te Pas et al., 2020); and third, interactions with a chatbot may help participants unfamiliar with these tools better envision using them as student assistants. In order to design a chatbot that could test this technology's effectiveness as an intelligent student assistant, we first queried students regarding their perceptions of chatbots for this purpose. Study 1 sought insights into the following research questions:

RQ1: How can chatbot intelligent student assistants help students?
RQ2: What are the strengths of chatbots as intelligent student assistants?
RQ3: What are the potential challenges with using chatbots as intelligent student assistants?

We developed Sammy (Fig. 1) using services provided by Juji Inc. (https://juji.io), a publicly available chatbot platform

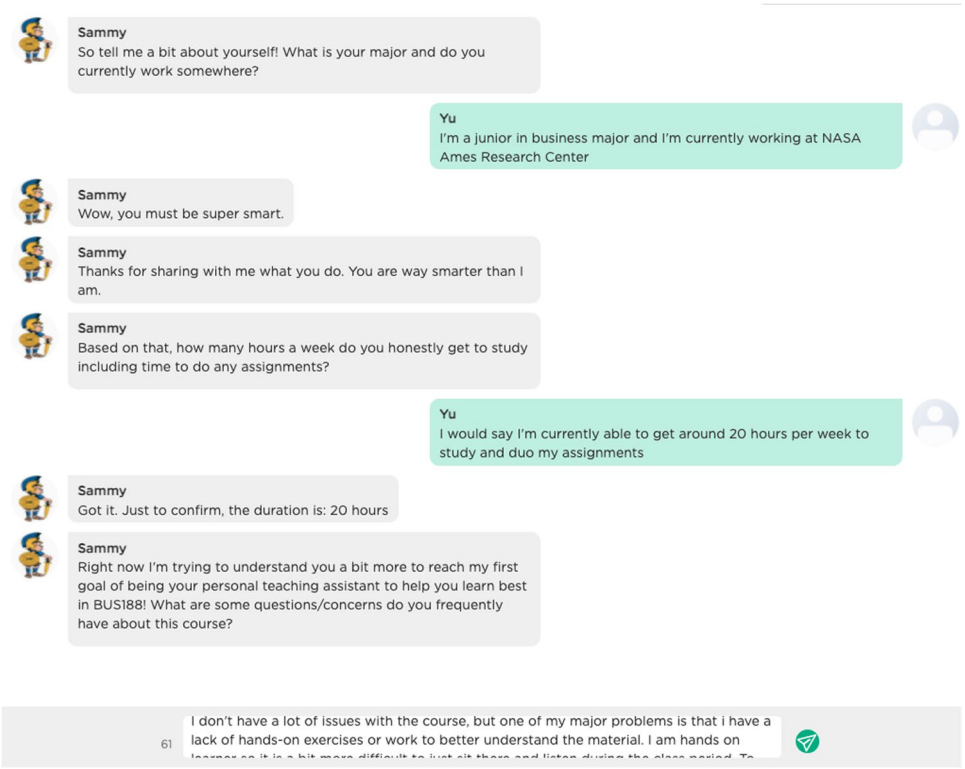

Fig. 1 Screenshot of the Study 1 Sammy chatbot interface

that allows users to easily create chatbots for personalized needs (Li et al., 2017). The Juji platform includes a hybrid of 1) a rules-based approach that handles user input via explicitly coded knowledge, and 2) a data-driven approach that integrates deep learning to handle complex and diverse conversations such as user interruptions and malicious input (Xiao et al., 2020a, b). Furthermore, Juji is capable of interpreting user characteristics, such as personality and sentiment (Zhou et al., 2019).

In particular, Juji provides a graphical user interface that allows chatbot builders to create an interview chatbot in much the same way they would create an online survey (Han et al., 2021). Juji provides a user interview chatbot template that is capable of supporting an ongoing conversation by asking users questions and then replying to the user's answer with one of three types of responses: 1) responses that are pre-built by the interview designer, 2) responses drawn from Juji's conversation libraries, or 3) a customized chatbot response based on the bot's own sentiment analysis of user inputs. For example, the designer can create a database of frequent user inputs, the possible responses to those inputs, and similarity scores for recognizing the user's intent. Designers can also configure the pace of a conversation by adjusting the chatbot's delay before responding in order to simulate a more natural conversation flow.

We designed the questions, dialog flow, and wording of Sammy's prompts and responses using colloquial language that students may find more natural (see Appendix 1). The participants for Study 1 were students recruited from five sections of an upper division undergraduate Introductory MIS class for business majors. Students were offered extra credit to participate in a chatbot-led interview with Sammy about their learning needs and the opportunities and challenges of using chatbots as intelligent student assistants. Participants were informed that they were chatting with a chatbot instead of a real human and that they could complete the "interview" on their own laptop at a time and place of their choice. To reduce the potential of positive response bias and student concerns that their responses might influence their grades, students were informed that their answers were not accessible to their instructors. The study was approved by the University's Institutional Review Board.

3.2 Study 2 Design

Drawing from participant input collected in the first study, we designed a new chatbot (also named Sammy), for Study 2 in order to conduct a user experience test of the effectiveness of chatbots in teaching basic knowledge. We deployed this new chatbot to teach introductory AI concepts to a new sample of students enrolled in several sections of an upper division business class. Our findings from this second study build on Study 1's insights to present a fuller picture of the potential benefits and challenges of using chatbots in higher education.

In Study 2, we designed an educational chatbot for undergraduate students, incorporating user requirements and design

elements that capitalize on the pedagogical strengths of chatbots identified in Study 1 and address some of their weaknesses. Specifically, we designed the chatbot to teach basic AI content and to encourage students to explore additional resources on AI. We also named this second chatbot "Sammy" in honor of the university's mascot. We chose the topic of AI as learning material for Study 2 for two reasons. First, most of the participants were majoring in non-technical subjects and thus were likely to have limited knowledge of AI. Using this topic allowed us to assess the effectiveness of chatbot-led learning and its impact on student learning behaviors. Second, using chatbot provided students with the opportunity to learn experientially, to see AI in action while learning about its applications. This provided a richer learning environment for our participants. Our research questions for Study 2 were:

RQ1: How effective are chatbot intelligent student assistants at teaching basic content?
RQ2: How effective are chatbot intelligent student assistants at encouraging students to explore additional resources?
RQ3: What are student perceptions of chatbot-guided learning experiences?

We again used the Juji no-code chatbot-building tool to redevelop our Sammy chatbot so that it offered a guided learning experience on the topic of AI basics using a conversational style. We deployed the newly designed chatbot (Fig. 2) in five sections of three upper division undergraduate business courses. The instructors for these classes agreed to use Sammy as an in-class, extra credit learning activity towards the end of the fall semester in 2020 as a way to teach students about AI.

