Chatbot as a learning resource? Creating conversational bots as a supplement for teaching assistant training course

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***Abstract*—One of the technologies that educators can leverage is the use of chatbots or conversational agent to support teaching and learning. Moreover, with the recent advancement in AI, companies like Google, IBM, and Amazon provide platforms that are focused on building conversation rather than the technicalities of computer programing, in particular, natural language processing. In this case study, we will look into the application of a simple rule-based chatbot, based on Google DialogFlow, in a teaching assistant training course run by a Center for Education Innovation at the Hong Kong University of Science and Technology. We will unpack the details of how a chatbot can be integrated into both online and face-to-face content to augment some of the challenges that can be encountered in teaching.**

Keywords—Chatbot, Teaching Assistant Training, Conversational Agent, Chatbot for Education

I. INTRODUCTION

The application of technology inside the classroom, such as using teaching videos for flipped classroom [1] and for MOOCs [2], embedding learning analytics to better understand students' online behavior [3], and producing gamified contents to engage students [4], [5] are some of the few trends in higher education. These trends, though they might not be entirely new, enables educators to see their practice into the new light brought by the fast-changing technology landscape. Advances in education technology provided the tools and application to collect data extensively and at the very minute level. It also allowed educators to scale up the delivery of their learning contents and provide a more personalized experience for the students.

These changes in education technology landscape call for a more personalized experience to support individual learning patterns and to cater to the diverse needs of each student in both online and face-to-face interactions [6]. Educators are now faced with this challenge to keep up with the needs of this generation of learners. Further, Rezende and de Souza Barros [7] find out that students who are using the online component as a resource view the online materials in a non-linear fashion. This finding was based on their study of the different navigation patterns of students in an online environment. This finding means that the students. Needs support and feedback at various learning points. Also, this is where technology should be maximized to ensure that learning support will be available for these students 24/7.

One of the technologies that educators can leverage is the use of chatbots or conversational agents [8], [9]. Fadhil and Villafiorita [4], in his paper on adaptive learning, noted that these chatbots enable the learners to personalize their learning based on their needs and behaviors. For example, a chatbot is available 24/7, can open a communication line that is more responsive than the traditional means such as email or forum.

However, creating a chatbot, like conversational agents, are challenging to build [10]. Chatbot usually requires a specific programming knowledge such as Natural Language Processing, and Machine Learning. These knowledge are just some of the technicalities that one should know before building a chatbot. However, with recent advancement in AI and conversational agents, companies like Google, IBM, and Amazon provide platforms that focus on the flow of conversation rather than the computer programing of [11]. These platforms democratize the technical know-how in building these chatbots, which makes it easier for a non-technical person to pick it up and build customized chatbots that will fit the learning context.

In this case study, we will look into the application of a simple rule-based chatbot, based on Google DialogFlow, in a teaching assistant training course run by Center for Education Innovation (CEI) at the Hong Kong University of Science and Technology (HKUST). The course team developed this bot as a supplement to the flipped classroom format created for the course. We will first look into the challenges and difficulties posed by the current course design such as

- providing scalable support for the Graduate Teaching Assistants (GTAs),
- addressing GTAs' diversity and
- maximizing efficiency in daily task routines

In section 2, we will tackle these issues by looking into the format of the current course design and the challenges met by the course team. Section 3 will focus on the chatbot design, using Google DialogFlow, how it will be used to address the concerns raised in this case study. Finally, the last section will give us the overall recommendation based on the lesson learned from this experience.

II. CHALLENGES WITH THE CURRENT COURSE DESIGN

Every year, HKUST assigns roughly 550 full-time research postgraduate (RPg) students to the role of Graduate Teaching Assistant (GTA) to support teaching and learning in undergraduate courses. These GTAs join the teaching support team in their respective departments to carry out various teaching functions such as teaching tutorials, conducting laboratory sessions, marking assessments, and providing feedback as assigned by the department. However, for most of the time, these GTA students are coming from

their discipline with little or no background in teaching. In a similar study with the engineering education, Sohoni, Cho, and French [12] mentioned that the skills in teaching are acquired during the on-the-job training, and the teachers practiced on their students, in this case, the undergraduate students. For this very reason, the CEI, the University's central unit dedicated to promote and develop pedagogical practices within the university, and designed a training course to augment the gap in the skills needed by the GTAs as they carry out their teaching duties in the University. The center aims to revamp the current GTA training program using a more proactive approach by creating an online component for the flipped classroom and using active learning strategies for the face-to-face sessions.

