Ebanshu: An Interactivity-aware Blended Virtual Learning Environment

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***Abstract*—Virtual Learning Environment (VLE), as a type of e-Learning platform, is widely used to serve teaching and learning for education in many countries. However, most of the existing systems fail to seamlessly support and monitor the real-time interactivity and collaboration among the learners and instructors in the virtual learning environment. Moreover, instructors are unable to know the real-time learning statuses of learners at distance, which is critical to effective teaching and learning achievement. This paper presents a novel interactivity-aware blended VLE system for synchronous and asynchronous teaching and learning. By using popularity dashboard, instructors can monitor real-time learning statuses of learners. Furthermore, all the teaching activities in the virtual classroom will be automatically recorded as lecture videos for self-directed learning.**

Keywords-e-Learning; interactivity; blended learning; MOOC

I. INTRODUCTION

A. Background

E-Learning is increasingly popular for instructors and learners in universities [8]. Blended learning is a formal e-Learning program in which learners learn at least in part through online delivery of content and instruction with some element of learners control over time, place, path or pace. While still attending traditional instructor-led, face-to-face classroom methods are combined with computer-mediated activities. Many e-Learning tools are available for blended learning. For example, Blackboard [18] and Moodle [19] are widely used in universities and institutions around the world. These tools make the learning and teaching more efficient and productive, but they usually lack effective real-time monitoring of the learning process [14]. In the meantime many universities and institutions planned to construct platforms for Massive Online Open Courses (MOOCs) [5], which lots of learners in or out of campus can much benefit from. The real-time teaching/learning feedback is important for the effectiveness of MOOCs.

B. Challenges

As emphasized in e-Learning theory and practice [3][4][14], effective human interaction is a vital factor for successful e-Learning and teaching. A previous study also showed that beginners of an e-Learning system might feel being isolated from the teachers and other students, because of missing essential interactions components in the system design [10].

Lack of interactivity, usually, leads to terribly negative impact on the outcome of e-Learning. The emotional illiteracy and the feeling of being isolated in e-Learning environments need to be addressed urgently for new generation of e-Learning systems [1][2]. The key solution and objective are to strengthen interactivities among instructors and learners. With well-designed synchronous virtual classrooms and collaborative tools, the negative impact incurred by the lack of interactivity can be significantly reduced. [3][4].

In addition, most of the current VLEs lack monitoring on the interactivity and collaboration activities during the teaching and learning process, especially lack of effective mechanism enabling instructor know learners' learning statues in real-time manner [14]. However, the tracing and monitoring of these activities is important and necessary to analyze the learning behaviors in the VLEs, to provide accurate feedback to instructors for refining the method of teaching [17].

C. Contribution

In this paper, our contributions are three-folded:

1) We propose an interactivity-aware blended e-Learning architecture of *ebanshu* for massive web-based learning. By utilizing the real-time web and HTML5 technologies, the *ebanshu* architecture can enable real-time interactivities and automatic monitoring and recording of the teaching & learning activities, which are very important for improving cognitive engagement that is poorly supported by today's e-Learning systems [14][15].

2) We implement and deploy the *ebanshu* system for MOOCs. The system is available on Internet [9] and has been used by more than 10 universities and institutions in China. More than 30 online courses are hosted by *ebanshu*, serving more than 10,000 users for their daily teaching and learning activities.

3) We conducted extensive evaluations of the *ebanshu* system using the course MATH 7090 in Hong Kong Baptist University, as a case study. The analysis based on the evaluation results indicates that by using the *ebanshu* system, the interactivity in the virtual learning environment can be enhanced significantly.

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The remainder of this paper is organized as follows. In Section II, we explain the architecture of *ebanshu*. A math course is used as an example to show the pedagogy design based on *ebanshu* in Section III. Evaluations and data analysis are presented in Section IV. Finally, we conclude the paper and describe some possible future work in Section V.

