1. Introduction

The widespread use of smartphones is reflected by the observation that most higher education students in Hong Kong own such devices. Subscribing to discounted or unlimited data plans is common among them. These devices allow them access to internet via high-speed WiFi connectivity around the campus and at home. Kukulska-Hulme et al. (2011) conducted an international survey on university students and found that “amongst the mature age students surveyed, receptive, productive, and communicative uses are shown across learning, social, entertainment, and workplace environments” (p. 30). Owing to the upsurge of smartphone penetration in recent years, over-the-top (OTT) messaging services on mobile instant messaging, microblogging, social networking chats, and voice-over-IP talks have become the prime communicative use of smartphones. The general public including students is receptive, language learning (Cavus & Ibrahim, 2009; Lauricella & Kay, 2008). Considerable work has been reported on the use of these tools for content learning (Bakker, Sloep, & Jochems, 2007; Brett, 2008; Lauricella & Kay, 2013; Quan-Haase, 2008). Considerable work has been reported on the use of these tools for content learning (Cifuentes & Lents, 2010), language learning (Cavus & Ibrahim, 2009; Levy & Kennedy, 2005; Lu, 2008; Zhang, Song, & Burston, 2011), classroom interaction and discussion (Hou & Wu, 2011; Jeong, 2007; Markett, Arnedillo Sánchez, Weber, & Tangney, 2006; Scornavacca, Huff, & Marshall, 2007), peer collaborative support (Ng’ambi & Brown, 2009; Timmis, 2012), administrative support (Goh, Seet, & Chen, 2012; Jones, Edwards, & Reid, 2009; Naismith, 2007) and more. However, many of these studies are limited to the exchange of text-based messages (e.g. SMS) and, in some cases, the messaging tools are resided in PCs (e.g. desktop instant messaging tools). Rambe and Bere (2013) have pointed out that the academic potential of MIM remains to be one of the least explored functionalities of smartphones in higher education institutions. The appropriate inclusion of these tools in higher education institutions is a challenge to the mobile learning research and the special features of these MIM apps have the potential to foster an effective environment to support teaching and learning. Since all the participants of this study had WhatsApp in their mobile devices, the mobile instant messaging support in this research is solely referred to the use of WhatsApp for teaching and learning.

In recent years, the popularity of text messaging and instant messaging has prompted educators to integrate messaging tools in higher education teaching and learning (Bakker, Sloep, & Jochems, 2007; Brett, 2008; Lauricella & Kay, 2013; Quan-Haase, 2008). Considerable work has been reported on the use of these tools for content learning (Cifuentes & Lents, 2010), language learning (Cavus & Ibrahim, 2009; Levy & Kennedy, 2005; Lu, 2008; Zhang, Song, & Burston, 2011), classroom interaction and discussion (Hou & Wu, 2011; Jeong, 2007; Markett, Arnedillo Sánchez, Weber, & Tangney, 2006; Scornavacca, Huff, & Marshall, 2007), peer collaborative support (Ng’ambi & Brown, 2009; Timmis, 2012), administrative support (Goh, Seet, & Chen, 2012; Jones, Edwards, & Reid, 2009; Naismith, 2007) and more. However, many of these studies are limited to the exchange of text-based messages (e.g. SMS) and, in some cases, the messaging tools are resided in PCs (e.g. desktop instant messaging tools). Rambe and Bere (2013) have pointed out that the academic potential of MIM remains to be one of the least explored functionalities of smartphones in higher education institutions. The appropriate inclusion of these tools in higher education institutions is a challenge to the mobile learning research and the special features of these MIM apps have the potential to foster an effective environment to support teaching and learning. Since all the participants of this study had WhatsApp in their mobile devices, the mobile instant messaging support in this research is solely referred to the use of WhatsApp for teaching and learning.

Smartphones could be the fastest spreading technology in human history. These mobile devices change the way we communicate and enable mobile and ubiquitous learning at a different level. This study evaluated the use of mobile instant messaging tools to support teaching and learning in higher education. A total of 61 undergraduate students enrolled at a teacher-training institute in Hong Kong who have smartphones with WhatsApp were assigned into experimental and control groups. Besides the traditional classroom learning for both groups, the experimental group was also supported with bite-sized multimedia materials and teacher-student interaction via WhatsApp outside school hours. The participants of the control group used WhatsApp only for academic communication. Pre-test scores were used as the covariate. The marginal means on the post-test scores showed that the participants in the experimental group performed better than those in the control group. The intervention of WhatsApp improved the learning achievement of the participants. The strength of the intervention between the two groups was medium to large. A questionnaire designed by the author was administered at the end of the study. The participants showed positive perception and acceptance of the use of WhatsApp for teaching and learning. The participants slightly rejected the view that receiving instructional materials and questions outside school hours could interfere with their private lives. The typical usability issues on mobile learning were found to be valid. The experience learnt in this research was discussed.

© 2016 Elsevier Inc. All rights reserved.
community. Teachers, who may be comfortable in using computers for teaching, may not be as comfortable in utilizing mobile technologies such as WhatsApp into their teaching. They may not realize that MIM has the potential to create alternative dialogic spaces for student collaborative engagement (Rambe & Bere, 2013). The approaches to deliver instructional materials and activities with these tools remain as an uncharted territory for many educators. This paper aims to fill the gap.

