Managing Graduate Student Advisement Questions during a Season of Explosive Growth: Development and Testing of an Advising Chatbot

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Abstract

Many universities have, or are facing, the task of providing high quality essential customer services with fewer financial and human resources. The growing diversity of students, their needs and proficiencies, along with the increasing variety of university program offerings, make providing customized, on-demand, automated solutions crucial to delivering high quality customer service. In this paper, the authors describe the development of an artificial intelligence-backed chatbot to aid in answering student advisement questions. The main objective of the chatbot is to provide 24/7 supplemental program specific advising assistance to graduate computer science majors to lessen the advising load of university faculty. In this paper, the authors describe the development of a chatbot prototype using IBM Watson Assistant running on a specially designed website and Slack platform to address frequently asked questions of computer science graduate students. Results of a pilot study conducted on 99 graduate students indicate that the prototype is a positive step forward in making student advising accessible, usable, and scalable to a broader audience.

Keywords: Conversational Recommender Systems, Machine Learning, Natural Language Processing, Artificial Intelligence, Learning Analytics

1. INTRODUCTION

Over the past few years, higher education has faced significant changes. The tentacles of COVID-19 stretched across multiple areas of higher education from changes in teaching, meeting, and conference modalities, to classroom size limits and gathering restrictions, to prompting a significant decline in national and international new student applications (Redden, 2021). Enrollment numbers were hit hard with restrictions placed on international travel. The

OpenDoors report on International Educational Exchange (IEE) - funded by the U.S. Department of State - indicated a 46% drop in new international students and a 15% drop in the total international student population for U.S. higher educational institutions from the 2019/20 to 2020/21 academic years (Redden, 2021).

However, according to a snapshot survey conducted by IEE and nine other higher education associations, the fall 2021 enrollment of new international students surged 68% over the previous fall 2020 numbers (Redden, 2021). This surge represented a 4% growth in the total number of international students across 860 U.S. colleges and universities. For university programs whose majority population consists of international students, the sudden onslaught of students following the reduction of U.S. visa restrictions caught many programs unprepared and under-staffed to provide standard services (e.g., advisement, small class sizes, and common services requiring individual interactions.)

In addition, university COVID-19-related protocols encouraging electronic communication, added to the number of individual interactions. The combination of sudden expansions in enrollment numbers, especially among international students, and multiple individualized repetitive responses resulted in higher education advisors being overwhelmed with inquiries from current and prospective students. In this paper, the authors describe a pilot study in which a chatbot was developed to assist in the advising workload of a graduate computer science program. The goal of the authors in the development of the chatbot is to provide high-quality, program-specific, immediate, individualized responses to student questions as a means of reducing the advising workload on already overtaxed faculty.

2. USE OF CHATBOTS IN HIGHER EDUCATION

The use of conversational recommendation systems, commonly referred to as chatbots, in higher education is not uncommon (Ho et al., 2018; Kumar & Rose, 2010; Nittaya et al. 2020; Nwanko, 2018; Sjöström et al., 2018; Wang et al, 2020). Chatbots have been used in education to boost student engagement (Wang et al., 2020), provide individualized tutoring (Goel, 2020), answer and respond to general needs and questions (Dibitonoto et al., 2018; Goel, 2020; Rana, 2019), and provide assistance when personnel resources are insufficient (de Lange et al., 2021).

Heller et al. (2005) introduced Freudbot to psychology students to determine their reaction toward chatbots. Although the students had basically neutral opinions, they recognized the potential chatbots had in the future. Kumar and Rose (2010) described the use of the Basilica architecture to develop chatbots that could provide engineering students with individualized tutoring. The Basilica framework demonstrated that chatbots could be developed that could give students individualized advising sessions. Further expanded research on Basilica demonstrated how chatbots could be used to assist students with productive feedback as well as grade student essay answers (Dyke et al., 2013). The chatbot used synonyms and example sentences to grade and compare student answers with the correct answer key. Jill Watson SA (Social Agent) was a virtual assistant (or chatbot) introduced in two online Master of Science classes in the computer science program at Georgia Tech. The chatbot encouraged students to engage with the other students in their courses and build communities (Wang et al., 2020). Jill Watson SA, an integration of three other AI technologies (VERA, Jill Watson Q&A, and Agent Smith), was used to help students get answers to common course questions saving instructors hundreds of hours of time (Goel, 2020).