II. Architecture and Functions

A. *Design Rationale*

The *ebanshu* system is designed as a web-based blended e-Learning platform, with support of full functions for VLE [11]. In particular, it is capable of supporting the monitoring of learning activities, the recording and delivering of massive online open courses. In *ebanshu*, all participants can freely join a virtual classroom with different types of devices. Two different learning models are supported by *ebanshu*: *synchronous learning* and *asynchronous learning*. *Synchronous learning* refers to the case when both instructors and learners are present in the virtual classroom during the teaching/learning process. For *asynchronous learning*, learners are allowed to study the course anytime without an instructor being online.

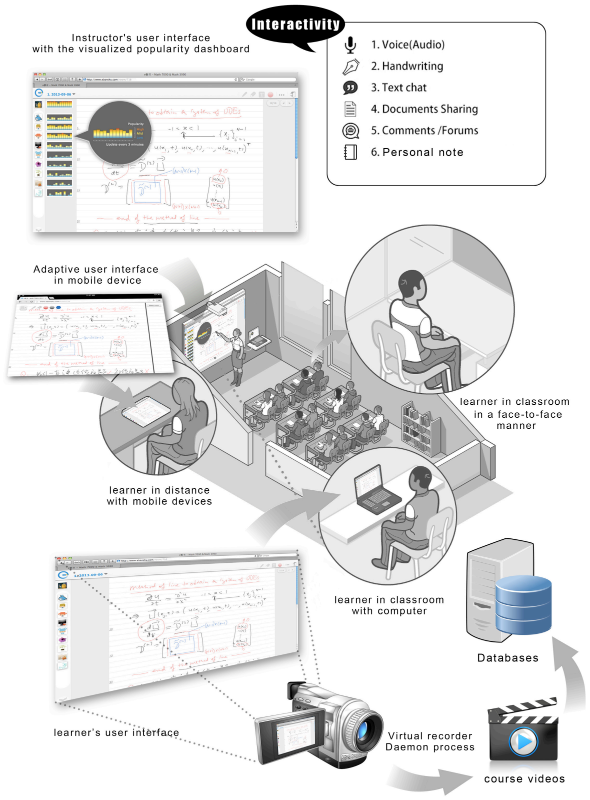

Figure 1. Overview of interactivity-aware blended learning scenario.

The whiteboard is a core module for *ebanshu*. All contents and actions on the whiteboard will be synchronized to all the participants in real-time. During the course, various communication media (e.g., voice, handwriting, text, video) are supported and strongly encouraged. Furthermore, instructors can know learners' real-time learning statuses through a visualized dashboard component. Besides, all the teaching contents and activities took place in the virtual classroom will be automatically recorded and archived in the background to generate course videos for asynchronous learning. A general scenario is depicted in Figure 1.

B. *System Components*

The proposed *ebanshu* architecture, which is described in Figure 2, includes four major components:

1) *Adaptive User Interface (AUI) component*: AUI offers a responsive web user interface adapting to various devices with consideration of the portability and user experience. Instructors and learners can use *ebanshu* simply through web browsers without installing additional application. The flash player embedded in web browser can be used as voice player and recorder. The HTML5 canvas is used to construct and render the whiteboard. The socket.io client can keep real-time connection with the server side and exchange data from time to time.

2) *Teaching & Learning Support Service (TLSS) component*: TLSS consists of the "virtual classroom" unit and the "course management" unit. The "user" module included in the "virtual classroom" unit serves as the attendance recorder and user manager. It also includes a popularity dashboard, which is updated periodically to show the learners' real-time learning statues. The popularity is defined as the frequency of the interactions (including raw Human-Computer interaction and predefined interactivities: Voice, Handwriting, Text chat, Document Sharing, Comments, Personal note) in ebanshu system. The numerical value of popularity ranges from 0 to 100. Learning status is defined as learner's response toward the teaching activities in ebanshu system, which can be quantitatively presented by the popularity. Instructors can adjust his/her teaching activities according to the popularity dashboard, and identify students who are passive and inactive toward the learning activities, and take actions to get them more involved into the virtual classroom [12][13].

