2023 Annual Conference & Exposition
Baltimore Convention Center, MD | June 25 - 28, 2023
The Harbor of Engineering
Education for 130 Years
ASEE
Paper ID #37941

# Creating and Implementing a Custom Chatbot in Engineering Education

**Mr. Shameel Abdulla, Texas A&M University, Qatar**

Shameel Abdulla is currently working as a Technical Laboratory Coordinator in the Mechanical Engineering Program at Texas A&M University at Qatar. He joined the MEEN program in December 2012. He is responsible for coordinating experiments in the Controls and Measurements labs. Shameel's professional interests include Product Design, Control System Design, and Mechatronics. He is a former student at Texas A&M University at Qatar.

**Dr. Yasser M. Al Hamidi, Texas A&M University, Qatar**

Dr. Al-Hamidi holds a Ph. D. degree in Mechatronics from the University of Bourgogne Franche-Comté (UBFC), France, and currently working as the Mechanical Engineering Laboratories Manager at Texas A&M University at Qatar. He joined Texas A&M University at Qatar in 2007 coming from University of Sharjah. Dr. Al-Hamidi had been appointed as a visiting lecturer in 2018 to teach design related courses in the mechanical engineering program. He specializes in product design, instrumentation, controls, and automation. Dr. Al-Hamidi founded the Engineering Enrichment Program in 2016, which is currently one of the Center for Teaching and Learning pillars. He received three Transformative Engineering Education grants related to multidisciplinary education in 2018, 2021 and 2022. In 2021 Dr. Al-Hamidi received the Dean's Achievement Award to recognize his contribution to the campus within that year. In 2015 he received the Association of Former Students AFS Distinguished Achievement Award as a recognition for his commitment, performance and positive impact on Aggie students. And in 2010, he received the STAR award as a recognition for his outstanding service and achievement at Texas A&M at Qatar.

**Prof. Marwan Khraisheh, Texas A&M University, Qatar**

Professor and Chair of the Mechanical Engineering Program at Texas A&M University at Qatar.

# Creating and implementing a custom chatbot in engineering education

Shameel Abdullah, Yasser-Al Hamidi, and Marwan Khraisheh

Mechanical Engineering Program, Texas A and M University at Qatar

**Abstract**

This paper investigates the development and use of a chatbot in an engineering curriculum. The chatbot helps students find course materials, answer general inquiries, schedule meetings with professors and teaching assistants, and much more. Students require assistance during their time at university. College life is stressful, and tasks such as keeping track of deadlines, scheduling meetings, and finding resources become daunting as the semester progresses. The constant email exchanges about general course information could also become tedious for the course instructors. The authors developed a chatbot using the Microsoft Power Virtual Agents App, which requires minimal coding, as the main framework consists of configuring and connecting nodes. The development stages require some considerations, such as setting up a hierarchical system to store information about various courses and creating a shared department email address to send and receive meeting requests. These considerations are addressed further in the paper. The chatbot will handle all repetitive tasks, thus freeing the instructors time for answering more challenging questions. It also promotes self-learning and allows students to ask questions beyond office hours and get responses. The chatbot developed is set up to source information from existing databases of deadlines, file directories, questions, and answers. Hence, it doesn't require reprogramming for a new course. The instructor needs to tabulate all necessary information in a predetermined location. Future variations of the chatbot will help students with coursework by providing them with practice problems when prompted. It will assist them further by giving instant feedback on their questions. Thus, students will get to practice and prepare for a course as they see fit. Since this process will be automated and randomized, the chatbot will always have sample problems. The chatbot will record any question that it is unable to answer. The instructors can further develop the chatbot's repository to answer those questions. The chatbot's impact on the student's university experience is measured in a class by conducting class surveys among the students. The authors have planned a pilot study of the chatbot and its implementation for a course in Spring 2023. Results will be reported in the final paper.

## Introduction:

Chatbots have revolutionized various industries, such as airlines, medical, and insurance. It can handle many customers and respond to their varying inquiries. This progress in chatbot technology is partly due to the recent advancements in natural language processing. There are limited empirical studies examining the effectiveness of various learning designs or strategies when incorporating chatbots in education [1]. Ongoing research has identified the challenges that chatbots can potentially solve. These include providing mentoring for students and leveraging the adaptation capabilities of chatbots [2]. Currently, prototypes of chatbots have been tested on small scales in the education sector where various chatbot programming platforms such as Google DialogFlow, and Amazon's Alex Skills were utilized [3]. However, the frequency of use of such chatbots has not been conclusively linked to improvement in student learning due to the lack of comprehensive question-answer databases [4].

ChatGPT is another recent advancement that looks promising. However, in terms of learning and teaching, the content it generates is not curated for any specific domain and cannot be used for training engineering students yet [5]. It may contain factual errors that look convincing to a novice [6]. This is because such AI systems are trained to produce human-like text based on the vast amount of information posted on the internet [7].

