A Review of Chatbots in Education: Practical Steps Forward

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Introduction

Context

The class size in a university often impacts on how an educator delivers the material, and how students interact in the class. Smaller class sizes often allow students and educators to interact and have a more positive rapport (Lee, 2009). Class sizes in many universities however, are quite large. This places an additional workload on the lecturer, and makes fostering this interaction more difficult. These large class environments are transitioning to be integrated with online components, and students often expect support responsiveness in line with other online platforms. Learners place importance on their communication needs and consider being treated as individuals, as a highly important contributing factor for enhanced academic performance and satisfaction (Dennen, Aubteen Darabi, & Smith, 2007). This need however can be difficult to meet with traditional in person or online methods such as emails. Chatbots, which are automated, online systems, can be designed to have conversations with users about a particular topic.

Purpose and Problem Definition

Chatbots applied within an educational context are one method for encouraging and fostering a more individualised learning experience. Two research questions have been identified,

1. How Chatbots are currently being used in the wider community?
2. How could Chatbots be applied to enhance a student's learning experience?

Overview of Chatbots

Perhaps the most common application of a Chatbot, often seen and used in many online websites, is in the form of a "personal assistant". In addition to personal assistants, Chatbots can be used for a range of services. These include booking taxis, filing complaints, offering medical advice, offering fashion advice, and simply being a conversationalist (Brandtzaeg & Følstad, 2017). With the ability to integrate Chatbots with most messaging platforms such as Facebook messenger and Skype, they are becoming more accessible to everyone.

One application of a chatbot was the Intelligent Healthcare Chatbot, HECIA. She was a chatbot stationed in a medical centre, designed to save time for medical staff. It is said that 4500 hours per year were spent by medical staff directing patients to the correct area of a hospital. HECIA was designed to direct patients to different areas of the hospital, as well as take symptoms as input, and either offer a diagnosis or direct the patient to a doctor that could assist in making diagnosis (Kasinathan, Xuan, Wahab, & Mustapha, 2017).

The Potential of Chatbots in Education

In particular, the use of Chatbots to enhance student interaction is becoming more popular in a world where tech-savvy students rely heavily on social media and instant messaging platforms, such as Slack and Facebook Messenger. Chatbots have the potential to provide standardised information to students instantaneously, including assessment criteria, due dates and location of recommended resources. Not only can such Chatbots increase student support and engagement, but they can also significantly reduce the administrative workload

of lecturers, freeing them up for course development and research (Singh, 2018). Currently, methods of interaction exist, such as communication via email, and interaction in person, however these do not facilitate instant and personalised communication at times that are more convenient to students.

Deakin University's virtual assistant, "Genie", represents an example of the application of Chatbots in education. The platform, presented through an iOS and Android mobile application, utilises artificial intelligence, voice recognition and predictive analytics. It is integrated with existing systems, including the University's learning management platform, digital library and IBM's Watson question-answering system (Scheepers, Lacity, & Willcocks, 2018). It has three core elements:

- a 'mobile-first,' multi-channel application with both text and voice controls;
- a back-end administration suite that enables staff to create 'conversation trees' and push notifications;
- a technical layer that includes Natural Language Processing, Artificial Intelligence and data analytics (Deakin University, 2019).

Background

The History of Chatbots

A Chatbot called ELIZA was created in 1966 at MIT to mimic human conversation to emulate a physiotherapist in clinical treatment (Shawar & Atwell, 2007). Using keyword matching, the Chatbot aimed to encourage users to disclose information about themselves and family members. The chatbot ALICE was created in 1995 and was inspired by ELIZA (Shawar & Atwell, 2007). ALICE was designed as a conversationalist, and at the time, many people believed they were talking to a real human when interacting with it. There is an extensive and detailed history of Chatbots which have been used in various applications, and this can be seen more broadly in the literature (Raj, 2019).

