The Hong Kong Polytechnic University
Department of Computing
COMP4912 — Capstone Project II

Computer-Supported Collaborative Learning in Mass Lectures

Final Report

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ABSTRACT

The increasingly popular trend of collaborative learning prompted a change in the way Higher Education Institutions (HEIs) to deliver courses and knowledge. However, there are still a great number of challenges that educators have to encounter to promote the new means of teaching and learning in classroom.

On the other hand, affordability of technology increase learners' use of them in routine life. In developed societies like Hong Kong, almost everybody own at least one device that connected them with the Internet. The observed phenomenon created an enormous opportunities in supporting the change in teaching and learning from a teacher-oriented approach to a student-oriented one.

To mitigate some of the challenges of engaging student in collaborative learning, the current project proposed a solution to foster interactions and collaborations between students-students and students-instructors. The solution incorporates a real-time question raising system with a handful of periphery features to deliver a social-network-like interaction experience. It is believed that the interactivity in mass lectures can be enhanced. With the help of the proposed solution, instructors shall also be able to receive important feedback towards their teaching activities, thus are able to adapt better to the need of students.

A preliminary research was carried out to current university students for evaluation the validity of the proposed ideas. In general, positive attitudes are recorded. Respondents indicated that they would be motivated to interact and collaborate in mass lectures with support from the proposed solution.

Keywords: Collaborative Learning, Computer-supported Collaborative Learning, Engagement, Motivation, Higher Education, Mass Lectures, Real-time Communications

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1. INTRODUCTION

1.1. Overview

Traditionally, passive learning is identified as the most economical and efficient way to deliver knowledge from content expert to learners in the higher education sector (Sikarwar, 2015). However, this long-established teacher-oriented model has been disrupted by the introduction of student-oriented models recently. In particular, researchers and instructors looked into **Collaborative Learning** in attempt to improve learners engagement in learning activities. By definition, collaborative learning is ***a process where 2 or more learners interact actively and contribute constructively to complete an assigned task and ultimately, achieve a shared learning goal*** (Pluta, Richards, & Mutnick, 2013). Yet, developing a collaborative learning classroom environment is a difficult task. Desirable outcome may not be achieved regardless of the effort invested (Nokes-Malach, Richey, & Gadgil, 2015).

Innovative technological advancements during recent years created more opportunities for the above-mentioned shift of the knowledge transfer process. For instance, introduction of touch-enabled human-computer interface provided a more intuitive way for us to interact with our devices (Fisher, Lucas, & Galstyan, 2013). The technology makes computers evolve from a medium to deliver learning materials to a platform for students to interact with their peers (Liu, Chung, Chen, & Liu, 2009). In addition, the transition is furtherer motivated by the increasing affordability and penetration of mobile devices and laptop computers, particularly in developed economies. For example, in the United States and Hong Kong, the penetration rate reach over 85% (The Nielsen Company, 2014-05-09) and 88.8% (H.K.F.Y.G. Youth Research Centre, 2014) respectively. Undoubtedly, students no longer face barrier in accessing the technology. Hence, computers and mobile devices become the universal medium for students to carry out meaningful interactions and collaborations, creating great

opportunities to develop, implement, and promote a successful Computer-Supported Collaborative Learning environment.

1.2. Motivation

Observations conducted in classes of Computer Science and Business Administration disciplines revealed that **majority of courses are delivered in a traditional Passive Learning approach**. Throughout the class time, lecturers sometimes packed so much information and knowledge to deliver, and students often hesitated to interrupt the class, such that students are **hindered from raising questions** when they are having difficulties during the class. On the other hand, as learners perceived that length teacher-oriented lectures being length and boring, they often **distracted from the class activities** and instead focused or multi-tasking on irrelevant materials, such as browsing Facebook, Instagram, and other online social media. The distraction causes these learners to fall behind on progress, or even negatively influencing their peers when they need explanation to the missed concepts. In general, such phenomenon prohibited learners from learning efficiently, while also contrasted from the definition of “Learning”.

According to Dolmens, et al. (2005), “Learning” can be defined as “a collaborative, constructive, contextual, and self-directed process”. Addressing the observed concerns, instructors are starting to integrate collaborative learning activities into class agenda. Typical attempts include studying real-world uses in jig-saw classroom settings and participating in cooperative tasks. Nevertheless, the result was not always desirable in terms of promoting engagement, interactions, and collaborations. However, as the teaching and learning community have greater acceptance in computer-supported learning applications nowadays, **it is believed that the barriers to collaborative learning could be resolved with adequate use of technology**.

1.3. Problem Statement

The discussed observations can be translated into 3 problems that needed to be resolved for learners and teachers. They are listed and described as the followings:

P1: Learners unable to seek assistance

Learners ofter found themselves unable to raise their questions in front of the large class. This is sometimes a consequence of **time constraints** during the mass lecture (Sikarwar, 2015). Teachers prepared too many materials and unable to leave time for a Q&A session. Apart from that, numerous challenges, for example **cultural difference** (Barros-Castro, Cordoba-Pachon, & Pinzon-Alcedo, 2014), **language proficiency** (Cohen, 1994), and **past achievement level** (Webb & Palincsar, 2014), would lead to such phenomenon. Yet, in such circumstances, students prevented themselves from learning more efficiently and generating better understanding on the concerned subjects. They may need to spend additional efforts to revise the concerned subject matter.

P2: Lack of collaboration between learners within large class

As learners are unable or unwilling to raise their questions regarding different subject matters, they **reduced opportunities of engaging in collaborative tasks** for their peers, such as offering assistance to each others in form of discussion, debating, and explanation. The restrictions in high cognitive order tasks prohibited the chances for students to exchange ideas and creativity (Collins, 2016), to improve their communication and interpersonal skills (Jones & Hosein, 2010), and to develop their sense of learning responsibilities (Lawrie et al., 2014). Potential achievement of learners regarding the discipline might also be undermined in such circumstances.

P3: Teachers unable to receive feedbacks

Being unable or unwilling to raise their concerns during class time, learners do not just impeded themselves from having better learning experience, but also prohibiting instructors to receive timely feedbacks regarding their teaching. Consequently, teachers need to rely on their experience, or even be unable, to make correct judgements on the learning progress of students. As they assumed the progress inaccurately, the **teaching and learning activities will be ineffectively designed and carried out** (Capdefeno & Romero, 2012). As a result, insufficient class time might be allocated in explaining and discussing a relatively complex concept, while excessive time is assigned to clarify a relatively simple topic. It may lead to **undermining of learners' potential achievement** regarding the subject matter, under such circumstances.

1.4. Objectives

With regard to the problem stated above, the current project is aimed at **Create a Computer-Supported Collaborative Learning Application that Stimulate Learners' Engagement in Large Class Settings**. To achieve the goal, the following sub-goals are proposed:

O1: Encourage Student-initiated Student-Teacher Interactions

Regarding problem P1 and P3 discussed in Part 1.3, with a computer-supported collaborative learning application, it is hypotheses that barriers prohibiting learners to speak up in class are mitigated. Thus, learners would be motivated to initiate interactions with their instructors, mainly in form of **raising questions**. Consequently, instructors can **offer assistance**, for example answering the raised concerns, to learners. In addition, they could also interpret these interactions as **feedback of their teaching activities**.

O2: Encourage Peer Interactions within a large class

Regarding problem P1 and P2 discussed in Part 1.3, as students initiate interactions with their instructors, instructors may delegate the responsibilities of answering to learners, thus helping students to initiate interactions and **encouraging collaborations between learners** through discussion activities. Students with questions or concerns may also **receive the necessary assistance** from their peers.

1.5. Expected Outcomes

The proposed Computer-Supported Collaborative Learning Application is expected to influence both teachers and students positively. A solution should be proposed to deliver the following values:

(a) Instant Collection of Questions

***Students raise questions without interrupting the* class**

Students can raise their questions or concerns to the system instantly in class, whenever they encountered difficulties in understanding a subject matter. Instructors do not need to respond immediately: They read and respond to questions when they feel appropriated to.

Anonymous postings

A typical scenario in lecture might be **no one raising their hands during Q&A sessions**. Students often shy or nervous when they have a question regarding the subject matter. Anonymous postings would lower the barrier for them to speak among a large class.

Unlimited number of questions

Another common scenario observed in lectures is that **overwhelming hands raised during Q&A sessions**. Actual number of questions addressed in class time have always been limited by the amount of available time. Students often unable to raise their questions after the lecture. The proposed system allow all students to raise **all** their questions and instructors may address some of them after class.

(b) Social-media-like Experience

Contributing in ideation

Instructor may start **a multiple-choice or an open-ended poll**. Students contribute their instant thoughts to a concerned subject matter. The collected ideas will be presented as a collaborative artifact.

For Students: Showing interests to questions

Like the Facebook "Like" mechanism, students who have similar queries may **"Upvote"** the respective question to show their interests in it, while those who have confidence in solving questions of their peers could **"Raise Hand"** to the question.

For Instructors: Prioritising questions to be addressed

In a typical lecture, it is difficult for lecturer to confirm that every part of their sharing is well received by audience. With students demonstrating their interests through upvoting, instructors can **identify and address the more popular enquired subject matter** in-class.

(c) Decision-making for Instructors

More relevant course activities

The proposed system let students to raise and demonstrate their interests. Instructors can make use of such information to start and engage learners in

further discussion. Through learners-learners interactions, deeper reflection and learning on the matter can be achieved.

Future course design

Information collected instantly may be a useful source of feedback to improve teaching and learning experience for future students in future semesters. For instance, course material and time allocation can be better managed to deliver more effective lectures.

2. LITERATURE REVIEW

2.1. Collaborative Learning

2.1.1. Overview of Collaborative Learning

The introduction of collaborative learning have led to a disruption to the traditional passive teaching and learning methods. As discussed in Section 1.1., **Collaborative Learning** is often defined as ***a process where 2 or more learners interact actively and contribute constructively to complete a task and ultimately, achieve a shared learning goal*** (Pluta, Richards, & Mutnick, 2013).