Students have a variety of common general needs and questions that they would like answered quickly (Dibitonoto et al., 2018; Rana, 2019). Previous research has shown that chatbots offer a better experience for users with general inquiries than traditional menu-based interfaces (Adamopoulou & Moussiades, 2020). Chatbots have been used in connection with web sites to direct students to appropriate web pages (Ghose & Barua, 2013). They have also been used in a study examining automated consent management of learning management system logs (de Lange, et al., 2021). Thus, chatbots have been proven an effective resource to students as well as others in many different cases (Goel, 2020; Yilmaz & Yilmaz, 2020).

2.1 Chatbots and advisement

Jiang, Pardos, & Wei (2019) noted that students needed help with course advisement and selection and that chatbots could be used to provide that assistance (Suschevskiy & Khalil 2021). Wagner et al. (2021) found that students do not always know what courses to take for their programs nor how to get recommendations. In addition, some courses have prerequisites requiring students to take courses in sequence with some courses offered

in certain semesters (Laghari, 2014). Some students do not know the requirements of their program or courses while others just want to take courses that are interesting to them (Maphosa, Doorsamy, & Paul, 2020).

Chatbots are already being used in many ways to help students with the advising process. The MOOCBuddy chatbot was created to help students find the best courses for their area of interest and needs (Holotescu, 2016). Even in the development stages with limited capabilities, MOOCBuddy received mostly positive feedback implying that students could use help in identifying the best courses to take. Course Recommender, another e-advising tool, was developed using state-of-the-art data mining techniques and conversational recommenders (Guruge, Kadel, & Halder, 2021).

Chatbots offer students a means of providing personalized advice on selecting the best courses for their degrees and possibly suggestions of courses that might be of greater interest (Suschevskiy & Khalil, 2021). Artificial intelligence (AI) such as machine learning (ML) and natural language process (NLP) are part of the innerworkings behind chatbots helping to provide personalized course and information support (Yu et al., 2017).

3. BACKGROUND IN AI, ML, AND NLP

Artificial Intelligence (AI) machines mimic the human brain's functionality as to how they think and perceive. The ideal AI machine may have its own knowledge base and may be able to operate on its own with very little, if any, human support. A powerful chatbot needs to utilize AI with as little human support as possible since the fundamental purpose of a chatbot is to automate tasks and queries.

Machine Learning (ML) is a technique of having a program look for, find, and determine what patterns exist in a dataset and then learn from the patterns. To do this, a machine is given training samples from which to extract data and learn. For example, a camera learning to detect whether subjects are smiling would analyze many samples of photos of subjects and find patterns in their features. After this, the machine would be given more training samples to test what the "machine" had learned. ML is critical in the development, improvement, and usability of a chatbot (Hiremath et al., 2018).

Natural Language Processing (NLP) is used to make machines "understand" how humans naturally communicate. This is critical for a chatbot as the users are free to type in content using any arbitrary language style. This means that a user can use their own grammar/dialect and still be understood by the chatbot. Thus, a user could ask the same question in multiple ways and get the same results. For instance, a user trying to learn about an advising form could ask a chatbot having NLP "Where's the advising form?" or "How do I find the advising form?"

In 2018, Hiremath et al. found that the use of ML and NLP was critical for improving the usability of chatbots. The authors also concluded that users were more satisfied with chatbots' responses when they were detailed, yet concise and avoided unwanted information. Al Muid et. al (2020) found that an unsupervised approach to ML in chatbots in which the chatbot recognized patterns on its own (without interference or limitations) was more successful, especially in the field of education. In addition, Debnath & Agarwal (2019) emphasized the importance of having a mobile-accessible interface to be critical in user acceptance. The next section describes the impetus behind, and development of, an AI driven advising chatbot developed at the authors' institution for their graduate program.