The "Interactivity" module included in the "virtual classroom" offers various interactive and collaborative tools. The host of the classroom can communicate with participants in the virtual classroom by the "Voice" tool. There can be up to 5 participants speaking concurrently in classroom. The host can use the "Handwriting" and "Document sharing" tool to conveniently present and share documents in the whiteboard. Participants can communicate with each other through the "text chat" tool. The "Comments" tool is designed for asynchronous interactions, allowing learners can post questions to instructor about the course even if the instructor is absent. By using the "Personal note" tool, learners can note down personalized notes.

The course homepage included in the "Course" unit consists of syllabus, course forum, etc. Once instructor-led learning session completed, lecture videos would automatically generated by the *virtual recorder*, which was watched in the course homepage.

3) *Real-Time Service Cluster (RTSC)*: RTSC serves as the core middleware in the system, which employs the message notification and distributed computing. These technologies enabled the system capacity of high availability and high

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concurrency. RTSC consists of “Socket.io Engine” module, “Document Interpreter” module and “Voice Service” module.

The “Socket.io Engine” module aims to make real-time apps possible in every browser and mobile device, blurring the differences among different transport mechanisms. It utilizes the event-driven and asynchronous model to smoothly handle the high concurrency issue, running websocket protocol and offering the real-time data synchronization service for the system, by which the content and actions in the whiteboard can be synchronized to all participants in real time manner.

The “Document Interpreter” module serves as the powerful web service for archiving and converting uploaded files (e.g., doc, ppt, pdf files) to portable format. It is running as distributed computing clusters with capacity of high availability and high performance.

The “Voice Service” module consists of several media servers running RTMP protocol, which are geographically distributed at different cities and offer reliable voice communication service.

4) *Virtual Recorder*: VR serves as daemon process on the server side, which enables the system support MOOCs. VR can continually record what happened in the virtual classroom. All recorded data will be saved to different data collections in the mongoDB.

MongoDB is an open-source document database, which can offer data storage service with high availability and high performance, we deployed the mongoDB enabling both the “Replica Set” and “Sharding” features, “Replica Set” enabled the mirror access LANs and WANs scale and peace of mind, and the “Sharding” enabled scale horizontally without compromising functionality.

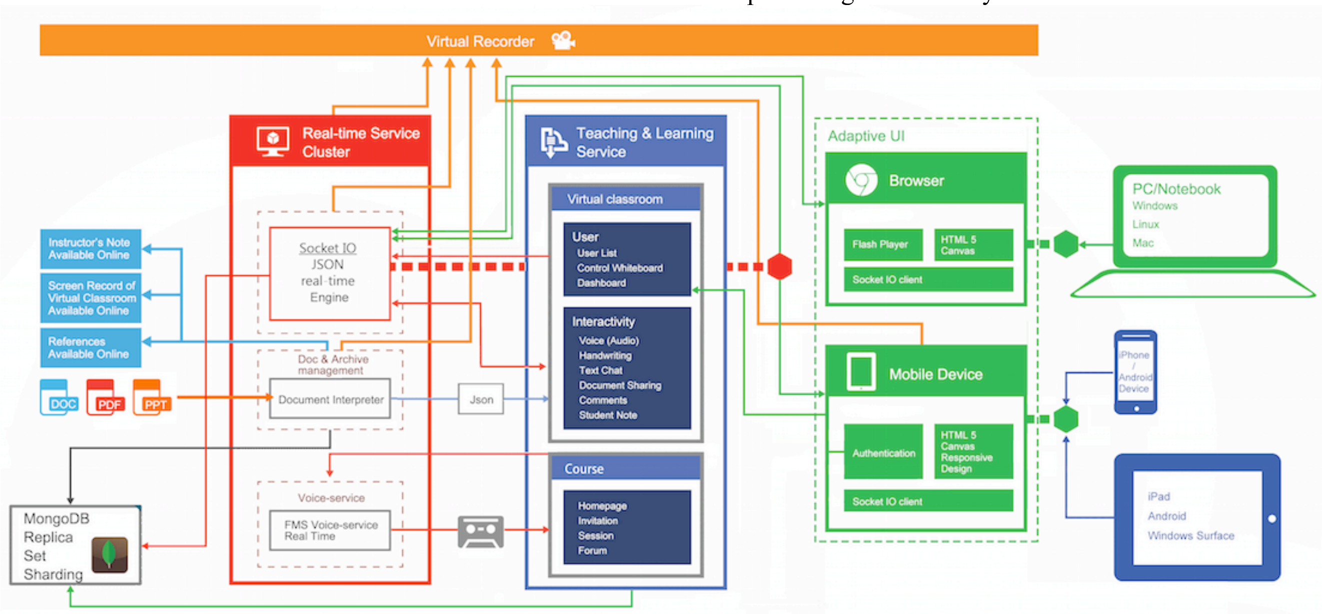

Figure 2. *ebanshu* components architecture.