Previous research (Johnson, Johnson, & Smith, 1991; Pluta et al., 2013; Springer, Stanne, & Donovan, 1999) on undergraduate students pointed out that collaborative learning could lead to a number of benefits, including:

- Achieve better academic achievement;
- Achieve higher order learning goals;
- Develop favourable attitude towards a discipline;
- Develop higher persistent through course;
- Demonstrate greater self-esteem;
- Enhance team skills;
- Enhance interpersonal relationships;

On the other hand, despite the term “Collaborative Learning” is commonly associated with other phrases like “Team-based Learning” or “Corporative Learning” (Pluta et al., 2013), it is important to distinguish Collaborative Learning from these associated terms. Specifically, to achieve the desired outcome of collaboration, ***purposeful engagement towards the shared learning goals must be occurred*** (Blumenfield, Marx, Sikiwatm, & Kraiclk, 1996; Dillenbourberg, 1999; Chi, 2012). In other words, collaborative learning should not just be

assigning a group task and let students break it into sub-tasks for each group members to complete; It is also not just about having students with higher ability or being the knowledge expert in the group to complete the work for other members. A collaborative learning group should carry out substantial dialogue where students discusses different perspective of a concerned topic, articulate and defend their ideas, and co-create new knowledge regarding the issue.

2.1.2. Group Size and Collaborative Learning

Another characteristics that commonly associated with the collaborative learning discipline is small group learning. Researches had discovered that the small group settings, typically composed of 3 to 8 learners, provide a favourable condition for learners to carry out the meaningful interactions with their peers efficiently and effectively (Pluta et al., 2013; Monteiro & Morrison, 2014).

However, with emerging technology in the education sector, there are greater opportunities for learners to collaborate with the whole class and even learners from other classes. Considering such possibilities, collaboration shall be classified into 3 types, namely (i) between members of **small study group**, (ii) between peers in **large class**, and (iii) between members of **learning community**. Table 1. describe the characteristics of each type and list examples of collaborations.

In the current project, the main type that is concerned will be the **collaboration between learners in a large class**. The proposed solution will be designed with the specific type of collaboration as first priority.

Collaboration Type	Characteristics	Examples
Small Group	• Divided from larger class	• Joint tasks • Brainstorming Map
Large Class	• Entire mass class as a collaborating group	• In-class discussions • Online asynchronous discussions (Kim & Shaw, 2014) • Online wiki (Kafai & Peppler, 2011)
Learning Community	• All learners of a course • **Previous**, **Current**, and **Future**	• Make content generated by **previous** students accessible to community • Allow **current** students to gain insights from previous content • **Current** students generate new understandings and ideas through other type of collaboration

Table 1. Characteristics of 3 types of collaboration

2.1.3. Challenges in Promoting Collaborative Learning

Despite the fact that a collaborative learning environment could lead to positive impacts in teaching and learning, there are various challenges in creating such learning environment. They will be discussed in the remaining parts of this section.

(i) Time Constraint in Teaching

According to Sikarwar (2015), classes in mass lecture mode face a significant challenges of time constraint in adopting collaboration activities. In a typical lecture, instructors have to deliver the relevant course content so that learners can establish understanding to the topic. It is not rare that some lecturer could only just finish their speaking within class time. In such scenario, learners have **little opportunities to inquiry** the lecturer about the course content, **or to complete collaborative tasks** in class.

(ii) Class Activities Design

Even though instructors have the time to embed collaborative learning activities during lectures, **investment of extensive efforts are required** to design the suitable activities that create opportunities for student-student or student-teacher interactions. The investment often do not materialise. **Low degree of engagement** is often observed as the topic chosen for such activities might not interests learners; **Low learning effectiveness** may also be observed as learners fail to align learning activities with learning objectives.

2.2. Engagement and Motivation

2.2.1. Overview of Engagement

Chi and Wylie (2014) defined **Engagement** as ***"the way student engage cognitively with the learning materials, in the context of the assigned learning task, as reflected from the overt behaviour students exhibit while undertaking the activity"***.

Using behaviour as a indication, the researchers proposed the ICAP framework with 4 modes of engagement behaviour during learning, namely: (i) **Passive** mode; (ii) **Active** mode; (iii) **Constructive** mode; and (iv) **Interactive** mode. Each mode of engagement also inherit the characteristics of the its lower counterparts. For example, to attain the active mode, a learner would first get through the passive mode of engagement.

The characteristics of each mode and respective exemplar behaviour are described in Table 2..

Mode of Engagement	Characteristics	Examples
Passive	• Learners receive and remember knowledge from experts.	• Listening in lectures
Active	• Learners extract important information and manipulate knowledge	• Highlighting important points
Constructive	• Learners generate knowledge by integrating new information with existing knowledge	• Jotting notes • Create explanation using own words
Interactive	• Interact with other learners • Exchange understandings • Co-construct new ideas • Achieve shared learning goals	• Answer each others' inquiry on the concerned topic • Debate a controversial issue

Table 2. Characteristics of 4 modes of engagement

2.2.2. Overview of Motivation

Cognitive engagement of learners are influenced by various interdependent motivational factors (Blumenfeld, Kempler, & Krajcik, 2006), including: (i) **Intrinsic Value**; (ii) **Instrumental Value**; (iii) **Attainment Value**; (iv) **Sense of Competence**; (v) **Sense of Relatedness**; and (vi) **Sense of Autonomy**.

Motivational factors are determined based on ***classroom context***, ***teaching activities or mechanisms***, and ***individual background***. Furtherer noted by researches, motivation is an iterative process where influence are accumulated and thus make greater difference in motivation.

The characteristics of each factors and respective exemplar influencer are described in Table 3..

Motivational Factors	Characteristics	Examples of Influencer
Intrinsic Value	• Interests of learners toward the concerned topic	• Personal interests • Enjoyment in learning activities
Instrumental Value	• Perception of learners towards the concerned topic and daily life	• Examples applied in explanation of complicated concepts
Attainment Value	• Perception of learners towards the concerned topic and future life	• Ideal occupation of learners
Sense of Competence	• Confidence of learners to complete a given task using their own ability	• Recognition • Feedback • Past experience
Sense of Relatedness	• Sense of belongings with the study group / class	• Mutual respect between students • Opportunities of cooperating or collaborating (Cohen, 1994)
Sense of Autonomy	• Perception of agency of learners	• Ability to make a choice • Opportunities in decision-making

Table 3. Characteristics of 6 motivational factors

2.2.3. Challenges in Motivating Engagement

Stimulating students' motivation to engage in learning had been an important research topic for educators since the past decades. Over the years, researchers identified a number of challenges in enhancing motivation, they are discussed in the remaining parts of this section.

(i) Low Sense of Competence

Low sense of competence often serve as a virtual barrier of engagement. There are numerous potential explanation for such observed phenomenon. For instance, students often do not learn in their first language. **Low language proficiency** may affect learners' confidence in elaborating their thoughts using the required language (Lee, 2003), thus reduce the motivation of them to make interaction during class. In addition, **past achievement level** could also similarly contributed to sense of competence. When a learner do not earn good grade previously, the sense of competence dropped, causing them to have low motivation to engage in learning activities.

(ii) Low Sense of Autonomy

Another barrier that often prohibit learners from interacting with others in class is low sense of autonomy. Possible explanation to such observed phenomenon include **different cultural or educational background** (Bluemenfeld et al., 2006). For instance, Asian cultures generally do not support learners to interrupt and question the authority. Instead, they tend to follow instructions issued by instructors, even if they do not make sense sometimes.

(iii) Low Sense of Relatedness

Low sense of relatedness is often associated with scenario where students fail to find a mean to interact with others in a classroom (Bluemenfeld et al., 2006). For instance, When learners found themselves disconnected with others, they felt a lesser responsibility to engage and to reach a shared learning goal by collaborating. In some cases, low sense of relatedness is often causes by similar reasons stated in **(i)** and **(ii)** of this section. Low language proficiency, past achievement level, difference in cultural and educational background make learners unable to feel the need to relate with other learners in a class.

2.3. Collaborative Learning and Engagement

Collaborative learning activities created opportunities for teachers to produce positive influence on students' motivation on learning (Cohen, 1994).

First of all, collaborative learning emphasise in students explaining, clarifying their own understanding in the subject matter, critiquing others' ideas, and debating between understandings and ideas. This emphasis generally requires higher degree of cognitive engagement in nature (Yackel, Cobb, & Wood, 1991; Liu, Liang, Wang, Chan, & Wei, 2003). Some researches also found out that these tasks contributed in developing better attitude such as being attentive and participative in class time (Haseman, Polatoglu, & Ramamurthy, 2002).

Secondly, the collaborative learning activities mitigate bad feelings regarding the motivational factors. For instance, a group formation composed of learners of different academic achievement level often helps in promoting higher competency (Hickey, 1997); The assignment of joint tasks give learners a shared goal to attain, thus improving the relatedness of the learner to the corresponding study group (Wentzel, 1997; Palincsar, 1998); A well-designed collaborative task would sometimes also demonstrate the social value of a concept to learners, thus uncovering the instrumental value of the subject matter to learners (Hickey, 1997).

Combining different influences, learners often generate interests to the concerned discipline with their higher degree of engagement, giving them the sense of intrinsic value. It also lead to the iterative processes where they became more actively interacting with their peers and contribute their strengths to the group, furtherer improving the feeling of competence and relatedness (Holbrook, & Kolodner, 2000).

2.4. Computer-supported Collaborative Learning

2.4.1. Overview of Computer-supported Collaborative Learning

Addressing the challenges on facilitating collaborative learning in classroom environment, the **Computer-supported Collaborative Learning** discipline has been an increasingly popular area for researchers to work on. With adequate usage of technology, collaboration in both face-to-face and distant settings is supported (Jeong & Hmelo-Silver, 2010). In face-to-face settings, learners typically communicate and collaborate **around** computers. The computer become a focus of interaction in such scenario, where learners discuss the material displayed on the device (Lehtinen, Hakkarainen, Lipponen, Rahikainen, & Muukkonen, 1999; Fisher et al., 2013). On the other hand, in distant settings, learners collaborate **through** computers. The devices act as the medium of communication and interaction, for example learners collaborate in creating the artifact (Lehtinen et al, 1999).