The purpose of this study was to explore the use of a mobile instant messaging tool to support the teaching and learning of a Database course in higher education. The intention of this research was not to conduct the entire course within WhatsApp. Instead, the traditional method of teaching such as face-to-face lectures and tutorials was supplemented with the delivery of succinct instructional materials and activities through WhatsApp outside school hours. WhatsApp was used to extend and re-enforce the concepts learnt in the class, and provide a channel for the students to communicate with the instructor and their peers ubiquitously. The following two research questions were addressed in this study:

Research Question 1: Does the intervention of WhatsApp, which supports the traditional classroom instructions of an undergraduate Database course outside school hours, improve the learning achievement of the participants?

Research Question 2: To what extent do the participants perceive the usefulness and accept the use of WhatsApp for teaching and learning?

The rest of this paper is organized as follows: the pertinent literature of text messaging and instant messaging for educational purposes is reviewed in Section 2. Section 3 presents the rationales for using WhatsApp to support teaching and learning. The arguments are based on the salient characteristics of modern MIM tools. It is followed by a discussion of the methods and data analysis. Section 4 provides the details on the process of setting up the research and the highlight of the intervention. The detailed results of the quantitative analysis derived through the instruments are reported in Section 5. The main findings, the limitations of the study, the practical implications and suggestions for future research are discussed in Section 6. Section 7 provides the concluding remarks of MIM support for teaching and learning in higher education.

2. Relevant research

Computer- and mobile-mediated communication provide users the opportunity to facilitate social affinity and social presence. Communication using messaging tools is versatile. Users have control over when and with whom they interact. A number of research publications in the last decade have shown that messaging systems can be utilized in many educational activities. These applications can be largely categorized into (1) teaching and learning support and (2) communication and administrative support. This categorization follows the conversational framework of Laurillard (2002) and her notion on the effective use of digital technologies to facilitate learning through instruction, construction, discussion, and collaboration (Laurillard, 2010). In the proposed intervention specified in the first research question, these two domains of applications with WhatsApp could be found and discussed in the later section. The following literature review provides the relevant studies which have implemented the two modes of messaging communication, namely text messaging and instant messaging, in the two supporting domains described above.

2.1. Text messaging

Text messaging (texting) typically refers to the asynchronous mobile communication service between mobile handsets using SMS. Texting has been popular for communicating short messages prior to the widespread ownership of smartphones and the shift of more users to OTT messaging apps in developed societies (ITU, 2013). Many educators and scholars use text messaging as the form of communication for educational purposes (Brett, 2008, 2011; Coh et al., 2012; Jones et al., 2009).

For teaching and learning support with text messaging, many researchers have reported its use in language learning. Levy and Kennedy (2005) described a project on learning Italian via mobile SMS in an Australian university context. Lu (2008) explored the application of SMS in L2 learning in Taiwan. Cavus and Ibrahim (2009) reported an experiment on the use of SMS to support the learning of technical words. Zhang et al. (2011) reexamined the effectiveness of vocabulary learning between an SMS group and a paper-based group. Hayati, Jallifar, and Marshhad (2013) examined the push aspect of SMS affordability in relation to the delivery of bite-sized English idioms. A number of studies explored the use of SMS to increase classroom interaction and discussion (Markett et al., 2006). Scornavacca et al. (2007) presented an SMS-based classroom interaction system and explored its effect on the learning experience of the students. Ng’ambi and Brown (2009) implemented a dynamic frequently asked questions tool that incorporated SMS. The tool was intended to facilitate consultation among students and with the lecturer anonymously and inclusively. The MeLAS project (Brett, 2008) was an institution-wide implementation of SMS-based technology. SMS tools allowed the creation of three types of messages, namely, one-way communication, formative assessment with feedback, and collaborative learning.

In the area of communication and administrative support with text messaging, Naismith (2007) reported an e-mail to text message service that supported administrative communication for higher education staff and students. Message types included notifications of room changes and class cancellations, reminders on assignment submission and collection, notifications of relevant instructional activities, warning messages to absentees, instructional messages, and greeting messages. Furthermore, many education institutions such as Deakin University and Victorian Curriculum and Assessment Authority (VCAA) of Australia release examination grades and results via SMS.

2.2. Instant messaging

Instant messaging (IM) can be classified as quasi-synchronous communication. IM apps allow interlocutors to exchange short typed-texts anywhere across the globe. The actual communication channel is normally bi-directional, although turn-taking in conversation is a common practice. IM is a form of OTT services, which can be further categorized into mobile instant messaging (MIM) and desktop instant messaging (PC IM). The cost of sending and receiving messages is negligible in comparison with that of SMS texting. Modern IM apps can support multimedia data and hyperlinks. Most of these apps allow group communication and help to build a closer social networking environment for users (Vrochidou & Efthymiou, 2012). IM tools facilitate many significant opportunities for higher education (Farmer, 2005). University students are heavy IM users (Quan-Haase, 2008). Researchers have shown considerable interest in how students use IM (Bakker et al., 2007; Flanagin, 2005) and how IM can be integrated into their social and academic lives (Ogara, Koh, & Prybutok, 2014; Quan-Haase, 2008). Lauricella and Kay (2013) have found that both text and IM are useful and viable tools to augment the communication among peers and faculty in higher education.

For teaching and learning support with instant messaging, IM tools could be used to support synchronous discussion activities (Hou & Wu, 2011). Formal and informal interactions integrated with IM tools in online learning environments could have positive effects on learning (Contreras-Castillo, Pérez-Fragoso, & Favela, 2006; Hrastinski, 2006; Jeong, 2007). In studying subjects, such as a biology course for forensic science (Cifuentes & Lents, 2010), IM could encourage students to approach their professor with confidence as well as to increase their interest and success in their study. Timmis (2012) argued that IM conversation offers a means of sustainable peer support among
undergraduate students through digitally mediated communication and collaborative activities that cross formal and informal boundaries. The co-creation of artifacts, meaning making, motivation, and affective support were also demonstrated.