Before beginning the experiment, we provided students with an explanation of the study's purpose and procedures. We then provided students with two links: 1) a link to access the Sammy chatbot, and 2) a link to an anonymous post-study survey asking for feedback about learning AI with Sammy. The experiment began with Sammy chatting with students to build its own understanding of their prior knowledge about AI. Next, Sammy provided AI examples and formal definitions. Spread throughout the student's conversation with Sammy were five multiple choice quiz questions and hyperlinks to ten additional resources which provided applications and further information on AI. Of these ten articles, three had associated tasks requesting students to read the article and give their opinions to Sammy. The Sammy chatbot was also able to answer selected pre-programmed questions and provide variations on how these questions were asked. If a student asked a question Sammy was unable to answer, the question was recorded and sent to the course instructor to answer. Students were given 30 min in class for the Sammy tutorial with the option to complete it after class if they were unable to do so during the allotted time. We designed the study to be a 30-min activity after conducting a pilot study with two students who finished the study in less than 20 min without any time constraints.

4 Findings

4.1 Study 1: Understanding Student Perceptions of Chatbots as Intelligent Student Assistants

In Study 1 we collected chat responses from 215 students, which included 95.6% of students in the five classes from

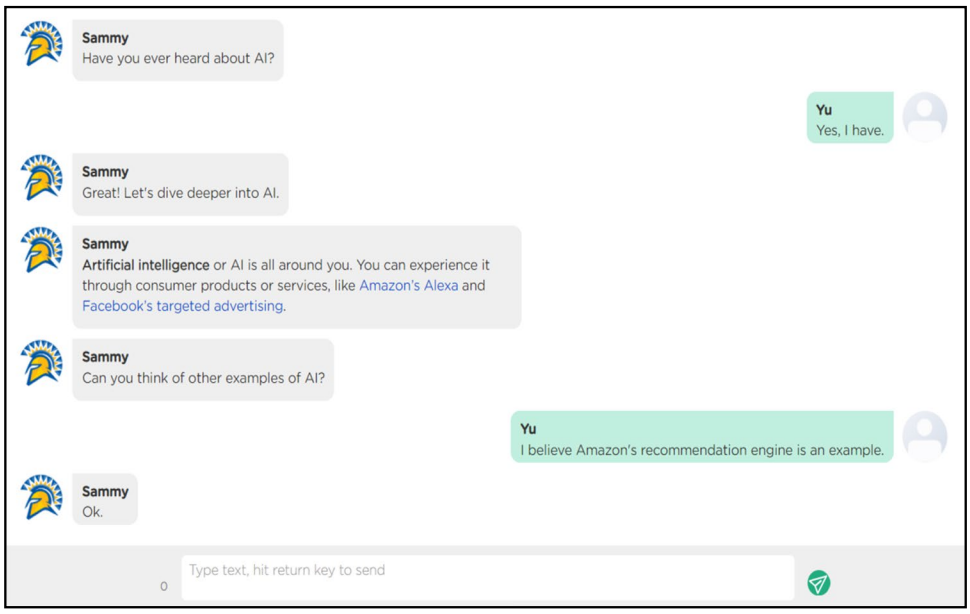

Fig. 2 Screenshot of the interface for the Sammy chatbot used in Study 2

which we recruited participants. The sample includes 211 from business majors (e.g., MIS, accounting, marketing, finance, entrepreneurship) and 4 from non-business majors, 132 males and 83 females. After gathering student chat logs, we conducted a thematic analysis (Braun & Clarke, 2006), a well-established qualitative data analysis method. Two of the authors first independently read and then re-read the chat log data from all participants and noted down initial ideas about coding around the three research questions. We then coded the data across the entire data set, discussed and organized codes into potential themes, and extracted chat data relevant to each theme. Finally, we iteratively refined and defined the specifics of each research question-based theme as explained below.

4.1.1 RQ1: How can Chatbot Intelligent Student Assistants Help Students?

When asked how chatbots could support their learning, participants were overwhelmingly supportive of chatbots intelligent student assistants, with the following functionalities being those most frequently proposed.

Teach basic content & answer basic questions Participants resoundingly asserted that they frequently needed answers to basic information about their courses, such as information on course materials, due dates, study tips, and office hours. They also wished a chatbot could provide highlights of course content. For example, one participant wrote: "*I think sometimes it's hard to pay attention to the lectures in class so I would ask questions from you [Sammy] related to the topics I don't understand."* Another wrote, *"I think it would be great if you can be a platform for studying for a test, like a person to review exam materials with… Basically, it is like reviewing with a friend and [testing] each other out."* By providing basic course information and content, chatbots could be a helpful addition, particularly in classes with high student/teacher ratios or when students are too shy to communicate directly with their instructors. This finding reinforces those of Chuah and Kabilan (2021) whose survey of teachers revealed educators' positive perceptions of chatbots' ability to provide useful information to students in a timely manner, and in doing so, increase student engagement.

Encourage exploration of additional resources Participants also expressed an interest in chatbots that could provide additional resources that would help them understand the application of course content. As one participant mentioned: *"It would be beneficial in providing real-world examples to certain applications and terms described in the textbook."* According to participants, chatbot-provided additional resources could also encourage students to further explore topics that interest them. Additionally, a few participants suggested that interacting with chatbots could also help them with higher order thinking, e.g., *"You could help me develop critical thinking skills by asking meaningful questions that provoke critical thought,"* however, further advances in natural language processing may be needed before chatbots can offer this functionality (Wambsganss et al., 2020).

Assist with career- and life-related issues In addition to addressing their academic needs, students also suggested that chatbots might support student success by providing interactive assistance with career exploration, finding mental health tips and resources, and providing a confidential ear for their worries and concerns. As one student chatted: *"Would you be available for counseling students? I feel like you would be very useful to students who have depression or anxiety and don't have people to talk to."* Although we are not suggesting chatbots could replace qualified counselors, they could serve as an always-available, and highly responsive first touch point for struggling students, guiding them to appropriate mental health professionals and support groups on campus. Chatbots could also connect students to other campus and community resources such as the career center, internship / job boards, financial aid, academic counselors and tutors, local food banks, and housing assistance.

4.1.2 RQ2: What are the Strengths of Chatbots as Intelligent Student Assistants?

We identified three themes from the chat logs regarding the strengths of chatbots as intelligent student assistants: responsiveness, interactivity, and confidentiality.