4. AUTHORS' INSTITUTION

The Master of Science in Computer Science (MSCS) program at the authors' institution was started in 2018 with 30 students. Since that time, the number of students in the program has exploded to 400 and continues to receive substantial active interest from both domestic and international students. This rapid growth created multiple pressure points, especially since computer science faculty are being asked to advise upwards of 150 students while carrying teaching loads of four and five courses each semester.

4.1 Advising Process

The advising process for the MSCS program began by replicating the standard advising practices implemented across campus. General program and course information was posted to the University's web site. Program specific advising information was shared by the program coordinator via individual emails to each prospective and current student. The process gradually morphed into intermittent email broadcasts to regularly updated group mailing lists.

The university's website, the "starting point" of the academic journey for many students, provides a broad spectrum-view of the various university program offerings without addressing the special needs of high-growth programs like the MSCS. Hence, it is difficult, especially for first-time users, to find appropriate program details from the existing pages. The site lacks navigational features (e.g., actionable buttons/widgets, etc.) that can systematically guide the students through the various aspects of their academic journey (e.g., selecting a concentration, developing a degree path, choosing classes, etc.).

Although existing tools such as degree audits are available, providing customized on-demand advising help, specific to each student, has been difficult with limited resources. Thus, MSCS students generate an overwhelming number of emails requiring additional faculty time and effort for personally crafted responses. Because the advisors' time is limited and they are not always available to address advising needs, a backlog of emails often accrues waiting future attention.

4.2. Advising Issues

Common student advising questions usually focus on the courses students need to take for their program of study, the prerequisite requirements for their courses, frequency of course offerings, the modalities in which the courses are offered, graduation requirements, thesis expectations, and internship requirements. In addition, international students often have questions related to maintaining their I-9 visa status.

The advising process, in an ideal world, would be simple (Figure 1). The student would be able to attend an advising session, fill out their advising form correctly, have the form approved by the advisor, and then sign up for their courses without any errors or issues. Unfortunately, the actual advising process usually has additional steps, as many students struggle with the advising form and other areas of advisement.

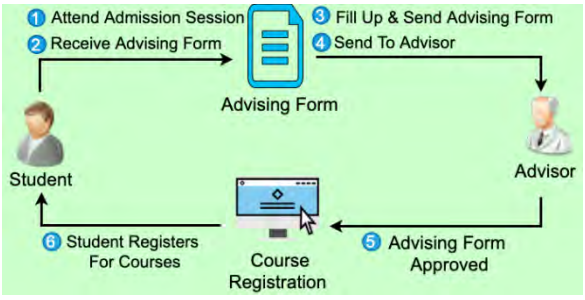

Figure 1: Ideal course registration process

Figure 2 illustrates the difficulties faced by students and advisors during the course registration process. Each exchange of the advising form between student and advisor adds additional layers of communication wasting time for both. The two major periods of this hyper-active advising process can be categorized into: (a) a 2-month window around the start of the semester for enrolling new students, and (b) a 1-month window in the middle of the semester when current students need advising for the next semester's courses. Hence, this activity essentially takes up most of the 4-month semester with brief periods of dormancy.

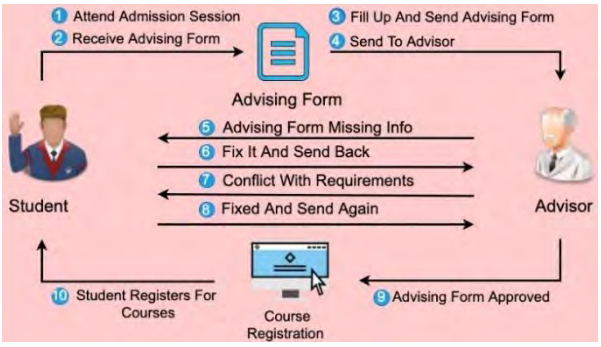

Figure 2: Actual course registration process

4.3 Steps Taken to Address Advising Process Issues

The authors used a multi-step approach to lower the cost of student advisement support while helping the students assimilate into the academic program. *First*, the authors approached the university's undergraduate advising center to learn about their best advising practices. *Second*, several bite-sized (8-10 minutes) carefully crafted videos were recorded describing the various steps of the advising process. A content-rich curated playlist was created by combining MSCS advisor created videos with other videos from the university's collection. Advisors shared the playlist with all incoming and current graduate students. This playlist has proven to be a popular student resource with, in less than a year's time, each of the videos garnering between 600-1000 views on the MSCS YouTube channel.