2.4.2. Seven Affordance of Computer-Supported Collaborative Learning

In a recent research, Jeong and Hmelo-Silver (2016), proposed a framework of 7 core affordances, where collaborative learning can be support with adequate use of technology. These affordances include:

(1) **Engage in Joint Task;**
(2) **Communication;**
(3) **Sharing Resources;**
(4) **Engage in Productive Processes;**
(5) **Engage in Co-construction;**
(6) **Monitoring and Regulation;** and
(7) **Finding and Building Groups and Communities.**

Table 4. describes possible resolution to the challenges discussed in Section 2.1. and 2.2., with the affordance of computer-supported collaborative learning.

Challenges	Affordance	Description / Examples
Time Constraint in Teaching	(2) Communication	• Communicate outside class time
Class Activities Design	(1) Engage in Joint Task	Examples: • Multimedia product (Peters & Slotta, 2010) • Scenario simulations (Pifarre & Staarman, 2011)
	(4) Engage in Productive Process	• Structure tasks to align with learning objectives • Ensure students understand the expectation (Rummel & Spada, 2005) Examples: • Scripted instructions
	(6) Monitoring and Regulation	Monitor: • Planning of tasks • Participation within group • Discussion within group • Learners' interpretation of materials • Feedback for improvement of teaching activities (Capdeferro & Romero, 2012) • To provide learners with timely feedback
Low Sense of Competence	(2) Communication	In less synchronous environment: • Draft / elaborate ideas, understandings, questions before express publicly
Low Sense of Relatedness	(5) Engage in Co-construction	• Establish shared goal

Challenges	Affordance	Description / Examples
Low Sense of Autonomy	(2) Communication	Removal of social context: • Tone of voice • Emotional expression

Table 4. Resolving challenges with affordance of computer-supported collaborative learning

2.5. Existing Interactions within Class

2.5.1. Existing Interactions within Large Class

Although it is observed that limited interactions are conducted within the whole class settings, such kind of interactions have been promoted in different ways in current classes. For instance, as a component of collaborative learning, the small study groups in a class are required to conduct **Peer Evaluations** on their peers work. Other than that, online Learning Management Systems also provided features such as the **Knowledge Forum** for students to initiate interactions with their peers ubiquitously.

Peer Evaluations

As Collaborative Learning became increasingly popular in the tertiary education sector, instructors are discovering ways to foster more interaction within the class. Peer Evaluations is one of these methods. It is usually implemented as a part of the group task. A small study group is required to attend, listen, evaluate, and critique the project presentation given by other study groups, in addition to completing their own project (Lawrie et al., 2014).

Currently, similar to the experience of delivering a lecture, the presenters only receive questions to their project work at the end of the presentation. The Q&A sessions are often being shortened due to **limited class time**. Some audience

may not be able to raise their questions to the presents. At the same time, introverted learners **lack motivation to proactively raise their questions**. In addition, these Q&A is made verbally during the class. In most cases, the **dialogue could not be sustained** and the chance to a meaningful discussion is prohibited. All in all, the opportunity for learners, especially the presenters, to gain insights in how to improve their work is limited under the existing interaction.

Online Knowledge Forum

In the past decade, a number of Learning Management Systems had been developed and implemented in tertiary education sector. These systems provided numerous ways for instructors and learners to carry out interactions among the entire class. One most significant example is Knowledge Forum, where learners conduct asynchronous communication online. It is introduced to most of the major Learning Management Systems, including the Blackboard Learn, Canvas, and Moodle.

Despite the existence and promotion of the feature, it is observed that there are very **little usage** on the Knowledge Forum. There could be several possible explanation to the observed phenomenon. Firstly, taking the “Discussion Board” feature on the Blackboard Learn as an example, **instructors need to spend effort** to design guidelines and set up the discussion board before the course commerce. Secondly, **user interface is unattractive and complicated**, on both instructors’ and students’ portal. According to Barros-Castro, Cordoba-Pachoni and Pinzon-Salcedo (2013), simple and intuitive user interface can exaggerate the effect of a computer tool on learners engagement. Finally, the **discussions are registered**. Learners can view the name of contributors of corresponding post. Such design may not be able to overcome the factors hindering learners to raise questions, such as past achievement level, as discussed previously.

2.5.2. Existing Interactions within Small Groups

From the discussions in previous sections, it is observed that interactions between learners mainly carried out within the corresponding small study groups. In the process of carrying out collaborative tasks, students apply a number of methods to facilitate the interaction between each others. Apart from face-to-face communication, they often discuss the subject matter using different **online instant messengers**, such as Whatsapp or Telegram. Regarding the joint tasks, students often use **online collaboration software**, for example Padlet and Google Apps for Work.

Online instant messengers

The increasing penetration of smartphones and other mobile devices enlarged the market for instant messengers. Nowadays, we have lots of different options. Among them, Researches pointed out that Whatsapp and Facebook Messenger are the most popular ones in Hong Kong (Go Globe, 2015). These applications provided platforms for students to make communication, especially outside classrooms, more instantly and conveniently.

However, when students are communicating about their collaborative tasks on these applications, they often being **distracted** when dialogue on off-task issues are initiated. Such discourse often overwhelmed the original discussions. The mixture of content made members of the group **difficult to trace previous useful conversation**. In particular, members may spend time on briefing the discussion again to those who missed the instant discussion. Such observed phenomenon may hinder the efficiency of a study group.

2.5.3. Existing Interactions within Learning Community

As discussed previously, limited opportunities are provided for learners to interact with their peers in the learning community, outside the respective classes and study groups. However, different orientation programmes provided channels for learners to develop and **interact in their personal social network**. From time to time, they acquire the relevant learning resources from their seniors.

Interactions within personal social network

In order to help new students to adapt to the new environment, orientation programmes are hosted by the institution, faculty, department, and even student organisations. These activities provided platforms for students to establish connections with their seniors. When learners obtained insufficient support from their instructors, many of them turned into their seniors to obtain the relevant resources from their seniors. These resources often include the solution, or previous assignments and project works.

The observed interactions between learners may not be optimal in teachers' perspectives. Equipped with these resources, learners often complete their individual assignments or collaborative tasks by simply **copying**, **imitating**, or **paraphrasing** the resources. They prevented themselves from engaging in higher cognitive order tasks, such as elaborating the material they read and generating deep understandings in concepts (Handley & Williams, 2011). On the other hand, even though learners aimed at elaborating the resources and apply them into their own work, the previous exemplars learners obtained from their seniors may be **unreliable or inappropriate**. Learners may develop incorrect knowledge on the concerned disciplines. All in all, such ways of accomplishing the course requirement may not be aligned with the learning objectives and the expectation of teachers, as the teachers have little control on the information learners received.

2.6. Related Work

2.6.1. Padlet

As the Internet technology advanced and penetrated in our lives, online collaboration had became possible. There are increasing number of online software where users can facilitate collaboration between each others. **Padlet** is one of them. It is an opened online platform that allows users to share different type of resources and work collaboratively on an artifact. Adapting it to the teaching and learning process, learners can invite their peers, or even their teachers, to post their ideas on the "Padlet" such that they can read, consider, improve, or critique others ideas. It could be viewed as a free-form and real-time wiki on a concerned topic that instructors and teachers contributed in (Padlet, 2015).

As an opened platform, Padlet provide easy-to-access solution compared to different Learning Management Systems. However, to teachers and students, the data and information on the platform may seems **lack of organization**. For instance, if different courses uses the Padlet platform at the same time, learners may have an unorganised "dashboard" on the platform. The chaotic layout may causes collaborators to spend unneeded time in finding the correct Padlet to collaborate (Figure 1), and also decrease their motivation in collaborating. In addition, learners may not grant instructors' access to their own Padlet as well, preventing instructors in providing constructive feedback and scripted instructions in the group work.

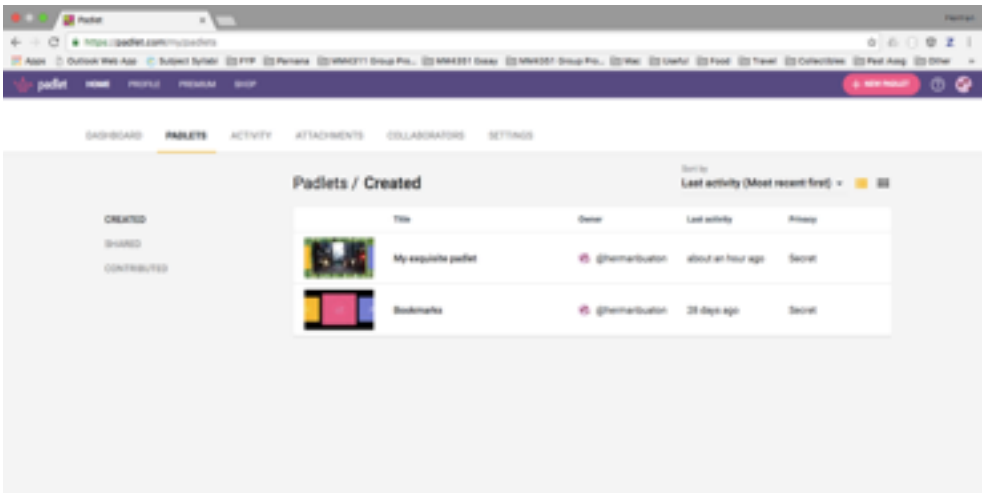

Figure 1. Screen capture of Padlet "Dashboard"

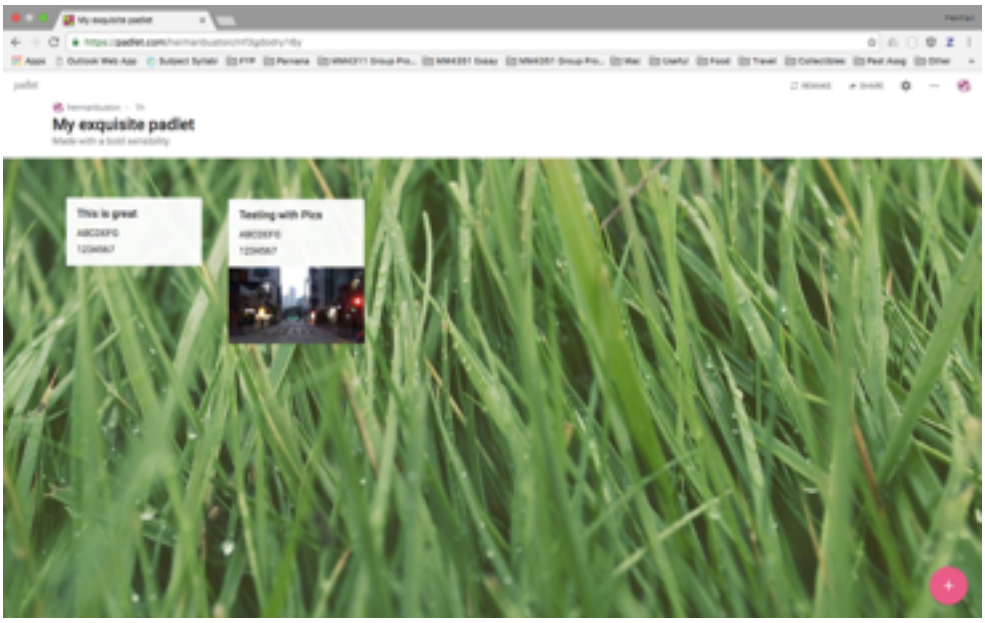

Figure 2. Sample "Padlet"