III. PEDAGOGY DESIGN

In this section, we will take the course MATH7090 - "The high-precision Numeric Calculation" as a case study to show the pedagogy design based on *ebanshu*. MATH7090 is the first online open course offered in Hong Kong Baptist University. Considering the need for both synchronous learning and asynchronous learning, the pedagogical design of the course includes three separate components: Pre-course Learning Activities, Teaching & Learning Activities, and Assessment & Feedback.

A. Pre-course Learning Activities

Generally, instructor-led courses are usually organized by sessions, which can be daily or weekly, depending on the duration of the courses and learners’ available time. The course MATH7090 was delivered to Science students during Semester 2013-2014-1. The course included 12 sessions, each session lasted two hours. 29 students officially enrolled the course. The course was hosted by the *ebanshu* system, and also was open on the Internet. 53 learners subscribed the course in the *ebanshu* system, including the 29 officially enrolled students and 24 Internet learners.

The course syllabus and *ebanshu* system instructions were automatically sent to subscribers by the system. The course syllabus describes the session topics and learning objectives. The instructions explained how to conduct teaching and learning activities.

Prior to the beginning of each session, Teaching Assistants (TAs) uploaded the teaching materials and references to the virtual classroom in the *ebanshu* system. TAs can join the virtual classroom in advance and perform the teaching assistance for the instructor. The instructor could perform the teaching anywhere, as long as the Internet was available (microphone is required). At the beginning of each session, a remainder letter was automatically sent to learners. They can come to the classroom where they can communicate with the instructor in a face-to-face fashion. They can conveniently join the virtual classroom with mobile devices anywhere.

B. *Teaching & Learning Activities*

During each session, there are many teaching and learning activities in the virtual classroom. Teaching activities are usually initiated and conducted synchronously by instructor. Learning activities consist of the synchronous interactive learning with the instructor and learners in the virtual classroom, and the asynchronous learning with less interaction and collaboration.

The *ebanshu* system offers various synchronous communication tools for instructors to conduct ***synchronous teaching***. The instructor can use the real-time voice and whiteboard to present the lectures, Additionally, the handwriting function is very helpful for presenting complicated questions with much descriptions; and the document sharing function usually is used to present documentations and references.

Learners are encouraged to hand up to (an alert message will be sent to instructor's interface) the instructor if they do not understand some teaching materials. Instructor will handle this case, and further communication with learners. Instructor usually much cares about learners' learning statuses during the teaching, which is crucial for learning outcome. The popularity dashboard described in the Figure 3 is a good assistant for instructor. The instructor can accurately know the learners' learning statuses, and intervene with inactive learners, so that the adjustment of the teaching pace can be conducted timely.

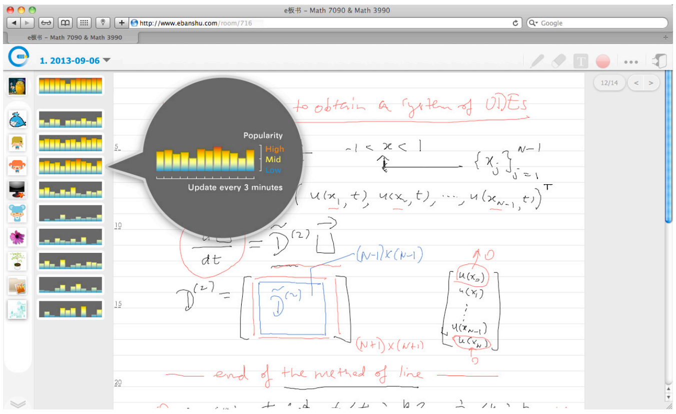

Figure 3. The instructors' user interface with the popularity dashboard.

