The development of Messenger bots for teaching and learning and accounting students' experience of the use thereof

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Abstract

This study reports on the development of two Messenger bots, designed to facilitate the learning of introductory and intermediate accounting. The Messenger bots were developed using a visual development environment that requires no coding knowledge. A thick description of the development of the Messenger bots is provided to encourage replication. It is submitted that instructors, rather than programmers, should take ownership of developing Messenger bots for teaching and learning. Preliminary exploration of the students' satisfaction yielded positive results. Suggestions are made for specific applications of Messenger bots in teaching and learning and for further research exploring the use of Messenger bots in teaching and learning.

Practitioner Notes

What is already known about this topic

- Mobile instant messaging (MIM) applications (apps) have potential to facilitate effective social constructivist-based collaborative learning.
- Students extensively use MIM apps.
- There is reluctance from instructors to engage in after hours MIM student consultation.
- Messenger bots can deliver content on demand, using inter alia text, images and video, and the effective use thereof in teaching and learning has not yet been explored.

What this paper adds

- Instructors, without coding knowledge, are enabled to develop Messenger bots for teaching and learning.
- Social constructivist-based suggestions for specific teaching and learning applications of Messenger bots are provided.
- Preliminary evidence suggests students positively experienced the use of Messenger bots in their learning.

Implications for practice and/or policy

- Messenger bots may support instruction in large classes.

- Messenger bots may be suited to supplemental instruction rather than replacing face-to-face instruction.
- Specific teaching and learning applications of Messenger bots should be implemented and the effectiveness thereof explored.

Introduction

Bots are artificial narrow intelligence (ANI) programmes designed to interact through text, or voice, with users in a human-like way, answering questions and performing tasks (Abushawar & Atwell, 2007; Bii, 2013) by harnessing the power of machine learning and cognitive engines such as Watson (by IBM) (McFarland, 2016). Artificial narrow intelligence (ANI) is the only form of Artificial Intelligence that humanity has managed to achieve to date. ANI can perform a single task, such as making purchase suggestions, sales predictions and weather forecasts. At present though, given the complexity of ANI technology, the vast majority of bots rely more simplistically on menu prompts to guide discussion and/or a database of information triggering automated responses to user inputs (Miller, 2016). There has been a significant growth in the number of these more simplistic bots since Facebook, in particular, enabled, in April 2016, the functionality that these bots could use Facebook's mobile instant messaging application (MIM app), Messenger, to interact with users on their mobile devices. Bots interacting with users through Messenger, as opposed to a standalone platform, are referred to as Messenger bots. Other popular messaging applications supporting bot integration include, *inter alia*, Slack and Telegram.

The development of bots, designed to interact with users in MIM apps, was motivated by two recent occurrences. Firstly, the use of mobile devices now exceeds the use of desktop computers to access the Internet (Hart, 2016). Secondly, people are now spending more time using MIM apps on their mobile device than social networks (BI, 2016; Hart, 2016). MIM apps may therefore be the platform of the future, through which users will access services provided by bots, rather than by other mobile apps (Schlicht, 2016). Where users have in the past had to download, log into, and update several apps separately, bots in MIM apps are readily and conveniently available within a MIM app and are always up to date (Miller, 2016).

The use of MIM apps as a learning tool may enhance student learning (Chuang & Tsao, 2013; Rambe & Bere, 2013; So, 2016; Sun, Lin, Wu, Zhou, & Luo, 2018) despite the fact that students may multitask and be distracted by unrelated messages (Bowman, Levine, Waite, & Gendron, 2010; Junco & Cotten, 2011). It is natural for today's students to receive motivational messages, get reminders about upcoming tests, seek answers to study questions, or find another student revising the same topics, through MIM apps (Timmis, 2012). Affordances of MIM apps such as flexible use, continuity of use, timely feedback, personalization, socialization, active participation, peer coaching, and self-evaluation promote opportunities for social constructivist-based collaborative learning, through enabling productive conversation and collaboration between the student and knowledgeable others, including their instructors and fellow students. (Kukulska-Hulme & Viberg, 2018). While offering potential as a learning tool, the use of MIM apps in teaching and learning is constrained by instructors' reluctance to merge academic and family life through after hours MIM consultations with students (Rambe & Bere, 2013). Further, class size may also constrain the use of MIM apps for learning, as instructors cannot reasonably engage constructively with every student in a large class individually via MIM apps. Some potential for engaging with the group of students collectively exists within the "Group chat" function

of many MIM apps. However, this results in students receiving generic feedback and mass communication rather than facilitating social constructivist learning opportunities between the instructor and a student.

Unlike a fellow student or instructor, bots in MIM apps are able to offer help on demand and are always "at the other end of the line." Bots interacting with users in a MIM app may, therefore, offer instructors an alternative, automated means of content delivery and instruction (Nakpodia, 2017; Riel, 2016). Bots in MIM apps are ideally placed to fulfil the roles of *inter alia* motivator, advisor or assistant in a student's learning (Pokatilo, 2016). Asking questions and getting help from a bot in a MIM app can be beneficial in other ways too. Some students may be anxious about asking instructors questions directly and may prefer interacting with a bot in a MIM app (Riel, 2016). This may again be useful in large classes where students are not always able to get full attention or help from the instructors easily when they face problems (Dean & Wright, 2017), which may end up causing frustration and demotivating students and may discourage the students from asking further questions or seeking additional clarification from the instructors (Dean & Wright, 2017). On the other hand, the instructors may also feel overwhelmed by many enquiries from students at one time (O'Flaherty & Phillips, 2015). Moreover, if the same question is asked by many different students, it is inefficient for the instructor to repeat the answer frequently. Bots in MIM apps could assist in these circumstances. Instructors can review the bots' chat history and sift through the more meaningful questions and address these questions with students (Riel, 2016) or enable the bot to personally respond to these questions at the appropriate time in a particular student's learning.

Despite the significant potential for automated personalized learning and differentiated instruction offered by bots in MIM apps (Pokatilo, 2016; Riel, 2016) there are at present few educational bots in MIM apps and the focus of research into educational bots is on the more complex stand-alone bots, functioning independently of MIM apps (see for example: Akcora *et al.*, 2018; Bii, Too, & Langat, 2013; Burbules, Blanken-Webb, Herrera, Shipman, & Stewart, 2013; Heller, 2017). There is no formal research, outside of the popular media (see for example Srdanovic, 2017, 2018), exploring the use of bots in MIM apps, and in particular Messenger bots, in teaching and learning. Despite being less advanced than standalone bots in terms of ANI processing of user intent, Messenger bots are easier for instructors, who may lack coding skills, to develop (Srdanovic, 2018), particularly when considering that there are many visual development tools to assist in developing the Messenger bots.

The purpose of this study is, therefore, to provide a thick description of the development of two Messenger bots, Accounting Rookies (https://m.me/accountingrookies) and International Financial Reporting Standards (IFRS) Rookies (https://m.me/ifrsrookies), using a visual development tool—Chatfuel. These Messenger bots are designed to act as virtual "tutors" for introductory (Accounting Rookies) and intermediate (IFRS Rookies) accounting students. This study then documents potential applications of Messenger bots in teaching and learning, before exploring students', as end users', experience of learning with the Messenger bots. In this study, collaborative learning involves the student interacting with the bot to construct their knowledge of accounting.

Messenger bots and learning theory

In developing a bot, including a Messenger bot, it is important to maintain a strong commitment to learning theories and design principles that are known to foster constructive

learning, rather than merely encouraging behaviourist rote memorization and drilling activities (Riel, 2016).

Social constructivism theory

The affordances of collaborative learning with bots, is framed by social constructivism. In terms of Vygotsky's theory of social constructivism, every conversation or encounter between two or more people presents an opportunity for new knowledge to be obtained, or current knowledge to be expanded (Powell & Kalina, 2009). Although students may be aware that they are chatting with a bot, early bot developers found indications of anthropomorphism (Pokatilo, 2016). That is the tendency of bot users to treat a bot as another human being. This phenomenon may give bots an advantage over apps and other forms of web-based learning. If the bot's dialogue and flow of content and discussion can mimic that of social interaction, it may be possible for the bot to facilitate social-constructivist teaching and learning (Bii, 2013), particularly where the bot engages with students in a MIM app.

Instructional mediation

Beyond social interaction, bots have potential to facilitate basic instructional mediation (Bii, 2013). Bots provide an engaging and intuitive interface to a body of knowledge that can be accessed in a personalized and adaptable format (Cassell, Sullivan, Prevost, & Churchill, 2000). Through their social interaction and connection to a body of knowledge, bots could empower students to develop their self-knowledge and become independent, self-directed learners, constructing knowledge by connecting "the external and the internal, the social and the individual" (John-Steiner & Mahn, 1996, p. 4). Through careful design, bots may scaffold and differentiate students' learning in a student's "zone of proximal development" (Figure 1). This may be particularly the case in courses with a hierarchical structure (Dempster, 1989; Schneider, Hein, & Murphy, 2014), like accounting, where topics build directly on earlier course topics.

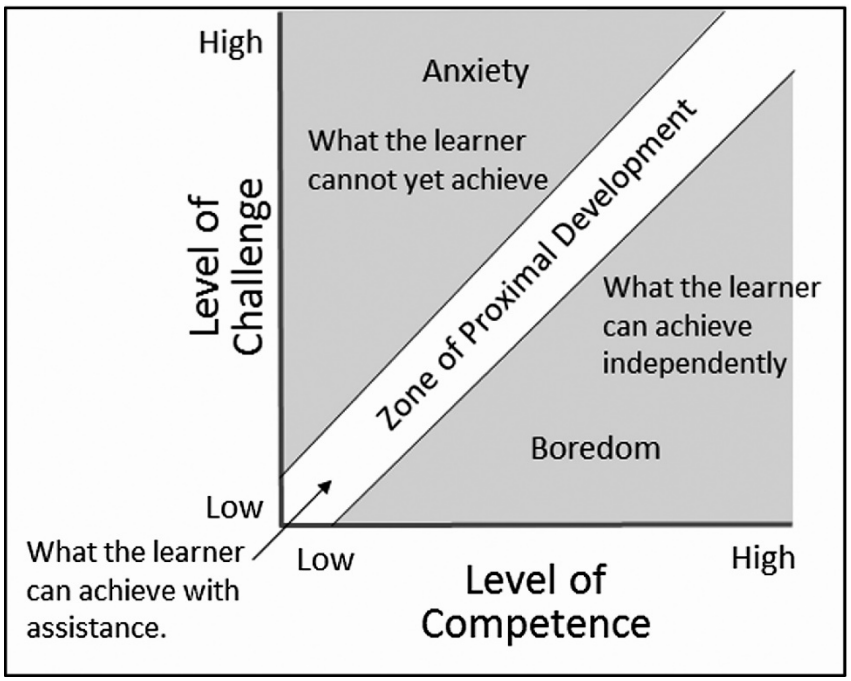


Figure 1. Vygotsky's zone of proximal development (John-Steiner & Mahn, 1996)

Bots may engage students and support, or scaffold, their progression through course material, at their own pace in and outside of the class, in bite-sized chunks, using, *inter alia*, video, animated GIF images, and text-based explanations. Bots can also differentiate between students. Based on a discriminator, for example a response to a particular prompt while chatting through an interactive example, a bot can offer a student the most appropriate information or learning experiences relevant to that student's particular learning needs, as identified by their response to that particular prompt.