2.6.2. Blackboard Collaborate

Blackboard Collaborate is an extension of the popular Learning Management System (LMS), Blackboard. The application provides teachers and students an online learning environment where classes can be delivered and learners can collaborated, regardless of the geographical location one lives. The Blackboard Collaborate offers a wide variety of features, **through web browsers**, to facilitate the teaching and learning processes (Blackboard, Inc., 2016). Some main features includes:

(a) Video Conferencing *and* ***Interactive Whiteboard***

Video conferencing is the main method for instructors to deliver their teaching and transfer knowledge to students. During the "conference", instructors will also present the material on the ***Interactive Whiteboard***. A notable point on the features is that the video conference can be captured and stored for learners' access after the "live" class time. It allows learners to review the lecture if they missed the live classes or if they feel they have not receive the knowledge properly during the live classes.

(b) Classroom Chatter

The ***Classroom Chatter*** feature allows teachers to promote participation in classes by letting students to exchange understandings and ideas with other participants during "live" classes. The chatroom is compatible with "emoji", which allows students to communicate more informally but express themselves more accurately. To avoid students misusing the feature, instructors can turn off the chat temporarily if discussion is not appropriate in certain class activities.

Figure 3. Screen capture of Blackboard Collaborate.

The default user interface with the **Interactive Whiteboard** that shall present the lecture material on the left side of the screen, and the **Classroom Chatter** on the right side of the screen for real-time interactions.

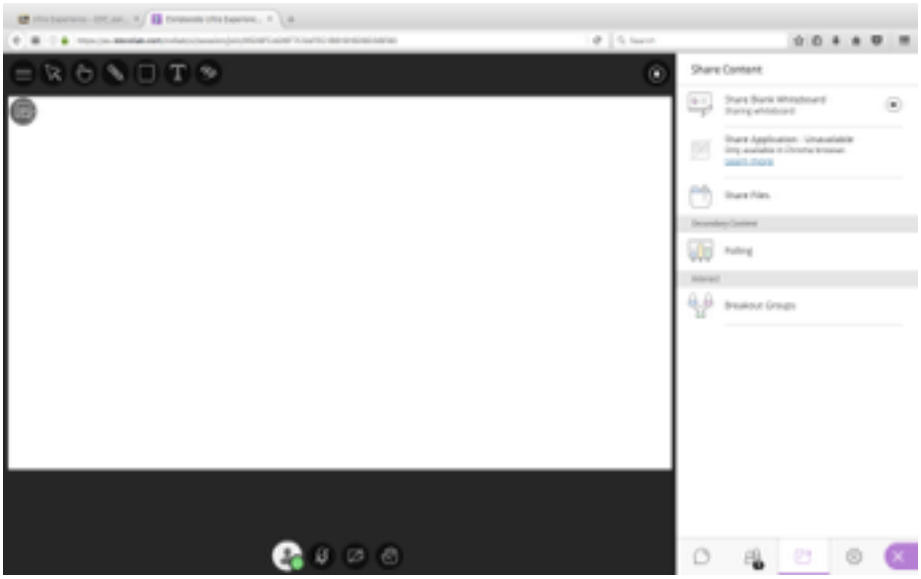

Figure 4. Screen capture of Blackboard Collaborate.

The user interface for resource sharing, learners may selected to draw understandings and ideas on the **Interactive Whiteboard**, or upload any type of **files**, or sharing their desktop screen using the **AppSharing** feature.

(c) Raise Your Hand

The ***Raise Your Hand*** feature enables learners to post questions during the "live" classes. To instructors, the feature give them the opportunities to receive feedback and questions on the teaching materials or activities in a timely manner. In addition, instructors can allow students to answer the question of their fellow peers. This created an opportunity for collaborative learning among the large class.

(d) Breakout Rooms

The ***Breakout Rooms*** feature is designed to provide a ground for learners to share resources, and co-construct their collaborative work. Some functions in the breakout rooms include an ***Interactive Whiteboard*** that group members can present their understandings and ideas with a drawing of conceptual map. Other form of resources, such as text file and image file can also be shared with the ***File Sharing*** function. Finally, an ***AppSharing*** function allows learners to show their desktop screen to their peers, letting them to demonstrate actions that may require the use of specific software. To sum up, the Blackboard Collaborate application created a flipped classroom environment that highly encourage learners to engage in active and collaborative learning. A case study investigated by Blackboard, Inc. (2014) claimed that such learning environment that help instructors to inspire learners' curiosity, and to keep excitement of learning to students.

However, since the application is an extension of Blackboard, **accessing to the platform could be too complicated** if the institution or the instructors did not organise the content of the learning management system properly. Furthermore, the Blackboard Collaborate is designed for Mass Opened Online Classes. **Some of the features do not cater the need in a physical classroom settings**. For instance, the "Raise Your Hand" feature may not be

appropriate in such settings where students might not be able to overcome the cultural context if their peer could identify them in the classroom. The way to collaborate could also be different in such environment. With the chances to interact face-to-face, it is highly probable that they would be communicate “around” the computers rather than “through” the computer.

3. PROPOSED SOLUTIONS

3.1. Theoretical Framework

As previously discussed in Section 2.1., collaborative learning activities can be classified into 3 types, including (i) between members within small study groups, (ii) between peers in large classes, and (iii) between members of the learning community. The current project will focus in proposing a solution to encourage **(ii) Collaboration between peers in large classes**.

It is proposed that using a Computer-suppered Collaborative Learning application, we can provide different affordances to support collaborative learning activities (Jeong & Hmelo-Sliver, 2016). The features designed to achieve the objectives are summarised in Table 5 and discussed in the remaining part of this chapter.

Proposed Feature	Description	Affordance Supported
Real-time Q&A	• Ask Questions during class • Post anonymously • Interpret as feedback of teaching	(2) Communication (6) Monitoring and Regulation
Upvoting	• Upvote a question asked by peers • if learners have similar concerns	(2) Communication (5) Engaging in Co-construction (6) Monitoring and Regulation
Respond	• Lecturer answering / resolving a question	(2) Communication
Raise-my-hand	• Raise hand to a question asked by peers • if learners feels they can answer it	(2) Communication (4) Engaging in productive processes (6) Monitoring and Regulation
Delegate Respond	• Lecturer delegate answering to a learner • identified by “Raise-my-hand” feature	(2) Communication (5) Engaging in Co-construction
Poll	• Real-time polling during class	(2) Communication (5) Engaging in Co-construction

Table 5. Summary of proposed solution

3.2. Proposed Features

This section discusses the proposed features and how they are related to the project objectives.

3.2.1. Real-time Q&A

As previously discussed, a phenomenon observed in classes is that students rarely speak up when they have difficulties regarding the ongoing subject matters. On occasions where lecturers want to verify the progress of students, there are only a few or even no responses. Considered that this phenomenon potentially affect the effectiveness of the class, it is suggested that a **Real-time Q&A** feature could offer an alternatives for students to raise their questions in an immediate manner, and if their instructors allowed them to, **anonymously**. Using the proposed alternative, the psychological barrier regarding interruption of class proceedings, doubting authority, self-esteem, language proficiency, or past achievement level, could be lowered. On the other hand, with the proposed feature, instructors are enabled to **receive feedback regarding their teaching**. They can design learning activities that better suit current and future students' needs, thus improve the class effectiveness.

The proposed feature should provide support in Affordance **(2) Communication** and **(6) Monitoring and Regulation**.

3.2.2. Upvoting

Considered that the proposed Real-time Q&A feature might generated a large number of questions during class time, an important question is: How can lecturers process large amount of questions, and select the more common ones to respond, in the limited class time. Regarding such challenges, an **Upvoting**

feature is introduced to allow students upvoting questions that they would also like to ask. With the proposed feature, **instructors can be better informed** about the area where majority of students have questions on, quickly address the current problems, and make adjustment in future teaching.

The proposed feature should provide support in Affordance **(2) Communication**, **(5) Engaging in Co-construction**, and **(6) Monitoring and Regulation**.

3.2.3. Respond

The proposed features collect questions of learners when instructors are delivering the lecture. As teachers identified the more popular questions and responding to them in class, some students may not still be able to clearly understand the concept immediately. A **Respond** feature is suggested to record the teacher's response to the question. It could provide students with endorsed supplement information and help them in revising the subject matter.

The proposed feature should provide support in Affordance **(2) Communication**.

3.2.4. Raise-your-hand

The features mentioned from Section 3.2.1. to 3.2.3. mainly concern about the student-teacher interactions. In contrast, the **Raise-your-hand** feature is proposed to promote collaboration between peers. When students saw a question and they thought that they are capable of answering the question, they can "raise their hand" to the question to indicate it. With the proposed feature,

instructors can be better informed about the learning progress of different students in the same class. Also, if permitted, in dealing with popular questions that also have many students want to answer, instructors could leave the question for post-class discussion and ask students with better progress to help those not. Through the process, interactivity among students and opportunities of exchanging thoughts could be increased.

The proposed feature should provide support in Affordance **(2) Communication**, **(4) Engaging in Productive Processes**, and **(6) Monitoring and Regulation**.