Each session of the course is composed of a sequence of ***synchronous learning*** activities, which include a range of individual and collaborative activities between instructors and learners.

Learners can view the references and teaching materials, which may include different types of contents, e.g., learning resources (documents and presentations), video and audio contents. They can also take private notes on the whiteboard. Learners' user interface on desktop PC is depicted in Figure 4, and while that on mobile device is depicted in Figure 5. In the virtual classroom, all lectures and materials will be automatically saved and accessible to all participants, which is more convenient and efficient than the traditional classroom learning. Learners can also initiate group discussions and are encouraged to create new virtual classroom for learning proposes. In the background, the system tracks interactivities so that instructors or the TAs can review them afterwards and evaluate learners' involvement and filter out the hard questions in each session.

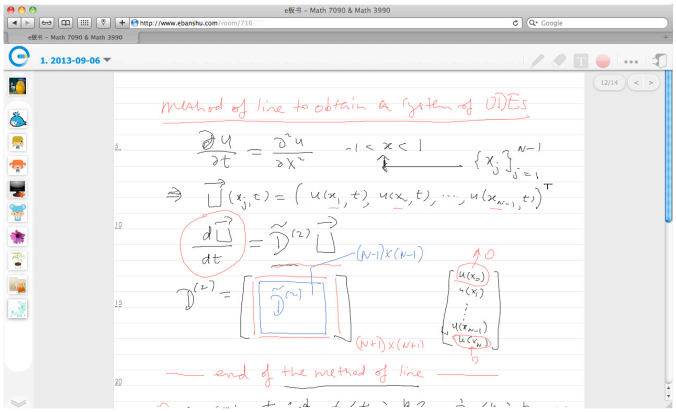

Figure 4. Learners' user interface on desktop PC and laptop.

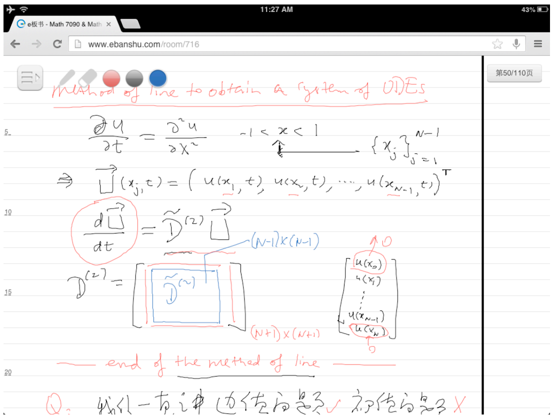

Figure 5. Learners' user interface on mobile device (iPad).

Asynchronous tools are available for learners to conduct ***asynchronous learning***, which includes the assignments requiring detailed response and more time, asynchronous discussions, self study by the learners, who are unavailable for synchronous teaching, and course review. Learners can download the lectures and references, and watch the online course videos, which can be used for self-study and course review. Learners can also leave comments about the course in the instructor's homepage. When the instructor was present, he/she would get the message, allowing to further communication with the learners.

C. *Assessment and Feedback*

In each session, the instructor uploads the assignments in the virtual classroom, which were attached in the whiteboard as separate page. Learners are expected to submit the answer sheets of the assignments in the virtual classroom directly by using uploading function. Finally, the instructor or the TAs can assess the learners' performance and comment on these assignments in the whiteboard. The comments would individually help learners to review the highlighted contents. In order to further enhance the teaching quality through learners' feedback, an evaluation survey was conducted at the last session of the course by utilizing the questionnaires and short talk with learners and instructors. This is a critical component for e-Learning systems since it allows system designers to improve it over time.