In the area of communication and administrative support with instant messaging, IM enables libraries such as the National Library of Australia (NLA) to provide responsive and streamlined services (Davis, 2007). NLA’s virtual reference service was a resounding success. Popular IM clients were supported. Librarians could use IM to provide direct responses to user queries (Chua & Goh, 2010; Doan & Ferry, 2006; University of Illinois at Urbana-Champaign, 2014). IM can also offer a range of other institutionally provided services such as the release of grades and notification of class cancellations (Lauricella & Kay, 2013).

3. Rationales for using WhatsApp to support teaching and learning

Web 2.0, sometimes referred to as the “read/write web”, is a breeding ground for engaging educational endeavors. As a myriad of Web 2.0 tools are available today, the actual activity that can be achieved by a Web 2.0 tool can be very different. Crook et al. (2008) outlined twelve major categories of Web 2.0 activities ranging from media sharing to social networking. Different and competing tools support different activities. Typically, these tools are evolving and more features are continually added. Hence, sometimes it is difficult to classify the tool. Nevertheless, WhatsApp as a Web 2.0 IM tool can also be considered as a social networking tool. The functionalities supported by WhatsApp can widen opportunities for pedagogical rethinking (Conole & Alevizou, 2010). By making use of the special features offered by WhatsApp, purposeful activities can help students to learn more effectively (Beetham & Sharpe, 2013). This section will highlight some of these features which are capable of enabling various pedagogical activities. Studies of WhatsApp for educational purposes and the aim of this study are presented at the end of this section.

3.1. Over-the-top messaging services can support formal and informal learning

Over-the-top (OTT) services refer to the delivery of media contents such as video, audio, images, or texts over the Internet rather than via dedicated service providers or exclusively over mobile carriers. Some examples are Skype for video/voice calls, WhatsApp for messages on mobile devices, and YouTube for streaming video delivery. MIM apps enable users to exchange messages and to deliver images and video clips for free. The readily available service is well-suited to the continuum of formal, non-formal, and informal learning environments (Cross, 2007; Eshach, 2007). In higher education settings, most in-campus locations like classrooms have Internet access. Students can use OTT services and apps to support their formal learning (Lockyer & Patterson, 2008). To bridge in- and out-of-school learning (Eshach, 2007), OTT services can have important roles in some of the informal learning activities such as scientific field trips and museum visits (Meek, Fitzgerald, Sharples, & Priestnall, 2013; Pachler, Bachmair, & Cook, 2010).

WhatsApp can support spontaneous communication, the exchange of images, and sharing of captured video clips in teaching and learning activities. The mobile connectivity and instantaneous services provide an opportunity to offer new ways of teaching and learning that can ultimately improve performance. On-demand access to media contents is beneficial to busy and independent learners. By allowing learners to select their needed learning materials, this can cultivate a responsive pedagogy for individual differences.

3.2. Bite-sized approach to learning

To use technology fluidly and ubiquitously, a flexible learning environment should entail digital-minded students (Andone, Dron, Pemberton, & Boyne, 2007). Learning materials should be presented to learners over time in bite-sized chunks (Stahl et al., 2010). Traxler (2009) argued that the need to organize and navigate through bite-sized pieces of mobile learning content will affect the personalized learning journey of individual learners. For mobile phones, short and bite-sized resources are most effective (Bradley, Haynes, Cook, Boyle, & Smith, 2009). Provided the material pieces are succinct and concise, WhatsApp can be a flexible medium that can support teaching and learning. Furthermore, the Ebbinghaus savings function informs us that the course of forgetting can best be described by a power curve of time (Wixted & Ebbesen, 1991; Wixted & Carpenter, 2007). This is widely accepted as a general theory for how we learn and retain information. The retention of new information degrades rapidly unless the knowledge is reviewed in some manner (Stahl et al., 2010). To “fight” the forgetting curve, experts have come up with many strategies. Overlearning, immediate recall and spaced repetition are some of the learning techniques. Revising the learning materials methodically could reduce the steepness of the forgetting curve. Furthermore, revisiting materials in bite-sized chunks is more effective than to learning the same amount of material as a large bolus (Stahl et al., 2010).

Bite-sized approach to learning is both pedagogical and pragmatic. WhatsApp is a suitable tool to facilitate this form of learning. WhatsApp allows the teacher to deliver learning materials in small chunks. This method of presenting information is less overwhelming for the learners and makes it easier for their learning. This can also be well-suited for students with a busy lifestyle. WhatsApp also retains the chat history chronologically. Bite-sized materials are stored in the learner’s device for easy access. Learners can conveniently revisit these materials at their own pace and time.

3.3. Studies of WhatsApp for educational purposes and the aim of this study

The uptake of WhatsApp as a MIM tool has been phenomenal. As of September 2015, WhatsApp had a user base of up to 900 million, making it the most globally popular messaging application. The system handles >10 billion messages each day (Wikipedia, 2015). WhatsApp can be a serious tool to support teaching and learning. Despite the ubiquitous use of WhatsApp, only a few research studies have reported on its application for teaching and learning. Rambe and Bere (2013) reported a case study on an undergraduate IT module at a South African university that integrated WhatsApp into classrooms and out-of-the-classroom tasks. They argued that MIM has the potential to create alternative dialogic spaces for student collaborative engagements and to transform teaching and learning. Ngaleka and Uys (2013) explored the use of WhatsApp for a group of undergraduate students on collaborative research projects. Conversation analysis was used to analyze the test messages (ten Have, 2007). Gutiérrez-Colon et al. (2013) reported the use of WhatsApp for English language learning. Salem (2013) studied the effect of MIM applications on the use of English language in Kuwait. This paper focused on the issue commonly known as “textisms” in the composition of text messages using IM tools (Rosen, Chang, Erwin, Carrier, & Cheever, 2010).

