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Using the Community of Inquiry framework to develop an educational chatbot: lesson learned from a mobile instant messaging learning environment

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Abstract: Chatbots can be defined as artificial narrow intelligence (ANI) that is programmed to perform a single task such as answering customers' questions by harnessing the power of machine learning. However, there is a lack of educational-related chatbots developed to interact with learners in mobile instant messaging (MIM) apps, as well as a lack of theoretical grounding for chatbots for teaching and learning purposes. In this study, a chatbot taking on the role of an instructor, was developed to teach adult students fake news identification in an online course via the WeChat MIM app. We provide a detailed description of the MIM chatbot development guided by the Community of Inquiry theoretical framework. We present the evaluation of the MIM chatbot based on a self-reported survey regarding students' perceptions of the teaching presence, social presence, and cognitive presence. The findings revealed social presence mainly existed between the chatbot and individual student in a MIM learning environment. We hence offer some preliminary design principles for future educational chatbot design.

Keywords: Chatbot, mobile instant messaging, WeChat, artificial narrow intelligence

1. Introduction

Chatbots have made inroads into the educational environment with its capability of interacting with students in natural language. The common ways of implementing chatbots include chatbot taking the role of teacher to delivery instructional materials (Heller, Proctor, Mah, Jewell, & Cheung, 2005), and chatbot playing the role as a learning partner to facilitate learners' understanding of the subject matter (Fryer, Ainley, Thompson, Gibson, & Sherlock, 2017). Presently, many chatbots have been developed to interact with users on standalone platforms, rather than through mobile instant messaging (MIM) apps (Schmulian & Coetzee, 2019). Educators can make use of these applications to build up an accessible communication channels with students (Tang & Hew, 2017). Unlike mobile apps which need to be downloaded and take up valuable space on a user's phone, chatbots in MIM are readily available within a MIM app and they do not need to be downloaded (Schlicht, 2016). Yet, despite the significant potential for automated learning, there is very little research exploring the use of educational chatbots in MIM apps (Schmulian & Coetzee, 2019). The purpose of this study, therefore, is to fill this research gap. We aim to provide a detail description of the development of a MIM educational chatbot, using a visual chatbot development platform *Dialogflow* that does not require computer programming knowledge. The theoretical rationales employed in this study is based on the Community of Inquiry (CoI) framework. A two-round case study was conducted to investigate students' experience in learning with the MIM chatbot. The effects of the CoI framework the MIM chatbot design were measured by students' self-reported surveys to answer our research question: What are students' perceptions of the teaching presence, social presence, and cognitive presence afforded by the MIM chatbot?

In the following sections, we will present (a) the theoretical background of our work, (b) an instructional design of MIM chatbot with the CoI framework, (c) MIM chatbot evaluation based on students' self-reported surveys, and (d) a set of preliminary educational chatbot design principles.

1.1 Chatbot-assisted Learning

Chatbot is a dialogic system that can interact with users in natural language. Unlike a human employee, chatbots can always offer help on demand 24/7 (Garcia, Fuertes, & Molas, 2018). Early chatbots were created by using the Artificial Intelligence Markup Language (AIML), a type of XML programming language (Kane, 2016). With the help of visual development platforms, programming knowledge is not a must-have skill to design a chatbot. Via built-in Application programming interface (API) keys generated by the development platforms, chatbots can be handy for non-technical users. Chatbots show the pedagogical value in facilitating learners' language knowledge acquisition (Ruan et al., 2019; Wang, Petrina, & Feng, 2017), and fostering learners' willingness to communicate (Ayedoun, Hayashi, and Seta, 2019).