IV. IMPACT EVALUATION

A. Evaluation criteria

According to Graham et al. [16], seven principles (including "Instructors should provide clear guidelines for interaction with students", "Well-designed discussion assignments facilitate meaningful cooperation among students", "Students should present course projects", "Instructors need to provide two types of feedback: information feedback and acknowledgment feedback", "Online courses need deadlines", "Challenging tasks, sample cases, and praise for quality work communicate high expectations", "Allowing students to choose project topics incorporates diverse views into online courses") are helpful to significantly improve learning outcomes. Ebanshu can perfectly meet 4 principles (including "Instructors should provide clear guidelines for interaction with students", "Well-designed discussion assignments facilitate meaningful cooperation among students", "Students should present course projects", "Allowing students to choose project topics incorporates diverse views into online courses") out of these principles [9]. Furthermore, studies show that "interactivity" is the most crucial evaluation criteria for e-Learning systems [7][8][16]. In the following, we conduct a comparative analysis of interactivity from four aspects, which includes "Participants' attendance", "Interactivity by instructor", "Interactivity by learners", and "Popularity", "Records" in Figure 7 and Figure 8 are actions in the whiteboard, which will be saved to database and automatically counted for data analysis.

There are kinds of metrics available to evaluate the performance of online courses in the administrative page of the system, aiming to evaluate and analysis "the way to join the course", we focus on four metrics: "*Device used - Mobile*" describes how many learners use mobile device in each session; "*Device used - PC*" counts how many learners use PC in each session; "*Participants - Synchronous*" records how many learners attend the virtual classroom synchronously; "*Participants - Asynchronous*" records how many learners attend the virtual classroom asynchronously.

Interactivities among the participants help to understand how participants react to the teaching. This can be measured through the real-time tracking and statistical analysis of activities of instructors and learners. For instructors, "*Whiteboard - Handwriting*" describes the usage of the whiteboard-based handwriting tool in each session; "*Whiteboard - Document Sharing*" – describes the usage of the whiteboard-based document sharing. For learners, "*Notes*" records the learners' private note in each session, "*Hands up*" records the learners' handing up during the synchronous virtual classroom in each session, "*Comments*" records the learners' comments on the course in each session, and "*Text chat*" describes the learners' text communication in each session. "Popularity of instructor" will be used to track the change of the average value of the popularity index in each session; "popularity of learner" will be used to track the change of the average value of the popularity index of all the learners in each session.

B. Data Analysis

The following figures show the collaboration and interactivity throughout all the 12 sessions of the course.

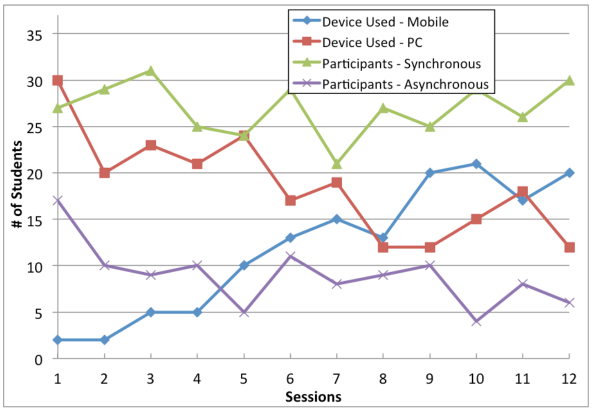

Figure 6. Participants' attendance in virtual classroom throughout the course.

Figure 6 shows that the learners prefer to attend the course by mobile device instead of PC in the end of the course. The instructor should prepare the teaching materials with extra consideration of document size. Most of synchronous participants attended all the 12 session, while asynchronous participants did not attend all sessions. The main reason is probably due to the feeling of being isolated.

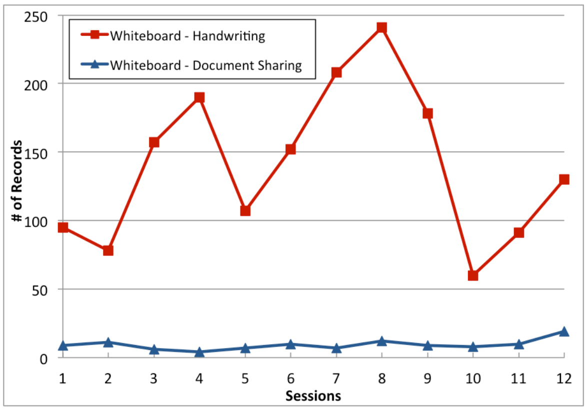

Figure 7. Interactivity by instructors in the virtual classroom in each session.