The challenges that students face at schools and universities are many. Many of the current educational institutes are understaffed and cannot adequately assist students when needed [8]. The effectiveness of office hours in improving grades have been demonstrated, however, only few students take advantage of such facilities [9]. One reason would be that the office hours may not always align with the time students are studying. Time management skills are essential for college success, but many students struggle to balance their academic, personal, and professional obligations [10]. As a result, they may miss out on valuable opportunities to get help from their instructors during office hours and fall behind on their assignments. Additionally, students may hesitate to ask questions for fear of seeming incompetent or inferior [11]. Implementing a chatbot in education can help alleviate these issues by providing an accessible platform for students to ask questions without fear of judgment and by providing information more efficiently. It can also provide customized and on-demand support with larger flexibility and acceptability [12]. It can also be useful for distance learning, night classes, and non-traditional learning schedules.

Implementing chatbots has become more accessible with technologies provided by Microsoft, such as Power Virtual Agents. The building, testing, and deploying stages have been streamlined so educators can get a custom chatbot up and running quickly. The covid pandemic has prompted many classes to shift to online mode. This has required the adoption of various technologies in the classrooms, such as LMS systems, video hosting, teleconferencing, online quizzes, and exams [13] [14]. The authors believe developing a chatbot is the next step in this technological exploration. As natural language processing improves over the years, chatbots will become essential to our daily lives.

Even with the current advancements, there are several challenges in using chatbots in education. Chatbots may struggle to handle complex or ambiguous questions from students and may lack the human touch and empathy that teachers provide. Additionally, chatbots require constant updating and maintenance to keep up with the curriculum and standards. There are also ethical and privacy concerns regarding the data that chatbots collect and use [15]. Furthermore, chatbots may not be accessible or affordable for all students and schools, and current chatbot technologies might not be readily accessible for people with disabilities [16]. Since Chatbots are trained based on information on the internet or human-curated content, they may carry the same biases as those of the original authors [17]. This paper details a framework to tackle a few of these challenges.

**ChatBot's Framework:**

The authors followed the design thinking approach to develop their Chatbot. Design thinking is a hands-on approach to solving problems by prioritizing the consumer's needs above all else. It is "human-centered," in which designers watch how people use a product or service and continue to refine the product or service to improve the consumer's experience. The design thinking approach was introduced at Stanford University in the '70s to teach engineers how to think like designers. It aimed to help them solve complex problems in a more human-centered way. Its framework encourages decisions based on evidence and customers' actual needs instead of assumptions. And because this approach has such broad use, the authors decided to use it as a helpful tool to create an effective chatbot for their students. The design thinking process is divided into 5 stages: Empathize, Define, Ideate, Prototype, and Test. We explain below how each stage helped to deliver a better chatbot project.

*Empathize*: During this phase, we step into our students' shoes to learn more about their actual needs, what problems they face, what causes those problems, and what they want to achieve. For that, we drafted the student's journey through a course in a semester. This journey is shown in Figure 1. In some cases, students need information, and in others, students require some assistance. Tasks such as keeping track of deadlines, scheduling meetings, and finding resources become daunting as the semester progresses.