Now, Chatbots are used by some people daily. Apple's Siri, Amazon's Alexa, Microsoft Cortana, and Samsung's Bixby have the ability to open apps, play music, set calendar events, and overall be a virtual assistant (Dale, 2016). There were over 30,000 text based chatterbots on Facebook messenger alone in 2017 (Brandtzaeg & Følstad, 2017). By 2024, Global Market Insights believes that the chatbot market size will exceed USD $1.34 billion (Global Market Insights, 2018). These facts and figures clearly display the fast-growing technology of chatbots, and their many uses.

Chatbot Frameworks

Chatbot frameworks are software frameworks that provide a predefined set of functions that abstract away the complexities of building a chatbot, such as the NLP engine (Techlabs, 2019). S. Raj outlines the following chatbot frameworks (Raj, 2019):

1. QnA Maker - a cloud-based framework provided by Microsoft that allows a simple Q&A chatbot to be developed based on FAQs, URLs and structured documents.
2. Dialogflow - a popular cloud-based framework provided by Google that is simple to use and allows integration with many platforms.
3. Rasa NLU & Core - an open source framework provided for the Python development environment. It is a powerful toolkit with a steep learning curve.
4. Wit.ai - a cloud-based framework provided by Facebook that is similar to Dialogflow but not as feature-rich. It works best when integrated with Facebook Messenger.
5. Luis.ai - a cloud-based framework provided by Microsoft that has similar functionality as Dialogflow and Wit.ai.
6. Botkit.ai - similar to Rasa as it is essentially a programming library using Javascript, but it does offer a GUI. Raj also covers in detail the building of a chatbot using Dialogflow and RASA stack (Raj, 2019).

There are several other books that cover chatbot frameworks and provide in-depth tutorials on using them. For example, Manisha (Biswas, 2019) discusses the Microsoft Bot Framework, Wit.ai, Dialogflow, IBM Watson and Tensorflow, a data science framework that can be used in conjunction with other frameworks to create Chatbots. There is a wide range of frameworks available as alternate options as well.

The following table (Table 1) compares some common frameworks according to some general parameters. These are examples of some current frameworks that exist, but due to the rapid development in this field, these may change in the future.

Table 1 – Comparison of Common Chatbot Frameworks

	Company	Paid/ Free	Ease of Use	OTB Integration	Open Source	Popularity	Web based	Language
QnA Maker	Microsoft	Free	High	Yes	No	Med	Yes	C#
Dialogflow	Google	Free	High	Yes	No	High	Yes	JavaScript
RASA	RASA	Free	Low	No	Yes	High	No	Python
Wit.ai	Facebook	Free	High	Yes (Facebook)	No	High	Yes	JavaScript
Luis.ai	Microsoft	Free	High	Yes	No	Med	Yes	JavaScript
Botkit.ai	Botkit	Free	Low	Yes	No	Med	No	JavaScript

*OTB = Out of the Box

Common Chatbot Applications

Perhaps the most common form of chatbot seen, is the FAQ chatbot. FAQ chatbots can be seen across many businesses as an interactive way for customers or users to gain knowledge of the business. One example is the Louis Vuitton chatbot, which is linked to Facebook messenger, and can be seen at the following link:

https://www.messenger.com/t/LouisVuitton

This chatbot allows users to type directly to the chatbot to enquire about a product, or select from a predefined menu.

One of the benefits of this chatbot is its predefined menu: users are likely to click on buttons as opposed to type directly to the chatbot, reducing the number of times the chatbot is unable to return a response to the user. Linking to a website is also a good marketing technique, as users are likely to browse the site, potentially leading to a sale.

Chatbots with a main goal of answering questions, as opposed to attempting to send the user to a website, are difficult to find online. One of the reasons for this, is that some companies like to maintain the illusion that the chatbot is a human answering the questions. Another reason involves FAQ chatbots often not being hosted on a specific web page; instead, they are connected to the Facebook page associated with the company.

There are several limitations to FAQ chatbots and what they can achieve. One of these limitations is the need for the user to have an account for the website the company chooses to launch their chatbot on. This specific problem relates to companies that launch their chatbot on platforms such as Facebook or Slack for example. Although Facebook has over 1.5 billion daily active users (Statista, 2019), it can be assumed that people who do not have a Facebook account may want to have questions answered about a company. This means that, although a chatbot is an interactive and interesting way to display frequently asked questions, the more traditional method of a list of questions and their answers is still necessary.