Retention of new knowledge constructed may degrade if not revised regularly, however, revision in large volumes may not be effective (Stahl *et al.*, 2010). Bots enable students to selectively revise content in bite-sized chunks at a convenient pace and time. Traditionally, students learning with MIM apps would need to review the chat history, if stored, chronologically in order to revise the material (So, 2016). Bots are, however, always available and able to repetitively deliver relevant content to the student on demand.

Development of Accounting Rookies and IFRS Rookies Messenger bots

To inform the discussion on the development of the Messenger bots, the authors, as "complete participants" (Gold, 1958) in the development process, relied upon their development notes, personal experiences, conversations and reflections during the period prior to and since the launch of the Messenger bots.

Initial development

In December 2016, the idea to build a Messenger bot as a tutor and student assistant was discussed by the authors. The Accounting Rookies and IFRS Rookies Messenger bots were connected to Messenger in April and February 2017 respectively. The content of the Messenger bots was not regarded as complete at launch. Unlike an app, the content of a Messenger bot is not downloaded to a user's device and does not require subsequent updates. The content remains available online and is accessed by users on demand. Updates, including additional content, are immediately available to users. Both Messenger bots were designed to be interactive, friendly and above all, facilitate learning of Accounting and IFRS at an introductory and intermediate level respectively. The Messenger bots were initially "tested" by informing students, that were enrolled for courses facilitated by the developers, about the bots, encouraging them to engage with the bots and then monitoring these interactions.

Not having coding background, Chatfuel was selected as the tool to develop the Messenger bots. Chatfuel is a Messenger bot builder that is free and has a visual development environment, allowing the results of the bot development, rather than a screen of code, to be seen. For building Messenger bots, the Messenger Send/Receive API (An application-programming interface (API) is a set of coding instructions and standards for accessing a web-based software application or Web tool (see Gazarov, 2016)), accessed through Chatfuel, offers, *inter alia*, support for: defining a welcome screen for setting the context and different controls; sending and receiving text, images and interactive bubbles containing multiple calls-to-action; and possible integration with a more advanced ANI engine or the more simplistic database of prepopulated responses for interpreting the users' intent from their inputs. These development options are presented visually by Chatfuel as a series of connected blocks. A block is the basic "building block" of a Messenger bot. It consists of one or more message cards that are sent together to the user. Each card may have a button or quick reply bubble that links to the next block (Figure 2).

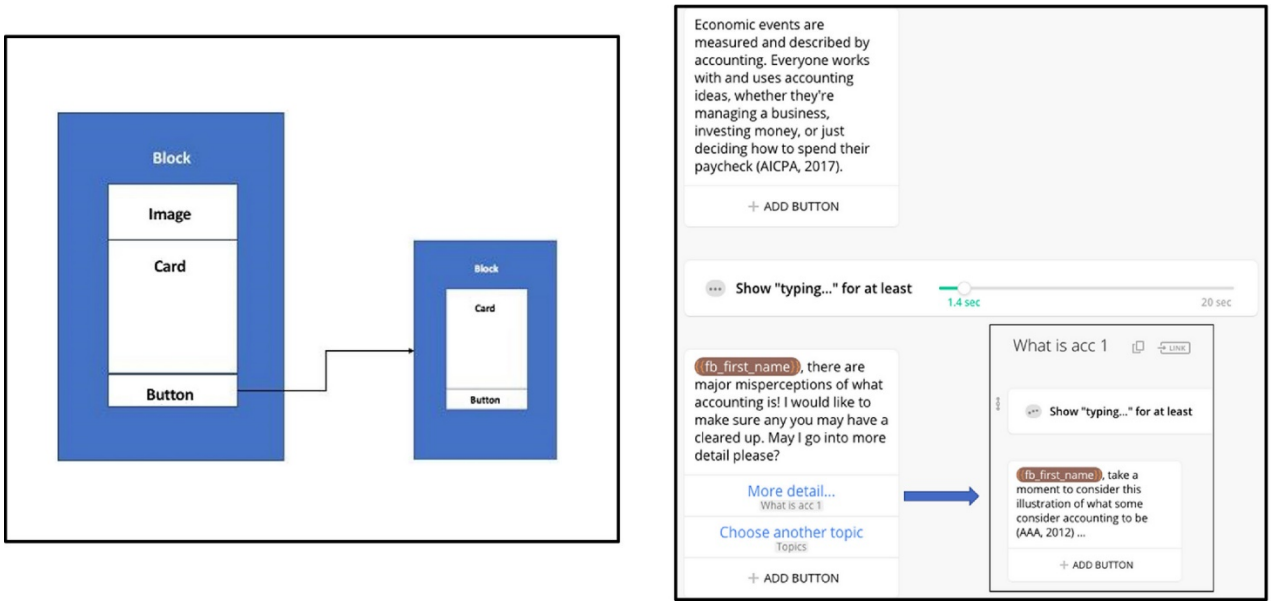


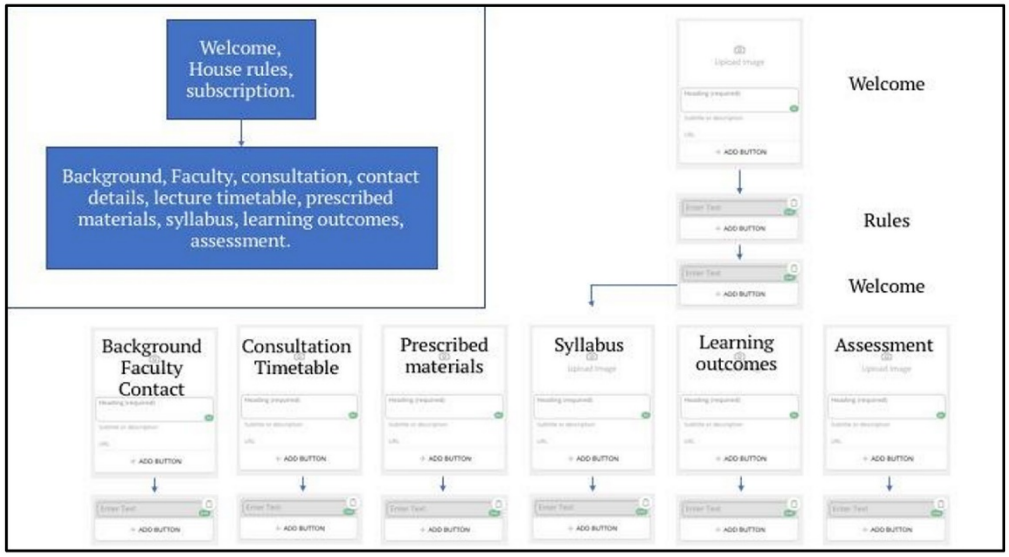
Figure 2. Message blocks

Replicable instructions for the initial development of a Messenger bot with Chatfuel are included in Appendix A.

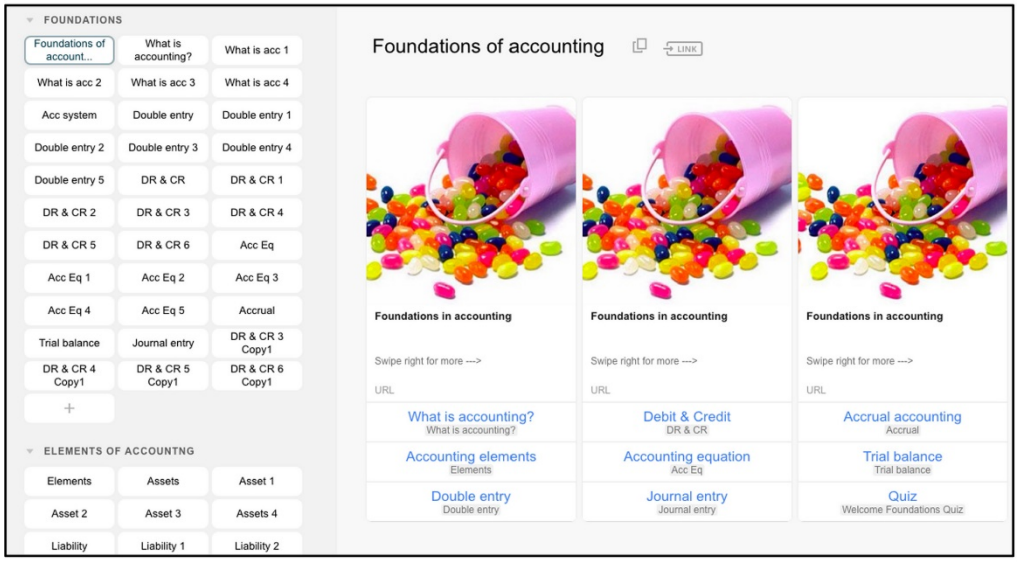
Content

Before adding content to the Messenger bots, a basic content map for each bot was created (Figure 3, Panel A). This assisted visualization of the communication flow. Informed by social constructivist learning and the scaffolding of students' learning in their zones of proximal development, the technical content of the Messenger bots was mapped to take advantage of the hierarchical nature of accounting (Figure 3, Panel B). Students are enabled to diagnose their learning status and knowledge level, using, for example, formative quiz options. Should the student make the appropriate selection, the Messenger bot guides the discussion to the next level. Should the student make incorrect selections, the Messenger bot provides remediation, to support the student create this knowledge before proceeding further (Figure 3, Panel C).

PANEL A: Course administration



PANEL B: Technical content overview



PANEL C: Technical content scaffolding

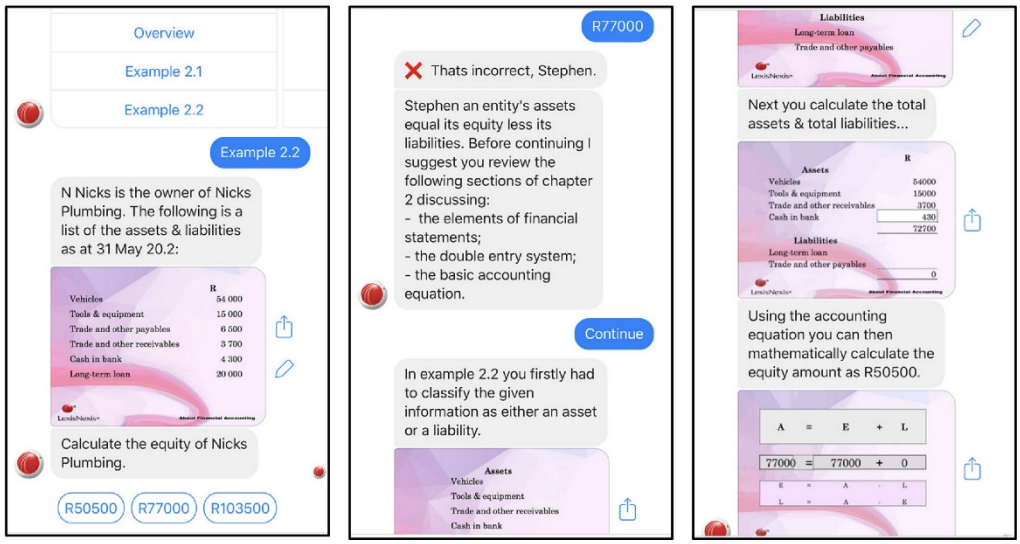


Figure 3. Content map

The text messages communicating content were carefully scripted to encourage anthropomorphism. Where possible, messages were personalized to create a rapport between the Messenger bot and the student (Figure 4). An effort was made to use friendly, inclusive language to simulate a conversation with a tutor or someone familiar. Messages were kept short as far as the content allowed and included emoji's to add colour and personality (Figure 4). Short, bite-sized resources are most effective for supporting learning through MIM apps (Bradley, Haynes, Cook, Boyle, & Smith, 2009).