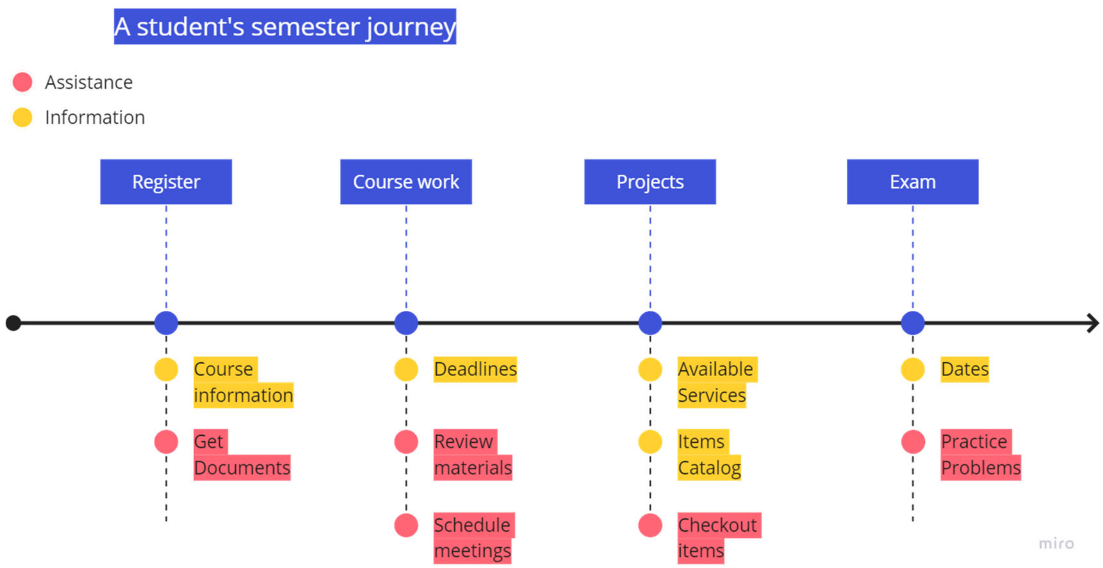



*Figure 1. A student's journey throughout a semester is mapped out.*

*Define:* During this stage, we try to focus on students' needs and brainstorm how such needs can be addressed, so an accurate need statement can be articulated. For that, we used the 5 Ws and H framework that consists of 5 questions: Who is the person experiencing the problem? What problems do the students want to solve? Where is the student when he/she wants to solve the problem? When does the problem occur? Why solving the problem is essential? How does the student reach the goal?

Problem Statement: The chatbot must be able to augment the work of a teacher or a professor by taking care of repetitive tasks that require minimal input from them.

*Ideate:* Now that the problem statement is ready, it's time to start the ideation phase. This is the stage where we need to generate all possible ideas and where our chatbot solves the students' problems. The rule of thumb in this stage is not to judge any idea that appears, as even the weirdest one may be the ideal solution.

The authors, during this phase, consulted with faculty and teaching assistants (TA) to identify the areas where the chatbot could help. The identified areas are shown in Figure 2. Course information can be found on the course syllabus or course LMS page. It should also assist with course materials by clarifying definitions and explaining course concepts. This could also include providing students with practice problems. The chatbot should help with project-related tasks such as checking out equipment and requesting services. Such information is usually hard to find, and students might not even know the facilities they have access to. Another tedious task is scheduling meetings. Students tend to send back-and-forth emails to set meetings with professors and TAs. The chatbot should assist with scheduling meetings based on the availability of the student and the professor or TA. The chatbot should also be able to provide general information unrelated to a particular course such as Q-drop dates or registration information. Finally, it should easily provide the students with access to all safety documents, such as Safety Data Sheets (SDS), lab layouts, Project Safety Analysis (PSA), and other safety-related documents. Such information is usually provided as hard copies in the labs. However, they are not easily accessible digitally. Having a chatbot fetching this information would make the students' and educators' life easier.

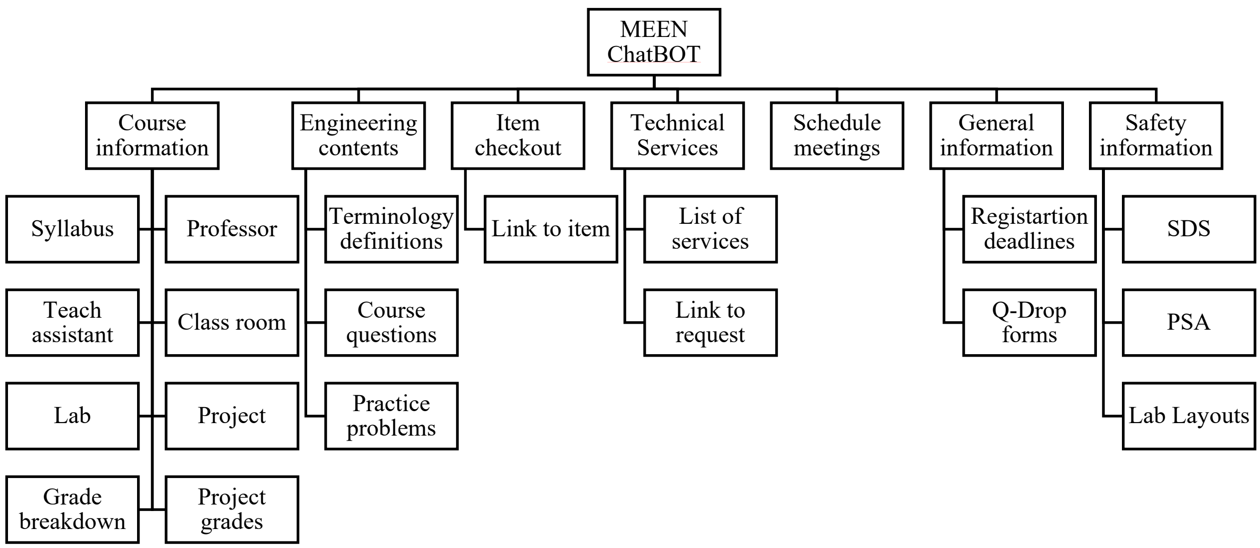



*Figure 2. List of the topics and information provided by the chatbot.*

*Prototype:* After we finished the ideation phase, we now have plenty of ideas about what our chatbot could do to help the students find necessary information. Now, we need to narrow them down. We used the following conditions to evaluate them: Which ideas are technically possible? Which ideas solve the problem and provide the best user experience? Which ideas can we afford, and which are too expensive?