Responsiveness Participants indicated that one of the strengths of a chatbot student assistant is its 24/7 responsiveness, which allows students to access course information and get assistance with course materials at any time from anywhere. Students also noted that a chatbot student assistant could also shorten response time, often making it a much faster way to access help than communicating with a professor. As one participant mentioned: *"Your best strength as a potential course assistant is that you can answer my questions quickly and at any time, unlike a human, so I won't have to wait for someone to help me."*

Interactivity Another chatbot strength identified by participants was interactivity. Chatbots can help students learn key course concepts through conversations that may engage the learner more deeply than would static texts or videos (Hwang & Chang, 2021). They can also adjust their feedback and provide additional information, such as examples, based on student interactions. As a participant mentioned: *"I like interactive activities so I think you can help enhance examples to get a better understanding by using videos and activities in our conversations."* Chatbots can also create a

tailored learning experience, providing a diverse range of resources and formats, such as videos, images, and audio files, based on a student's preferences. Chatbots may even provide a "social" connection through chats that mimic the way many of today's college students interact with their peers (Chuah & Kabilan, 2021). Again, here we see how students believe that a chatbot intelligent student assistant's timely and meaningful interactions could help them stay engaged and learn content.

Confidentiality In addition to responsiveness and interactivity, some participants suggested that chatbots could also provide confidential learning support by allowing students to ask questions about course content or materials without revealing what they know (or don't know) to the course instructor. While instructors may not see this as a positive use of chatbots, some students may be shy or uncomfortable sharing their learning progress with the instructor or in front of other students. As one student expressed in the chat log: *"I think you can be of great help since you can keep conversations confidential…"* Similarly, by providing confidential interactions, students may be more likely to ask a chatbot questions they feel are too simple or ask last minute questions before an exam or assignment. In addition to course content, some participants also mentioned the value of confidentiality when seeking basic information on career and non-academic student support services, which was mentioned in RQ1 (c). Of course, since chatbots generate log files, this could lead to student misperceptions of the extent to which their interactions are confidential.

4.1.3 RQ3: What are the Potential Challenges with Using Chatbots as Intelligent Student Assistants?

Study participants were also asked about the challenges of using chatbots as intelligent student assistants. Participants noted that chatbots may not be able to respond to student input in a helpful and realistic manner and that their interactions lack emotional connection.

Enhanced dialog flow One of the potential challenges of using chatbots as tutors is that they may not be able to fully understand and process student chat entries as well as humans and thus not be able to tailor the learning experience to individual students as a human assistant would. Similarly, chatbots may be unable to mimic the natural flow of human-to-human conversations and instead provide an off-putting or distracting experience. As one participant commented: "*I think as an AI, and learning the kinds of this program, your [Sammy's] greatest weakness is the flow of the conversation. It's a good conversation for the most part but sometimes the flow of it can have awkward replies."* However, machine learning enabled by sufficient interactional data may help chatbots adjust their understanding of student needs and provide a more human-like conversational style.

Emotional connection The second challenge facing chatbot intelligent student assistants identified by participants is their inability to react with normal human emotions, resulting in conversations with a "transactional" feel. Some participants noted that teacher-student interactions frequently offer more than just content—that part of their value is the emotional connection that's made. As one participant wrote, *"You [Sammy] are a robot and robots do not understand human emotions."* The inability of chatbots to fully support emotional expression and exchange is a limitation instructors should keep in mind.

4.2 Study 2: Investigating the Effectiveness of Teaching AI Basics via a Chatbot

In total, 195 undergraduate students participated in Study 2, including 187 from business majors in varying concentrations (e.g., accounting, analytics, entrepreneurship, finance, management, management information systems, marketing, and human resources) and 8 students from other majors. The average chat lasted 23.10 min.

We analyzed the quantitative data, including the quiz error rates, click rates, and responses to the Likert scale questions in the post-study survey, using descriptive statistics. We again analyzed the qualitative data using thematic analysis (Braun & Clarke, 2006), including the chat log and open-ended questions in the post-study survey. In the following section we present our findings on the effectiveness of chatbots in teaching students basic content and in encouraging them to explore additional resources, as well as student sentiments regarding chatbots as intelligent student assistants.

4.2.1 RQ1: How Effective are Chatbot Intelligent Student Assistants at Teaching Basic Content?

In Study 2 we examined how effectively Sammy was able to teach basic AI content. According to Bloom's Taxonomy (Krathwohl, 2002), learning effectiveness is a comprehensive concept encompassing increasing levels of learning / topic mastery: remembering, understanding, applying, analyzing, evaluating, and creating. As the first step to examine Sammy's learning effectiveness, we focused on designing questions that assessed a student's ability to remember and understand factual and conceptual knowledge delivered via five multiple choice questions interspersed within the chatbot conversation. These questions appear after Sammy has covered the related knowledge. The responses are summarized below in Table 1.

As may be seen from Table 1 above, students performed well on three of the five multiple choice questions, with an

Table 1 Distribution of student quiz results

Questions	Correct Answer	Incorrect Answers			
Q1: What is an example of an Amazon practical artificial intelligence (AI) application?	Echo	DeepText	Cortana	Siri	Homepod
% of Students	**81.44%**	**3.09%**	**0.52%**	**13.40%**	**1.55%**
Q2: _____ is the process of making systems operate without human intervention	Automation	Artificial Intelligence	Computer Programming	Knowledge Management	Belief
% of Students	**42.19%**	**55.73%**	**1.56%**	**0.00%**	**0.52%**
Q3: What is one way humans can survive the workplace shift caused by artificial intelligence?	Develop skills machines cannot do	Stop experimenting	Discourage creativity	Create personal goals	Fight back
% of Students	**92.75%**	**0.52%**	**0.52%**	**5.18%**	**1.04%**
Q4: _____ is focused on completing a single task	Weak AI	Super intelligent	A machine	Strong AI	Singular
% of Students	**96.79%**	**0.00%**	**1.07%**	**1.07%**	**1.07%**
Q5: Artificial intelligence (AI) requires a large amount of _____ in order to learn, represent knowledge, and process natural language	data	time	consumers	developers	permission
% of Students	**91.94%**	**4.84%**	**1.08%**	**1.61%**	**0.54%**

accuracy rate of 92.75% for Q3, 96.79% for Q4, and 91.94% for Q5. They performed moderately well on Q1, with an accuracy rate of 81.44% but did not score well on Q2 (42.19%).

Students found Sammy's approach of embedding quiz questions at different points in the lesson to be an effective instructional approach. As one student wrote: "*I like how it quizzes in between, to test if I'm really reading.*" After students provided the correct answer, they appreciated that "*the chatbot replies fast with good examples*," while another appreciated Sammy's feedback when they answered questions incorrectly, "*I like how it quizzed us to see if we have a better understanding and corrected us when we had a wrong answer.*" Students also reported that the chatbot was an engaging tool that helped them better understand the content by providing explanations of the answers.