The aim of this study is to examine how smartphones installed with MIM tools such as WhatsApp may effectively be used to engage students in their learning. We are interested to explore how MIM can enhance traditional teaching and learning in higher education. It is not the intention of this study to disturb the existing classroom practices; rather, the focus is on how MIM can support their learning outside school hours. This research was carried out in a teacher-training institute in Hong Kong. The selected unit is an undergraduate database course for pre-service and in-service ICT teachers in Hong Kong. Many of these in-service students have full-time posts in primary or secondary schools. The ubiquitous nature of smartphones could extend their learning beyond the regular lectures and promote closer interaction among the tutor and student-peers. The extended dialogic space may provide an additional support in constructing their ICT knowledge as well as fostering active discussion in motivating their learning.
purpose of this study, therefore, is twofold: (1) to examine whether the intervention of WhatsApp outside school hours for a traditionally taught ICT course could improve the learning achievement of the participants; and (2) to evaluate the views on the use of WhatsApp for teaching and learning among the students. A two-group pre- and post-test experiment aimed to answer the first research question and for the second research question, a questionnaire designed by the author was used to analyze the students' perception and acceptance of WhatsApp for teaching and learning. In addition, the typical usability issues were explored and the experience learnt was discussed. This research was designed to fill the gap in the literature on the use of MIM to support teaching and learning in higher education.

4. Methodology

4.1. Pedagogical intervention of WhatsApp

To evaluate the effectiveness of MIM in supporting teaching and learning, a two-group pre- and post-test experiment accompanied by the pedagogical intervention of WhatsApp was conducted on a higher education course in Hong Kong. The course teacher is also the author of this paper and has over ten years of experience in teaching the ICT course in Database. Both the experiment and control groups in two parallel classes received the same traditional instruction and identical contents as if the course was taught in the past. The pedagogical intervention of WhatsApp was to enhance teaching and learning outside school hours. The support was not meant to replace the classroom teaching or to introduce new topics in WhatsApp. Succinct key points and supporting multimedia materials were provided in WhatsApp to consolidate the concepts presented in class. The teacher posted questions to the students and encouraged them to respond to the questions. The students could also use this medium to ask and discuss any queries with the teacher and their fellow students. The control group was limited to the use of WhatsApp for administrative support only. After completing the experiment, a questionnaire was administered to the participants to elicit their views on the use of MIM for teaching and learning. Fig. 1 shows the setup and the procedure of the experiment. The details of the participants, the measures and the procedure are described in the subsequent sections. The collected data are analyzed quantitatively to answer the two research questions introduced above. The results can then be reported in detail.

4.2. Participants

Participants were students at a teacher-training institute in Hong Kong. Students were recruited from two parallel evening classes of a database management course during the winter semester of 2014. The students had the same instructor, course content, and teaching schedule. Participation in the study was voluntary. They signed a consent form and were informed of their rights to withdraw at any time during the study. One class mainly consisted of in-service ICT students enrolling in mixed-mode programs. These students have full-time teaching or non-teaching posts in primary or secondary schools in Hong Kong. A small number of pre-service full-time students were also enrolled in this class. The intervention was conducted outside school hours and the learning support was believed to be beneficial to this group of students. A total of 31 students participated in the experimental group and all of these students are regular users of MIM tools like WhatsApp. The other class consisted of full-time pre-service students majoring or minoring in ICT. This class was designated to be the control group. A total of 30 students participated in the control group and they are also regular users of WhatsApp. However, their participation using WhatsApp was limited to the exchange of messages related to the administration of the course.

Fig. 1. The setup and the procedure of the experiment.
4.3. Measures

4.3.1. Pre- and post-tests

The instructor designed an instrument with 50 quiz items to assess the participants’ prior knowledge and their learning of the class content at the end of the semester. The pre- and post-tests were administered to students in both the treatment and control groups prior and after the course. The pre-test served as the covariate for the analysis and measured before the experimental intervention began. The identical post-test was given to the students at the end of the course. Analysis of covariance (ANCOVA) was used to evaluate the two-group pre-test/post-test design (Hogg & Tanis, 2010). After completing the course, it is expected that there will be an improvement on the database knowledge in the participants for both groups. This design allows the researcher to answer the first research question by measuring any significant learning improvement for the participants in the treatment group as compared to the control group with the pre-test as the covariate.

4.3.2. Questionnaire

To establish a better perception on the use of WhatsApp for teaching and learning, a questionnaire was administered to both the experimental and control groups at the end of the course. This instrument was designed by the author and referred to as WhatsApp for Teaching and Learning Questionnaire (WATLQ) in this research. WATLQ intended to measure the acceptance and perceived usefulness of WhatsApp for teaching and learning from the perspectives of the participants. The instrument allows the researcher to answer the second research question. The formation of the instrument was drawn from the literature review (Bakker et al., 2007; Cavus & Ibrahim, 2009; Davis, 1989; Flanagin, 2005; Gutiérrez-Colon et al., 2013; Lauricella & Kay, 2013; Ogara et al., 2014; Rambe & Bere, 2013; Venkatesh, Morris, Davis, & Davis, 2003).