Third, students' questions and comments from advisor emails, phone calls, and office hour meetings were compiled. Learning Analytics (LA) was used to determine the most frequently asked advising questions. The questions and requests were reorganized into meaningful categories to provide a planned approach capturing the complexities of student-advisor interactions. Considerable effort was made to specify goals and

define potential next steps in the advisement process.

The table of questions, as well as the insights gained from advising center discussions, were then used to design a highly structured interactive web environment. (See Table 2 in Appendix.) A Jekyll-based content management system, hosted free of charge on GitHub, was used to publish bite-sized informational posts on advisement. In addition, a chatbot, named after the University's mascot, was developed using IBM Watson Assist to assist in answering frequently asked questions and encourage a rapport with the students.

5. DEVELOPMENT OF AN ADVISING CHABOT

The chatbot gives students an efficient and informed advising experience during course registration at the beginning of each semester. Using IBM Watson Assistant as a backend, the authors were able to integrate a chatbot into both a website and Slack. The chatbot is currently designed for a limited student population of Computer Science and Cybersecurity (CS/CY) masters students but can be expanded to include all university departments in the future.

5.1. Tree Design

The landing page for the web-based advising tool begins with a "topic tree" that visually represents the interrelationship of critical categories for the main advising tasks. Each category in the topic tree is associated with branches that can be expanded into sub-categories essentially representing FAQ items or pathways for user queries. By pruning or adding new branches, the tree structure systematically customizes to the complex knowledge landscape of student advisement. For example, the advisors found that many recently admitted students had queries about pre-requisite waivers. The sub-tree was modified to include the list of pre-req courses, waiver options, and general messaging explaining the reasoning behind prerequisite requirements.

The topic tree morphed into a "conversation tree," the backbone for conventional *digital conversations* in the automated chatbot. It is essentially a collection of narrative pathways in which the user creates a personalized dialog flow through the choices to meet the desired advising outcomes. Complex conversational flows can be addressed by placing strategic links. Well-designed chatbot dialog is delivered through planned recommendations that quickly resolve user queries in a matter of few seconds. In contrast, bad dialog design can lead to unnecessary user aggravation and ultimately, poor tool adoption.

5.2. Website Layout

The website caters to three distinct student roles: prospective, newly admitted, and current students. A vertical navigation bar and an accordion view limits the views to only those posts associated with the selected role. For example, online-only domestic students are concerned about exam modality, whereas international students are curious about visa issues related to internships. (See Table 2 in the Appendix.) This planned web layout (Figure 3) is a space for implementing navigational tools to guide students through various advisement goals and associated recommendations. The student can independently peruse through the webpages, or the advisor can recommend a specific page during the advising appointment.

The website is built using Jekyll, a static website generator with built-in support for GitHub. GitHub Render hosts the pages free-of-charge. Assumedly, the site should remain secure provided the users' credentials remain confidential. In addition, GitHub offers their own SSL certificates that require minimal effort in providing website security. The site uses markdown and HTML files with customized layouts for MSCS program-specific content.

The vertical accordion view of stacked header list items was chosen for housing the content, as it is the established workhorse for responsive web design. This pattern facilitates progressive disclosure by displaying the critical broad categories from a carefully designed topic tree while the rest of information is just a click away. The focused approach of the accordion view allows users to choose between skimming the topics or revealing details only when necessary. This approach makes digesting the web page content less daunting. This is especially helpful for Gen-Z prospective students with limited attention spans. This population is shifting towards independently exploring education content with minimal human contact, especially in light of the aftermath of the pandemic.