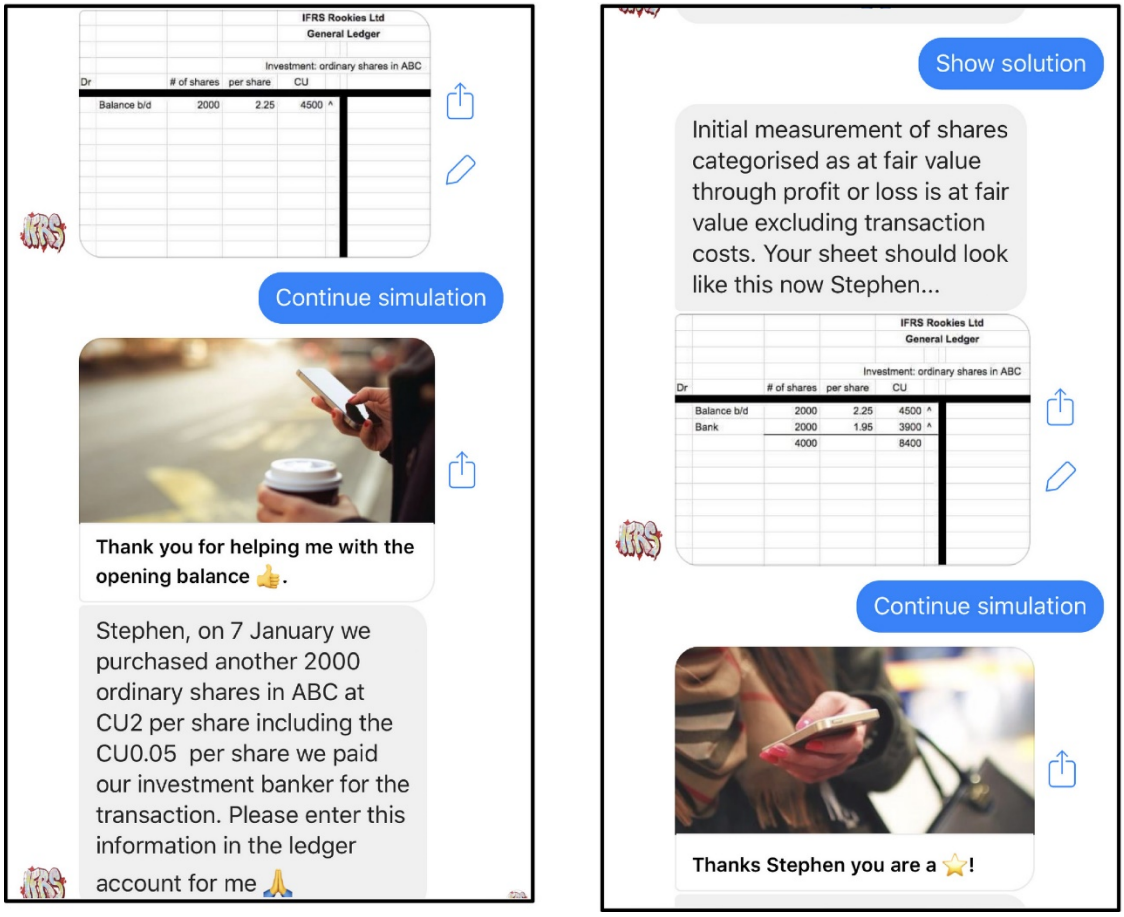


Figure 4. Personalized messages

Post-implementation review

In reviewing the initial deployment, it was noted that many students were unfamiliar with Messenger bots and were not sure how to interact with them. In response, basic text instructions were included (Figure 5), including links to explanatory videos (https://youtu.be/X_x0XIksfm8 (Accounting Rookies) and https://youtu.be/eaj5cHNMWF0 (IFRS Rookies)).

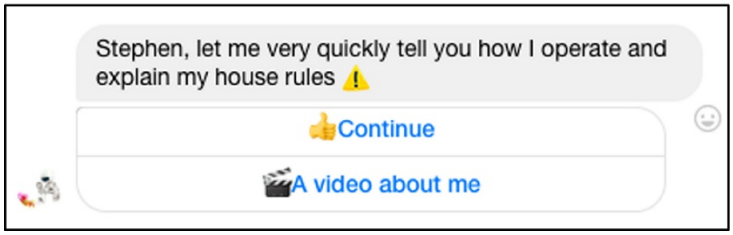


Figure 5. Basic instructions

Although attempting to embrace the potential learning benefits from anthropomorphism, given the current limitation of ANI, it was deemed necessary to manage the students' expectations of the capabilities of the Messenger bots (Figure 6). It was clearly communicated to the students that they are interacting with a Messenger bot, to avoid inadvertently frustrating students. Siri, Alexa and other virtual assistants may be making students more comfortable with interacting with bots, helping them understand the capabilities of bots. Students appear to naturally adjust their expectations when knowingly engaging with a bot, instead of a human, creating a smoother experience (Astute Solutions, 2017).

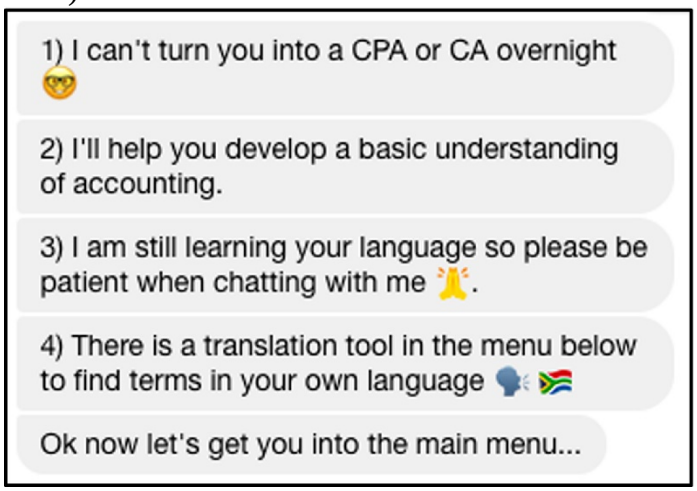


Figure 6. Managing students' expectations

Despite creating awareness of the Messenger bots' limitations, it was observed that students continued conversing with the bots. The Messenger bots were, therefore, enabled to respond to common words and phrases. The Chatfuel prepopulated knowledge database, supplemented by the Dialogflow ANI engine (Dialogflow is a Google platform for building conversational experiences for bots and other conversational applications), was adopted to achieve this. A common approach is to populate the Messenger bot's knowledge database with questions, Dialogflow is a Google platform for building conversational experiences for bots and other conversational applications. Phrases or words, and how the bot is to respond to each question, phrase or word (Kerly, Hall, & Bull, 2007). Alternatively, an empty database can be used, to which content is added automatically as the bot is used (Abushawar & Atwell, 2007). The Chatfuel database follows the former approach. Questions, phrases, words and anticipated technical terms, with appropriate responses, for the content area, were manually added to the existing Chatfuel database (Figure 7).