Reviewing previous questions helped us decide which idea has the best chance of success. And when you choose it, you can start prototyping your chatbot Story draft which is a conversation scenario.

Microsoft Power Virtual Agent (PVA) was used to implement the chatbot because of its easy programming through an intuitive graphical interface. PVA can be integrated with Microsoft Teams which educators use to organize online classrooms. Such integration allows students to use the chatbot within Teams. PVA uses bot context-based variables that allow for a more streamlined user experience. To make reprogramming each semester easier, information is tabulated and stored in Excel files that can be updated at the beginning of a semester. Most advanced programs, such as creating links to files, scheduling appointments, and retrieving course information from Excel files, were created on Microsoft Power Automate. These mini programs are called flows. PVA can trigger the appropriate flows based on the user inputs. Once a chatbot is created on PVA, it can be published, and users can use it immediately. The published bot can be linked to external services like Slack, a custom website, a mobile app, or email.

Responses by the chatbot in PVA are created based on trigger phrases. These trigger and response sets are stored as topics. Figure 5 shows an example of a power virtual agent topic used in the MEEN 364 – Dynamics systems and controls course. Here, the trigger phrases that involve "peak time" will initiate a response from the chatbot defining peak time. The bot can continue the conversation by posing a question to the user. This can lead the user toward other relevant topics. For example, a question about the "time domain specifications" would lead the bot to ask the user, if they would like to learn more about the terminologies discussed, such as "rise time" and "peak time." Figure 4 shows an example of such topic redirections. The objective is to engage students and provide them with quick access to course-relevant information.

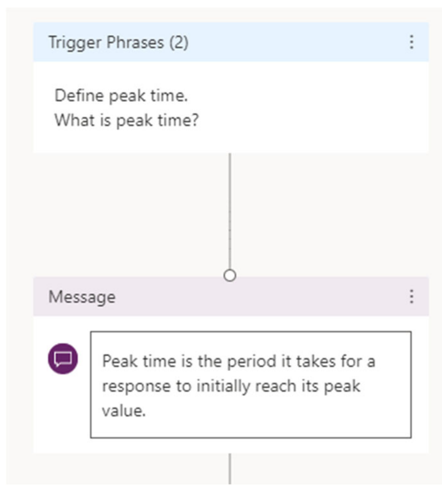



*Figure 3. Responses are created based on set trigger phrases.*

*<u>Test:</u>* After the chatbot was ready, it was tested to verify whether it works as intended and can address all students' questions.  Testing our chatbot before the launch was vital to catch and fix weak points before it connected with all the students.  This is an important phase and should not be omitted. Students may lose confidence if implemented with poor user experience (UX), and it will be difficult to rebuild it even if significant adjustments are made.

**Results:**

An initial stage prototype was developed. The information shown in Figure 2 was collected for two MEEN courses: MEEN 364 and MEEN 210. Sample screenshots from the conversations with the chatbot are shown in Figure 5. It was then published and tested with a selected set of users. The set included students and TAs. The user would then enter their questions and engage with the chatbot. At the end of the testing session, the chat log is studied to see the shortcomings of the chatbot. A sample of the chat log of failed cases is shown in Figure 6b. New topics are then added to the chatbot to address the missing information. The chatbot is then updated and published. The tests are repeated. This cycle is shown in Figure 6a.