In order to design a questionnaire that addresses the needs of the research, comprehensive and frequently cited models such as the Technology Acceptance Model (TAM) (Davis, 1989) and the United Theory of Acceptance and Use of Technology (UTAUT) (Venkatesh et al., 2003) were examined but not all of these models’ constructs and items were fully adopted for the parsimonious reason. However, some constructs proposed by these models are highly relevant to this study. Most specifically, TAM assumes that the beliefs about usefulness and ease of use are always the primary determinants of information technology adoption. According to Davis (1989), Perceived Usefulness (PU) is defined as the degree to which a person believes that using a particular system would enhance his or her job performance. A number of measured items related to this construct were formulated for the proposed instrument to suit the context of this study. For examples, these specific questions focus on whether WhatsApp can bring new learning opportunities and be an effective tool for learning. Furthermore, Perceived Ease-of-Use (PEOU) is defined as the degree to which a person believes that using a system would be free of effort. Examples of these questions include whether WhatsApp can help learners to easily review all multimedia materials by keeping all the records of the contents and whether WhatsApp is more flexible for learning as it can be done at anytime and anywhere. The UTAUT model can be used to understand the factors that influence the acceptance of a specific technology. The model includes four key constructs largely derived from a variety of theoretical models including TAM. UTAUT posits that performance expectancy, effort expectancy, social influence and facilitating conditions are the determinants of behavioral intention or use behavior, and that gender, age, experience and voluntariness of use have moderating effects in the acceptance of technology. The original UTAUT model included a large number of items to measure the various factors with a number of modulating effects. This model is too comprehensive to be fully adopted into this study for practical reasons. Similar to the constructs of PU and PEOU proposed in TAM, performance expectancy and effort expectancy are the two most relevant constructs to this study. Effort expectancy, for example, is defined as the degree of ease associated with the use of the system capturing the concept of perceived ease of use, complexity and ease of use from existing models (Venkatesh et al., 2003). From a technical perspective, using WhatsApp for learning may be hindered by the screen size, one-finger interaction, internet speed and battery life of mobile devices. These factors may increase the difficulties in accessing instructional materials and facilitating interactive activities on mobile devices with WhatsApp.

A crucial aspect of the questionnaire design is to address the specific nature of WhatsApp in supporting teaching and learning. Many of the items were formulated by identifying WhatsApp’s unique features in the context of mobile learning. The questionnaire has a range of WhatsApp-specific questions which focuses on whether WhatsApp can elicit new learning opportunities, foster effective communication, allow relevant feedback, offer informal and formal learning opportunities, and support collaborative learning. WATLQ was also designed to address the concern asserted by Rambe and Bere (2013) that merging academic learning with family life after hours using MIM was known as a cause of resentment.

4.4. Procedure and instruction

The traditional approach of instruction was provided to the students enrolled in the introductory course of Database Management System. The course prepares students to teach the database strand of ICT within the curriculum framework of secondary schools in Hong Kong and provides sufficient knowledge of this field to primary ICT teachers. The students received regular lectures on the theories in relational databases, query language, and web-based database construction. To practice what they had learned in the lectures, they also had to complete a hands-on database project in groups.

During the first lecture, the instructor recruited the participants for the study. They were asked to provide their mobile contact information to the instructor and to undertake the pre-test. In the subsequent class lectures, lecture slides were typically used to teach the formal database theories. Hands-on database tasks were completed with the class computers. Besides the regular instruction, students in the experimental group frequently received bite-sized instructional materials via WhatsApp. The small chunks of materials were designed to support and supplement the lectures. The bite-sized materials included video links to YouTube (e.g., Fig. 2a), diagrams (e.g., Fig. 2b), and point-form notes (e.g., Fig. 2c). The intention was to engage the learners and to maximize their learning in a succinct manner. Students could choose not to study the materials if they felt they were familiar with the topics. The instructor also posted questions regularly and encouraged the students to respond (e.g., Fig. 2d). Any student could respond or the instructor could elicit answers from specific students. The instructor would also release the answers after a day of prolonged silence. Students could also freely post questions to their instructor and fellow students (e.g., Fig. 2e). The instructor would usually respond to the questions within a day. The dynamic of the dialogue resembled the conversation they would normally have with their family and friends. For the students in the control group, the exchanged messages were limited to concerns related to the administration of the course, such as forming project groups and making announcements to students (e.g., Fig. 2f).

The instructor informed the participants on the time when materials would be posted. The first preferred time was between 4:30 pm and 6:30 pm. At these times, the participants were expected to travel on public transport to reach the institute or to return home. Rather than phubbing with their smartphones in subways and buses as most people do in Hong Kong, they could use the time to learn. The second preferred time was anytime in the evening and weekend hours (Cavus & Ibrahim, 2009). The instructor was aware that the participants were working during the day. He avoided posting messages between 8:00 am and 4:30 pm on weekdays because many participants have daytime jobs. This was proven correct because numerous participants interacted
with their instructor and fellow students during the evening until midnight, especially a few days before the final test.

5. Results

The demographic information of the participants is shown in Table 1. The majority of the participants were second year students aged between 18 and 23. Smartphone ownership is 100%.

5.1. Pre- and post-test results

The mean and standard deviation of the pre- and post-test scores are shown in Table 2. The pre-test scores for the experimental and control groups were similar, and the post-test scores for both the experimental and control groups were higher than the pre-test scores. At first glance, the descriptive data indicated that the participants in the experimental group performed better than those in the control group. A detailed analysis was conducted to examine the effects of the intervention.