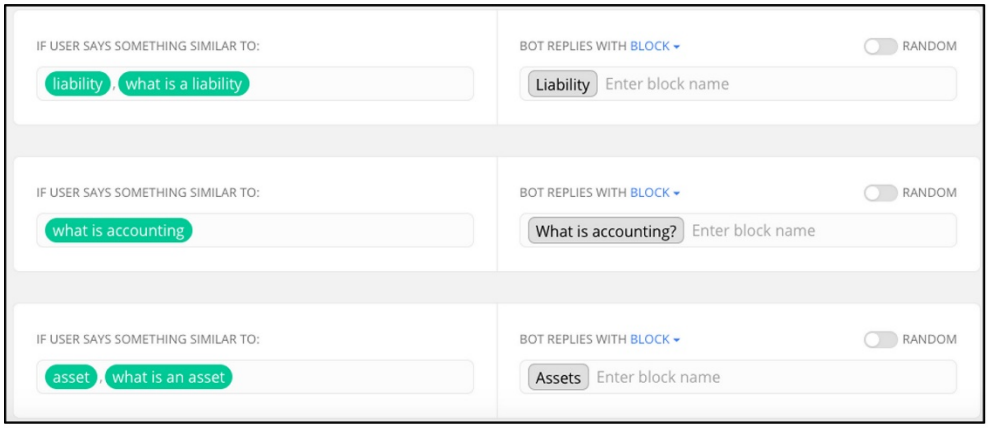


Figure 7. Chatfuel knowledge database

To respond to common “small talk” words and phrases, Dialogflow’s “Small Talk” agent was adopted. This agent is prepopulated with specific “small talk” words or phrases. Should the Chatfuel database not be able to respond, the Dialogflow engine is triggered (Figure 8).

```
User: How are you?
Agent: Wonderful as always. Thanks for asking.

User: You're so sweet.
Agent: Thanks! The feeling is mutual.
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Figure 8. Dialogflow

Chat-logs created, during interactions with the students, served as sources for bot response improvement. The authors regularly reviewed samples of interactions between the bots and the students and updated the Chatfuel knowledge database accordingly.

While it has been deemed sufficient to manage students’ engagement with the Messenger bots through the design of the dialogue and the use of the Chatfuel and Dialogflow Engines, some instructors may prefer retaining control over any “loose ends”. A live chat function can be included in the Messenger bots, allowing students to converse directly with the instructor where the bot is unable to respond. This may, however, be impracticable in a large class.

Teaching and learning with Accounting Rookies and IFRS Rookies

Students gain access to the bots in Messenger, by searching for the Messenger bot by name (Figure 9), or by following the direct link to the Messenger bot provided by the instructors, fellow students or friends. To access the Messenger bots, students must download and open the Messenger app for Android or IOS (alternatively via www.messenger.com on a computer). Initially, the students may be prompted to login to Messenger with their Facebook account or to create a new account. Once the Messenger bot is located, the students tap on it to open the chat window for that Messenger bot. Then the students tap on “Get Started.” The Accounting Rookies and IFRS Rookies Messenger bots have been used in various pedagogical scenarios, commonly faced by instructors.

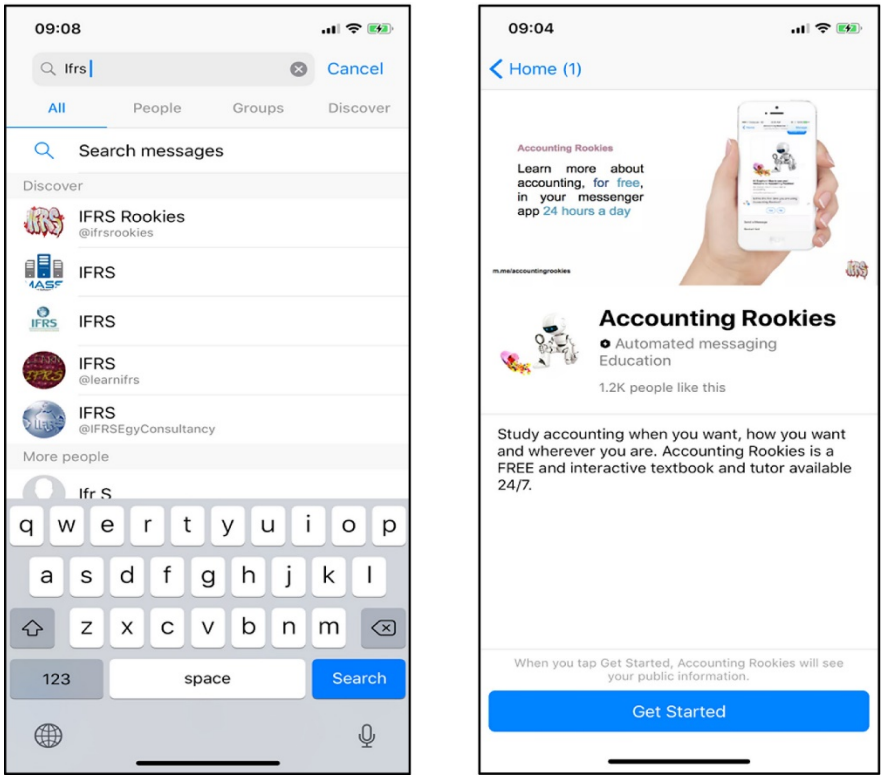

Figure 9. Messenger bot welcome screen

The flipped classroom

"Flipping the classroom" implies that students gain their first exposure to content outside of class, by reading prescribed material or watching lecture videos, freeing up class time to facilitate assimilation of knowledge, through for example problem solving, discussion and debates (Bergmann & Sams, 2012; Sahin & Kurban, 2016).

This means that students are learning (gaining knowledge and comprehension), at the lower levels of Bloom's revised taxonomy, outside of class, while focusing on the higher levels of learning (application, analysis, synthesis and/or evaluation) in class, where they can be supported by instructors and peers. The flipped classroom contrasts the traditional model of teaching, where the focus in class is on lower levels of learning with students assimilating knowledge, through homework, outside of class.

The Messenger bots have been designed to transform the students' work outside of class in a social constructivist manner. An instructor may enable collaborative learning through the Messenger bot's dialogue, scripted to encourage students to watch specific videos or read specific material, before asking questions in a quiz style format. By doing this, the Messenger bot supports the student's knowledge construction and comprehension (Figure 10).

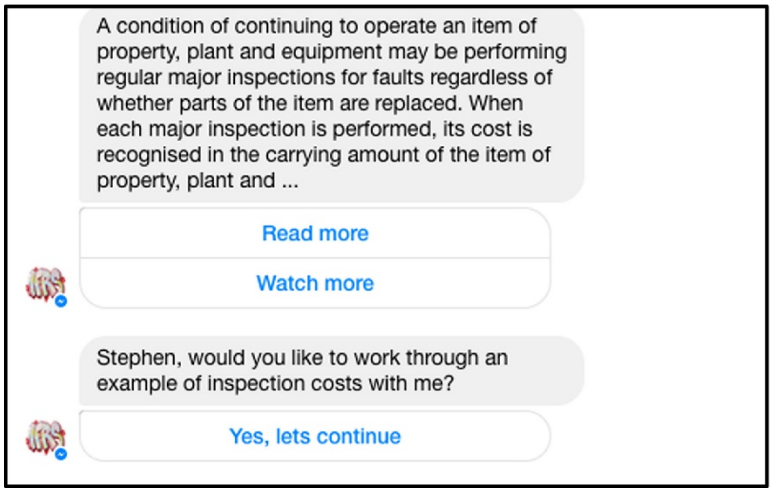

Figure 10. Using a bot in a Flipped Classroom

"Co-teacher"

To overcome some challenges of teaching large groups (such as students not receiving personal attention), instructors may "team teach" with the Messenger bot. At its most basic level, team teaching takes the form of One Teach/One Guide (or Support) (Baeten & Simons, 2014). One instructor leads in facilitating learning, while the other supports and guides students that may need additional assistance. One Teach/One Support can be adopted for teaching new content or when one instructor has greater subject knowledge (Baeten & Simons, 2014).

The Messenger bots fulfilled the role of co-teacher in the support role. Students are able to personalize their learning and engage with the Messenger bot, finding answers to commonly asked questions, without disrupting the flow of the class. This enables students to work through material at their own pace, allowing differentiation in instruction. At key points, instructors can interject to add additional explanation or information. IFRS Rookies in particular includes elements designed to lead the students through examples during class (Figure 11) (https://m.me/ifrsrookies?ref=Shares%20case%201).

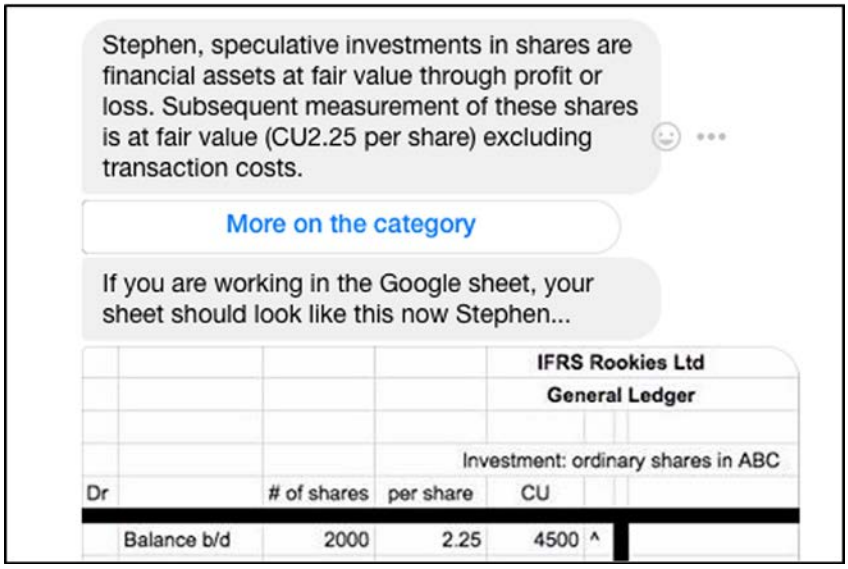

Figure 11. Examples during class

Keeping students engaged

In addition to enhancing the students' engagement before and during class, the Messenger bots encourage students to reflect on their learning after class, reinforcing what was taught and ensuring that the material has crossed the students' minds again, strengthening the learning pathways. The Messenger bots achieve this by sending a message to the students in Messenger, containing, for example, a text message with a link to a revision quiz (Figure 12).

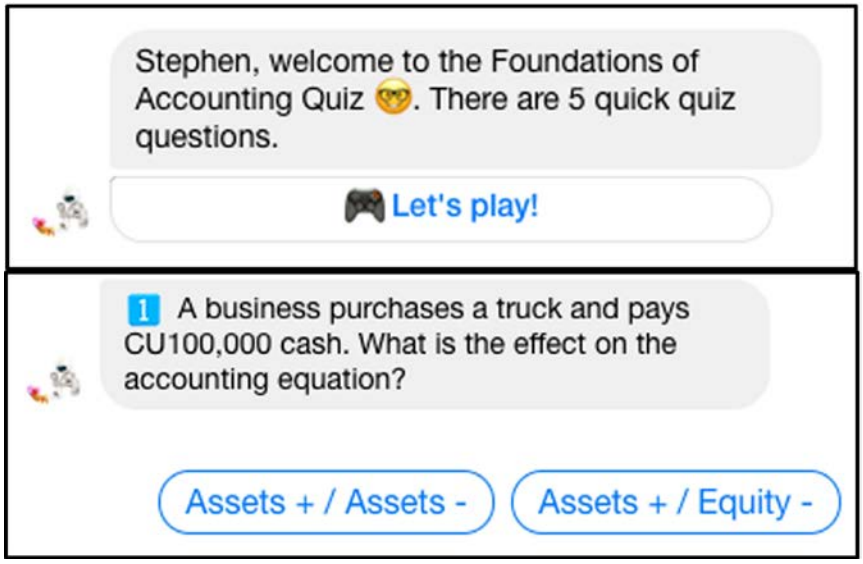

Figure 12. Revision Quiz

Additionally, students can subscribe to a financial news service within the Messenger bots to receive the latest financial news headlines on a daily basis (Figure 13).

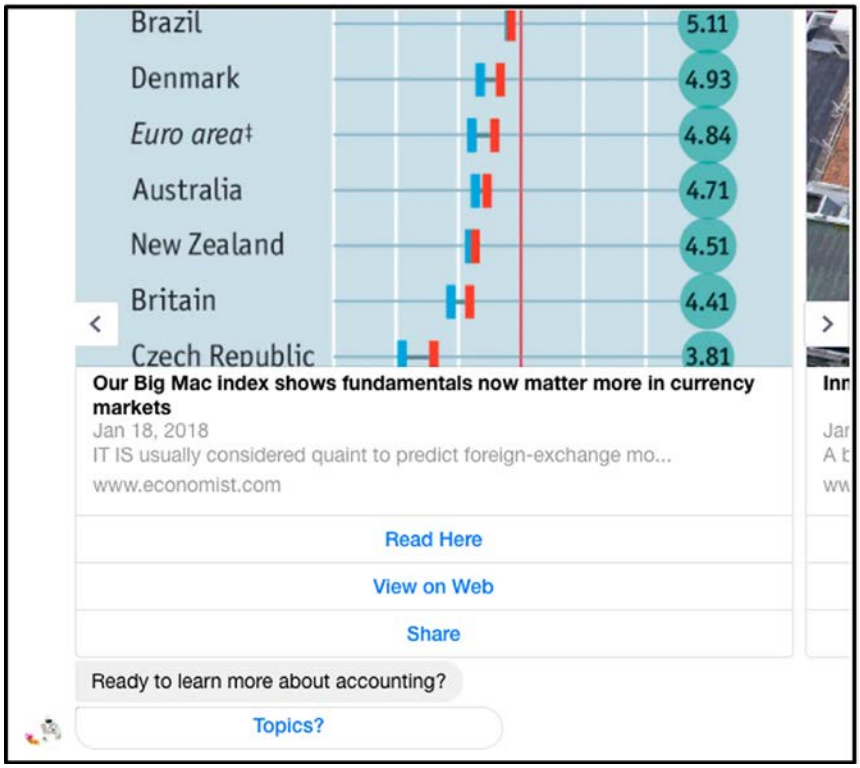

Figure 13. Latest financial news

Students' experience of using Messenger bots in teaching and learning

While Messenger bots potentially facilitate new approaches to teaching and learning, it is not guaranteed that significantly better learning effectiveness than conventional approaches, or appropriate learning outcomes, will be achieved. Understanding students' perceptions regarding the Messenger bots' effectiveness in their learning activities, is influential and critical to the success or failure of integrating Messenger bots into teaching and learning.

Method

As a preliminary evaluation, exploring the users' experiences of the Accounting Rookies and IFRS Rookies Messenger bots, user analytics were collected from Chatfuel and the results of the Messenger bots' "Rate us" block. Chatfuel analytics are based on user data returned by the Facebook Graph API and is, therefore, restricted by Facebook's and the individual user's privacy settings. For example, Facebook allows Chatfuel access to users' time zones to allow, for example, the scheduling of messages. Access to a user's specific country information is, however, restricted by a user's privacy settings. As Messenger bot users are not Facebook "Friends" with the Messenger bots, specific country information is not available. Information not made available by the Facebook Graph API, as well as user feedback, must be collected directly from the users. Consequently, the "Rate us" block was included in the bot design from initial launch of each bot. User feedback is voluntary and freely available at all times in each bot's persistent menu (Figure 14). The collection of data for this study, from the Chatfuel analytics and the bots' "Rate us" block, was approved by the Institutional Review Board of the authors' university. All respondents to the "Rate us" block whose data are included in the data set underlying this study, were informed of and consented to the anonymous use of their responses for purposes of this study.

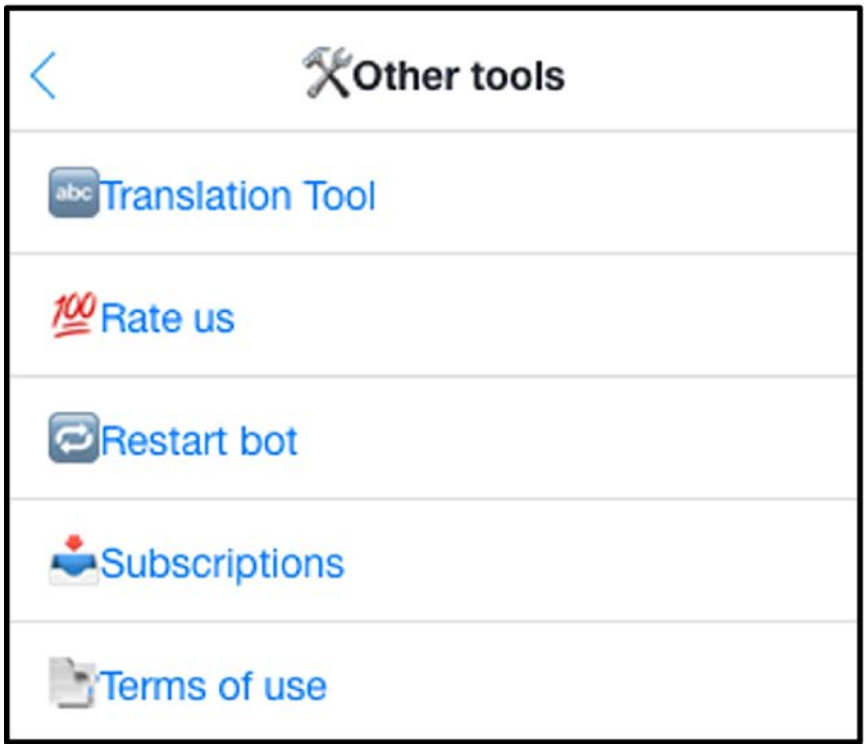

Figure 14. Persistent menu