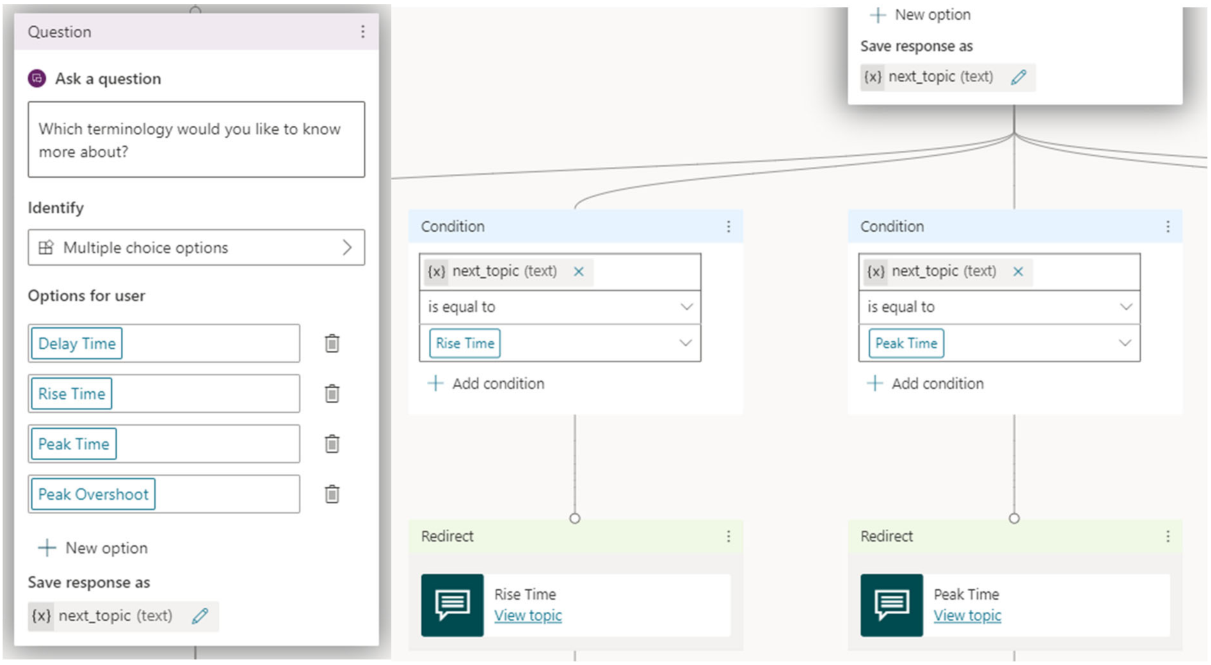
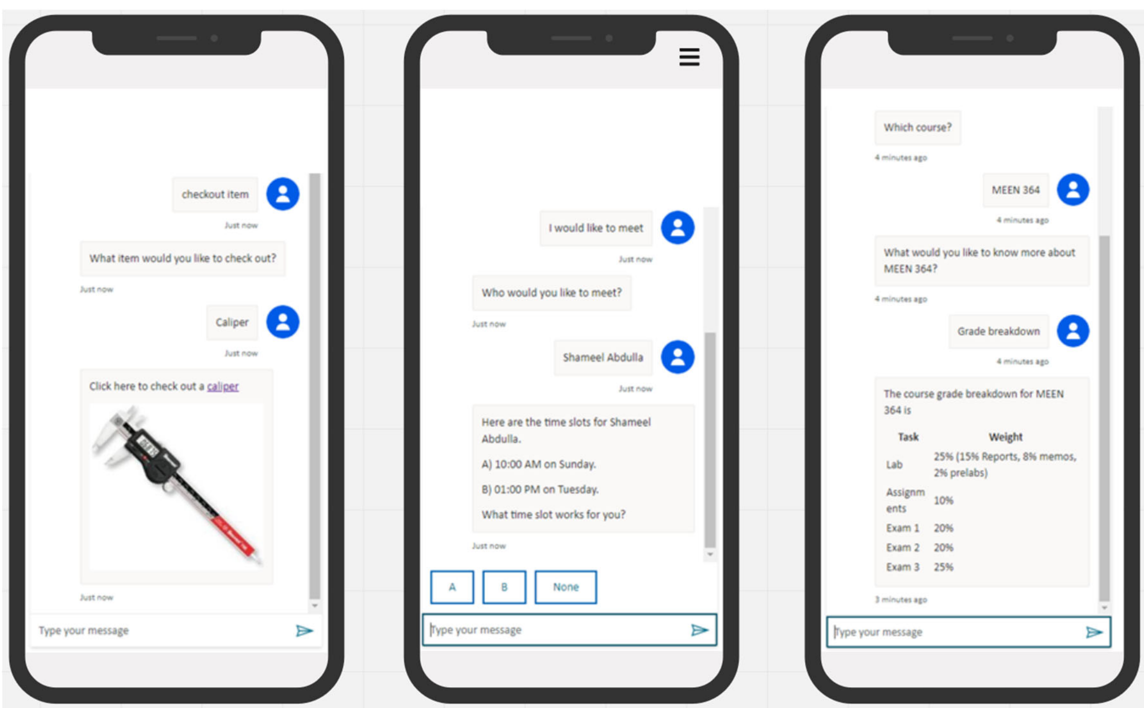
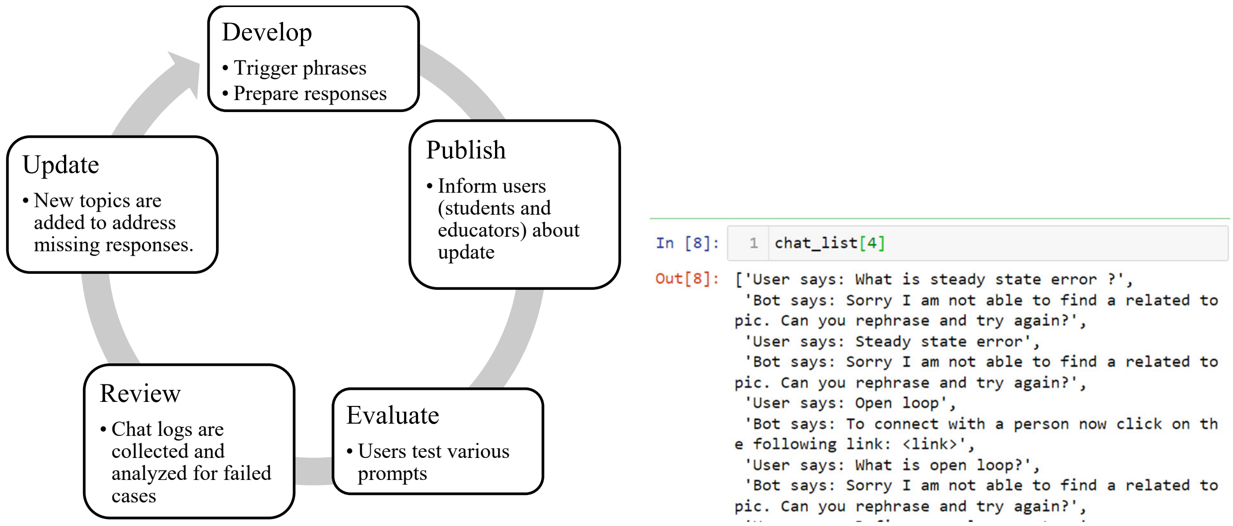