We then examined the possible reasons for the lower accuracy rate in Q1 and Q2. It is likely that some students may not have read Q1 carefully, selecting Siri since it is a common application with high name recognition. For Q2, almost 56% of participants selected an incorrect answer, "artificial intelligence." Students may have thought the correct answer was artificial intelligence because the chatbot focused on teaching AI. However, the correct answer, "automation," was introduced before the quiz, which may mean students might not be reading the content closely prior to answering the multiple-choice questions.

Our analysis of participant quiz responses suggests they were able to understand basic AI concepts and examples taught by Sammy. Interestingly, the embedded quiz questions seemed to help students understand the content better by engaging them more, checking their learning effectiveness, and providing feedback when they answered incorrectly.

4.2.2 RQ2: How Effective are Chatbot Intelligent Student Assistants at Encouraging Students to Explore Additional Resources?

We also investigated the effectiveness of chatbots at encouraging students to explore additional resources. Specifically, we analyzed participant exploration behaviors by tracking their clicks on the hyperlinks to online articles about AI, which Sammy provided. These articles were carefully selected to help students understand the applications of AI and to entice them to read more deeply about AI topics that might interest them. Although Study 2 was introduced during class, students had the option to complete the study outside of class, allowing them the time and flexibility to explore the provided additional resources if desired.

Somewhat unsurprisingly, the three articles with associated tasks received a higher number of clicks than did the seven optional articles (these did not have associated tasks). The first two tasked articles were placed at the beginning of the chatbot conversation, while the third was placed at the end of the conversation. The seven optional articles were scattered throughout the conversation. An average of 94.78% of students clicked on the three task-related articles while only 7.94% of students clicked on the other seven. This may indicate that student engagement in this context depends less on resource placement and more on requirements for them to review the materials.

Additionally, task wording appeared to influence the way in which students responded. For example, two questions asked students to respond with details from the provided articles that interested them. These questions received mostly copied and pasted excerpts from the articles. The last question asked students to think about how AI could affect their future careers; this open-ended question received original and detailed responses.

To summarize, among the provided resources and links, most students did not review resources unless they were associated with a task or a quiz question. Further, students responded differently based on how Sammy asked its questions, sometimes answering questions by copy-pasting content from the learning materials, other times providing their own opinions.

4.2.3 RQ3: What are Student Perceptions of Chatbot-Guided Learning Experiences?

We also reviewed participant reflections on their experiences learning AI via a chatbot, as captured by a post-study survey. The survey first asked participants to rate their experience with Sammy on the following three questions: Q1. How easy or difficult was it to use the chatbot Teaching Assistant you experienced? (1: extremely difficult; 7: extremely easy). Q2. How high or low was the quality of the features you experienced in the chatbot Teaching Assistant? (1: extremely low quality; 7: extremely high quality). Q3. How comfortable or uncomfortable would you be using these features without help? (1: extremely uncomfortable; 7: extremely comfortable). The distribution of the responses are shown in Fig. 3. In general, participants felt it was easy to use the Sammy chatbot as a teaching assistant (M = 5.79, SD = 1.35, Min = 2, Max = 7). They also considered the quality of the features in Sammy to be high (M = 5.58, SD = 1.20, Min = 2, Max = 7). In addition, participants were comfortable using Sammy without help (M = 5.82, SD = 1.34, Min = 1, Max = 7).

We further analyzed student responses to two open-ended questions designed to understand what students liked about their chatbot learning experience as well as areas that could be improved. In general, students reported positive experiences of their chatbot-lead learning experience. In particular, students commented on Sammy's conversational style, which made learning AI engaging and interactive. For example, a student reflected: "*Engaging, interactive/conversation mode, responds well, fast, responsive.*" Additionally, students also commented on the responsiveness of chatbots that can be accessed at any time: *"I liked how fast the responses were and how the information needed to be learned was right in front of us on the screen."* Some students found it engaging when Sammy seemed to understand their answers and provided acknowledgement, e.g.: *"I like how it is responsive to what you say instead of moving on to the next subject. For example, it responds with "I hear you," and "Thanks for your input,"* even though some students suggested that their engagement and learning would be greater if the chatbot provided more personalized messages instead of general responses.

Additionally, participants thought the chatbot was a helpful assistant thanks to the additional articles and quizzes it offered. Students found it valuable to have different layers of learning in the chatbot-guided lesson, including quiz questions for basic learning and open-ended questions for advanced learning. As one participant wrote, "*It quizzed you and all the topics tied nicely together to really drill in understanding."* One student expressed, *"I feel like I got a thorough understanding of what AI is through real life examples and through the articles."* The additional resources Sammy provided also helped further engage students. As a student reported: *"It kept me engaged throughout since there were many articles shared that needed to be discussed."* In addition, students also appreciated "*how it educated me after every response."* Students also perceived that Sammy was able to understand their answers to open-ended questions, e.g., "*It's knowledgeable and could understand simple sentences; It can totally understand what I typed and reply fast.*" They also appreciated Sammy's responses, "*I liked the responses it gave because they did not seem like they came from automation.*" This perceived "humanness" of Sammy helped more fully engage students in the lesson by answering their questions in real time. Occasionally, student participants did suggest that more personalized answers would be beneficial, for example: "*it should say a more personalized response instead of just saying "ok" or "thanks for sharing.*"

Despite the positive feedback, students also pointed out some limitations they saw with Sammy. Students wanted Sammy to improve its conversational capabilities in two ways: (1) understanding the subtle nuances of language and (2) accepting responses, then continuing on with the conversation. For the first suggestion on improving Sammy's conversational capabilities, students noticed that Sammy sometimes did not recognize misspelled words, acronyms, or slang words and encouraged Sammy to be trained on more vocabulary and cases of misspelled words. For the second suggestion, students became slightly frustrated when Sammy did not understand or accept their answers, causing them to repeat themselves and to become stuck on one particular topic. Aside from feedback on improving conversational abilities, students mentioned issues with Sammy's response variety, which many thought took away from the experience.