To compare the learning effects of the intervention using WhatsApp, a one-way ANCOVA was conducted on the post-test scores (DV) of the experimental and control groups (IV). Pre-test scores (CV) were used as the covariate to control the potential differences in the prior database knowledge of the students. Before presenting the results, several assumptions of ANCOVA were tested. From the Shapiro-Wilk analyses shown in Table 2, all the tests were not significant ($p > 0.05$). The data were normally distributed across each group. No violation of the...
The timing of social network interaction for learning support is an important issue for those who are practicing mobile learning in higher education. Inappropriate timing can hinder learning effectiveness. Rambe and Bere (2013) reported that learners had some reservations and resentment toward receiving and sending messages after hours. In our study, the mean responses for Q15 (a negatively phrased item) were 3.22 for the experimental group and 3.79 for the control group. The participants in the experimental group slightly rejected the view that receiving instructional materials and questions after school hours could interfere with their private lives. In other words, they did not really mind the irregular timing of the WhatsApp activities as mentioned in the previous section. For the participants in the control group, perceived inconvenience might be an explanation for the mean response (Neo & Skoric, 2009).

6. Discussion

6.1. Summary of main findings

This section presents a summary of the main findings from the quantitative measurements in response to the two established research questions. The first research question looked into the pedagogical intervention of WhatsApp outside school hours to support the traditional classroom instructions for an undergraduate course in Database. The improvement of students’ learning was measured from their performance in a knowledge test given before and after the course. In comparing the results from the post-test scores with the pre-test scores as the covariate for the experimental and control groups, the ANCOVA analysis indicated that the improvement of the test scores was significant. The pedagogical intervention of WhatsApp outside school hours for the classroom instructions for an undergraduate course in Database could help students to improve their knowledge on the subject.

Table 1
Participant demographics.

<table>
<thead>
<tr>
<th></th>
<th>Experiment group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18–20</td>
<td>3</td>
<td>21</td>
</tr>
<tr>
<td>21–23</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>24–26</td>
<td>7</td>
<td>1</td>
</tr>
<tr>
<td>27–30</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>&gt;30</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>University</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st year</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2nd year</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td>3rd year</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4th year</td>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>Smartphone ownership</td>
<td>31</td>
<td>30</td>
</tr>
</tbody>
</table>

Table 2
Pre-test and post-test scores.

<table>
<thead>
<tr>
<th></th>
<th>Pre-test</th>
<th>Post-test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groups</td>
<td>n Mean/SD Shapiro-Wilk/p</td>
<td>n Mean/SD Shapiro-Wilk/p</td>
</tr>
<tr>
<td>Experimental</td>
<td>31 18.16/6.080 0.952/0.176</td>
<td>31.00/6.802 0.958/0.260</td>
</tr>
<tr>
<td>Control</td>
<td>30 18.23/3.989 0.962/0.354</td>
<td>27.47/6.095 0.977/0.772</td>
</tr>
</tbody>
</table>

The assumption of normality was found. The Levene’s test of equal error variance was not significant, $F(1,59) = 0.91, p = 0.345 < 0.05$. This result indicated that the group variances were equal. The assumption of homogeneity of variance was satisfied. The correlation between CV and DV was acceptable and significant, $r = 0.31, p = 0.015 < 0.05$. The two variables were reasonably correlated, but the correlation was not too high. The independent t-test was used to test CV between the two groups. No significant difference in the pre-test scores between the experimental and control groups was found, $t = -0.054, p = 0.957 > 0.05$. We could use the covariate in the experimental outcome. The assumption for homogeneity of regression slopes was tested between IV and CV, $F(1,57) = 0.98, p = 0.326 > 0.05$. No significant interaction (group x pre-test) was observed. The application of ANCOVA was justified.

The post-test scores shown in Table 3 indicated a significant difference, $F(1,58) = 5.087, p = 0.028 < 0.05$. The marginal mean adjusted for the covariate of the post-test results of the experimental group was 31.01, which was higher than that of the control group, 27.45. The participants in the experimental group with the intervention of WhatsApp performed better than those in the control group. This result implied that the pedagogical approach for WhatsApp to support teaching and learning was helpful. Cohen’s $f$ was computed (G*Power, 2013), $f = 0.297$. Cohen (1988) suggested that “values of $f$ as large as .50 are not common in behavioral science” (p. 284). “SMALL,” “MEDIUM,” and “LARGE” $f$ values are defined as 0.1, 0.25, and 0.4, respectively. Based on this effect size, the strength of the intervention between the two groups was medium to large.

5.2. Questionnaire results

An item-by-item analysis of WATLQ was conducted. Results are shown in Table 4. The Cronbach’s reliability for the main part of the scale (Q1 to Q11) was $\alpha = 0.885$. The overall Cronbach’s $\alpha$ was very good. The internal consistency for the items measuring WhatsApp for teaching and learning was high. No obvious items should be deleted. The mean responses for this part ranged from 4.44 to 5.11 for the experimental group and from 3.36 to 4.46 for the control group. The mean values were all higher than 3.0 in the six-point Likert-type scale, suggesting that generally, the participants had a positive perception and acceptance of the use of WhatsApp for teaching and learning. All the mean responses of the experimental group were consistently higher than those of the control group. One possible reason for this finding is the first-hand experience on the use of WhatsApp for teaching and learning. The participants of the control group responded to the questionnaire merely based on their perception of WhatsApp for teaching and learning. They could be more reserved in answering the questionnaire compared to the participants of the experimental group. This argument could be supported by the t-tests of Q5, Q6, Q8, and Q10, which showed significant differences. The participants of the experimental group had stronger views on these items than those of the control group based on their first-hand experience (e.g. Q6, Q8).