3.2.5. Delegate Respond

To complete the "Raise-my-hand" features, a **"Delegate Respond"** feature is also proposed. The feature allow instructors to delegate the respond to students who have indicated that they are willing to answer a question. Similar to the Respond feature for instructors, the selected student could make the respond by speaking in front of the class and record it, or just by typing in text in the system. With the delegation, students are given more opportunities to **express their thoughts** and, possibly, **exchange with others' ideas or opinions**. The answering students would also have a high probability to obtain an immediate feedback about his/her understanding on the concerned subject matter as teachers make comments on their response.

The proposed feature should provide support in Affordance **(2) Communication**, and **(5) Engaging in Co-construction**.

3.2.6. Poll

In addition to the Real-time Q&A feature and its periphery features, a **Polling** feature is proposed to allow instructors to collect the whole class' opinions on concerned topics or issues more easily. Conducting a poll during class time can help the lecture to **gather attention** of learners, **encourage reflection and engagement** on the subject matter. Interaction, between students-teachers and students-students, can be stimulated given that appropriate duration is allowed for short discussion on the polling topic.

The proposed feature should provide support in Affordance **(2) Communication**, and **(5) Engaging in Co-construction**.

3.3. Resolving Challenges of Collaborative Learning

(1) Constraints of Class Time

Concerning the observed phenomenon of limited class time causing students unable to make inquiry (Section 2.1.3.), the proposed solution enabled students to **raise questions in real-time**, during the delivery of lecture. The ***upvoting feature*** gathers students' support to a question, while the ***raise-your-hand feature*** assists instructors in identifying students who are able to develop sufficient understandings on a concerned topic, thus **foster collaboration between students**, and prioritise inquiries to be resolved so that **timely feedback is provided** to majority of students.

(2) Design of Class Agenda

Apart from directly benefiting students, instructors are also enabled to **obtain important feedback for class activities design**. The ***automatic question***

tagging feature of the proposed solution, for example, allows instructors to identify course topics where more students are unable to establish good understandings. Instructors can therefore **devote class time** in explaining the identified topics, or **organise collaborative learning activities** to foster reflection of materials, thus help students to develop better understanding on the concerned course topic.

3.4. Resolving Challenges of Engaging Students

(1) Low Sense of Autonomy

An observed phenomenon is that students did not make inquiry because of their low sense of autonomy (Section 2.2.3.), which is contributed by their cultural or educational background. To mitigate such barrier, the proposed solution equipped them with ability to ask questions in ***real-time*** and ***anonymously***, while not interrupting the lecture. Both functionality should motivate their sense of autonomy, thus prompting them to **initiate interactions** by raising an inquiry when it sparks in their mind.

(2) Low Sense of Competence

Low sense of competence is also regarded as an important factor to students' motivation in engagement (Section 2.2.3.). It is often contributed by their past achievement or language proficiency. To mitigate the barrier, using computers as a mean of communication allow them to **have more time to elaborate** their thoughts and ideas. **Getting support for the questions** they raised shall also help them to fulfil their sense competence, while also establish a sense of relatedness of them with other classmates.

4. PROJECT METHODOLOGY

4.1. Development Process

The development of the proposed application will briefly follow the **Iterative** Software Development Lifecycle (SDLC). There will be 6 main phases throughout the project, including (i) Planning, (ii) Analysis, (iii) Design, (iv) Implementation, (v) Testing and Evaluation, and (vi) Maintenance. The followings discuss different tasks in the corresponding phases.

Planning

The planning stage of the project involved efforts in researching on the domain of the project. Problems of the existing system should be identified and ideas of proposed solution should be brainstormed. An objective of the project should also be defined at this stage. The findings and ideas is included in the **Project Proposal** document.

Analysis

The analysis stage of the project involved efforts in collecting and understanding the user requirements. In the current project, 2 main categories of users are targeted, namely **Instructors** and **Learners**. Their requirements are being understood by communicating in form of interviews, questionnaires, and by observation. The product of this stage will be documented in the **Milestone Report**.

Design

The design stage of the project involved efforts in selecting the appropriate system architecture and formulating the human-computer interactions. The user interface will be designed and presented in form of **sketches** and **storyboards** to obtain useful feedback from potential users. The process will be carried out

iteratively as improvements are introduced to the designed interface, such that to ensure it satisfies different concerns of the targeted users. Useful graphical representation of the design will be included in the **Milestone Report**.

Implementation

The implementation stage of the project mainly involved the efforts in coding the application. The necessary back-end function, for example inserting data to and fetching data from database, will be implemented. Sketches and storyboards created in previous stages will also be converted into a **workable prototype**.

Testing and Evaluation

The testing and evaluation stage of the project involved verifying the functionality of the workable prototype and putting it into real-life use. The testing activities are important to the whole development cycle as it ensures the prototype functions as designed. The deployment activities give opportunities in collecting feedback and data for conducting evaluation on validity of the proposed ideas. Relevant records and findings will be documented in the **Final Report**.

Maintenance

The maintenance stage of the project involved efforts in fine-tuning of interface and performance of the application, and possibly adding new features to deliver a more completed system. However, due to the time constraint of the current project, maintenance and advancement of the application are not guaranteed.

A prototype of the project is completed by March 2017. Testing and evaluation are carried out afterwards. Refinement will be made shall the solution is deployed in real-life application.

A detailed schedule is presented in Section 4.2..

4.2. Project Schedule

Stage	Planned Date	Estimated Duration	Actual Date	Actual Duration	Description
Initiate	Jun - Aug 2016	30 Days	Jun - Aug 2016	30 Days	**Tasks** Background Research **Expected Outcome** Basic understanding of Collaborative Learning
Planning	Sep 2016	10 Days	Sep - Oct 2016	10 Days	**Tasks** Idea Brainstorming **Expected Outcome** Project **Ideas**
		10 Days		10 Days	**Tasks** Literature Review **Expected Outcome** Define the **Objective** of the current project
	Oct 2016	5 Days	Oct - Nov 2016	5 Days	**Tasks** Explore feasible implementation techniques
		5 Days		15 Days	**Tasks** Project Planning **Expected Outcome** **Project Proposal**
			Project Proposal (Due 6 November, 2016)		
Analysis	Oct - Nov 2016	5 Days	Nov - Dec 2016	10 Days	**Tasks** Requirement Collection
		10 Days		10 Days	**Tasks** Requirement Analysis
Design	Nov - Dec 2016	5 Days	Nov - Dec 2016	10 Days	**Tasks** System Design
		5 Days		5 Days	**Tasks** User Interface Design **Expected Outcome** Storyboards

		15 Days	Jan 2017	15 Days	**Tasks** User Interface Prototyping **Expected Outcome** Semi-application
		10 Days		10 Days	**Tasks** User Interface Refinement
Milestone Report (Due 15 December, 2016)					
Implementation	Jan - Feb 2017	3 Days	Feb - Mar 2017	3 Days	**Tasks** Database set-up
		2 Days		2 Days	**Tasks** Web Server set-up
		30 Days		30 Days	**Tasks** Back-end Implementation **Expected Outcome** Semi-application
Testing	Feb 2017	5 Days	Mar 2017	2 Days	**Tasks** Test Plan Design
	Mar 2017	5 Days		3 Days	**Tasks** Test Plan Execution
		10 Days		5 Days	**Tasks** Fix Bugs and Defects **Expected Outcome** Application
Evaluation	Mar 2017	2 Days	Mar - Apr 2017	3 Days	**Tasks** Interview Questions Design
		5 Days		2 Days	**Tasks** Conduct Interview
		5 Days		5 Days	**Tasks** Result Analysis **Expected Outcome** Comments from User, effectiveness of application
Completion	Apr 2017	12 Days	Mar - Apr 2017	10 Days	**Expected Outcome** Final Report
	Apr 2017	2 Days	Apr 2017	4 Days	**Expected Outcome** Final Presentation

Table 6. Project Schedule

4.3. Tools and Resources

The development of an application involved adequate use of different resources. They are discussed and listed as the followings.

Hardware

Hardware	Purpose
Computers	App Development
	Testing
Tablets	Testing
Smartphones	Testing
MySQL Database Server	Storing the relevant data

Table 7. Required hardware for prototype development

Software

Stage	Purpose
Asana	Collaboration
	Progress Monitoring
Git Hub	Storage of Code
	Manage the collaborative work
Adobe Brackets	IDE for App Development
Google Chrome	Web Browser
	Testing and Debugging
MySQL Workbench	Database Implementation
	Progress Monitoring
iWork by Apple	Documentation

Table 8. Required software for prototype development

Human Resources

Apart from the work described in this document, the current project is collaborated with CHIU, Chin Ting [12102278D]. He is working features that foster collaboration within small learners group.

5. REQUIREMENT ANALYSIS

5.1. User Classes

The current project aimed at creating a computer-supported collaborative learning environment to stimulate student engagement in large class settings. To achieve the sub-goal of the project, the proposed application will serve 2 main categories of users, including **(1) Learners**, and **(2) Instructors**. Their needs and expectations are discussed as the followings.

Learners

Learners can be considered as the most important users to the proposed application. They initiate interactions on the application by raising questions to teachers. In addition, they would also participate in discussion of questions. The functional user requirements of the user class are summarised in the list below:

- Raise questions during class time using portable devices;
- "Upvote" questions raised by their peers during class time;
- Initiate discussions outside class time;
- Read and participate in discussions;
- Search previous questions and discussions.

Instructors

Instructors are also considered as targeted users of the proposed application. They set-up the learning environment with the proposed application to facilitate interaction and collaboration. In general, it is expected that they would use tools of the proposed application to monitoring students' progress on learning, and provide assistance for their students when necessary and appropriate. The functional user requirements of the user class are summarised in the list below:

- View questions raised by students instantly during class time;

- Response to questions in text online;
- Monitor and participate in discussions.

As illustrated in previous sections, it is essential that the proposed application is equipped with a simple and intuitive user interface. It improves motivation of students to engage and interact in the computer-supported collaborative learning environment. In addition, both **students** and **teachers** are likely to deploy different portable devices, including laptops, tablets, and smartphones, to access the proposed application. The proposed application should be functional in all these devices.