This new format will provide more time for GTAs to reflect on their learning experience. It will also allow them to discuss how the strategies observed can be further applied in their actual teaching. The new course design is consist of five modules focusing on various aspects of teaching, such as marking, presentation, and classroom management. Each module is delivered through a 120-minute workshop where GTAs receive goes through various activities followed by a few minutes of consolidation in between. However, this new course format still poses multiple issues in the delivery and facilitation, particularly in providing support, addressing diversity, and optimizing routines.

A. *Providing scalable support for the GTAs*

In one of the conversations with the course instructor, she mentioned that the "workshops are run in multiple sessions, covering similar if not the same content." She further added that the "questions raised by GTAs are similar...". In the previous course design, each module is conducted for at least 15 times every year to make it available for more or less 600 GTA students. Further, there are only three instructors in the course team, making a ratio of one instructor to 200 students. This ratio makes it difficult, if not impossible, for the instructor to provide scalable support to their students. However, there is a silver lining in this issue since it is a training program, most of the lessons are repeated, and the majority of the contents are shared among the 600 GTA students. This repetitive process of delivering the same materials and answering similar questions in every session can take a tremendous amount of time from the instructor and limit her from addressing GTAs' concerns or focusing her time on more meaningful activities with her students. On a similar note, Chickering and Gamson [13] suggested that constant communication with the students and prompt feedback are some of the good practices in teaching in higher education.

B. *Addressing GTAs' diversity*

Currently, a majority of the GTAs are coming from Hong Kong at 55%, followed by students from Mainland China with 37% while the distribution between MPhil and Ph.D. students will be at 25% and 75% respectively. On top of that, the University is divided into four schools with 18 divisions and departments. This structure of the university makes it challenging for the course team to address the diverse needs of GTAs coming from diverse subject matter expertise and educational background. Furthermore, the instructors have to cater to department-specific needs in terms of the teaching materials, presentation skills, and content-specific feedback. Nolan [14] defined it as tailoring to fit individual needs and giving the learners the ownership of their learning.

Further, in another study, Merrill [15] pointed out the importance of guidance as to the students' learning progress. In this case, there is a need for a mechanism where students can ask questions particular to the theories and concepts within their discipline. They also need a space where they can bounce back their thinking from the things they learned online or during the activities in the F2F sessions.

C. *Optimize daily task routines*

This issue is tied with the scalability of support but instead framed in classroom management thinking. As previously mentioned, each module is delivered at least 15 times a year, which means that the instructor will have to repeat the same lesson multiple times. On top of that, these sessions are delivered using active learning strategies where GTAs need to work on a series of activities through the entire session. This issue was raised by the instructor when she mentioned that "It is hard for the [her] to give feedback to individuals or groups and to keep everyone moving or on the right track." This issue can also be seen in running flipped classroom approach where the focus of in-class activity gears towards student-centered learning. It is also assumed that in an active learning classroom, there is a shift from information giving to facilitating a role for the instructor [16]. Also, receiving prompt feedback will allow the student to explore deeper into the topic. The prompt feedback is essential, especially during the F2F session, where the students are expected to consolidate their learning from the online materials and the activities.

III. Research Method

The design-based research [17] approach was used to document the course design, chatbot's multiple iterations, the interaction between the users, in this case, the GTA students and the course team [18]. This research methodology focuses on the. Principles underpinning the design process by identifying the problems, refining the solution, and documenting the entire process. The research team collected 12 hours of lecture videos, recorded 4 hours of the interview from the course team, documented 11 course development meetings, and aggregated 300 students' feedback. The team collected the data from September 2018 till June 2019. This methodology fits well in this study since it will allow the researchers to outline the details of the development which will enable readers to understand the design process of the study entirely.

IV. Addressing the Course Design Challenges Using Chatbot

In the coming semester, Fall 2019, CEI redesigned course will provide robust learning content and hands-on experiences for the GTAs. In the new course design, the program will have five modules which focus on active learning, presentation and facilitation, feedback, micro-teaching, and Canvas Learning Management System (LMS). These modules are offered in a flipped-classroom approach where the learning theories are delivered online, and the face-to-face hands-on activities consolidate the theories learned. The flipped classroom approach allows the team to double the class size, which enabled them to maximize room utilization and halved the number of sessions. Furthermore, moving the learning contents online creates more time for in-class activities [19]. Given this situation, facilitation is needed more than ever for both online component and face-to-face sessions.