The first question in the "Rate us" block is, "Hello, thank you for supporting Accounting (or IFRS) Rookies. What has your experience of Accounting (or IFRS) Rookies been? Have we won your heart? Or maybe just earned a balloon? Or are you feeling a little cold and disappointed? Please tap the button below to tell us how you feel…"

The remaining questions were based on an existing instrument (Rambe & Bere, 2013) investigating physical, technical and functional affordances of WhatsApp in relation to their pedagogical value. This instrument was chosen, as WhatsApp is a MIM app offering similar functionality to Messenger, although to date does not allow bot integration. Students were required to indicate their agreement with each statement on a 4-point Likert scale, ranging from strongly disagree to strongly agree. A neutral point on the scale was not offered, to ensure that students took a stance on each question (positive, or negative). Also, the 4-point Likert scale fits on a mobile screen in portrait mode, without the need for excessive scrolling (Figure 15). One question from the instrument was deleted, to improve internal reliability. Cronbach's alpha (α = 0.72) exceeded the required threshold of 0.7, implying a high internal consistency of the scale (Field, 2013).

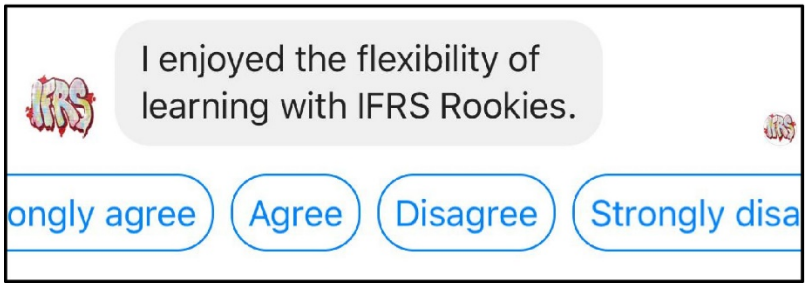

Figure 15. Likert scale

Data collected were analysed using the Statistical Package for the Social Sciences 22.0 for Windows (SPSS Inc., Chicago, IL). Descriptive statistics were used to examine respondents' demographic data and satisfaction levels. Differences in the respondents' satisfaction levels, between Accounting Rookies and IFRS Rookies, were explored using Analysis of Variance. Given the limited statistically significant differences identified in the respondents' satisfaction levels between the two Messenger bots, the discussion reports on the respondents' experiences of the Messenger bots collectively.

Results and discussion

Demographic profile of users

The Accounting Rookies and IFRS Rookies Messenger bots are freely available in Messenger and not restricted to users from any particular course or institution. The developers promoted the Messenger bots amongst introductory and intermediate accounting students attending their higher education institution. The South African Institute of Chartered Accountants, advised faculty at Departments of Accounting at other South African universities of the availability of the bots. The Messenger bots also include a "Share" option, allowing users to share the Messenger bots with Facebook and Messenger contacts. Finally, the Messenger bots are also listed in the "Discover" section (equivalent of an app store) in the Messenger app. At 31 January 2018, Accounting Rookies, targeted at the introductory level, had accumulated significantly more reachable users (n = 4627) than the more specialist IFRS Rookies (n = 1757). Both Messenger bots have more female than male users, with the majority of

users being in the GMT + 2 time zone (South Africa), where the Messenger bots were developed and promoted (Table1).

Table 1: Demographic profile of users

	Accounting Rookies		*IFRS Rookies*		*Total*	
	n	%	*n*	%	*n*	%
Gender						
Male	2053	44	753	43	2806	44
Female	2574	56	1004	57	3578	56
Total	4627	100	1757	100	6384	100
Time zone						
GMT + 2 (South Africa)	3292	71	1561	89	4853	76
GMT (United Kingdom)	589	13	162	9	751	12
GMT − 5 (Eastern Standard Time)	233	5	–		233	4
GMT − 6 (Central Standard Time)	175	4	–		175	3
GMT − 4 (Puerto Rico and US Virgin Islands Time)	96	2	–		96	1
GMT − 8 (Pacific Standard Time)	95	2	–		95	1
Other	147	3	34	2	181	3
Total	4627	100	1757	100	6384	100

Feedback rate and respondent profiles

For the period since the Messenger bots' launch in early 2017 to 31 January 2018, 608 evaluations of the students' overall satisfaction with the Messenger bots were received (Table 2). This represents a sampling rate of 10% (6% for Accounting Rookies and 18% for IFRS Rookies) with a 95% confidence level and a 4% margin of error. The sample decreases to 251 (4%) evaluations (n = 104 (2%) for Accounting Rookies and n = 147 (8%) for IFRS Rookies) when exploring the students' experience in greater detail (Table 3). This smaller sample offers a 95% confidence level and a 6% margin of error. These feedback rates approximate typical customer survey response rates, which are often below 2% (Customer Thermometer, 2018). The gender profile of the respondents, for the overall satisfaction (Table 2) and the more detailed feedback (Table 3), is similar to the total population. The majority of the respondents for the overall satisfaction are again from the GMT + 2 zone (Table 2). In respect of the respondents who provided more detailed feedback, it was established, through information provided by the users, that the majority of the respondents are South African university students (Table 3).

Table 2: Demographic profile of respondent users for overall satisfaction

	Accounting Rookies		*IFRS Rookies*		*Total*	
	n	%	*n*	%	*n*	%
Gender						
Male	117	40	119	38	236	39
Female	171	59	195	62	366	60
Unknown	4	1	2	0	6	1
Total	292	100	316	100	608	100
Time zone						
GMT + 2 (South Africa)	256	88	296	94	552	91
Other	19	7	13	4	32	5
Unknown	17	6	7	2	24	4
Total	292	100	316	100	608	100

Table 3: Demographic profile of respondent users for detailed responses

	Accounting Rookies		*IFRS Rookies*		*Total*	
	n	%	*n*	%	*n*	%
Gender						
Male	38	37	67	46	105	42
Female	62	60	80	54	142	57
Unknown	4	3	–	0	4	1
Total	104	100	147	100	251	100
Current enrolment						
University	64	62	129	88	193	77
Secondary school	28	27	8	5	36	14
Unknown	12	12	10	7	22	9
Total	104	100	147	100	251	100

Overall satisfaction

The majority of the respondent students expressed overall satisfaction with the Messenger bots (Table 4). Ninety-three percent of respondents suggested the Messenger bots had "won their hearts" (72%) or "earned a balloon" (21%). Only 7% of respondents were left "cold and disappointed." Comments received from respondents included: "*This platform is superb*," "*I would like to thank you for giving me more knowledge on accounting*" and "*I love the chat bot!*". Some differences in the respondents' satisfaction with the Messenger bots were observed. A chi-square test of independence was performed to examine the relationship between the satisfaction of the respondents using the Accounting Rookies and the IFRS Rookies Messenger bot respectively. The relationship between these variables was significant, X2 (2, n = 608) =5.74, p = 0.057. More of the Accounting Rookies users (10%) suggested that the Messenger bot left them "a little cold and disappointed" as opposed to IFRS Rookies respondents (5%). Female respondents were slightly more positive, with 74% suggesting the Messenger bots had "won their hearts" as opposed to 69% of male respondents. A chi-square test of independence was performed to examine the relationship between the male and female respondents' satisfaction with the Messenger bots. The relationship between these variables was insignificant, X2 (2, n = 602) =3.15, p = 0.207.

Table 4: Overall satisfaction

	Panel A: Total per Messenger bot					
	Accounting Rookies		*IFRS Rookies*		*Total*	
	n	%	*n*	%	*n*	%
Won your heart ❤	210	72	227	72	437	72
Earned a balloon 🎈	53	18	72	23	125	18
A little cold and disappointed ❄	29	10	17	5	46	10
Total	292	100	316	100	608	100
	Panel B: Total per gender					
	Male		*Female*		*Total*	
	n	%	*n*	%	*n*	%
Won your heart ❤	163	69	269	74	432	72
Earned a balloon 🎈	57	24	67	18	124	21
A little cold and disappointed ❄	16	7	30	8	46	7
Total	236	100	366	100	602	100
Unknown gender					6	
Total respondents					608	

Teaching and learning with Messenger bots