*Figure 4. The conversations can be branched out in meaningful ways.*



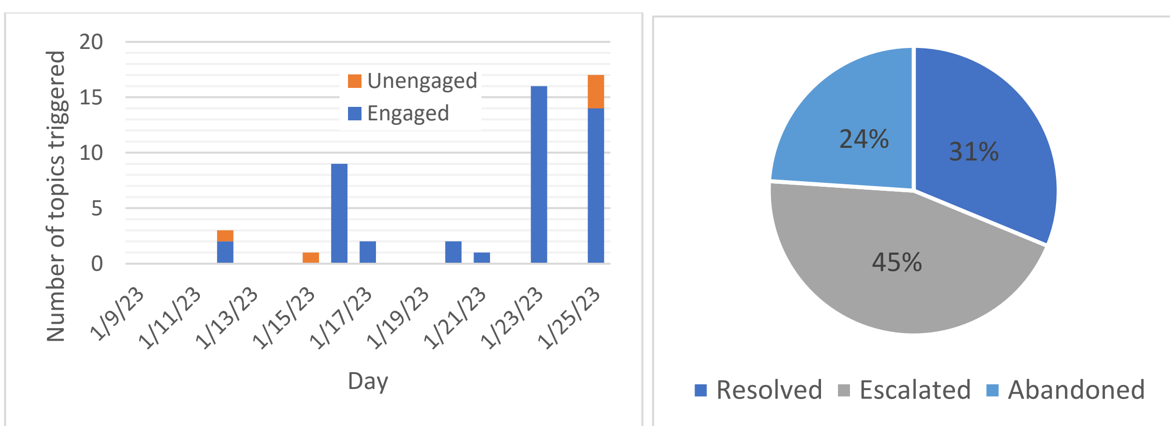

(a) (b) (c)

*Figure 5. Sample screenshots of sessions with the chatbot. a) Student asks for checking out a caliper. b) Student asks about meeting a TA. c) Student asks about the course grade distribution.*




(a) (b)

*Figure 6. a) The chatbot responses are continually updated to fill any missing gaps. b) Failed cases in the chat log are used to improve the response of the chatbot in every update*




(a) (b)

*Figure 7. Analytics generated by PVA to gauge chatbot engagement.*

In addition to the chatlogs, PVA also generates analytics that can help further improve the chatbot's effectiveness. One such metric is engagement over time shown in Figure 7a. This shows the number of successfully triggered and unsuccessful topics for a given day. The phrases that failed to trigger any topics can then be studied, and changes can be implemented. Other important metrics to look at are:

- Resolution rate: The resolution rate shows how many sessions ended on a good note (exit survey, goodbyes, thank you) and needs to be maximized.
- Abandon rate: The abandoned rate shows the number of sessions that were abruptly abandoned by the user.
- Escalation rate: The ratio of sessions that could not be resolved and required a human intervention.

Regarding the metrics, the main objective should be to increase the resolution rate while minimizing the abandon and escalation rates. The current state of the metrics are shown in Figure 7b. The resolution rate is 31% and indicates that the chatbot has a lot to improve. Another metric is the Customer Satisfaction Score. The chatbot ends every topic with a customer survey. Users can rate their experience from 1 to 5. The responses are recorded per topic to monitor which topics are doing well and which are not. Table 1 shows a few of the highly engaged topics. There were 40 sessions recorded in total. Each session could have multiple topics triggered. Not all users attempted the surveys. An average CSAT score of 3.7/5.0 was achieved in the first trial run with 20 students.