On the one hand, the course team realizes that when the GTAs are online, their access for support and feedback relies heavily on the automated feedback from the LMS. Further, if they would like to ask open-ended questions, they can only do it either using the discussion forum or through email. However, getting feedback through the discussion forum or email may take some time, and it depends on the availability of the instructors. On the other hand, GTAs may have some quick questions that they would like to ask or verify as they go through the series of activities. Some of these questions deal with administrative inquiries such as submission format or grading criteria, or it can be about the learning content. These questions can be repetitive, and dealing with these may cause valuable time for the instructors, and the execution of the in-class activity can be interrupted.

TABLE I. MAPPING OF MODULE FLOW WITH LEARNING CONTENT AND CHATBOT ROLE

Module Flow	Learning Content	Chatbot Role
Pre-class	Lecture videos Online activities	For dictionary or FAQ; Information giving For formative assessment; MCQ quiz
In-class	Group activities Individual activities	Administrative, Instruction giving
Post-class	Readings Deep-dive materials	For dictionary or FAQ; Information giving

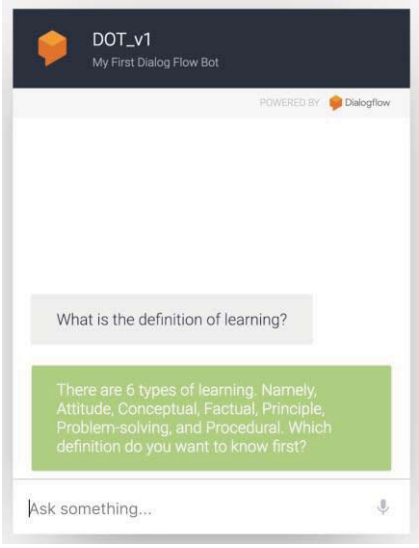

Fig. 1. Sample questions

Fig. 2. Chatbot embedded in Canvas LMS

One solution that the team came up with is to create a simple rule-based chatbot that can handle some of these questions from the GTAs. In table 1, we have mapped out the general flow for each module with the main learning content and the role of the chatbot in supporting these learning contents.

A. *Creating a User-Led Chatbot*

In addressing the diversity and optimizing issues, a User-led conversational chatbot was designed to serve as an FAQ or a dictionary type chatbot where GTAs can ask a question, and the chatbot will give out a definition (see image 1). This type of chatbot is widely used in the field of finance and technology sector. Chatbots like Siri, Cortana, Bixby, and Google assistants are just some of the few chatbots that are common to us. However, unlike these commercial chatbots, the ones that are being built for this course are explicitly designed to do a handful of tasks such as defining words that are specific in each the module.

These bots can be embedded throughout the LMS, and it can serve both as a pre-class and post-class of each module. The goal of these chatbots is to encourage the students to think and ask questions during the learning process. By embedding these chatbots, GTAs can quickly raise their question that they may have as they go through the learning process. Moreover, since the chatbot can handle multiple questions from various users at the same time, it can give the GTAs a more personalized experience in learning the content.

B. *Creating a Bot-Led Chatbot*

Another type of chatbot is a bot-led chatbot. These types of chatbots use a reversed approach where the initiator of the question is the bot itself (see image 2). These bots can be designed to address the diversity of learners by creating a branching scenario [10] initiated by a question. These branching scenarios can adapt to the learners' ability and knowledge. One common application is to convert the typical multiple-choice question into a chatbot, and instead of static feedback, the chatbot can further ask a question that can lead the students back on the correct learning path. Though this process can be designed into a learning management system or other learning packages authored in Adobe Captivate or Articulate Storyline, one clear advantage for these bots is the ability to discern simple conversation language. Meaning that the MCQ can allow students to respond in free or open reply.

For example, the chatbot can start with the question regarding facilitation, and it can further ask whether the GTA

is interested in knowing more about laboratory facilitation or tutorial facilitation. This can immediate help the GTAs who will focus on helping in the laboratory and vice-versa.

C. *Creating a Chatbot for Education*

To build these chatbots, we have to rely on the instructors' experience, notes, and reflection to list the initial question needed for the training phases (see image 3). At this point, Google DialogFlow only requires at least 3-5 questions for it to be able to run its machine learning algorithms for natural language processing. Then, we map out these questions with the learning content in order for the chatbot to determine content-specific words or phrases that the GTAs may ask. These set of words are saved as entities in the system (see image 4).