5.3. IBM Watson Assistant

IBM Watson Assistant uses ML and NLP in order to provide real-time responses to text-based questions, essentially FAQ questions containing custom-crafted content appropriate to the students' level of academic maturity. This

programmable tool is extremely effective in handling hundreds of simultaneous student conversations in diverse topics (IBM, 2022). For programming the Watson chatbot, the developer needs to create *entities, intents, and dialogs*. (See Table 1 in the Appendix for a summary of terms). Relevant examples of multiple possible user questions are listed beneath each intent. The chatbot learns from these examples and infers potential user queries which may not be explicitly specified in the intent.

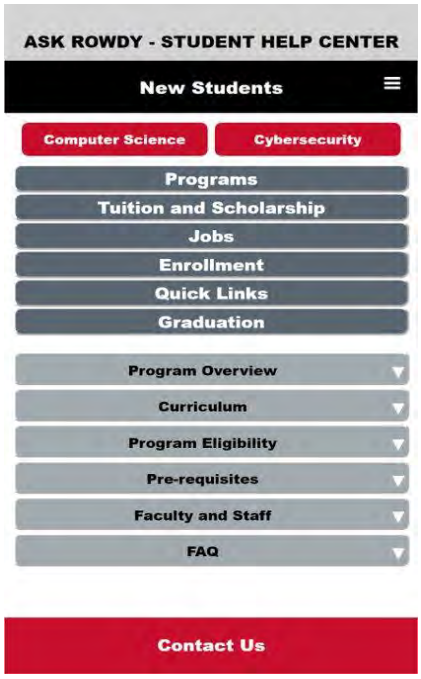

Figure 3: Website Layout

An entity is specifically tied closely to a time, item, or name. Intents and entities are linked to dialogs which are the responses that will be given back to the user. Once the assistant recognizes an intent or entity, a dialog associated with that intent/entity is returned. Sometimes there is a hierarchy of dialogs. Under such cases, the chatbot will send a message to the user seeking more information to clarify the user request. For example, when a user asks for the core courses for their degree, the chatbot must discover which specialization the user is pursuing (e.g., CS/CY). The program names and their corresponding courses are under one main dialog (e.g., 'core course') with each having a separate dialog for their own specialization. Both the Slack and webpage integrations use the same hierarchy of intents, entities, and dialogs in Watson Assistant to obtain their responses. The infrastructure of the advising chatbot is shown in Figure 4.

We used the Slack app to create separate virtual group chats, called a "channel," which are dedicated to individual query. For example, there might be a channel for students to network with each other, a channel for users to message the administrators about an error, or even a channel for just the administrators to converse about an issue. Individuals would have to be invited to join the channel before they would be able to see or contribute content.

This allows for fostering student conversations and reduces information overflow. The MSCS student workspace containing several such channels was created during the pilot study. (Figures 5 and 6 show some of these features.) The next section describes the results of the pilot study survey.