As an emerging technology, a significant number of students strongly agreed (n = 122, 49%) or agreed (n = 125, 50%) that Messenger bots provided an opportunity to experiment with new ways of learning online (M = 3.46, SD = 0.54) (Table 5). Many students also strongly agreed (n = 114, 45%) or agreed (n = 127, 50%) that learning with the Messenger bots afforded them flexibility (M = 3.40, SD = 0.60). This may be indicative of Messenger bots being situated in MIM apps on mobile phones and, therefore, being accessible 24 hours a day, seven days a week.

Table 5: Students' experiences of using Messenger bots in teaching and learning

	Accounting Rookies (n = 104)		*IFRS Rookies (n = 147)*		*Total (n = 251)*	
	M	*SD*	*M*	*SD*	*M*	*SD*
The opportunity to experiment with new ways of learning online was possible with the Messenger bot	3.45	0.54	3.48	0.54	3.46	0.54
I enjoyed the flexibility of learning with the Messenger bot	3.36	0.64	3.43	0.57	3.40	0.60
The Messenger bot helped with my knowledge creation	3.36**	0.57	3.22**	0.57	3.27	0.57
I would recommend Messenger bots for all my courses	3.28	0.65	3.23	0.82	3.25	0.75
My participation in learning activities on the Messenger bot was effective	3.15	0.65	3.17	0.58	3.17	0.61
The Messenger bot allowed me to have more time to reflect deeply as I was learning	3.16	0.70	3.05	0.71	3.10	0.70
The Messenger bot encouraged me to construct knowledge instead of acquiring it passively from the instructor	3.13*	0.76	3.05*	0.70	3.08	0.72
The Messenger bot facilitates collaborative learning with the Messenger bot	2.95	0.69	3.14	0.64	3.06	0.67
The Messenger bot is cost-effective	2.82	0.92	3.01	0.83	2.92	0.87
The Messenger bot can supplement face-to-face classroom learning	2.87	0.80	2.67	1.00	2.75	0.93
My engagement level is higher in the Messenger bot than in a face-to-face classroom environment.	2.81	0.88	2.54	0.92	2.65	0.91
Receiving messages from the Messenger bot frustrates me because I am not given time to rest	2.15	0.80	2.09	0.78	2.12	0.79

Notes: M = Mean; SD = Standard deviation.
Scale: 1 = Strongly disagree; 2 = Disagree; 3 = Agree; 4 = Strongly Agree.
*Mean scores differ significantly (F = 5.108, p = 0.025).
**Mean scores differ significantly (F = 3.430, p = 0.065).

It was anticipated that Messenger bots may enable social constructivist teaching and learning, where students independently create and construct their knowledge through social interaction with the Messenger bots (Bii, 2013). The students strongly agreed and agreed that the Messenger bots helped their knowledge creation (n = 85, 34%; and n = 151, 60%) (M = 3.27, SD = 0.57), encouraged them to construct knowledge instead of passively acquiring it from instructors (n = 74, 29%; and n = 128, 51%) (M = 3.08, SD = 0.72) and facilitated collaborative learning with the Messenger bot (n = 56, 22%; and n = 164, 65%) (M = 3.06, SD = 0.67).

The students strongly agreed (n = 73, 29%) or agreed (n = 132, 52%) that the Messenger bots allowed more time to reflect deeply while learning (M = 3.10, SD = 0.70). The conversation with the Messenger bots flows at a pace controlled by the student. The Messenger bot pauses should there be no response from the student, thus allowing the student to pace their own learning, and to continuously reflect and consolidate their knowledge while learning. A respondent commented that "*This Messenger bot was a great idea. You get to see where your problem areas lie*." The ability to control the conversation's pace may also be evident in the students strongly disagreeing (n = 46, 18%) or disagreeing (n = 150, 60%) that "receiving messages from the Messenger bot frustrates me because I am not given time to rest" (M = 2.12, SD = 0.79).

While many students strongly agreed and agreed that engagement levels were higher with the Messenger bots than in a face-to-face classroom (n = 54, 21%; n = 79, 31%), many students disagreed (n = 97, 39%) (M = 2.65, SD = 0.91). It may be that quieter, shyer, less assertive students may benefit more from increased engagement levels with the Messenger bot than their peers who more actively engage in a face-to-face classroom (Riel, 2016). However, given that several students disagreed, this suggests that Messenger bots' potential lies in supplementing, rather than replacing, the traditional classroom. This suggestion was supported by many students strongly agreeing (n = 112, 44%) or agreeing (n = 54, 22%) that Messenger bots could supplement face-to-face classroom learning (M = 2.75, SD = 0.93). These results provide initial evidence supporting the use of Messenger bots, particularly given their ability to communicate in a more natural and conversive manner, as a support "teacher" with the instructor taking the lead. A respondent student commented that, "*Accounting Rookies is like having a 24/7 tutor. One who answers quick and in an understandable manner*." Additionally, the motivational aspect (Pokatilo, 2016) of the conversation between the Messenger bot and a student is acknowledged, *"Thanks for encouraging me to do better*." The instructors, therefore, appear to be appropriately scripting the Messenger bots' dialogue to take advantage of anthropomorphism (Pokatilo, 2016) by mimicking the dialogue of a co-teacher or tutor.

The majority of students strongly agreed (n = 68, 27%) or agreed (n = 161, 64%) that learning with the Messenger bots was effective (M = 3.17, SD = 0.61) and strongly agreed (n = 105, 42%) or agreed (n = 110, 44%) that they would recommend Messenger bots for all courses (M = 3.25, SD = 0.75)—"*This has been a wonderful experience and I wish there could be something like this on lessons such as Mathematics*" (Respondent student), and "*Create economics and business studies rookies*" (Respondent student). Analysis of the students' experience by gender (untabulated) revealed no statistical differences between the male and female respondent group other than the male students more strongly agreeing (M = 3.40, SD = 0.767) than the female students (M = 3.15, SD = 0.734) that they would recommend the use of Messenger bots for all their courses (F = 6.857, p = 0.009).

Finally, students strongly agreed (n = 67, 27%) or agreed (n = 119, 47%) that the Messenger bots were cost-effective (M = 2.92, SD = 0.87). Messenger bots are freely available within Messenger and use the same amount of data as traditional interaction via MIM apps.

Discussion and conclusion

This study provides a thick description of the development of two Messenger bots, Accounting Rookies and IFRS Rookies, designed to act as virtual "tutors" for introductory and intermediate accounting respectively. The Messenger bots were developed using

Chatfuel, a visual development tool, as the authors do not have any coding knowledge. Informed by social constructivist learning, the Messenger bots were designed, to fulfil the support role offered by a co-teacher in the context of a large class, to support learning in the absence of a teacher or as part of a flipped classroom outside of class, and to increase student engagement in and outside of the classroom by pre-empting and responding to frequently asked questions on the course content. Through careful design of the discussion flow, scripted responses and prompts, the Messenger bots were designed to scaffold each individual student's learning and to encourage students to reflect on their learning through, *inter alia*, broadcasting messages to the students, containing, for example, a link to a revision quiz.