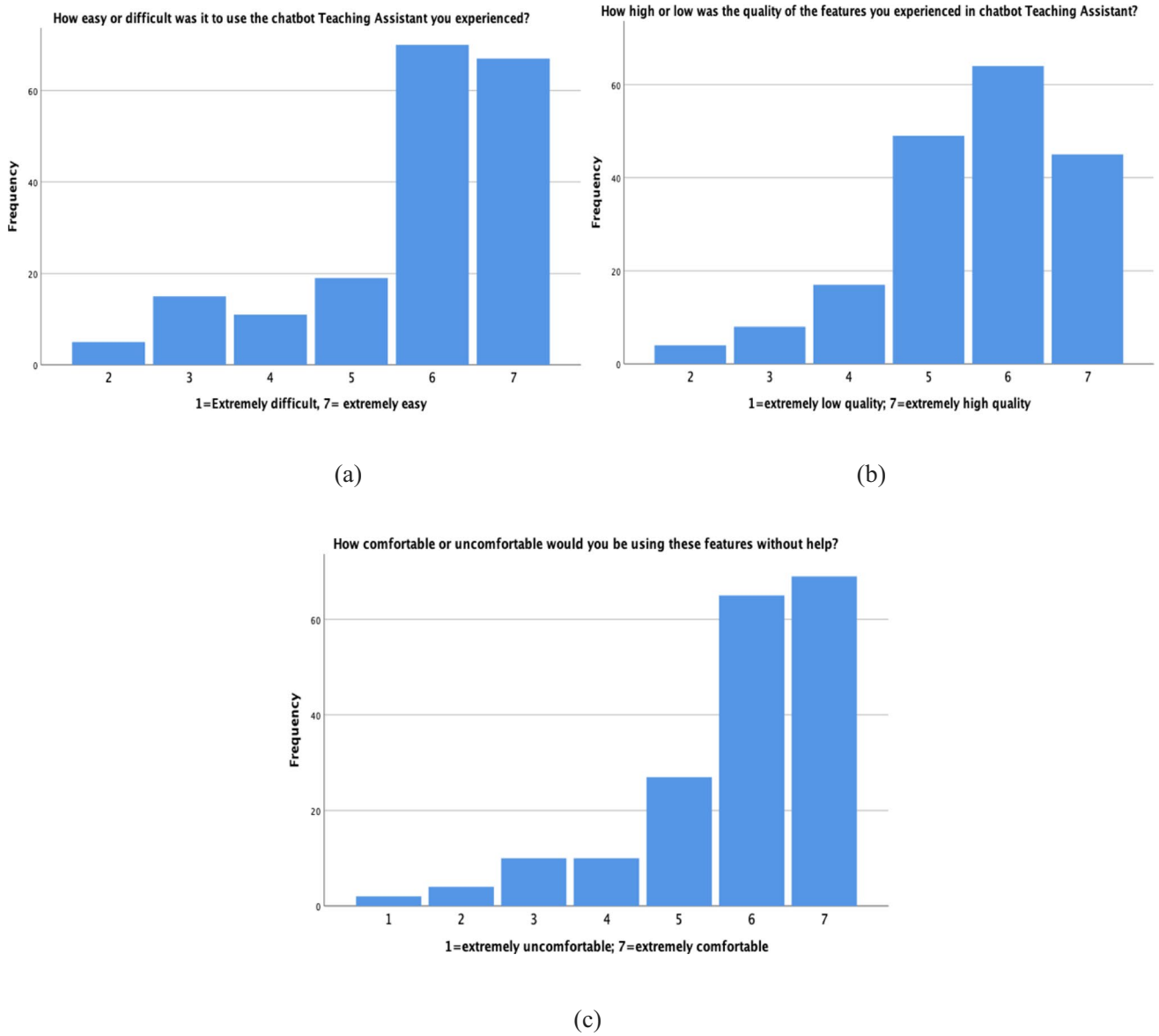

Fig. 3 Distribution of participant responses to post-study questionnaires. **a** How easy or difficult was it to use the chatbot Teaching Assistant you experienced? **b** How high or low was the quality of the features you experienced in chatbot Teaching Assistant? **c** How comfortable or uncomfortable would you be using these features without help?

Overall, our Study 2 findings confirm the findings of Study 1—that students valued the interactivity and responsiveness of chatbots as learning assistants. Students evaluated Sammy's interactivity based on its capability to provide a variety of learning resources and to respond to and acknowledge users based on their conversations. Meanwhile, our findings also suggest chatbots still have room for improvement in their ability to understand the nuances of user inputs and to provide more varied responses.

5 Discussion

5.1 Key Findings

In this two-study research project, we first used a chatbot to query undergraduate business students regarding how chatbot intelligent student assistants might help them succeed and gather student perceptions of the benefits and challenges of using these tools as a supplement to student / instructor interaction (Study 1). Then, in Study 2, we designed and

developed a chatbot teaching assistant based on our Study 1 findings and tested the effectiveness of the chatbot in teaching non-technical students basic AI concepts.

Our findings from both Study 1 and Study 2 suggest the main benefits of pedagogical chatbots are responsiveness, ability to provide real-time feedback and increase student engagement, and their scalability, confirming prior research on the three technological affordances of chatbots for language learning: timeliness, ease of use, and personalization (Huang et al., 2022). These technological affordances make chatbots a "tireless learning companion who can be contacted for domain-specific conversation in any accessible device" (Huang et al., 2022). Although chatbots could potentially make many services more available and affordable (Følstad et al., 2018), research on chatbots in education has focused on relatively simple applications, such as offering multiple-choice quizzes (Pereira, 2016) and answering frequently asked questions (Goel & Polepeddi, 2016). We found that students also see opportunities for chatbots to be used in answering basic course and content questions, offering supplementary course materials that provide examples of content application and encourage further topic exploration, and assisting students with career and life-related issues. Through the deployment of a chatbot student assistant that teaches students AI, our second study found that students valued Sammy's conversational style and the interactivity provided via chat responses, quizzes, external resources, and discussion questions. When we examined Sammy's ability to teach basic content, we found students performed well at basic memory and understanding tasks, as evaluated by their quiz results, and that they appreciated the quizzes as a way to reinforce and test their learning. We also investigated Sammy's ability to encourage further exploration of additional resources and found that few students read materials beyond those tied to a task or question. Additionally, we found the wording of chatbot questions impacted the types of answers students provided. Our studies also revealed a wide range of roles chatbots might play in assisting student learning similar to Huang et al. (2022), who identified five pedagogical uses of chatbots in language learning, interlocutor, simulation, transmission, help desk, and providing recommendations.