Chatbots Magazine describes five limitations of FAQ Chatbots: the nature of dialogue, and the scope, domain, and intent of typical FAQ content (Goebel, 2017). These encompass

problems involving a user not expecting a chatbot, the chatbot not understanding a question and the location of the chatbot not being on the website.

Natural Language Processing and Machine Learning

Chatbots require and rely on a level of ability to understand or perform Natural Language Processing (NLP). There is much existing text data; from posts made on social networks to customer-based survey data, to densely written articles. Using various text analysis techniques (such as NLP) and algorithms, text documents can be classified (Liu, 2012) or grouped into different clustered categories (Mijangos, Sierra, & Montes, 2017). These tasks could vary from topics within news articles to the sentiment of pieces of review text. This is becoming increasingly important, with the large amount of text available online, to ensure that computers can understand human written text.

Machine Learning is one technique currently being used in many applications, including information extraction from text. Machine Learning involves applying techniques of pattern recognition and classification in different situations. Specific algorithms and processes attempt to model human learning (Langley, 1996). Many different algorithms and processes exist within machine learning, and the choice of which algorithm to use depends on the situation. Machine Learning and NLP provide many potential areas for innovation in a university education environment.

Two preliminary applications for Chatbots within education have been identified, an FAQ Chabot to answer commonly asked questions, and a short response quiz Chatbot. These applications are discussed below.

Preliminary Application 1: FAQ Chatbot

Students often ask for clarifications or pose common questions to educators. These could be about assessment, due dates or resources, for example. The aim of this type of FAQ chatbot would be to anticipate and reply to some of these common queries. If a student writes a question to the Chatbot, the question can be matched with a question in the existing database that is most similar, and then the response that is most relevant is chosen and given to the student. This has several advantages over a normal FAQ list. In addition to allowing an educator to add to the knowledge across multiple semesters, the FAQ Chatbot would allow the knowledge to be passed between different educators teaching the same subjects.

Potential Benefits of an FAQ Chatbot

An FAQ chatbot has the clear benefit of being available for students 24/7, able to answer their questions when needed in time. It also allows a more personalised approach when responding to a large number of students. An FAQ chatbot has the potential for added functionality to encourage more of a dialog and discussion between students. Another potential feature of this type of Chatbot is the knowledge base of stored questions, to keep over multiple generations of use. Finally, this style of FAQ Chatbot has the potential to help identify communication issues between educators and educators and students. If one of the questions is asked more frequently by students, educators may need to consider how that is currently communicated to students.

Potential Drawbacks and Limitations of an FAQ Chatbot

There are several limitations to the integration of a chatbot for each subject at a university. Firstly, populating the database for the chatbot relies on accurate information given by university staff. If staff do not fill out the given forms, or give inaccurate data, the chatbot is rendered useless for that subject. Secondly, for it to save time for students and staff, students must use the product. This requires lecturers and tutors to inform students of the

chatbot, and **its** capabilities and purpose. Lastly, to determine whether the chatbot is effective, the users must fill out a survey after asking it questions, to allow the creators to quantify the success of the chatbot, or make modifications. In addition to this, there are also technical limitations around how Chatbots “understand” questions, and some level of human interpretation may be needed.

Preliminary Application of an FAQ Chatbot

A preliminary version of an FAQ chatbot is currently being developed, and tested in a class environment. The Chatbot currently can answer commonly asked questions around assessment, and exam requirements, as well as questions around class times. Figure 1 below shows a framework for the implementation of this Chatbot. The framework includes components such as developing the FAQs, and gaining feedback from various stakeholders. One key element in this implementation flow charge the need for continuous development of the Chatbot.