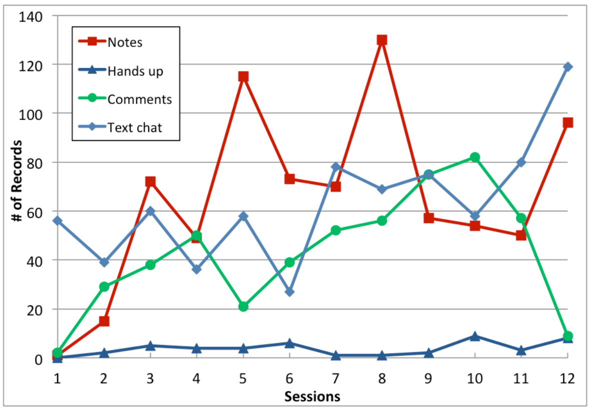

Figure 8. Interactivities by learners in the virtual classroom in each session.

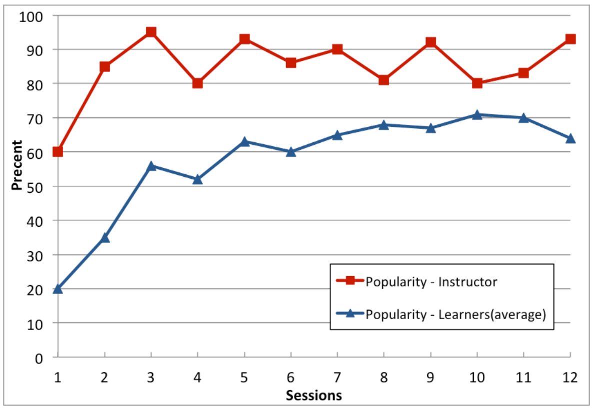

Figure 9. Popularity observation in the virtual classroom throughout the course.

Figure 7 shows that the instructor preferred using the handwriting to deliver teaching, which is very helpful to explain complicated problems. The handwriting is heavily used in Session 8, which is about the "Temporal discretization and FFT" and includes lots of mathematical formulae. The same observation is also found in Figure 6 for the activities of "Note". Figure 8 also shows that note is the most popular tool for learners, followed by text chat, comments, and "hands up". The text chat tool is frequently used and gets the highest record in the last session, which included the course review. In the last session, learners preferred to ask questions by the text chat instead of the "hands up" tool, and the instructor should adjust the pedagogical design to pay more attention to observe the contents of text chat.

Red curve in Figure 9 describes the change of the mean value of instructor's popularity throughout each session, and blue curve describes the change of the mean value of all the learners' popularity throughout each session. Figure 9 shows that the popularity of the instructor was always at a high level throughout the course. The popularity of learners increased over time, which indicates that if the instructor can accurately monitor learners' learning statuses, it is more likely to keep learners in active learning.

V. CONCLUSION AND FUTURE WORK

In this paper, a novel web-based e-earning system - ebanshu was presented. By providing real-time response and supporting mobile devices, *ebanshu* can help facilitate the activities of teaching and learning, improving the teaching efficiency and learning outcomes. In particular, *ebanshu* provides a real-time visualized popularity dashboard for instructors to monitor the learners' statuses in the virtual classroom. The system can also automatically record the instructor-led courses in the background and generate the courses learning materials for asynchronous learning. With *ebanshu*, courses can be easily delivered and made available online as the MOOC, benefiting many off-campus learners out of campus. We have also explored the pedagogical design with the novel e-Learning system and statistically evaluated the impact to the course MATH7090 at Hong Kong Baptist University. The ebanshu has been successfully used in more than 10 universities (including Peking University, Zhejiang University, and Jilin University), hosting more than 30 online courses, and offered teaching/learning service for more than 10,000 users.

The *ebanshu* apps for iOS and Android are under development, which will make offline asynchronous functions available in the future. With the rich performance data and user feedbacks obtained from many universities, the analysis based on the feedback will be an important work in future.

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