Chatbots interacting with users in a MIM app may offer educators an automated means of content instruction (Nakpodia, 2017). Carayannopoulos (2018) examined a messaging chatbot which was designed to help first-year students to adapt to university life. The chatbot in his study is as same as any friend in students' contact lists that students can seek information from the chatbot in the way of daily communication. The findings indicated that students gained a sense of being connected with their professors. Gengobot, a Japanese grammar dictionary chatbot integrated into the messaging application LINE, enables personalized learning for students to practice basic grammar knowledge (Haristiani & Danuwijaya, 2019). Similarly, Schmulian and Coetzee (2019) developed two Facebook Messenger bots to instruct university students in a large accounting class and assist students in understanding learning materials at their own pace. Chatbots merged with messaging applications can offer students a livelier and friendlier learning experience..

1.2 The Community of Inquiry as a Theoretical Framework

The Community of Inquiry (CoI) framework is initially intended to build a constructivist learning environment in computer conferencing and online learning in higher education context (Garrison, Anderson, & Archer, 2000). After nearly two decades, this theoretical framework has been applied to diverse educational settings, including face-to-face learning and K-12 learning (Garrison, 2016). The CoI framework is comprised of three constructs, namely social presence (e.g., personal, open communication, and group cohesion), cognitive presence (e.g., triggering event, exploration, integration, and resolution), and teaching presence (e.g., design and organization, facilitating discourse, direct instruction), to articulate the knowledge construction in online learning community. Social presence refers to students' the ability to present themselves as real in a community of inquiry with keeping their individual personalities (Garrison et al., 2000). Cognitive presence is defined as the extent of learners' information construction through the sustained interaction and reflection in the community. Teaching presence includes designing curriculum, giving direct instructions and facilitating disclosure (Garrison et al., 2000). A personal meaningful communication and learning experience can be offered to students by using the above three presences to develop learning contents. On that account, we designed a MIM chatbot guided by the CoI framework.

2. The Development of Fake News Bot

2.1 Chatbot Design with the CoI framework

We designed a chatbot as a role of online instructor to teach university students how to identify fake news. Table 1 presents the information in learning objectives and students' learning materials. Students are expected to interact with the chatbot to recognize the features of fake news, figure out fake news by using a four-step method and apply the methods in real life. The training data of chatbots were designed by the instructor with pre-set prompts according to the learning materials.

The learning activities of Fake News bot were grounded on the categories in social, cognitive, and teaching presence (Table 2). Social presence was visualized by the help of emojis to express the feelings of chatbot during the student-chatbot interaction and form a risk-free learning environment. For instance, the chatbot greeted students with a smiley face emoji and showed agreements with a thumb up

emoji. Vocatives were also merged to facilitate a collaborative climate. For example, chatbot called student's name at the beginning of the responses. Cognitive presence was presented with diverse teaching clues. When an example of fake news was given to students, the chatbot asked students whether the news is fake or real (triggering event). After students typed the answers, chatbot would give immediate feedback and explain the features of fake news through a dialogue way (exploration). Then, several cases were delivered to help students recall the factual knowledge of fake news (integration). Once students finished the knowledge construction via the interaction with the chatbot, additional learning materials would be given to let students apply the information in a new situation (resolution). Teaching presence was demonstrated by having an intro-video to illustrate learning outcomes clearly and using short video as knowledge instruction.

Table 1. Summary of Learning Objectives and Learning Materials

Learning Objectives	Learning Activities
Recognize the impact of the fake news on daily life	Course introduction video, discussion on daily fake news
Remember the definition and main features of fake news	Video lecture regarding definition and features, dialogue activity
Figure out how to identify fake news by a four-step method	A true or false game on fake news identification, video lecture regarding a four-step method
Apply the four-step method to identify real news from cases	Case study

Table 2. Design Examples on Social Presence, Cognitive Presence, and Teaching Presence

Element	Categories	Design example	Chatbot prompts example
Social presence	Personal/affective	Use emoji	"I'm your learning partner 😊."
	Open communication	Use vocatives	"Hi Irene, the next video is about the feature of fake news."
	Group cohesion	Agreements when user gives right answer	"I have the same idea with you."
Cognitive presence	Triggering event	Discussion about a fake news example	"Do you think this news is fake or real?"
	Exploration	Dialogue regarding the reason of fake news	"Why do you think it is a true news?"
	Integration	Quizzes to recall the features of fake news	"Can you tell me one of the features of fake news?"
	Resolution	Use 4-step method	"You may need to check the author of this news."
Teaching presence	Design and organization	Illustrate learning outcomes in intro-video	"Please watch the introduction video to know your learning objectives."
	Facilitating discourse	Provide step-by-step instruction	"Now we're going to explore a 4-step method."
	Direct instruction	Watch instructional videos	"Please tell me if you finish watch the video."