Although the number of respondents and limited contextual information available curbs the generalization of the results reported on the users' experience of learning with the Messenger bots, the initial results are encouraging. The majority of the respondents expressed their overall satisfaction with the Messenger bots, with 72% of the respondents suggesting that the bots had "won their hearts." The education benefits of using these bots, as perceived by the students, included experimenting with new ways of learning online, flexibility of learning with the bots, knowledge creation and construction being assisted, collaborative learning being facilitated, and the opportunity created for reflection. While many of the students strongly agreed or agreed that their engagement level is higher with the Messenger bot than in a face-to-face classroom environment, there were a number of students that disagreed, suggesting that the Messenger bots' potential may lie in supplementing, rather than replacing, the face-to-face classroom.

While several suggestions for the application of Messenger bots in teaching and learning are offered, and initial evidence supporting the use of Messenger bots in teaching and learning are provided, much speculation remains. To confirm or dismiss the effectiveness of each of the initial suggestions offered for the use of Messenger bots and the students' experiences thereof, further corroboration through exhaustive evaluation in various contexts is required. The methodology applied in the development of the different Messenger bots can be widely used by instructors in developing their own Messenger bots, without any coding knowledge. Instructors are, therefore, encouraged to develop Messenger bots for their disciplines, courses and students by following the replicable guidance provided in this paper.

Each suggested application of Messenger bots in teaching and learning represents an opportunity for in depth future research, to explore, *inter alia*, the students' lived experiences thereof, the instructors' experience of designing and using a Messenger bot, and the effect on student learning. Explorations of specific applications could include interaction patterns by the students, frequency of usage, types of interactions, and matching to sections of a course. Experimental research is encouraged to provide insights into whether, or not, Messenger bots offer significantly better learning effectiveness in specific applications than conventional approaches. Further, this study does not consider the use, and difference therein, of the Messenger bots as a mobile technology in formal and informal education settings. Future research in this regard is encouraged. Also, research is encouraged to explore whether Messenger bots, through embracing social constructivism, are able to more effectively achieve deeper learning than traditional mobile education apps that have been criticized for promoting rote learning.

In conclusion, the use of Messenger bots to support teaching and learning offers new possibilities, and has the potential to modify traditional teaching and learning, particularly as

the technology matures and becomes more accessible to instructors. Finally, given that the development of Messenger bots can be undertaken without any coding knowledge, it is, submitted that instructors, rather than programmers, should take ownership of developing bots for teaching and learning. The ability to communicate content to encourage social constructivist learning is a skill that instructors specialize in.

Statements on open data, ethics and conflict of interest

The data used in this study are available upon request.

The collection of data for this study was approved by the Institutional Review Board of the authors' university. All respondents to the "Rate us" block whose data are included in the data set underlying this study, were informed of and consented to the anonymous use of their responses for purposes of this study.

There is no potential conflict of interest that relates to this study.

Biographies

- *Astrid Schmulian* is a chartered accountant, senior lecturer and subject responsible for an intermediate accounting course at the University of Pretoria. She is currently enrolled for her PhD with a specific interest in competency-based accounting education.
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References

Abushawar, B. A., & Atwell, E. (2007). Chatbots: are they really useful? *Ldv Forum*, 22(1), 29– 49.

Akcora, D. E., Belli, A., Berardi, M., Casola, S., Di Blas, N., Falletta, S., Faraotti, A., Lodi, L., Diaz, D. N., Paolini, P., & Renzi, F. (2018). Conversational support for education. In International Conference on Artificial Intelligence in Education, June 14–19. Cham: Springer.

Baeten, M., & Simons, M. (2014). Student teachers' team teaching: Models, effects, and conditions for implementation. *Teaching and Teacher Education*, 41(2014), 92– 110.

Bergmann, J., & Sams, A. (2012). Flip your classroom: reach every student in every class every day. International Society for Technology in Education.

Bii, P. (2013). Chatbot technology: A possible means of unlocking student potential to learn how to learn. *Educational Research*, 4(2), 218– 221.

Bii, P., Too, J., & Langat, R. (2013). An investigation of student's attitude towards use of chatbot technology in instruction: The case of Knowie in a selected high school. *Education Research*, 4(10), 710– 716.

Bowman, L. L., Levine, L. E., Waite, B. M., & Gendron, M. (2010). Can students really multitask? An experimental study of instant messaging while reading. *Computers & Education*, 54(4), 927– 931.

Bradley, C., Haynes, R., Cook, J., Boyle, T., & Smith, C. (2009). Design and development of multimedia learning objects for mobile phones. Mobile learning: Transforming the delivery of education and training (pp. 157– 182). Athabasca: AU Press.

Burbules, N., Blanken-Webb, J., Herrera, H., Shipman, W., & Stewart, J. (2013). Benefits and limitations to chatterbots. Retrieved from http://chatterbotsineducation.wordpress.com/benefits-andlimitations-to-chatterbots/

Business Insider (BI). (2016). Messaging apps are now bigger than social networks. Retrieved from http://www.businessinsider.com/the-messaging-app-report-2015-11

Cassell, J., Sullivan, J., Prevost, S., & Churchill, E. (2000). Embodied Conversational Agents. Cambridge, MA: MIT Press.

Chuang, Y. H., & Tsao, C. W. (2013). Enhancing nursing students' medication knowledge: the effect of learning materials delivered by short message service. *Computers & Education*, 61, 168– 175.

Dean, K. L., & Wright, S. (2017). Embedding engaged learning in high enrollment lecture-based classes. *Higher Education*, 74(4), 651– 668.

Dempster, F. N. (1989). Spacing effects and their implications for theory and practice. *Educational Psychology Review*, 1(4), 309– 330.

Field, A. (2013). Discovering statistics using IBM SPSS statistics (and sex and drugs and rock'n'roll) (4th ed.). London: Sage.

Gazarov, P. (2016). What is an API? In English, please. Retrieved from https://medium.freecodecamp.org/what-is-an-api-in-english-please-b880a3214a82

Gold, R. L. (1958). Roles in sociological field observations. *Social Forces*, 36(3), 217– 223.

Hart, J. (2016). The future of work and learning 2: Chatbots. *Note on learning in the modern workplace*. Retrieved from http://www.c4lpt.co.uk/blog/2016/05/

Heller, B. (2017). Conversations with Freudbot in Second Life: Mining the virtuality of relationship. *Journal of Interactive Learning Research*, 28(4), 359– 370.

John-Steiner, V., & Mahn, H. (1996). Sociocultural approaches to learning and development: A Vygotskian framework. *Educational Psychologist*, 31(3–4), 191– 206.

Junco, R., & Cotten, S. R. (2011). Perceived academic effects of instant messaging use. *Computers & Education*, 56(2), 370– 378.

Kerly, A., Hall, P., & Bull, S. (2007). Bringing chatbots into education: towards natural language negotiation of open learner models. *Knowledge-Based Systems*, 20(2), 177– 185.

Kukulska-Hulme, A., & Viberg, O. (2018). Mobile collaborative language learning: state of the art. *British Journal of Educational Technology*, 49(2), 207– 218.