5.2. Functional Requirements

The functional requirements of the proposed application include:

- Allow learners to submit questions using portable devices;
- Allow learners to “upvote” questions raised by other learners using portable devices;
- Allow instructors to response to questions;
- Allow learners and instructors to start threaded discussions;
- Allow learners and instructors to read threaded discussions;
- Allow learners and instructors to participate in threaded discussions;
- Allow learners and instructors to search previous Q&As and discussions;
- Provide participation statistics to instructors;
- Allow instructors to edit inappropriate content;
- Allow instructors to remove inappropriate content.

5.3. Non-functional Requirements

Apart from the functional aspect, a number of requirements from different perspectives should be considered in implementing the proposed application. These non-functional requirements are discussed as below.

Usability

To ensure the proposed solution delivers great effectiveness in implementing a collaborative learning environment, the following requirements regarding usability principles should be fulfilled:

- Simple and intuitive user interface;
- Compatible with different types of devices.

Security

To avoid the learning activities being interrupted by inappropriate content, it is important to ensure that only the related personnel can access to the system and make contribution: Hence, the following requirements should be fulfilled:

- Restricted access;
- User authentication.

Performance

The proposed application may deal with large number of requests, as it is implemented in a large class setting. The following requirements regarding performance issues should be fulfilled:

- Handle large dataset;
- Handle multiple requests at the same time.

Modifiability

Different institutions have their own Learning Management Systems. To utilise the existing resources, communication between softwares might be necessary. Emerging technologies may also open new opportunities for the proposed application. Hence, the following requirements should be fulfilled:

- Interface to communicate with other software;
- Room for future development.

6. DESIGN SPECIFICATION

6.1. Software Architecture

The current project adopt a **client-server 3-tier architecture**. The 3 tiers in such architecture include **(i) Presentation Layer**, which facilitates the human-computer interactions; **(ii) Logic Layer**, which coordinates the application and performs the necessary logical decisions; and **(iii) Data Layer**, which is responsible for storing and retrieving data from a database system. By conforming to such architecture, any of the three tiers can be updated or upgraded independently using newer technology, thus providing greater flexibility for future development and enhancement.

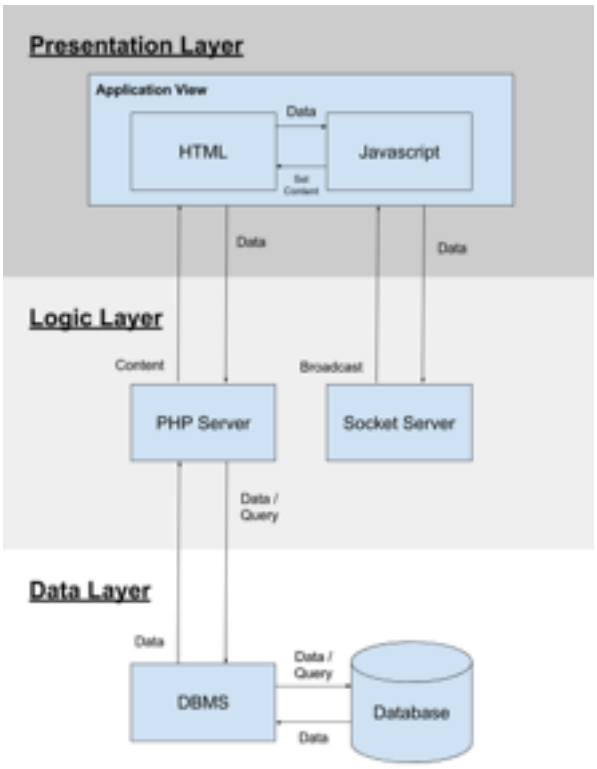

Figure 5. 3-Tier Architecture

The presented prototype incorporate of 2 main components: **(i) the Web Application** serves the **Presentation Layer** and the **Logic Layer**. The application included a front-end web server with static user interface and a application server with dynamic content processing. On the other hand, **(ii) the Database** serves the **Data Layer**. It stores and provides data when requested.

Figure 5. presented the architecture of the prototype as described in the above paragraph.

6.2. Web Application Design

As discussed in Section 5.1., the targeted users of the proposed system include Instructors and Students in a mass lecture. The web application component is implemented as a website, providing a human-computer interface for the system to receive input from these targeted users and transmit the data to the database. The application shall also receive the required information from the database and present them in user-friendly manner to the users.

Figure 6. presented the use case diagram that identifies the possible interactions between various user classes and different modules of the application.

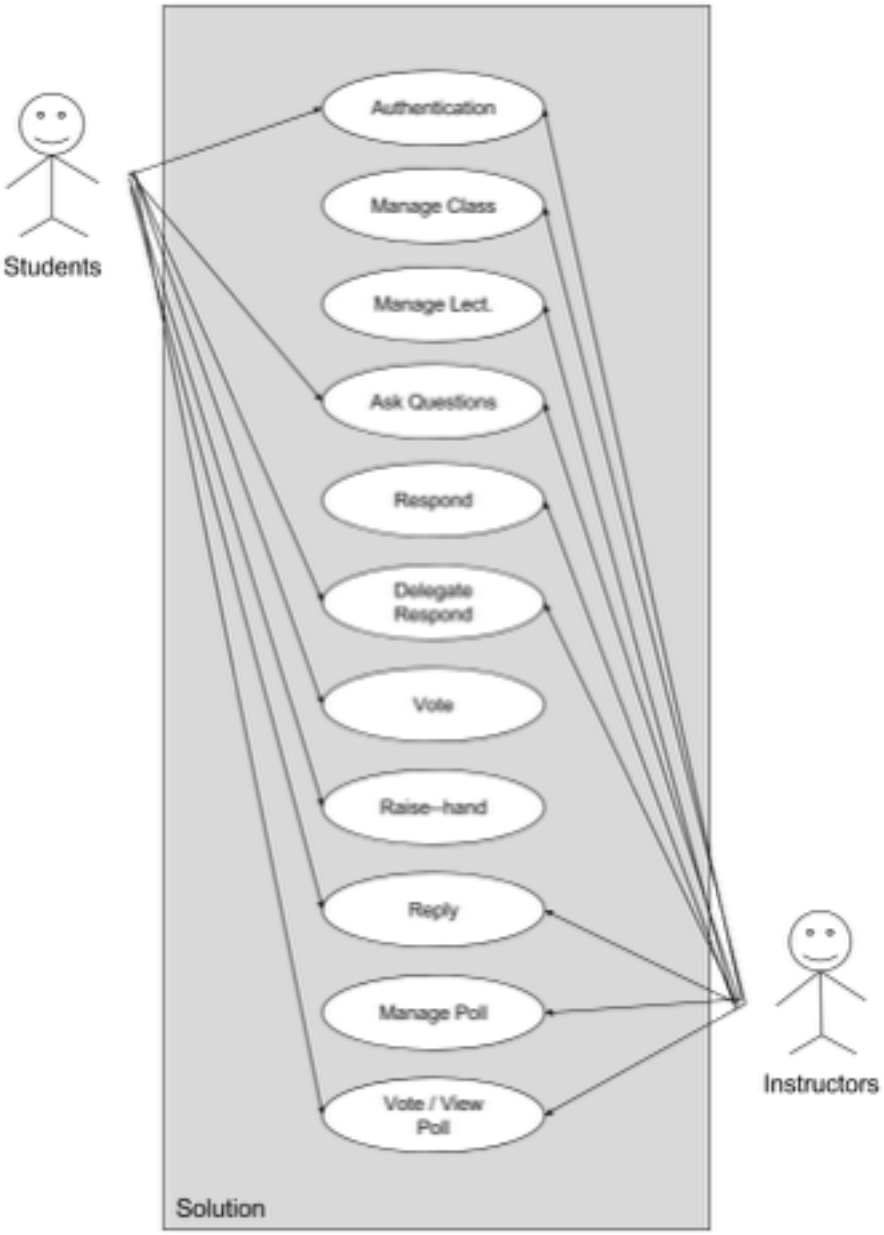

Figure 6. Use Case Diagram

6.3. Database Design

Database can be considered as an important component of the proposed system. The messages and interactions made by both students and instructors are stored in various tables of the database. The following describe the detailed design of the database.

6.3.1. Entity-Relationship Diagram

Figure 7. presents the entity-relationship diagram to describe the relationships between respective data tables.

6.3.2. Data Dictionary

The following data dictionary describe the use of each table, including the design of the columns, in the database for the proposed system.

Table Name: **class**

Description: *Store data of a class*

Field		Data Type	Format	Description
PK	class_id	INT(11)	AI	Identifier of a **class**, generated by the database
FK	course_id	INT(11)		Identifier of the **course**, which the class belongs to
	class_code	VARCHAR(40)		Displayed of the class
FK	sem_id	INT(11)		Identifier of a **semester**, which the course belongs to
FK	own_id	INT(11)		Identifier of an **instructor**, who started and administrates the class