2.2 Development of the MIM learning environment

The development of Fake News bot was supported by three software: Dialogflow, Respond.io (which was named Rocketbot before), and WeChat. Dialogflow is flexible enough to be integrated into most of the mainstream platforms in the form of webpage and mobile applications (Bollweg, Kurzke, Shahriar, & Weber, 2018). The visual development dashboard of Dialogflow helps reduce the challenges for non-programming users to design their chatbots. The monthly active users for WeChat is over 1.2 billion by the second quarter of 2020 (Statista, 2020), which takes the market of instant messaging application in China. Students chatted with a WeChat account for receiving the instructional materials

(end-user). The logic and sequence of interaction between chatbot and students were structured within Dialogflow (developer), which sent videos, pictures, and information to users. The Respond.io as a database stored the instructional videos and pictures as files and provided the file ID as a parameter to Dialogflow. Respond.io supported a workplace to embed chatbot form Dialogflow to WeChat, and automatically collected the chatbot-student dialogue records (bridge).

3. Learning with Fake News Bot

3.1 Instrumentation

We conducted two-rounds of implementation and testing with the Fake News bot. The first one is an exploratory case to test the operation of the chatbot. In the second round, a five-point Likert scale survey was collected to investigate students' perceptions concerning the Fake News bot designed by the CoI framework. In both rounds, participants were expected to interact with Fake News bot without any time limit. After students logged in the WeChat application on their mobile phones, they could find the account of fake new bots and started their learning. In Phase One, 43 participants, including university students and recent graduates, gained access to the Fake News bot in WeChat by following the account of the bot. The consent form was embedded in the chatbot before learning materials were presented to the participants. After the students agreed to participate in the intervention, the learning material and interaction would start. The dialogue records indicated that after receiving the consent form, 37% (16 out of 43) participants stopped exploring the chatbot because they were not engaged with it. The other 27 students continued until the link of an introduction video popped up, and subsequently 48% (13 out of 27) stopped going on further. Nine students stopped interacting because they felt "disengaged", while four students explained that the bot could not understand their inputs ("do not understand"). The records finally revealed that only 6 participants finished all the learning activities.

Initial findings from Phase One indicated two main challenges for students to continue interaction with the Fake News bot. First, students had to open the pop-up materials (such as the link of videos) to jump to another page. Students found this inconvenient and hence they were not interested in continuing with the lesson. The second challenge is related to the design of chatbot. Chatbot with a limited database cannot understand students' inputs. Therefore, with the bugs and wrong responses from chatbot, the learning environment was less convincing that students cannot gain a sense of immersion during the learning process.

3.2 Chatbot Revision and Evaluation

According to the findings from the exploratory intervention, several actions were taken to improve the Fake News bot. First, the pop-up link of intro-video was replaced by an embedded video to decrease the transferring between different learning interfaces and, therefore, to continue the student-chatbot interaction. Second, hints were added to increase the accuracy of student-chatbot interaction. For instance, once students cannot answer the questions or students gave unpredictable answers, the chatbot would send hints to lead students to work out the tasks.

During the second round, 40 volunteers participated in the conversation with chatbot. 28 participants undertook the online Five-point Likert scale survey, which was presented immediately after they finished the online learning with the Fake New bot. Since the original 34-item CoI measurement (Arbaugh et al., 2008, p.135) focused on the online learning community rather than a specific learning activity, we revised the questionnaire to a 26-item one to analyse the effect of three components of CoI framework on Fake News bot design. In this study, the Cronbach alpha coefficient for the revised 26-items survey showed that cognitive presence was 0.984, and social presence was 0.906, and teaching presence was 0.951, which were consistent with the original measurement.