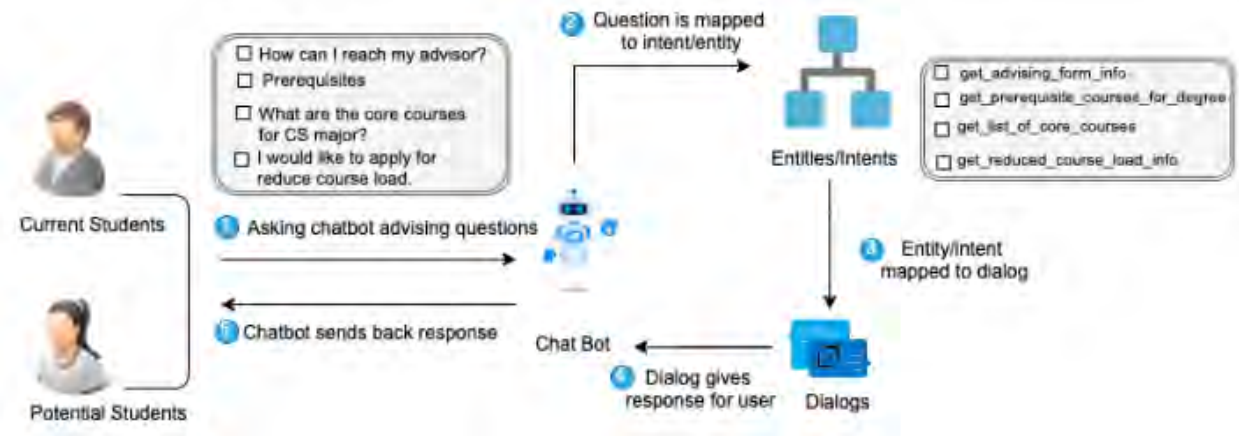

Figure 4: Infrastructure of Ask Rowdy Chatbot

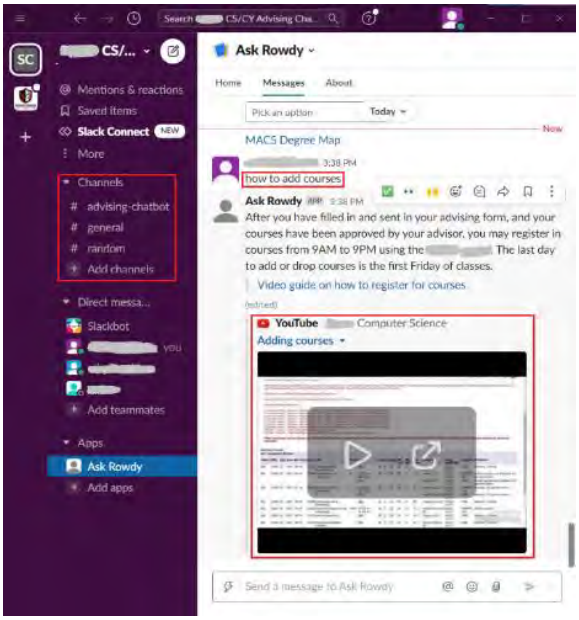

Figure 5: Slack integration

6. RESULTS AND ANALYSIS

A pilot study was conducted to gather student opinions on user experience, chatbot features, and chatbot responses for standard advising concerns. Most students found the chatbot to provide an overall positive experience and was useful for meeting advisement needs. However, further work will need to be conducted to continue to improve on the current functionality.

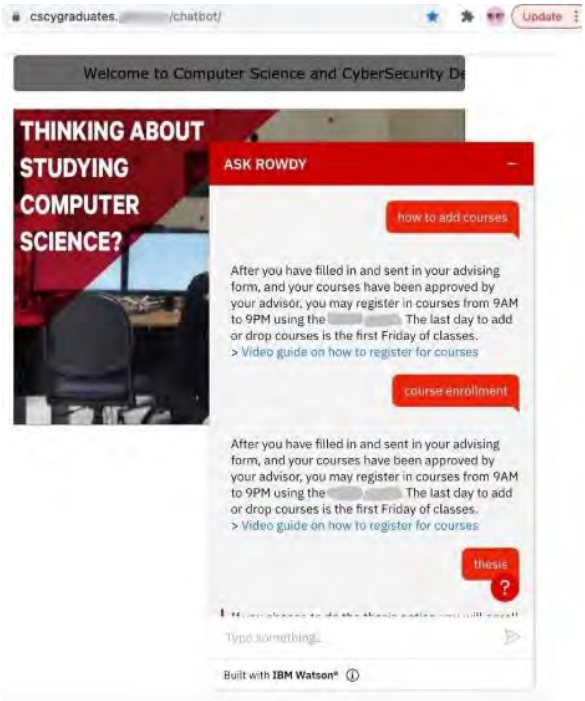

Figure 6: Webchat integration

6.1 Pilot Study

During the pilot study, students were asked to complete a survey form containing questions about usability, quality, functionality, speed, and design of both the website and Slack platforms. The study was targeted toward current and prospective CS/CY masters' students to limit the study to those who would benefit from the project. Out of a total population of 500 students, 99 students responded to the survey representing both newly admitted and current students coming from both domestic and international backgrounds. Students were asked to try out both chatbot interfaces and to answer a Microsoft Forms survey upon completion. Data was recorded anonymously to alleviate privacy concerns. The survey took less than three minutes for the students to complete. The sample questions are discussed in Section 6.2 and the feedback results are presented in Section 6.3.