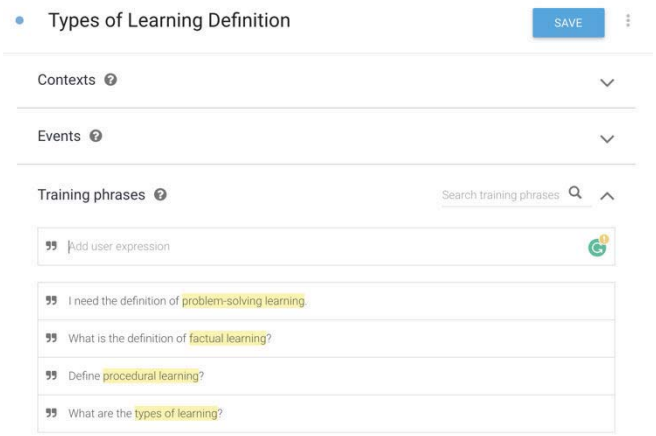

Fig. 3. Sample questions for Intent

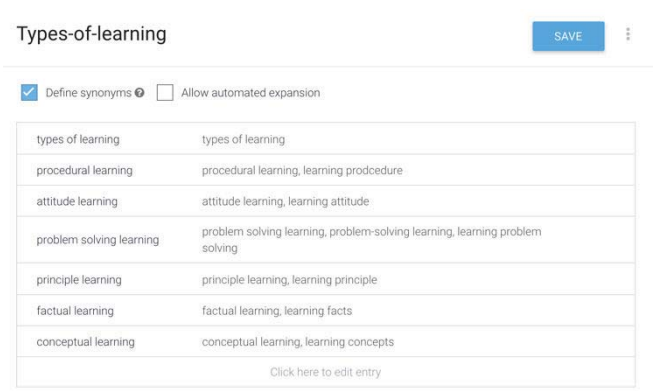

Fig. 4. Sample words for Entities

Moreover, these content-specific words or phrases is the key to personalizing the responses of the chatbot. Hence, address the diversity issue in the subject matter-specific content. For example, if a GTA would like to get some examples of procedural learning, the chatbot may further ask the GTA to be specific or which field of study. Alternatively, if a GTA an example of procedural learning in engineering, then the chatbot may give an example on using a formula to compute for the unknown. While if the GTA asked for procedural learning in the field of science, then the chatbot may provide a laboratory procedure example. The seemingly complicated questions that need to be addressed by the instructor can now be transferred to the chatbot system. This makes the chatbot an appealing tool to address low-level questions or repetitive question.

Once the content-specific (intents and entities) word have been placed, the next step is to design the conversation flow. This is where the commercial chatbot platform really shines. Commercial chatbot platforms provide an intuitive and straightforward process to create these conversations. Finally, what makes Google DialogFlow stand out from its competitors is that it provides a one-click integration solution. Therefore, further cutting down the technicality of implementing the chatbot. These allow the educator to easily embed the chatbot in an LMS or course website the same way as embedding a YouTube video.

V. Conclusion

This initiative, though there is still much work to do, shows that there is a gap in the teaching and learning landscape that chatbot can fill. However, the current natural language processing is still in its early stage, using a chatbot in the field of education is promising. In particular, these chatbots can address some of the logistical and diversity issues that a classroom might have. These issues, from simple Q&A and quick information to scenario-based question, can be addressed by a chatbot if appropriately designed.

A. *Chatbot and Dataset*

Provided with the current landscape of this technology, developing a chatbot is resource-intensive. Those who wish to develop a chatbot for a particular course would require at least a few semesters of data and a tremendous amount of time to clean and organize it. Hence, it is strongly advised to pick a course with at least a few hundred students. Using it in a large class will not only increase the impact of the chatbot but also make the data collection process faster. The clean and organized dataset is still the backbone of creating educational chatbots.

It is also worth noting that a carefully designed rule-based chatbot can augment the scarceness of data. Adjusting the number of questions and branches can make the chatbot-making process manageable and feasible. Another method to address the scarcity in data is to create a chatbot specific to a particular task. For example, creating multiple chatbots across the LMS to answer a specific topic is a lot more controllable in terms of the dialog flow and the collection of data.

B. *Need to Improve the Dataset for Educational Chatbot*

We also think that there is a need for educators to continue to push for the limits of this tool in education. This will steer awareness and curiosity among the members of the teaching community. Moreover, by doing so, we will be improving the quality of the data set for which can be beneficial for the wider community.

Another realization that we learn in building these bots is that there is a drought in the resources from these commercial platforms. Majority of the readily made chatbots can be found in the field of business and medicine. However, in terms of educational purpose with the learning design embedded, the resources are close to zero.

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