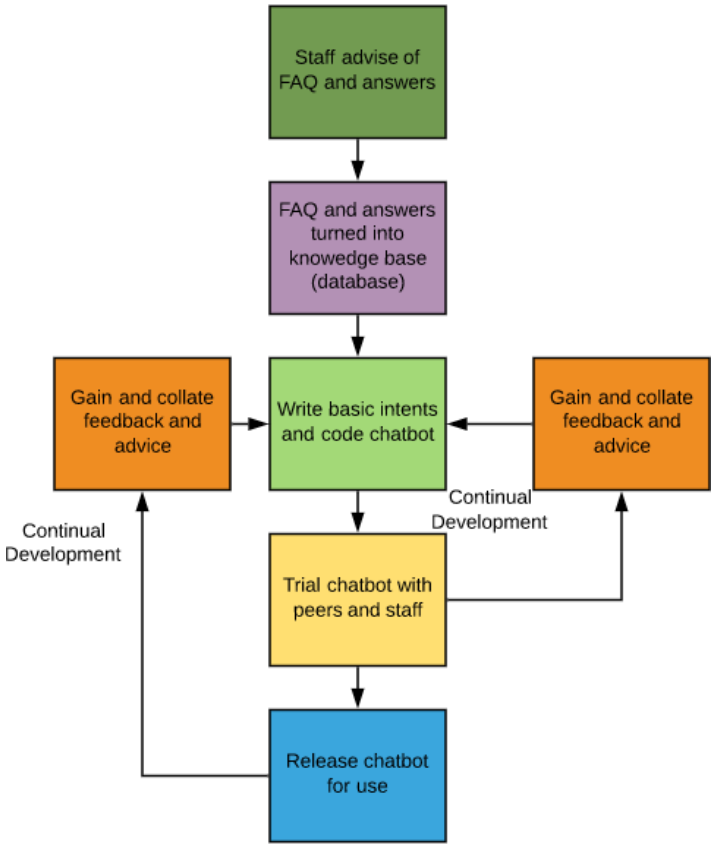

Figure 1 - FAQ Chatbot Implementation Flowchart

Future development of the chatbot within the university could allow it to answer questions about the university in general, and assist students in finding the location of buildings, as well as informing students of the contact details of important people within the university. In addition to this, as chatbot technology progresses, chatbot tutors may be developed to aid students with technical content related to their subjects.

Preliminary Application 2: Short Response Quiz Chatbot

Another application which we believe a chatbot could have a significant impact in, is in the context of online short response questions. For example, students may be asked to respond to a multiple-choice question, giving a justification about the answer they had selected. The

chatbot would facilitate this interaction and then provide some personalised feedback. This Chatbot application provides many potential benefits, which are discussed below.

Potential Benefits of a Short Response Quiz Chatbot

The benefits of this chatbot mirror the general benefits for Chatbots, including a more personalised approach for users and the 24/7 availability of the Chatbot. Implementing this style of textually enhanced concept inventory as a chatbot would allow for other benefits, specific to this application. One example of an added benefit would be the ability for a chatbot to confirm the wording, or understanding of a student. This could be especially relevant when a student gives an explanation which is different to a common example, or one previously seen. If decision made by a computer about a student's response given was not confident, the Chatbot could ask for further clarification. The chatbot could ask for similar clarification for words typed that have a potential spelling error.

The personalised feedback offered by a short response quiz Chatbot is an essential component. This would allow for individual misconceptions or errors to be identified with a students' response, and the student then directed to relevant resources. This quiz Chatbot also supports in time learning, allowing students to learn and receive feedback at points crucial to their learning process. One final benefit that this type of Chatbot presents is the possibility for educators to see and identified common areas that students struggle with. This would allow for class-wide interventions to be taken.

Potential Drawbacks and Limitations of a Short Response Quiz Chatbot

One difficultly in creating a short response quiz Chatbot is making conceptual decisions on student written pieces of text. These types of models can be quite difficult to make, requiring many text samples of correct and incorrect responses. It is then important to validate, and test the reliability of the automated decisions that are made. Another potential drawback for a short response quiz Chatbot is that less interaction between an educator and students may be encouraged. It is therefore important that a Chatbot is only offered, and seen as just one component of the learning experience.