6.2 Questionnaire for Chatbot Feedback

Questions 1 through 3 in the survey form were demographic questions such as length of study, part or full-time student, and domestic or international student. These questions were aimed at better understanding the student profile and reflected on the level of their experience with the university's advising procedures. The next set of questions asked the users about the chatbot's performance, usability, and responses. We used a 3-level Likert scale of satisfaction. Users were asked about the chatbot's response to see if they believed it was engaging, informative, and friendly.

The next question asked the users if the chatbot was able to accurately answer their questions about a variety of advising questions. The last question allowed the users to rank the chatbot out of 5 stars. The responses could be used to determine where the chatbot was working well and where potential holes in the program needed to be fixed. The rankings indicated whether the users would want to use the chatbot in the future (Figure 7).

6.3 Discussion on Pilot Study Feedback

Respondent feedback from the pilot study was mostly positive (Figure 8). The IBM Watson chatbot back-end supported both the web and Slack app versions. Students' preference for chatbot access was primarily based upon convenience. However, the web interface was used more often by international students.

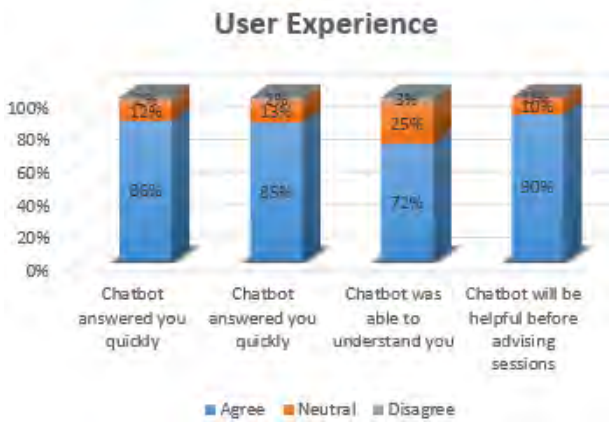

Figure 7: User Experience with Ask Rowdy

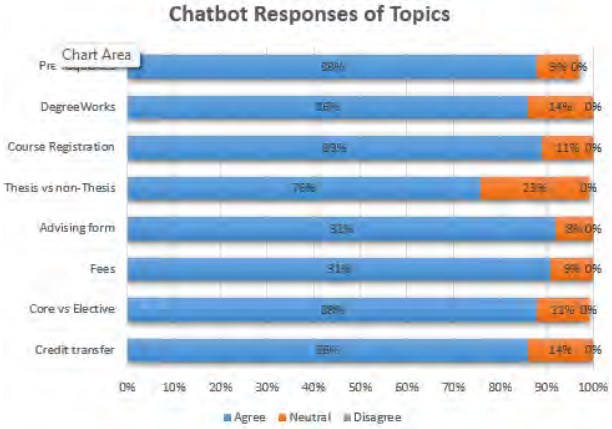

Figure 8: Chatbot Response Rating

Respondents were asked to rank the chatbot out of five stars. The overall rating for the chatbot was a 4.5 out of 5 stars. Most users were able to use the chatbot effortlessly and found its answers to be helpful in their academic advising experience. The respondents each had different academic maturity levels leading the researchers to conclude that all levels of students could potentially find the chatbot a reliable tool for their academic advising.

The students' academic maturity levels were also used in the chatbot to customize the question flow and provide suggestions to students. Overall, the chatbot was able to automatically broadcast solutions to main questions and concerns. Each question asked by the students improved the NLP in the chatbot and was stored for record. This can be later analyzed to identify gaps in terms of question content and information flow. Learning analytics data will be very important in the continued development of the chatbot. As an ongoing project, student preferences and priorities are continuously being incorporated into the workflow. This pilot study is a precursor to a large-scale usability study with a few hundred students and eventually, a department-wide project rollout so that this tool can be used actively by faculty advisors and students. More importantly, it is becoming a platform to present program-specific advisement content to a large diverse student population who can peruse the material at their own pace in a non-linear manner from remote/domestic locations.