Usability issues, such as the form factor, battery life, Internet speed, and interaction are frequently cited in mobile learning research (Looi et al., 2009; Elias, 2011; Nedungadi & Raman, 2012). Despite the significant advancement of smartphones and mobile gadgets at present, these issues remain valid. For Q12 to Q14, the participants expressed their views on these issues. Thus, the expected high mean responses were observed.

Table 3
ANOVA and effect sizes of the post-test results.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Mean</th>
<th>SD</th>
<th>Adjusted mean</th>
<th>Std. error</th>
<th>$F$</th>
<th>$p$</th>
<th>Partial $\eta^2$</th>
<th>Cohen’s $f$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Post-test</td>
<td>Experimental group</td>
<td>31</td>
<td>31.00</td>
<td>6.082</td>
<td>31.01</td>
<td>1.108</td>
<td>5.087</td>
<td>0.028*</td>
<td>0.081</td>
</tr>
<tr>
<td></td>
<td>Control group</td>
<td>30</td>
<td>27.47</td>
<td>6.095</td>
<td>27.45</td>
<td>1.126</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The second research question investigated the perceived usefulness and acceptance of WhatsApp for teaching. The participants in the experimental and control groups were asked to fill in WATLQ at the end of the course. In general, WhatsApp for teaching and learning was well received. They believed that WhatsApp can elicit new learning opportunities. WhatsApp can foster effective communication at any-time and anywhere. By forming discussion groups up to 50 members per group, WhatsApp can support collaborative learning. The special features such as the support of multimedia contents and keeping records in the history can help learners to review the contents quickly and easily. WhatsApp can supplement formal and informal learning. WhatsApp allows relevant feedback. Thoughtful responses can be furnished asynchronously. The item responses from the experimental group were compared to the control group using t tests. Comparing the means for each item indicated that there were significant differences on the questionnaire items of WhatsApp’s flexibility for learning, multimedia learning, content review, access of succinct materials and supplementing conventional teaching methods. Participants in the control group were more conservative with these items. These results are likely due to their perception and not their first-hand experience of WhatsApp for teaching and learning. Participants found that typical issues on mobile learning with WhatsApp were valid. Readability, conversational structure, physical appearance, limited input capability, internet speed and short battery life were some of these issues.

The participants slightly rejected the view that receiving instructional materials and questions outside school hours could interfere with their private lives. Learning in the evening and during odd hours did not concern them. This response is not surprising because the participants are young adult learners. The theory of andragogy of Knowles (1984) asserts that adults strongly adhere to self-direction and readiness in relation to learning. Adult learners are motivated intrinsically. Their motivation to learn could override the timing inconvenience.

6.2. Limitations of the study

There are several limitations in this study. It seemed that students in the experimental group received more instructional materials and learning opportunities than in the control group. They had more possibilities to interact with the learning materials, their peers and the instructor. Therefore, it is expected that students in the experimental group would perform better than those in the control group on the post-test with the pre-test as the covariate. This observation is generally correct and the casual relationship may be the limitation in this study from the research design perspective. However, this approach is sensible and this type of experimental design is common in the field of educational research (e.g., Spradlin & Ackerman, 2010). From the educational perspective, the purpose of the research was to improve learning with the proposed intervention. In fact, there was a large amount of effort required by the teacher to supplement the traditional classroom instructions with WhatsApp outside school hours. If the improvement of the participants’ learning was mild, the effort may not be cost effective and the intervention may not be worthwhile.

There is no strong reason to believe that the participants in both the experimental and control groups have experienced this level of application for teaching and learning with WhatsApp prior to this study. The researcher is confident that the responses collected from the survey should be genuine. However, it is possible that the survey results may have been affected by any number of extraneous variables. Their past experience of mobile learning could confound the survey results. The researcher was unable to control the bias of opinions but the specific and purposeful design of the questionnaire items could reduce concerns over potential confounding factors.

Another limitation is that this experiment is not a large scale research. The experimental and control groups had only 31 and 30 participants respectively. The sample size was relatively small. The normality
assumption was properly tested for the pre- and post-test data. The groups were confirmed by the Shapiro-Wilk tests. However, each of the pairwise means of the questionnaire items was not tested for normality. The normality assumption was relied on the rule of thumb in frequentist statistics. The sampling distribution can be approximated by a Normal model. The t-tests were employed.

6.3. Practical implications and suggestions for future research

This study investigated the use of MIM tools to support teaching and learning in higher education. The implications and the insights derived from the study are articulated through Laurillard’s Conversational Framework (2002), a highly influential framework for teaching and learning design that may be mediated by technologies. The framework is defined as “the minimum requirements that any learning environment should provide to support the complete learning process, embracing the learning experiences of instruction, construction, experimentation, discussion, collaboration, production, and articulation, as a unified way of challenging both conventional methods and learning technologies” (Laurillard, 2010, p. 419). Laurillard emphasized the iterative dialogue between teacher and learner in the constructed environment of a teacher. The three main components, namely, teacher, learner, and learning environment are discussed in the subsequent sections.

6.3.1. Teacher

Laurillard has argued that the teacher makes a difference and he or she is the key to innovations. Learners cannot be entirely left alone to learn and work independently. The intervention of the teacher at the right time and with the appropriate learning materials helps the learners in the formulation and construction of knowledge. In this study, the teacher attempted to provide the right supporting materials. Following the regular lecture, the teacher sent bite-sized materials via WhatsApp to students to supplement the lectures. The teacher was aware that the use of WhatsApp was intended to enhance learning beyond the lectures. In the iterative cycles of the conversational framework between teacher and learner, a range of narrative and interactive resources, such as videos and web resources, were used to support the learners through WhatsApp. The teacher engaged the learners in academic discourses by posting questions and eliciting responses. These activities provided different ways to explore the concepts. One drawback of WhatsApp is the linear structure of the dialogues. WhatsApp is not a threaded discussion tool. For a science course such as the database course in the study, the problem was not serious. Open dispute and interpretation on different topics were not required.