Although chatbots can supplement instructor interaction and increase student engagement, our studies also suggest limitations of chatbot-led learning. First, chatbot implementations are limited by the current capabilities of natural language processing. For example, our Sammy chatbot was able to ask students questions and offer personalized acknowledgements based on their responses – a feature appreciated by students – however, Sammy was not always able to understand students' open-ended answers. This limited the chatbot's ability to have in-depth, customized conversations with students, a key component of conversational learning. Additionally, Sammy's inability to react in real time to student comments and questions in a way that closely mimics human-to-human interactions, did create a dynamic different from that found in traditional classroom settings. Particularly, Sammy's occasional "less than human" conversational style seemed to distract some students from the lesson and to limit the chatbot's ability to encourage critical thinking about the content. Students also noted the inability for chatbots to make human-like emotional connections. Some prior studies have demonstrated evidence of social presence and social cues in human-chatbot interactions in business contexts, such as customer service (Nguyen et al., 2021), and others suggest that pedagogical chatbots may encourage students' social presence (Huang et al., 2022). However, we found that students generally expect more social and emotional connections in educational settings than chatbots can currently provide and that such chatbot "humanness" depends on technological capabilities and limitations. Furthermore, some students skimmed content superficially and provided copy and pasted answers rather than constructing their own thoughtful responses as they might have if participating in a classroom discussion. This finding is inline with Stieglitz et al. (2021) who reported that participants tend to engage in "smart loafing," ceding responsibilities to virtual assistants during collaborative problem solving tasks. Those findings, and ours, suggest that chatbots may best serve students when used to supplement classroom activities rather than replace them. Unlike prior studies which have largely ignored the potential risks of using chatbot in learning and education, we argue that it is important to design the learning materials and tasks in chatbot-assisted learning to avoid any unintended consequences such as reduced student learning effort. As Porra et al (2020) argued from a philosophical and ethical perspective, it is also important to consider the long-term consequences on human's learning and cognitive capabilities when living with digital assistants.

5.2 Implications for Research

Overall, our findings suggest students perceive chatbots as a potentially beneficial supplement to classroom learning. Students did suggest that these tools have limitations,, but did not appear to be concerned with any risks associated with chatbots as intelligent student assistants. We have drawn from these two studies to suggest several potential benefits to using chatbots as teaching assistants, as well as some potential limitations, ethical concerns, and data privacy risks.

Benefits of Conversational Learning with a Chatbot In conversational learning, students learn through discussions of

course content, a method shown to improve student learning over traditional lecture-style instruction (Atif, 2013). Although these discussions have traditionally been between students and their instructors, chatbots may be able to supplement the role of the instructor (Chuah & Kabilan, 2021). For example, Goda et al. (2014) designed a chatbot to supplement instruction for English foreign language learners and found that conversations with a chatbot before learning sessions increased users' engagement and performance. Our chatbot, Sammy, was similarly able to engage students through its conversational style, quizzes to reinforce learning, feedback on student answers, and embedded links to additional resources, all without increasing the instructor's time or effort. As such, chatbots may be a useful educational tool for engaging students, particularly in classrooms with high student–teacher ratios. These findings are consistent with the conclusions drawn by Okonkwo and Ade-Ibijola (2021) in their recent literature review regarding the potential benefits of chatbots in education.

As an interactive study aid, chatbots may keep a broader range of students engaged in the course material. This includes introverted students who may hesitate to ask or respond to questions in a classroom setting—instead they can engage one-on-one with the chatbot in a conversational format. Similarly, students learning online asynchronously or in self-paced courses are likely to find the interactive and conversational format of chatbots more engaging than the more passive pedagogical approaches often used in those formats. Additionally, students with less access to personal instruction due to physical distance, time conflicts with work, or family commitments could receive help from a chatbot student assistant at any time and from a variety of mobile devices.

Drawbacks of Conversational Learning with a Chatbot A challenge identified by participants in both studies was Sammy's less-than-human conversation style, in part because Sammy was not always able to understand misspellings or colloquial speech. Over time, this could result in students becoming less engaged with the chatbot. While the initial development of a chatbot assistant may be technically simple, developing an effective teaching assistant that students will repeatedly utilize may require significant human involvement and iterations of refinement over multiple semesters (Petrović & Jovanović, 2021). Students also noted the inability of chatbots to understand human emotions. Although sentiment analysis can be incorporated using Juji's no-code approach, it is a binary positive/negative evaluation, and does not detect a deeper understanding of the emotions being expressed. In addition, some emotions, such as sarcasm, are generally difficult for sentiment analysis tools to detect. However, with time, the conversational style and emotional capabilities of these platforms is likely to improve as commercial applications drive innovations in natural language processing.

As the ability of chatbots to understand a broader range of free text questions improves, their possible range of educational applications will also increase (Petrović & Jovanović, 2021), placing greater importance on the AI ethical principle of transparency. In their review of the literature on ethical AI, Jobin et al. (2019) found transparency to be the most often discussed principle of ethical AI, and although definitions differed, they centered on the concepts of explainability, communication, and disclosure in a human-readable way while also minimizing harm. For chatbots teaching basic concepts, this is not a significant concern. However, if chatbots in education were extended to include career advice or counseling, as some of the students in our Study 1 suggested, transparency would be critical. Further, if conversations with chatbots were to involve decisions impacting a student's academic career, regulations such as the EU's General Data Protection Regulation (GDPR) may apply as it includes provisions for a "right to an explanation" of automated decisions (Casey et al., 2019).

This ethical principle of transparency is more difficult to address in some AI models than in others. From a programmer's perspective, some models are inherently more explainable, such as decision trees, whereas more complex models, such as support vector machines (SVMs) and deep learning (DL) neural networks, are not directly interpretable and often referred to as "black-boxes." In these latter cases, techniques exist to interpret and justify the result (Biran & Cotton, 2017), but such explanations may not be human-readable or relevant to the typical user and would need to be tailored to the audience. Weller (2019) identifies eight different types of transparency for purposes of providing an explanation, with a technical explanation to the programmer being one type, and an explanation to the user (as required under the GDPR) being another type. He also notes that there could be different explanations needed for users to trust an application, or for society in general to be comfortable with it.

The second most common ethical AI principle identified by Jobin et al. (2019) was the principle of justice, fairness, and equity—one clearly relevant to the use of chatbots in education. As discussed in Sect. 2.3, Eicher et al. (2018) noted that the Jill Watson chatbot piloted at Georgia Tech was unable to understand the needs of minority students in STEM fields, a group of students who may already feel marginalized. Justice, fairness, and equity are also clearly important considerations when using AI to meet the needs of distance education, non-traditional, and underrepresented students. Two additional ethics principles enumerated by Jobin et al. (2019) that could be relevant in this context are trust and privacy—concerns echoed by other

researchers (Okonkwo & Ade-Ibijola, 2021). The students suggested that chatbots could provide a sympathetic ear to students experiencing anxiety or depression and said they valued Sammy's ability to keep conversations confidential. However, students who perceive their chats as private, and later discover that they were not, would likely lose trust in these technologies (Okonkwo & Ade-Ibijola, 2021). Similarly, students who converse more freely with a chatbot than they would with a professor, may feel their privacy has been violated, particularly if the logs are being read by student assistants.