7. CONCLUSION

Academic advising communication modes are undergoing tremendous change due to the diversity of student profiles as well as the variety of department-level program offerings. As high-profile programs continue to grow without corresponding resource allocations, alternative means for addressing student advisement questions must be found.

In this paper, the authors described the development of an AI-backed advising chatbot created using IBM Watson Assistant to help alleviate stress caused by explosive growth in an already popular academic program. This web-based tool provides compelling goals and clear academic pathways for advising related tasks. Advising information was provided on a readily available and easily accessible platform that easily conforms to the demanding constraints of cognition, time, and money. Two prototypes of the chatbot were tested on a small pilot study of graduate students, one created as an app and the other accessible via the web. Results from the pilot study found that overall, respondents found the chatbot to be helpful and engaging. Both the web page and Slack app interfaces performed equally well with choice of access relying more on convenience than performance.

Now that the chatbot has been piloted, the authors plan to use the data they have gathered to implement additional functionality and broaden the scope of MSCS advising questions. In the future, the authors plan to expand the reach of the chatbot to assist with advising needs in other university departments and programs.

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Editor's Note:

This paper was selected for inclusion in the journal as an EDSIGCON 2022 Distinguished Paper. The acceptance rate is typically 7% for this category of paper based on blind reviews from six or more peers including three or more former best papers authors who did not submit a paper in 2022.

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Appendices and Annexures

	Function	Explanation	Examples
Intent	Takes example user questions and extrapolates it to figure out what user is needing	• Used for majority of questions • Each new example shows the chatbot a different way to ask the same question	#thesis_info #get_course_info #get_advisor_info
Entity	• Specific time/item/thing user query	• Used for a limited number of user interactions • Can be used for semesters and courses • There are also built-in entities like day and time	@is_doing_thesis @queried_GA @queried_RA @queried_semester
Dialog	• Response given to user • Can have multiple responses that go sequentially or together	• Text options used to give users answers and links to find more information on topics • Buttons to suggest other topics under the chatbot the user might find helpful	• Specific Course Information • Advising Form Information • Thesis Questions

Table 1: Explaining Intent, Entity and Dialog

	Simple	Complex
Enrollment/ Registration Questions	1.How do I enroll in classes for the upcoming semester? 2.What is the "Portal"? How do I register for my courses using Portal? 3.Identify course modality: face-to-face or online. 4.How can I register for the course that is full? 5.How many face-to-face courses do I need to take to maintain my visa status?	1. What are the special requirements for international students? 2. When can I withdraw from a course without failing it? 3. If I fail a course and then re-register in the next semester for that course, am I required to attend that course's classes? 4. If I want to register for courses in the summer, can the department offer the courses I have not passed?
Program Questions	1. Which are the core courses for my program? 2. How many 600-level courses do I need to register for my program?	Where can I find a course description before registering for it? (e.g., Assignments, Projects & Presentations).
Advising Questions	1. I cannot attend the advising meeting. How can I register for the upcoming semester? 2. I am unsure about some of my courses. Can I request any changes later? 3. Who is my advisor? 4. What is the best way to communicate with my academic advisor?	1. How should I choose the courses I enroll in? 2. How do I complete my advising form?
Degree Prerequisites	1. What is the purpose of prerequisites? 2. What are the prerequisite courses for my degree?	1. I don't have a Computer Science background in Bachelor's degree, but I have enough work experience. Will the prerequisites be waived for me?
Graduation	1. What are the requirements for International Students to graduate? 2. What is the minimum GPA required to graduate?	1. I am an international student, and this is my final semester. I only have 1 or 2 courses left. Can I register for a reduced course load? 2. What should I do if I only have one course left for my last semester?
Thesis and Non-Thesis	1. How does the thesis process work? 2. What is the difference between thesis and non-thesis for graduation?	1. How many elective courses do I need if I choose the thesis option for graduation?
Other Questions	1. How many online courses can I take as an international student?	1. How many online courses can I take for my last semester as an international student?

Table 2: Sample advising questions based on categories