*Table 1. Customer satisfaction scores for different topics.*

| Topic | Engaged sessions | Avg CSAT |
|---|---|---|
| What is Laplace transform? | 7 | 3.8 |
| What is rise time in a control system? | 4 | 5.0 |
| Greeting | 2 | 1.0 |
| What is MEEN 361 course? | 2 | 4.5 |
| What is the difference between open-loop and closed-loop control systems? | 2 | 3.0 |
| What is the significance of the peak time in a control system? | 2 | 2.5 |
| What is a feedback control system? | 1 | 3.0 |
| What is a PID controller? | 1 | 5.0 |
| What is the difference between Laplace and Fourier transform? | 1 | 4.0 |
| What is the Routh-Hurwitz stability criterion? | 1 | 5.0 |
| **Average** | | **3.7** |

To understand students' perceptions of the chatbot, 20 students were asked to use it, and a separate survey was sent to collect their feedback. The survey contained the following questions:

1. How satisfied are you with the MEEN ChatBot's responses? (On a scale of 1-Not at all satisfied to 5 Extremely satisfied)
2. What did you like about it?
3. What did you dislike about it?
4. Any comments for further improvement?

Their self-reported satisfaction level is shown in Figure 8. 16 out of the 20 students responded to the survey. The average score was 3.2/5.0. This indicates that the chatbot needs more work to ensure that students perceive it as a useful tool. After reviewing their comments, the positive feedback about the chatbot was the ease of use and that it provides course-relevant information. The negative criticism was that the chatbot had difficulty understanding the students' questions, and some of its answers were vague. Here are some samples of the comments from the students:

- Pros
  - "I liked the ease of use, and the information it provided."
  - "What I liked about it Chatbot, is that if the student have a simple question he may ask Chatbot instead of emailing the TA or the Professor."
  - "Easy to use, short helpful answers"
  - "it is specific to the course, answers inquiries that people often have like course grade breakdown. Its more convenient than looking through canvas, many modules, and sometimes not finding what i want"
- Cons
  - "It did not understand a lot of things I said, asked me to repeat a lot of things, and it took a long time to get what I wanted."
  - "Also, the bot wasn't understanding my questions and didn't/couldn't answer some of my questions. Also, the answers of the questions were a little basic, for example if you asked what is Laplace transform it would give a very simple definition."
  - "What I disliked about Chatbot, is that when I ask a question it gives me a list to clarify my question. Moreover, the options have nothing related to my question."

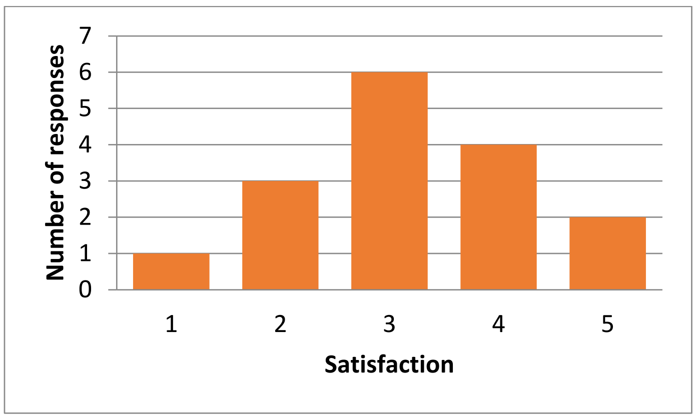



*Figure 8. Satisfaction level with using the chatbot. 1-Not at all satisfied, 5-Extremely satisfied.*

Students also provided some constructive comments to help improve the chatbot to make is more usable. Here are some of the comments:

- "More features, more detailed answers."
- "It can be helpful to add class time, exams dates, university calendar, lab equipment, key words and term definitions related to our courses."
- "Maybe add the feature of chatbot getting information from engineering books. For instance, if you need a definition or Laplace transform table you get it without having to navigate through the online textbook."
- "It needs to understand more questions and an AI Model ChatBox would be better. Everyone is used to that now and this ChatBox technology seems a bit outdated (e.g. people are using Google and this is Yahoo). Incorporating AI into it might make it a lot better."
- "Ask follow-up questions after asking ChatGPT, and somewhat integrate the chatbot answers with the response acquired from ChatGPT (record it in database or something so that when the same or a similar question is asked again the bot is able to provide answers relevant to the course)"

Overall, the preliminary finding based on the initial prototype of the chatbot was promising. The chatbot made accessing information much easier for students and other users. However, some difficulties were encountered when students were unfamiliar with the proper initial phrases. This was mediated by offering them options to click on. In addition, training material such as a tutorial video or a set of sample phrases would also be helpful. Short prompts that covered multiple topics also caused the chatbot to get confused. Instead of responding immediately, the chatbot would request clarification which frustrated many users. To mitigate some of the frustration, the chatbot was connected to OpenAI's chatGPT such that responses to unanswered questions were answered using chatGPT. A disclaimer was made that the answer may not be factually correct. The goal is to then review these responses manually and if accurate, add it to the database of questions that were created. To improve the response of the chatbot, more accurate trigger phrases are needed to ensure the responses are generated without needing further clarification.