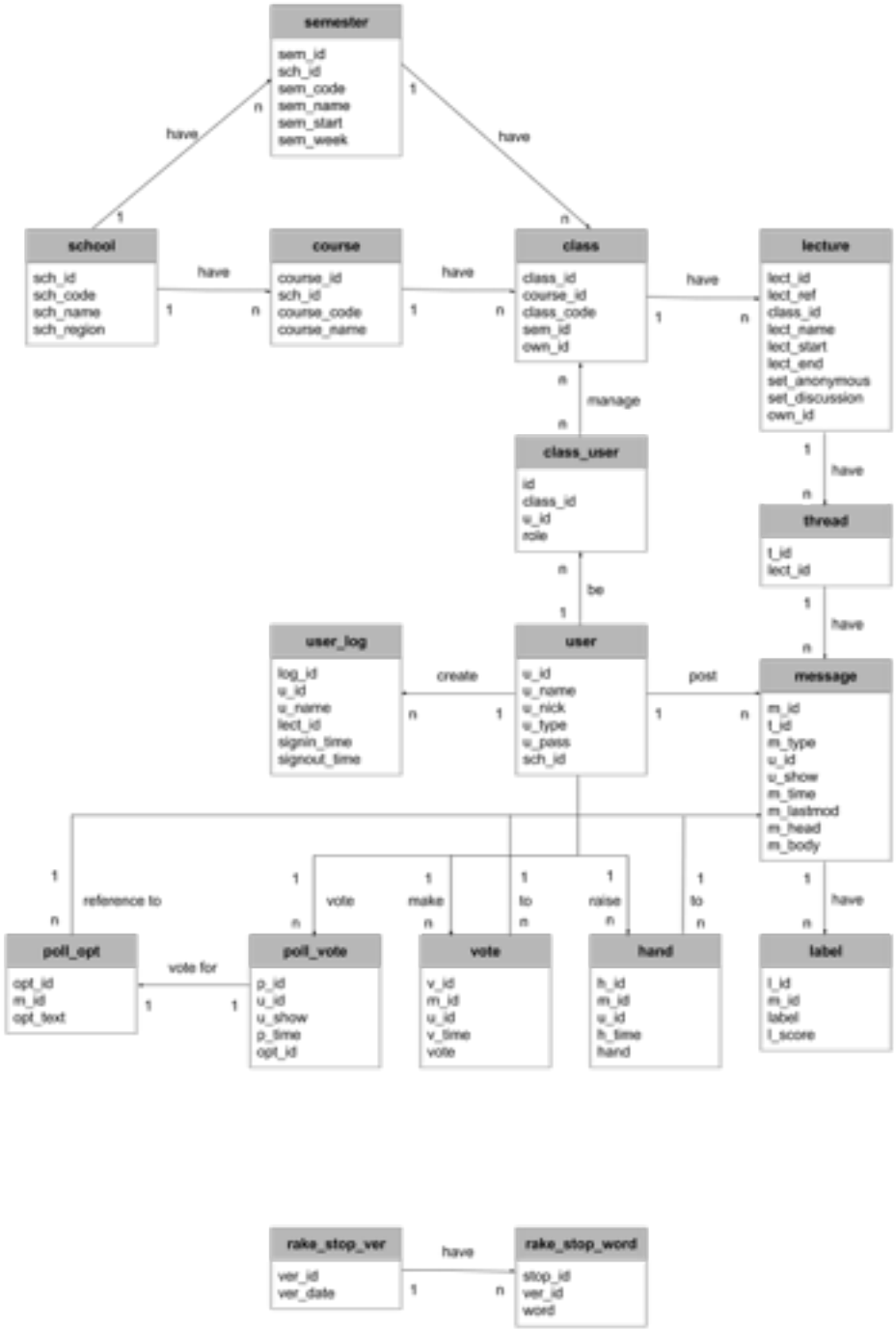

Figure 7. Entity-Relationship Diagram

Table Name: **course**

Description: *Store data of a course*

	Field	Data Type	Format	Description
PK	course_id	INT(11)	AI	Identifier of a **course**, generated by the database
FK	sch_id	INT(11)		Identifier of an **institution**, which the course belongs to
	course_code	VARCHAR(40)		Displayed identifier of the course
	course_name	VARCHAR(255)		Displayed name of the course

Table Name: **semester**

Description: *Store data of a semester*

	Field	Data Type	Format	Description
PK	sem_id	INT(11)	AI	Identifier of a **semester**, generated by the database
FK	sch_id	INT(11)		Identifier of an **institution**, which the semester belongs to
	sem_code	VARCHAR(40)		Displayed identifier of the semester
	sem_name	VARCHAR(255)		Displayed name of the semester
	sem_start	DATETIME		Date of which the semester starts
	sem_week	INT(6)		Length of the semester, in week(s)

Table Name: **school**

Description: *Store the data of an institution*

	Field	Data Type	Format	Description
PK	sch_id	INT(11)	AI	Identifier of an **institution**, generated by the database
	sch_code	VARCHAR(40)		Displayed identifier of the instituition
	sch_name	VARCHAR(255)		Displayed name of the institution

	Field	Data Type	Format	Description
	sch_region	VARCHAR(255)		Region where the institution located in

Table Name: **thread**

Description: *Store the data of a thread*

	Field	Data Type	Format	Description
PK	t_id	INT(11)	AI	Identifier of a **thread**, generated by the database
FK	lect_id	INT(11)		Identifier of a **lecture**, which of the thread was generated in.

Table Name: **message**

Description: *Store the data of a message*

	Field	Data Type	Format	Description
PK	m_id	INT(11)	AI	Identifier of a **message**, generated by the database
FK	t_id	INT(11)		Identifier of a **thread**, which the message belongs to
	m_type	VARCHAR(3)	• 0 • 1 • 10 • 90 • 98 • 99	Identify the type of message, possible values include: 0 => OPENER 1 => REPLY 10 => RESPOND 90 => POLL_STOP 98 => POLL_SAVE 99 => POLL_START
FK	u_id	INT(11)		Identifier of a **user**, who written and posted the message
	u_show	TINYINT(1)		Indicate whether or not the message is posted as anonymous
	m_time	DATETIME		Date and time, where the message is submitted
	m_lastmod	DATETIME		Date and time, where the message is last modified
	m_head	TEXT		The title of the message

	Field	Data Type	Format	Description
	m_body	TEXT		The body of the message

Table Name: **label**

Description: *Store the labels of a message*

	Field	Data Type	Format	Description
PK	l_id	INT(11)	AI	Identifier of a **label**
FK	m_id	INT(11)		Identifier of a **message**, of which the label generated from
	label	VARCHAR(255)		Label text
	l_score	FLOAT		Score of the label, computed by the RAKE algorithm

Table Name: **vote**

Description: *Store the vote of a message*

	Field	Data Type	Format	Description
PK	v_id	INT(11)	AI	Identifier of a **vote**, generated by the database
FK	m_id	INT(11)		Identifier of a **message**, of which the vote refers to
FK	u_id	INT(11)		Identifier of an **user**, who submitted the vote
	v_time	DATETIME		Date and time, where the vote is submitted
	vote	TINYINT	• 1 • -1	The value of the vote, possible values include: 1 => vote to question -1 => vote retreated

Table Name: **hand**

Description: *Store the hand-raised of a message*

	Field	Data Type	Format	Description
PK	h_id	INT(11)	AI	Identifier of a **hand**, generated by the database
FK	m_id	INT(11)		Identifier of a **message**, of which the hand refers to
FK	u_id	INT(11)		Identifier of an **user**, who raised the hand
	h_time	DATETIME		Date and time, where the hand is raised
	hand	TINYINT	• 1 • -1	The value of the hand, possible values include: 1 => hand raised to question -1 => hand retreated

Table Name: **poll_opt**

Description: *Store the options available in a poll*

	Field	Data Type	Format	Description
PK	opt_id	INT(11)	AI	Identifier of an **option**, generated by the database
FK	m_id	INT(11)		Identifier of a poll as a **message**, of which the option belongs to
	opt_text	TEXT		Text description of the option

Table Name: **poll_vote**

Description: *Store the vote made to polls*

	Field	Data Type	Format	Description
PK	p_id	INT(11)		Identifier of a **vote** to a poll, generated by the database
FK	u_id	INT(11)		Identifier of an **user**, who vote to the poll
	u_show	TINYINT	• 0 • 1	Indicate whether or not the vote is submitted as anonymous
	p_time	DATETIME		Date and time, where the vote to a poll is submitted

	Field	Data Type	Format	Description
FK	opt_id	INT(11)		The **option** selected by the user to a poll

Table Name: **lecture**

Description: *Store the data of a lecture*

	Field	Data Type	Format	Description
PK	lect_id	INT(11)	AI	Identifier of a **lecture**, generated by the database
	lect_ref	VARCHAR(11)	UNIQUE	An unique, 8-character, reference code of a lecture, generated by the php server during processing the insertion of lecture
FK	class_id	INT(11)		Identifier of a **class**, of which the lecture belongs to
	lect_name	VARCHAR(255)		Displayed name of the lecture
	lect_start	DATETIME		Date and time, where the lecture starts
	lect_end	DATETIME		Date and time, where the lecture ends
	set_anonymous	TINYINT		Indicate whether or not students can post anonymously
	set_discussion	TINYINT		Indicate whether or not students can participate in discussion
	own_id	INT(11)		Identifier of an **instructor**, who started and administer the lecture

Table Name: **user_log**

Description: *Store user activity, i.e. Login and Logout, in the system*

	Field	Data Type	Format	Description
PK	log_id	INT(11)	AI	Identifier of the **log**, generated by the database
FK	u_id	INT(11)		Identifier of an **user**, who engaged the activity

	Field	Data Type	Format	Description
	u_name	VARCHAR(40)		Login username of the user
FK	lect_id	INT(11)		Identifier of a **lecture**, of which the user log-in to
	signin_time	DATETIME		Date and time, where the user engaged the log-in
	signout_time	DATETIME		Date and time, where the user engaged the log-out

Table Name: **user**

Description: *Store data of an user*

	Field	Data Type	Format	Description
PK	u_id	INT(11)	AI	Identifier of an **user**, generated by the database
	u_name	VARCHAR(40)		Login name of the user
	u_nick	VARCHAR(255)		Displayed name of the user
	u_type	INT(3)	• 1 • 11	Identify the type of user, possible values include: 1 => STUDENT 11 => INSTRUCTOR
	u_pass	VARCHAR(40)		Password of the user
	sch_id	INT(11)		Identifier of an **institution**, of which the user belongs to

Table Name: **class_user**

Description: *Store the user authenticated for a class*

	Field	Data Type	Format	Description
PK	id	INT(11)	AI	Unique identifier of the record, generated by the database
FK	class_id	INT(11)		Identifier of a **class**, of which the record refers to
FK	u_id	INT(11)		Identifier of an **user**, of which the record refers to

	Field	Data Type	Format	Description
	role	INT(3)	• 1 • 11 • 99	Identify the role of the user in the class, possible values include: 1 => STUDENT 11 => INSTRUCTOR 99 => OWNER

Table Name: **rake_stop_ver**

Description: *Store the data about the RAKE analysis stop words list*

	Field	Data Type	Format	Description
PK	ver_id	INT(11)	AI	Identifier of the stop words list **version**, generated by the database
	ver_date	DATETIME		Date and time, where the version is created

Table Name: **rake_stop_words**

Description: *Store the stop words required for RAKE analysis*

	Field	Data Type	Format	Description
PK	stop_id	INT(11)	AI	Identifier of the **stop words**, generated by the database
	ver_id	INT(11)		Identifier of the stop words list **version**, which the stop word belongs to
	word	VARCHAR(255)		The stop word(s)

7. IMPLEMENTATION

7.1. Hardware

This section describe the hardware used to implement the prototype of the proposed solution.