Balancing the Benefits and Drawbacks As the AI models used in chatbots become more sophisticated, realizing the potential benefits while ensuring such systems remain ethical and safe may require a trade-off between explainability and the performance of the underlying AI models. Microsoft's guidelines for responsible bots briefly describe this trade-off as limiting the "surface area" of the app to a specific task. A more fine-grained approach to addressing the trade-off between explainability and performance is the concept of "enveloping" AI applications. According to Asatiani et al. (2021), enveloping is used in robotics to outline the physical range of a robot—its entire movement range is outlined on the manufacturing floor to reduce the risk of unintentional human interaction with the robot. They propose a similar enveloping concept be applied to AI. This could be done by limiting the topics on which a chatbot could converse, (the response envelope), the student data it considers in making decisions (the input envelope), or even limiting the data used to initially build the chatbot (the training data envelope). The use of AI in educational chatbots is still in the early stages of development, but as they become more sophisticated and their reach grows, it will be critical for researchers and developers to keep AI ethics principles in mind to ensure they maximize benefits for users while minimizing potential harm.

5.3 Implications for Teaching

Our findings also provide implications for teaching regarding the feasibility of pedagogical chatbots and how chatbot design may impact their pedagogical efficacy and ability to augment student–teacher interaction and the current limitations of chatbot IQ and emotional intelligence.

Feasibility of Integrating Pedagogical Chatbots for Conversational Learning The chatbots for our studies were designed using a low cost, no-code development platform, and the structure of the conversations was designed by business student research assistants with little coding experience or expertise in AI suggesting that chatbots can be financially and technically feasible for many college-level instructors. Further, instructors in prior studies of pedagogical chatbots have reported that these tools are both easy to use and to introduce to students (Chuah & Kabilan, 2021; Kohnke, 2022), suggesting chatbots may be a simple, scalable approach to increasing student engagement. This could free the cognitive resources of instructors from repetitive tasks and enable more meaningful interactions with students (Stieglitz et al., 2021). Although the Juji platform we used allows for human monitoring of conversations in real time, such instructor involvement is not required. Once the chatbot is set up, it could be leveraged across multiple course sections and semesters. Further, any questions the chatbot cannot answer could be forwarded to the instructor, allowing for a gradual expansion of the chatbot's question / answer sets driven by student needs.

Designing Chatbots for Supporting Holistic Academic Success Our expectation was that students would only see chatbots as a tool for learning basic course content, similar to chatbots in prior pedagogical studies. However, our findings suggest students see opportunities to gain a deeper understanding of course materials through chatbot interactions, highlighting the importance of a holistic view of student success which includes advanced learning, higher order thinking, and personal well-being.

Designing Chatbots to Augment Teacher-Student Interaction Our findings also suggest students appreciate interactive learning, preferring it to studying alone, and value timely responses to their questions. Chatbots serving as always-available and highly responsive intelligent student assistants can fulfill this need. Surprisingly, we also found that some students wished for greater social interaction (i.e., chatting) about their career interests and personal issues while also preserving their anonymity—a function that, in certain situations, chatbots might also provide.

Limitations of Chatbot IQ and EQ One issue that some participants raised was the need for chatbots to be more "intelligent" in understanding dialog flows and learning about each student over time. This will require further advances in natural language processing and deep learning to enhance chatbots' "IQ." Participants also expressed a desire for chatbots possessing greater emotional intelligence (EQ) that would allow them to mimic the emotions typical of human–human interaction, suggesting opportunities for developing more "emotionally aware" chatbots for higher education.

5.4 Limitations and Future Research

Like all research, our research has limitations. In our first study, we queried non-technical students on their perceptions of chatbots, asking them to think about the opportunities and potential benefits and challenges of chatbots in education. Although we collected this data via a chatbot, thus giving the participants some experience with these tools, it is possible that they lacked sufficient knowledge and experience with chatbots to foresee how they could complement more traditional educational approaches or understand their challenges, risks, and limitations. Future studies could address this issue by providing participants with greater training on chatbots prior to collecting their thoughts on the role of chatbots in education. In the second study, we tested the effectiveness of our chatbot in teaching basic AI concepts collecting both objective data, test scores and clicks, and student perceptions of their learning experiences. As with our first study, participant inexperience with chatbots could have influenced their interactions and reflections. Further, some participants in our two studies may have personified the chatbots (Okonkwo & Ade-Ibijola, 2021) and therefore felt hesitant to share their negative views towards these tools in their chatbot responses. Follow-on studies could address some of the inherent limitations of perception-based, self-report data by including additional objective measures or by conducting experiments that test differently-featured chatbots to more directly assess how chatbots can affect student learning. Additionally, the content of our AI lessons in Study 2 could have influenced participant scores and perceptions, limiting our ability to tease out the unique contribution of providing these lessons via a chatbot. Future research might address this limitation by comparing the pedagogical effectiveness of different teaching methods (in-person instruction, chatbot-led learning, autonomous student learning) while holding the lesson materials constant. The exploratory nature of our studies further limited us to relatively simple analysis methods—qualitative analysis and descriptive statistics. Researchers could extend our work by testing our findings in experimental settings.

The implications of our findings also provide avenues for future research. Future studies could investigate the impact of student traits, such as personality, gender, ethnicity, educational background, experience with technology, privacy expectations and needs, etc. on the effectiveness of pedagogical chatbots. The need for additional research into the ethical considerations of AI educational applications will also continue to grow as chatbots increase in popularity and advances in natural language process, machine learning, and deep learning extend the human-ness, IQ, and EQ of chatbots. Experiments helping us understand the features of chatbots that maximize student learning (quizzes, Q&A, links to additional resources, options for content repetition, etc.) will also extend the literature and increase the value of chatbots in classroom settings.

6 Conclusion

The two sequential studies in this paper provide insight regarding student perceptions on how chatbots could be utilized as intelligent student assistants. This includes both favorable student attitudes towards the interactive, responsive, and conversational approach chatbots provide for learning new content and the possibility of serving as a study partner, as well as the limitations students perceive regarding the inability of chatbots to fully mimic the human flow of conversation or express human emotions. Although the Juji platform used in this study can perform binary sentiment analysis (Zhou et al., 2019), and such ability to capture social cues has been used effectively in business contexts such as customer support (Nguyen et al., 2021), students did not perceive the chatbot as being sufficiently human in an educational setting. Student perceptions of chatbots from the first study were incorporated into the design of an educational chatbot used in the second study to assess the effectiveness of chatbots in teaching basic concepts in a new field of study and the impact of chatbots on student learning behavior. Although prior research on the use of chatbots in education has mainly focused on their use in language learning (Huang et al., 2022; Kohnke, 2022) and offering multiple-choice quizzes (Pereira, 2016), the favorable student perceptions found in this study regarding responsiveness and ease of use aligns with the findings of prior research in language learning (Huang et al., 2022).