**Conclusion:**

In conclusion, the chatbot improves the quality of an engineering student's education by providing information more efficiently, saving time, and allowing students to focus on critical content. It also educates students about access to facilities to enhance their project experiences. It frees time for teaching assistants to engage in more challenging problems. From the limit surveys conducted, it is clear that students can easily use the chatbot. The comments and reviews collected from students will be used to release and test an updated version of the chatbot. The updated version will be tested on a larger student base. More detailed responses and information will be added to cover a wide variety of courses.

References

[1] G.-J. Hwang and C.-Y. Chang, "A review of opportunities and challenges of chatbots in education," *Interactive Learning Environments,* pp. 1–14,, July 2021.

[2] S. Wollny, J. Schneider, D. Mitri, J. Weidlich, M. Rittberger and H. Drachsler, "Are We There Yet? - A Systematic Literature Review on Chatbots in Education," *Front Artif Intell,* vol. 4, July 2021.

[3] S. Ondas, M. Pleva and D. Hladek, "How chatbots can be involved in the education process," in *2019 17th International Conference on Emerging eLearning Technologies and Applications (ICETA*, 2019.

[4] M. C. Sáiz-Manzanares, R. Marticorena-Sánchez, L. J. Martín-Antón, I. G. Díez and L. Almeida, "Perceived satisfaction of university students with the use of chatbots as a tool for self-regulated learning," *Heliyon,* vol. 9, pp. 12843,, January 2023.

[5] C. K. Lo, "What Is the Impact of ChatGPT on Education? A Rapid Review of the Literature," *Education Sciences,* vol. 13, p. 410, April 2023.

[6] D. Gašević, G. Siemens and S. Sadiq, "Empowering learners for the age of artificial intelligence," *Computers and Education: Artificial Intelligence,* pp. 100130,, February 2023.

[7] A. Azaria, *ChatGPT: More Human-Like Than Computer-Like, but Not Necessarily in a Good Way,* 2023.

[8] "Higher Ed’s Invisible Understaffing Epidemic | Learning Innovation.," [Online]. Available: https://www.insidehighered.com/blogs/learning-innovation/higher-ed%E2%80%99s-invisible-understaffing-epidemic. [Accessed 6 2 2023].

[9] L. Boyle and J. P. M. Reid, "Turning Office Hours into Study Sessions: Impacts on Students' Homework and Exam Grades," in *2021 ASEE Virtual Annual Conference Content Access*, Virtual Conference, 2021.

[10] R. V. Adams and E. Blair, "Impact of Time Management Behaviors on Undergraduate Engineering Students' Performance," *SAGE Open,* vol. 9, p. 215824401882450, January 2019.

[11] T. A. B. Sophia Lerner Pink and S. Sheppard, "What Makes an Inquisitive Engineer? An Exploration of Question-Asking, Self-Efficacy, and Outcome Expectations among Engineering Students," in *2017 ASEE Annual Conference & Exposition*, Columbus, 2017.

[12] C. W. Okonkwo and A. Ade-Ibijola, "Chatbots applications in education: A systematic review," *Computers and Education: Artificial Intelligence,* vol. 2, p. 100033, 2021.

[13] G. Okere, "Covid-19 and Virtual Learning: Challenges, Implementation, and Student Perception of Online Course Delivery Formats," in *2021 ASEE Virtual Annual Conference Content Access*, Virtual Conference, 2021.

[14] M. Koretsky, "Student Responses to Remote Teaching During the Covid-19 Pandemic: Implications for the Future of Online Learning," in *2021 ASEE Virtual Annual Conference Content Access*, Virtual Conference, 2021.

[15] M. Hasal, J. Nowaková, K. A. Saghair, H. Abdulla, V. Snášel and L. Ogiela, "Chatbots: Security, privacy, data protection, and social aspects," *Concurrency and Computation: Practice and Experience,* vol. 33, June 2021.

[16] J. Stanley, R. ten Brink, A. Valiton, T. Bostic and R. Scollan, "Chatbot Accessibility Guidance: A Review and Way Forward," in *Proceedings of Sixth International Congress on Information and Communication Technology*, Springer Singapore, 2021, p. 919–942.

[17] M. C. Marino, "The Racial Formation of Chatbots," *CLCWeb: Comparative Literature and Culture,* vol. 16, December 2014.