Preliminary Application of a Short Response Quiz Chatbot

Current work to date on the short response chatbot involves a previously created online interface (Cunningham-Nelson, Mukherjee, Goncher, & Boles, 2018). This created platform facilitates the completion of a multiple-choice concept inventory question, with a free text field added for students to justify their response. Figure 2 shows an example of the interface used. The multiple choice question in this interface was derived from the Signals and Systems Concept Inventory (Wage, Buck, Wright, & Welch, 2005). In this initial version, students can currently select the multiple-choice response, and justify that response with text through the interface. Feedback is then given to students immediately based on their response. Currently however, this platform does not act as a conversation, and does not provide students with the opportunity to clarify or correct any misunderstandings. This could be a future point to explore.

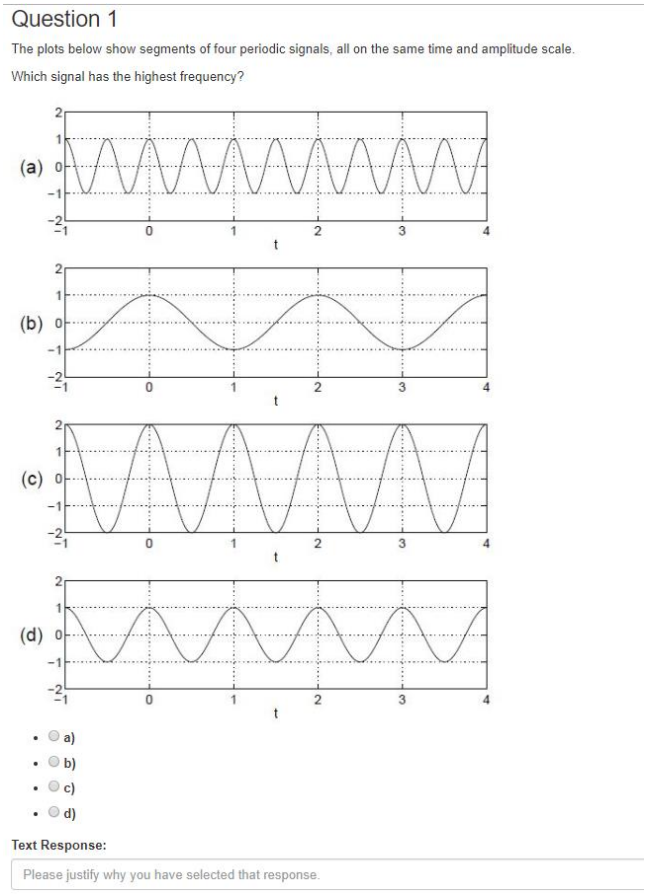

Figure 2 - Online Conceptual Question Interface

Conclusion and Recommendations

Chatbots are currently being used in a variety of online applications - often for shopping, or as “personal assistants”. These Chatbots provide a range of potential benefits, including personalisation and 24/7 instantaneous availability. These positive aspects of Chatbots lend them to applications within the educational sector.

This paper discussed relevant literature related to Chatbots. It presented two cases where Chatbots could be applied in an educational context, and introduces a preliminary application for each. An FAQ Chatbot allowed educators to deploy an interactive mechanism, and respond to students frequently asked questions. This Chatbot should remove some tasks from an educator’s workload, as well as supporting students to receive immediate and individualised responses to questions. This FAQ Chatbot has the potential to support knowledge retention, even if lecturers of a subject change, from one offering to the other.

The proposed short response quiz Chatbot would facilitate the delivery of a quiz with a student, prompting for answers with text justification. This type of Chatbot allows for instantaneous and personalised identification of misconceptions, and redirection to relevant resources. Opening a dialog with a student also allows for potential error correction, or receiving requests for clarification from students.

The Chatbots presented are not designed to be a sole resource that functions in isolation. Rather, they should be used as a support mechanism, and it’s an aid to deal with large student numbers, and individualisation. Chatbot operations will still need supervision, support and maintenance.

The literature provided in this paper directs educators to the variety of platforms and frameworks which are currently available for Chatbot development. The two preliminary

applications provide some possibilities of where Chatbots can be used within education, and present opportunities for educators to improve the student learning experience.

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