McFarland, M. (2016). What happened when a professor built a chatbot to be his teaching assistant. *Washington Post*. Retrieved from https://www.washingtonpost.com/news/innovations/wp/2016/05/11/this-professor-stunned-his-students-when-he-revealed-the-secret-identity-of-his-teaching-assistant/?noredirect=on&utm_term=.c90247d6d543

Miller, E. (2016). How chatbots will help education. Venturebeat. Retrieved from http://venturebeat.com/2016/09/29/how-chatbots-will-help-education/

Nakpodia, E. (2017). Chatbots and the future of education. *Chatbots Magazine*. Retrieved from https://chatbotsmagazine.com/chatbots-and-the-future-of-education-6c08db8f4c62

O'Flaherty, J., & Phillips, C. (2015). The use of flipped classrooms in higher education: a scoping review. *The Internet and Higher Education*, 25, 85– 95.

Pokatilo, A. (2016). Chatbots take education to the next level. *Chatbot News Daily*. Retrieved from https://chatbotnewsdaily.com/chatbots-take-education-to-the-next-level-23bc02cdbccf

Powell, K. C., & Kalina, C. J. (2009). Cognitive and social constructivism: Developing tools for an effective classroom. *Education*, 130(2), 241– 251.

Rambe, P., & Bere, A. (2013). Using mobile instant messaging to leverage learner participation and transform pedagogy at a South African University of Technology. *British Journal of Educational Technology*, 44(4), 544– 561.

Riel, J. (2016). How chatbots can help with learning. University of Illinois Chicago (UIC). *College of Education*. Retrieved from https://education.uic.edu/academics-admissions/student-life/how-chatbots-can-help-learning

Sahin, M., & Kurban, C. F. (2016). The flipped approach to higher education: designing universities for today's knowledge economies and societies. Emerald Group Publishing.

Schlicht, M. (2016). How bots will completely kill websites and mobile apps. *Chatbots Magazine*. Retrieved from https://chatbotsmagazine.com/how-bots-will-completely-kill-websites-and-mobile-apps-656db8e6fc03

Schneider, J. L., Hein, S. M., & Murphy, K. L. (2014). Feedback in testing, the missing link. In L. K. Kendhammer & K. L. Murphy (Eds.), Innovative Uses of Assessments for Teaching and Research, ACS Symposium Series 1182 (pp. 93– 112). Washington, DC: American Chemical Society.

So, S. (2016). Mobile instant messaging support for teaching and learning in higher education. *The Internet and Higher Education*, 31, 32– 42.

Solutions, Astute (2017). Bot, or not: should chatbots pretend to be humans? Retrieved from https://www.astutesolutions.com/blog/articles/bot-or-not-should-chatbots-pretend-to-be-humans

Srdanovic, B. (2017). Chatbots in education: applications of chatbot technologies. *eLearning Industry*. Retrieved from: https://elearningindustry.com/chatbots-in-education-applications-chatbot-technologies.

Srdanovic, B. (2018). Educational Chatbots and the use of Instant Messaging Apps in the Classroom. *eLearning Industry*. Retrieved from: https://elearningindustry.com/educational-chatbots-use-instant-messaging-apps-classroom

Stahl, S. M., Davis, R. L., Kim, D. H., Lowe, N. G., Carlson, R. E., Fountain, K., & Grady, M. M. (2010). Play it again: the master psychopharmacology program as an example of interval learning in bite-sized portions. *CNS Spectrums*, 15(8), 491– 504.

Sun, Z., Lin, C. H., Wu, M., Zhou, J., & Luo, L. (2018). A tale of two communication tools: discussion-forum and mobile instant-messaging apps in collaborative learning. *British Journal of Educational Technology*, 49(2), 248– 261.

Thermometer, Customer (2018). 20 Customer Survey Response Rate Facts | Infographic. Retrieved from: https://www.customerthermometer.com/feedback-surveys/online-survey-trends-2018/

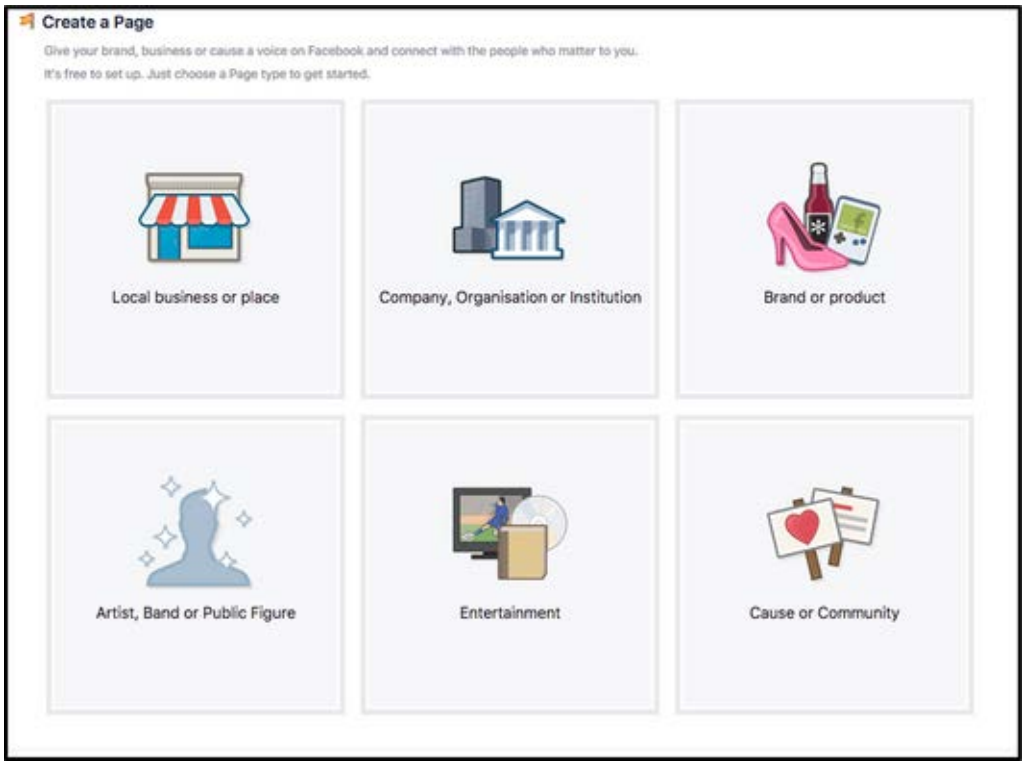
Timmis, S. (2012). Constant companions: Instant messaging conversations as sustainable supportive study structures amongst undergraduate peers. *Computers & Education*, 59(1), 3– 18.

Appendix A

Instructions for the initial development of a Messenger bot

Create a Facebook Page

A Messenger bot has to be connected to a Facebook Page for it to be discoverable and usable in Messenger. A Facebook Page is a public profile specifically created for a business, brand, celebrity, cause or other organization, such as a classroom. Pages are public for everyone to see, like, and comment on. A Facebook Page can be created at https://www.facebook.com/pages/create or by clicking in the bottom left corner of the Facebook Home page on “Create Page.” Click “Cause or Community” from the list of templates available.

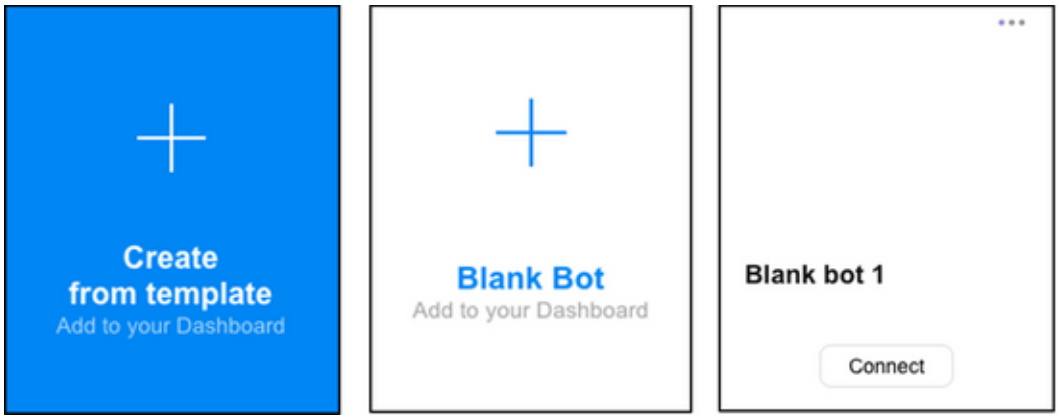


Type in the name of the Page, for example: Class 12 Accounting. Click “Get Started.” The next screen displays the new Facebook Page. Add a cover photo and profile photo. The profile photo will also be used as the Messenger bot’s profile photo.

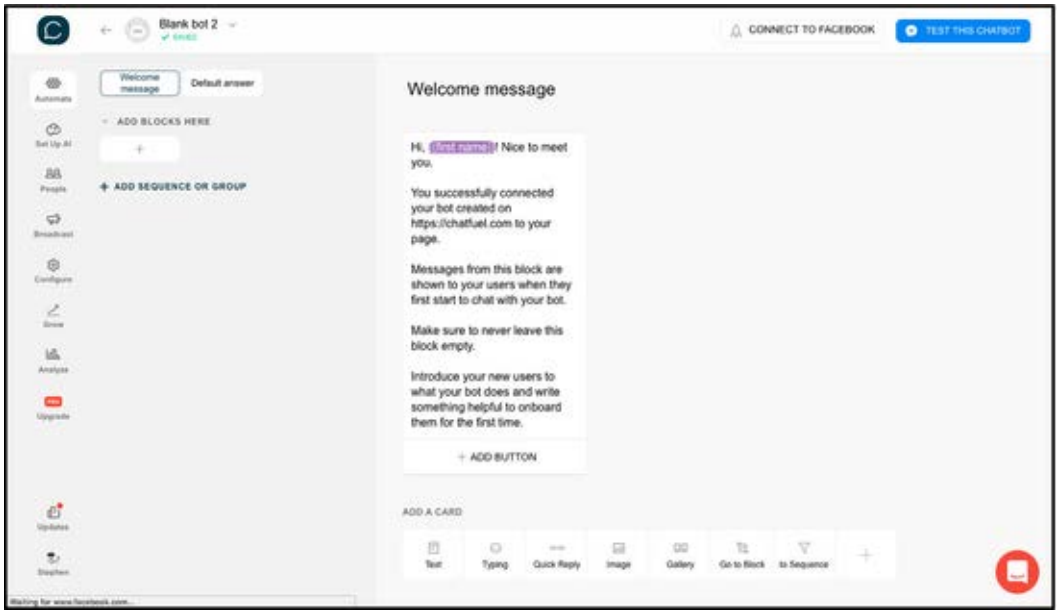
Click “Learn More” under the cover photo, select “Get in Touch” and then “Send Message” and finally confirm “Add Button.” You do not need to turn on instant replies. The “Send Message” button will allow students to connect with the Messenger bot through the Facebook Page as an alternative to directly connecting with the bot in Messenger.

Create a Messenger bot

Go to www.chatfuel.com and login with the Facebook account connected to the Facebook Page. After logging in via Facebook you can create a new blank Messenger bot by clicking on “Create from template,” then “Blank Bot.” The new bot will then appear on your home screen “Blank bot 1”:



Tap on the three dots in the top right corner to name your bot. Clicking on “Blank bot 1” (or as renamed) opens the development page:



Connecting the Messenger bot to the Facebook Page

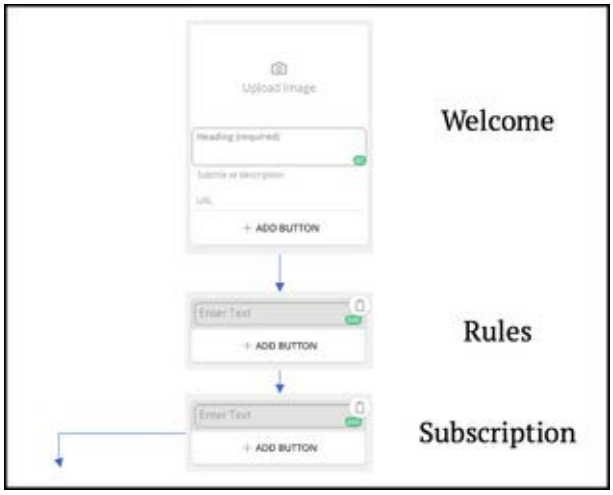
To connect the Messenger bot to the Facebook Page, in Chatfuel, on the development page, click on:

A list of Facebook Pages connected to the Facebook account used to login to Chatfuel is presented, locate the appropriate Facebook Page and click on:

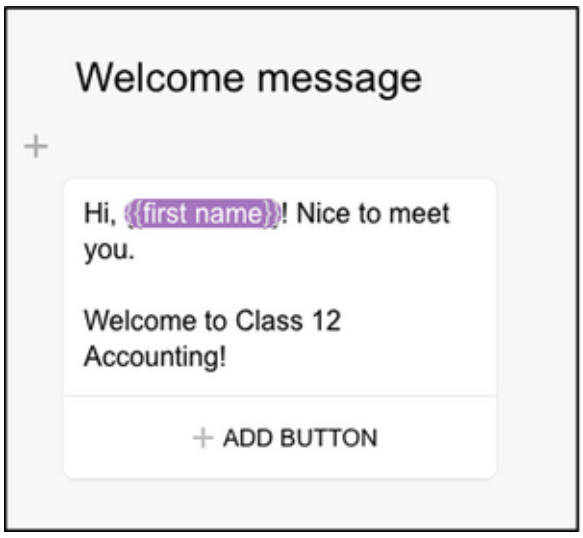
The Messenger bot is now published to Messenger and is discoverable by the students through searching for the bot in Messenger or in Facebook.

Adding content to the Messenger bot

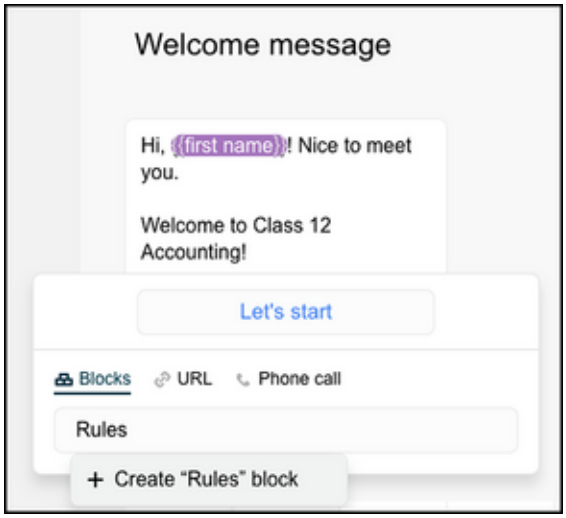
To illustrate adding content to the Messenger bot, the development of the welcoming block(s) is briefly discussed. The welcome section could be developed as 3 interlinked blocks for “Welcome,” “Rules” and “Subscription.”



For the initial welcome block, edit the existing text card in the “Welcome message” block. Any message can be personalized by typing {{first name}}. This instructs the Messenger bot to fetch the student's first name from their Facebook or Messenger profile and to insert the name in the message sent to the student.



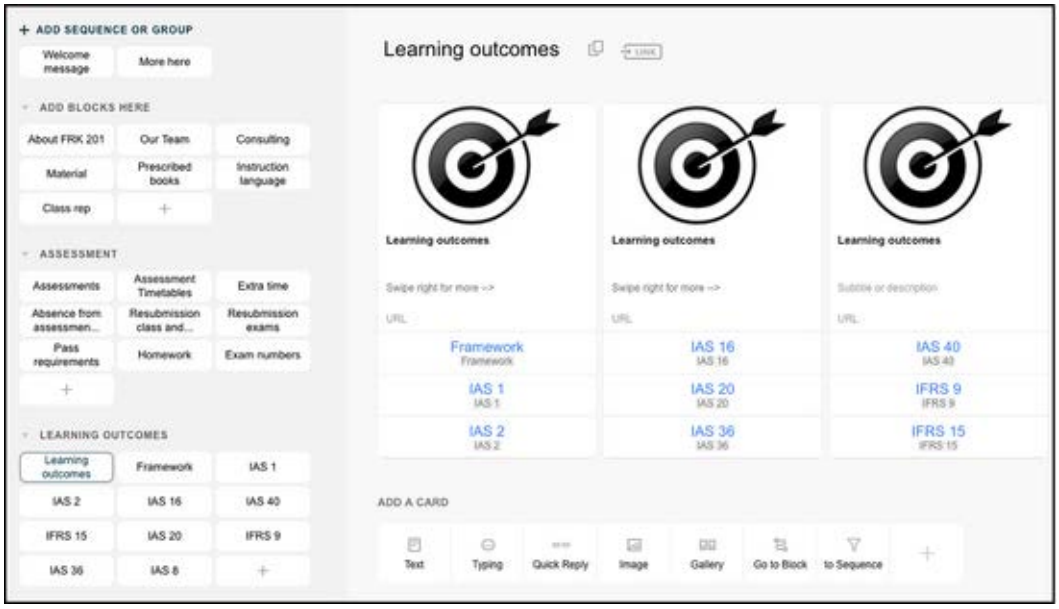
Use the buttons on the card to link this block through to the next block, which may contain the Messenger bot’s rules.



Type the message to be displayed on the text button (for example “Let’s start”). Select the option that specifies that the button will link to another “Block” (other options being an Internet url or phone number). Type the name for the block being linked to, in the entry field and click on “+ Create “blocks name” block.” The block created will appear on the development page.

Click on the new block and add text or other cards using the toolbar:

The following is an illustration of the development page of an existing course administration Messenger bot, utilizing gallery cards in a “Learning outcomes” menu block linked to blocks containing the learning outcomes of each topic:



For additional explanation please visit the website.