This research contributes to the discussion on the use of chatbots in education by identifying the benefits and limitations students perceive in the use of chatbots, and examining the use of chatbots in teaching a new domain, particularly in integrating additional resources and the structure of questions to effectively solicit detailed responses. In the second study, the results of the embedded quiz questions showed that the interactive learning and testing enabled by the chatbot was effective in teaching new concepts. However, to be effective as a guide to additional resources, it was found that the resources needed to be directly tied to answering the embedded quiz questions. Additionally, open-ended questions were found to be more effective in soliciting original and detailed responses. Although not addressed in prior research, this identifies the importance of how questions are structured and supported with additional resources in an educational chatbot. Surprisingly, students perceived chatbots as not only a way to learn basic concepts, but also as a means to develop a deeper understanding of course materials. The benefits from

an instructor perspective identified in this study are consistent with those of Okonkwo and Ade-Ibijola (2021) in a recent literature review on the use of chatbots.

An important finding regarding student perceptions of chatbots that has not been addressed in prior research is student lack of concern as to privacy and ethical issues. Students perceived chatbots as being able to provide a confidential aid for exploring career possibilities or addressing mental health issues, but as the AI models used in chatbots become more sophisticated, multiple ethical AI principles must be addressed, including transparency, fairness, trust, and privacy (Jobin et al., 2019). In addition, if chatbots serve as career advisors, the EU's right to an explanation (Casey et al., 2019) may also need to be addressed.

Appendix 1: Chatbot Interview questions in Study 1

1. I know we just met, but could you specify your gender? If you have a preferred gender identity, please let me know.
2. So, tell me a bit about yourself. What is your major and do you currently work somewhere?
3. Based on that, how many hours a week to honestly get to study including time to do any assignments?
4. Nice! So, what are some questions/concerns do you frequently have about this course?
5. Alright, I can see how some students could potentially have questions/concerns such as those. Let's say if I were to be always available to answer your questions about Business Systems, what would be some of the main questions you hope I can help you with?
6. Fasho, I can handle that! So, what kind of course materials do you think I could potentially be capable of presenting to you through chatting like this?
7. Hmm, interesting, I think there could be potentially various ways of presenting things to people since everyone learns in different ways. Do you think I could potentially help you in a few things such as developing critical thinking skills and understanding the course material better so you can get a better grade?
8. Okay makes sense, what do you think is my best strength as a potential course assistant for you?
9. Haha I'll do my best to live up to that standard, so based on that then what would you say is my greatest weakness as a course assistant specifically to you? Because I would love to know what I could do my best to improve on!
10. Thank you for sharing all these wonderful examples and experiences! Do you have any questions or comments for me before we wrap this up?

Appendix 2: Chatbot interview questions in Study 2

1. **Welcome message:** "Hello! I'm here to teach you more about artificial intelligence, my species. Buckle up and let's begin!"
2. **Background: Why is it important to you?**
    a. Have you ever heard about AI?
        i. Positive: …
        ii. Negative: ...
    b. "**Artificial intelligence** or AI is all around you. You can experience it through consumer products or services, like Amazon's Alexa and Facebook's targeted advertising.
    c. Can you think of other examples of AI?
    d. Here are some examples of AI that you may be familiar with**:**
        i. **Digital assistants**: Amazon Echo, Apple's Siri, Google Assistant?
        ii. **Recommendations**: Amazon, Spotify, Netflix
        iii. **Fraud protection**: Banking applications
        iv. **Personalized social media feeds**: Facebook, Twitter, Instagram, etc.
        v. **Self-driving parking cars**
        vi. **Quiz**:
            1. What is an example of an Amazon practical artificial intelligence (AI) application?

e. In addition to these examples, it is also used to allow business processes to be automated. According to Pew Research Center, 82% of U.S. adults believe automation will affect their work or take most of their work tasks being done today." The worries are reasonable because by 2025 about 100 million workers may be replaced by AI."

f. Now read this article from Pew Research Center, what is one thing that you found interesting?

g. "However, Harvard Business Review notes that 51% of executives use AI for product enhancements, such as performance, features, and functions. 36% express optimizing business processes to free up workers' time from routine or mundane tasks to handle more complex work."

h. In this article by Harvard Business Review, the authors mentioned three types of AI. Could you choose one that is most relevant to your major and tell me how it might affect your career?

i. "As a result, learning about AI is extremely important because your career could be threatened due to automation.

j. Given the potential of AI in replacing human jobs, what do you think you need to do to ensure job security?

k. You must be able to gather **critical thinking skills** or other **human skills** machines cannot emulate "

l. **Quiz**:

   i. _____ is the process of making systems operate without human intervention.

   ii. Jobs requiring _____ are prime candidates for automation.

   iii. What is one way humans can survive the workplace shift caused by artificial intelligence?

3. **Definition: What is AI?**

   a. **Artificial intelligence** or AI is a broad field under computer science. It is the ability of a machine to simulate human abilities such as vision, communication, recognition, learning, and decision making to achieve a goal.

   b. Similar to human learning, AI needs to learn constantly as well. What do you think is the most important element for AI to learn?

   c. AI needs large amounts of **data** and **algorithms** (or sets of procedures) to learn from and process patterns, which allows it to act as a human.

d. Good so far?

e. Three types of AI

   i. Weak AI is AI focused on a single task

   ii. Strong AI is AI that is equally as intelligent in completing a task as a human

   iii. Superintelligence is more advanced than human intelligence

f. What might be some of the examples of Weak AI? (Juji comments: interesting)

g. Example of Weak AI

h. What might be some of the examples of Strong AI? (Juji comments: interesting)

i. Example of Strong AI

j. **Quiz**:

   i. ____ is focused on completing a single specific task

   ii. Artificial intelligence (AI) requires a large amount of _____ in order to learn, represent knowledge, and process natural language.

4. **Business cases & impact**:

   a. Unilever launched its internal marketplace, called FLEX Experiences, which is powered by AI matching employees' profiles to projects they might be interested in. The platform is used to encourage employees to participate in projects of their interest and to help them gather new skills and experiences across the organization. They also use AI in their hiring prescreening, as well as in a chatbot, named Unabot to answer employees' questions normally directed to HR or IT.

   b. What do you find most interesting about this case?

   c. Coca Cola was able to use the data collected from its fountain drink dispensers where customers can customize their soda with flavored shots, leading to one of the popular combinations, Cherry Sprite being launched in stores in 2017. The company also uses algorithms to search through social media where their products are being mentioned, in what contexts, and in pictures to target their advertisements to the right customers.

   d. What might be some of the ways this case can provide inspiration of your Innovation Farm project?

Ask students whether they have questions…

End of conversation

Declarations

Conflict of Interest The authors have no conflict of interests to declare.

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