3.3 Results of Students' perceptions of the three CoI components

Teaching presence was measured by 9 items, such as "the bot clearly communicated important course topics", and "the bot helped to keep course participants engaged and participating in productive dialogue". Social presence was measured by 6 items, for example including "I felt comfortable

disagreeing with the bot while still maintaining a sense of trust" and "I felt that my point of view was acknowledged by the bot". Cognitive presence was measured with 11 items, such as "reflection on course content and discussions helped me understand fundamental concepts in this class." Social presence mainly existed between the chatbot and the user in the MIM chatbot based learning environment. The highest mean (M = 4.68, SD = 0.548) among teaching presence items indicated that chatbot was perceived to provide good organization and guidance. Students appreciated the use of emojis during the conversation (M = 4.46, SD = 0.838). Students perceived the reflection on course content and discussion helped them understand the fake news concepts (M = 4.54, SD = 0.576).

4. Lesson Learnt from the Fake News Bot

This study explores the development of an educational chatbot underpinned by the CoI framework. With two-round evaluation of students' learning with the Fake News bot, we conclude several actions and strategies to implement chatbot into educational environment effectively.

The first principle refers to training chatbot to be a smart partner by increasing the accuracy of chatbot responses. A training phase should be included before bringing the educational bot into learning settings. Pilot study with chatbot testing can be conducted simultaneously to collect students' real learning records as unpredictable information to enlarge the database of chatbot. The second principle is to increase students engagement by adding students' ownership during interaction and structuring learning materials in one interface (e.g., install video in chatbot). For example, when chatbot questions students with real-life cases, several hints can be delivered to students and give them more choices to answer. For instance, the Fake News bot can provide daily news in differing areas (e.g., sports, nature, political issues), and students can choose their interested category. Likewise, teachers can combine all learning materials in one interface (i.e., chatbot) to diminish the frustrating transfer during the learning process. Third, educators can use the CoI framework as a practical theoretical perspective to design educational chatbots in online learning environment. The social presence can be embedded with the use of emojis throughout student-chatbot interaction to enhance the characteristics of chatbot partner. A peer sharing forum can be set up for students' collaboration. Based on four categories of cognitive presence (triggering event, exploration, integration, and resolution), diverse scaffolding clues can be used. For instance, before instructing the features of fake news, chatbot can discuss a daily news with students as a warm-up activity, which is the triggering event. The teaching presence can be revealed through the clear illustration of learning outcomes, which can set up students' prediction on the role of chatbot and continue active learning with chatbot thereof.

5. Discussion and Conclusion

This study provides a development of an educational MIM chatbot, Fake News bot, as an online learning partner to instruct students the identification of daily fake news. Buttressed by the Community of Inquiry framework, the Fake News bot was designed to engage students' learning in a mobile instant messaging learning context. Students' use of chatbot and their perspective on the instructional design of chatbot were investigated using a two-round evaluation. Although the number of participants and specific learning domain limits the generalization of the results, the findings are encouraging. The Fake News bot revealed its advantages in facilitating students' knowledge construction. The use of the CoI framework in chatbot provided students a well-organized learning experience. The demonstration of chatbot development in that study is expected to encourage more instructors to design educational chatbots without the requirement of programming skills.

There are several limitations in this study. First, the format of learning materials was limited by the capability of system. For instance, the video should be less than 20M in size and was compressed by WeChat system automatically, which fell users' learning experience. Second, participants in two rounds were not same and the chatbot in the second round was more advanced, which impacts on students' perceptions. The other different individual variables were ignored (e.g., students' chatbot learning experience before and expectation on chatbot). Third, the short intervention period may lessen the effectiveness of the CoI measurement in this study. For future research, we call for more experimental designs in diverse learning domains and contexts to verify the chatbot design with the Community of Inquiry framework.

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