Overall, the teacher felt that the study was successful. MIM contributed to the learning achievements of these students. To facilitate WhatsApp for teaching and learning especially outside school hours, the teacher had to contend with high extra workload. On the one hand, the teacher had to prepare the relevant bite-sized materials that were consistent with the lecture materials. Carefully selected materials were disseminated regularly at the right time. On the other hand, the teacher should always be available to interact with the students. Responding quickly to queries and ideas of the students are important to avoid discouraging the students. Therefore, this highlights the implication of the significant time commitment required from the teacher.

6.3.2. Learner

In the experiential level of the conversational framework, learners transform their conceptual understanding into a practical adaption guided by the discussions and reflections with their teachers and peers. Learning through practice is an important process. MIM can support learners with these activities. In this course, the students had to collaborate in a team for a database programming project. The teacher frequently received questions on how to solve programming errors over WhatsApp. Learning through their peers was also important and WhatsApp was a good collaborative tool for them. This argument was supported by the results from the questionnaire.

Shy and reticent students participated more in MIM than in the classroom environment. The teacher received responses from these students as they posted questions through WhatsApp. In the face-to-face lectures, they were very passive and did not communicate with the teacher at all. Although this aspect was not thoroughly investigated in this study, it is an excellent topic for further research.

Rambling and irrelevant conversations by the students occasionally occurred. Some students used the platform to post unrelated messages. When a student posted a long social message, another student immediately responded by requesting that student to refrain from doing so, indicating that the students treasured WhatsApp for teaching and learning. They would like to devote the discussion group for the course and not for social interaction. Some students in the group deliberately chose to send messages to the teacher privately for matters unrelated to the course (e.g., request for sponsorship of a charity event).

6.3.3. Learning environment

The teacher attempted to establish a closely connected environment to support learning inquiry, encourage reflective practice and promote active learning. MIM tools have the potential to reorganize the learning process by steering away from didactic classroom teaching to spontaneous student-centered learning. Students could relate the contents to their prior knowledge, clarify misconception, develop accurate concepts, and co-construct meaning with their peers. The learning environment, however, had its limitations. First, forming subsequent chat groups dynamically was inconvenient for the teacher. For MIM tools like WhatsApp, a series of actions and notifications were necessary to establish the communication because of the privacy issue and the system server requirement. Therefore, the establishment of dynamic group interaction was not ideal for this learning environment. Second, there were many participants involved in the control and experimental groups. It was difficult for the teacher to conduct all the teaching and learning activities because the form factor of smartphones limited the input capabilities and restricted typing with the use of a single finger.

To resolve these issues, the teacher used a Bluetooth keyboard for typing operation and reverted to a tablet for a larger screen when possible. Third, on many occasions, access to learning materials shared between PC and mobile devices was required. Transferring the materials from PC to mobile devices and vice versa was tedious. Using cloud-based repositories to centralize the file storage and sharing among different devices could have addressed this issue. However, this suggestion was not taken by the researcher. Nevertheless, the suggestion should be explored in future research.

7. Conclusions

In recent years, the proliferation of smartphones in society has been witnessed. Students in higher education are heavy users of these mobile devices (Kukulska-Hulme et al., 2011). Mobile technologies such as smartphones and tablets offer the opportunity to embed learning in formal, non-formal, and informal education (Eshach, 2007). This study demonstrated how smartphones with WhatsApp can support teaching and learning in a database course at a teacher training institute in Hong Kong.

In this experiment, WhatsApp was used as the communication tool to support teaching and learning. This study offers teachers ideas about the use of MIM tools for educational purposes. Teachers can adopt a bite-sized approach in teaching and learning. They should also encourage students to actively discuss relevant topics. Students could use the ubiquitous learning environment to interact with their teachers and peers. As the ANCOVA results in Table 3 have shown, the learning achievements of the experimental group improved significantly compared to those of the control group. Since positive outcomes of using
WhatsApp to support teaching and learning are demonstrated in an ICT course, this encourages further investigation into whether this approach can be applied to other similar contexts.

From the survey results of WATLQ, the participants expressed positive perception and acceptance toward the use of WhatsApp for teaching and learning. They confirmed that WhatsApp could elicit new learning opportunities, foster effective communication, allow relevant feedback, offer informal and formal learning opportunities, and support collaborative learning. They also concurred on the typical usability issues of smartphones and WhatsApp for teaching and learning. The relatively small form factor of smartphones could hinder reading and interaction. Nevertheless, the overall experience of using WhatsApp to support teaching and learning was encouraging.

The participants slightly rejected the view that receiving instructional materials and questions after school hours could interfere with their private lives. Learning in the evening and during odd hours did not concern them. This experiment suggests that the appropriate time for the teacher to interact with students in MIM tools can be important. This factor should be considered for similar practices in the future.

In summary, the use of WhatsApp for teaching and learning can improve the learning achievements of students in a database course at a teacher-training institute in Hong Kong. The participants revealed positive perception and acceptance of the use of WhatsApp for teaching and learning. Some usability issues were discussed. Solutions to some of these issues were suggested. This experiment allows the researcher to explore the effective use of MIM tools in higher education ICT courses.

Acknowledgements

The study was supported in part by the Hong Kong Institute of Education under IRG RG 12/2013-2014R.

References

SMS=Revenue+Forecast+To+Grow=Until+2015.aspx)