7.1.1. Web Server Host

The web hosting server that host is essential to every web application. The ability of the server to handle traffic often defined the availability, reliability, and even the perceived usefulness of a system.

For the current prototype, it is hosted on **Google Compute Engine** (Google Inc., 2017) It is an **Infrastructure-as-a-Service** (IaaS) platform. As developers, using such services **reduced efforts and investment in managing complicated hardware**. It also provides high performance, high security, and high availability.

The **Red Hat Enterprise Linux 7** apache server is selected to deployed the prototype in real-life scenarios. A list of software that is required to be installed or configured in the apache server in provided in Table 9.

7.1.2. Database Server Host

The database server is another essential component to the proposed web application. It should allow access from the web server, store and supply the necessary data for the application.

Similar to the Web Server, the Database Server of the current prototype will be hosted on **Google Compute Engine** (Google Inc., 2017). The database and the application will be hosted in the same server initially. However, as the project deployed and usage increased, separation of the two component to different server should be considered to enhance the security, scalability, and performance.

A list of database management software that is required to be installed and configured in the apache server is provided in Table 10.

Software	Purpose
PHP (The PHP Group, 2017)	Process the logic of the application
NVM (Caswell & Harband, 2017)	Node version manager
Node.js (Node.js Foundation, 2017)	Server-side Javascript run-time environment
Socket.io (Automattic, 2017)	Facilitate real-time bi-directional communication
CodeIngiter (British Columbia Institute of Technology, 2017)	Configurations for URLs

Table 9. Software to be installed or configured on Web Server.

Software	Purpose
mySQL (Orcale Corp., 2017)	Relational modelling

Table 10. Software to be installed or configured on Database Server.

7.2. Techniques

This section describe the techniques used to implement the prototype of the proposed solution.

7.2.1. Socket.io

Socket.IO (Automattic, 2014) is an open-source Javascript library that facilitate **real-time, bi-directional interaction** between clients. It uses the WebSocket interface and conduct communications based on an event-based mechanism. The library relied on **Node.js** environment on server side, and run by **Javascript** on client side.

The main advantage of the library is that it can be properly **running across all platforms**. In addition, it provides an **easy implementation** of real-time web application, enabling quick development of prototype.

7.2.2. CodeIgniter

CodeIgniter (British Columbia Institute of Technology, 2014) is an open-source PHP framework that enable developers to implement dynamic webpages in **Model-View-Controller (MVC) pattern**. It follows the principle of object-oriented programming and **facilitates code reuse**. Thus, the redundancy of codes can be reduced while efficiency of development can be improved.

7.2.3. Google Web Speech API

Google Web Speech API (Google Inc., 2012) is a Javascript API providing audio-to-text translation using **speech recognition** techniques. The API is responsible for streaming the

audio data recorded by the web application to the Google server, where the recognition and synthesis is conducted.

The advantage of supporting voice input with this API is that it helps in **mitigating the gap between the physical classroom and the online environment**. It provides a practical way to allow the users of the proposed solution to input their opinion and ideas in both environment. On the other hand, a weakness of the API is that it only works in **limited web browsers**, and the workstations must **equipped with voice input devices**.

7.2.4. Rapid Automatic Keywords Extraction Algorithm

Rapid Automatic Keywords Extraction (RAKE) algorithm (Rose, Engel, Cramer, & Cowley, 2010) is applied in the prototype to extract the submitted questions and **use keywords in the question as tags**. The algorithm is an implementation of the 3 steps of natural language processing and keywords extraction. The 3 component of the algorithm includes:

(i) Candidate Selection

The candidate selection process concerns the identification of possible words, phrases, or terms. The algorithm first identify unimportant words by comparing with a “stop-words list”. These unimportant words then act as delimiter and separate phrases from a sentence. The separated phrases are regarded as candidate at this point.

(ii) Properties Calculation

The properties calculation process furtherer break down phrases and terms into words can compute the importance of each individual word in the given piece of text. The computation account of factors such as frequency of occurrence, position within the document, length of candidate, similarity to other candidates, etc..

(iii) Scoring and Selecting Keywords

The scoring process concerns the final selection of keywords. The process aggregate the scores of individual words in each phrases. This is the final part of the algorithm and a list of keywords and their respective scores will be returned at this point.

The current prototype adopted the RAKE algorithm in generating tags mainly because of its **easy implementation** on multi-words phrases extractions. However, the algorithm is restricted by its **limited accuracy** since the candidate normalisation is not conducted in the process. Possible enhancement and alternatives will be discussed in Section 9.3..

7.3. User Interface

The user interface of the prototype is developed under Bootstrap guidelines. Sufficient spacing between elements and appropriate colours are selected to make users perceived the consequence of an action easily. In addition, the user interface is developed with high emphasise for mobile environment, such that to ensure students could use the system with minimal effort in real-life classes.

Figure 8. - 10. provide screen captures to showcase the design of user interface.

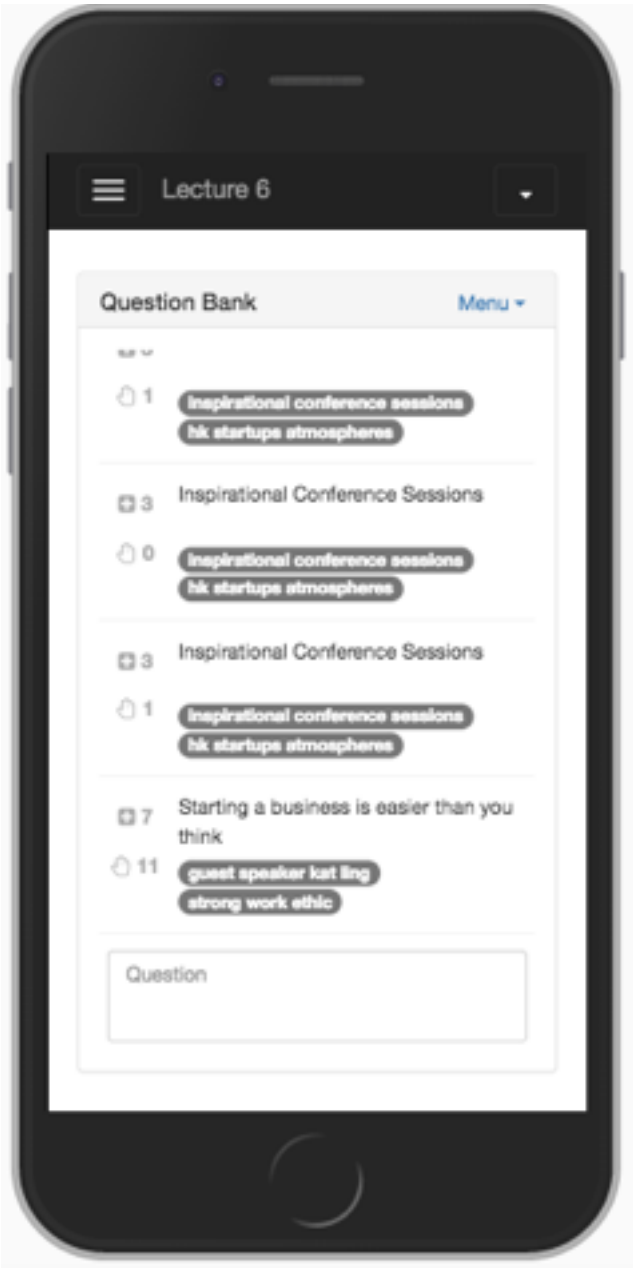

Figure 8. Screen capture of the main screen of the prototype

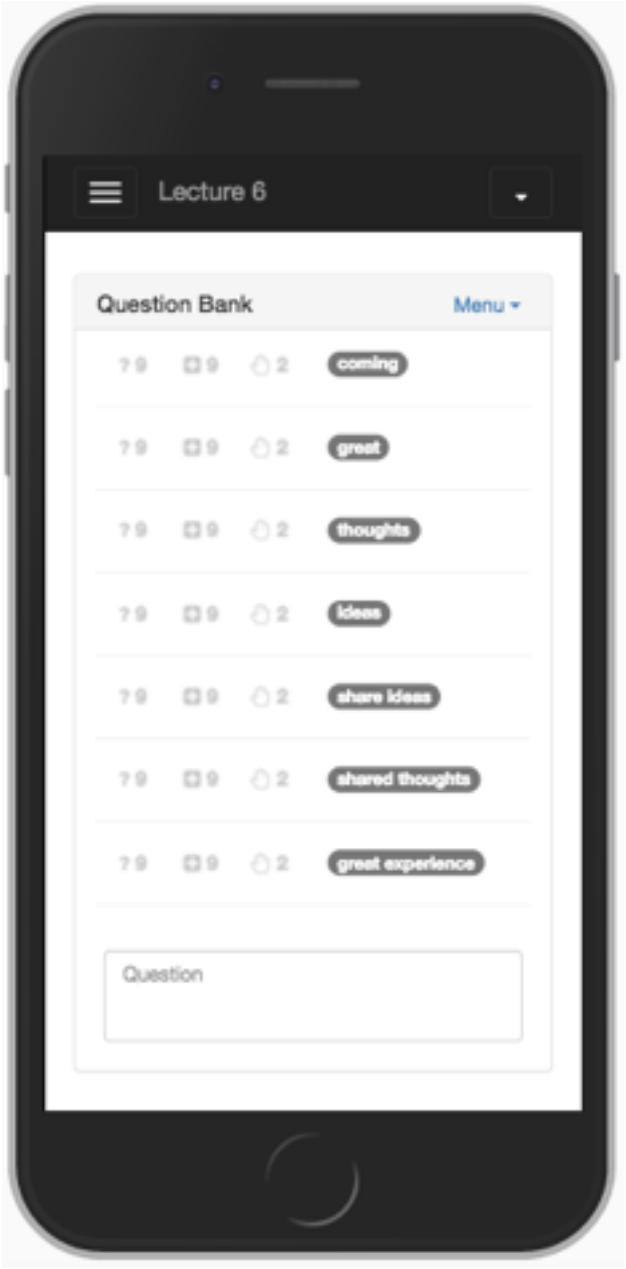

Figure 9. Screen capture of the main screen of the prototype

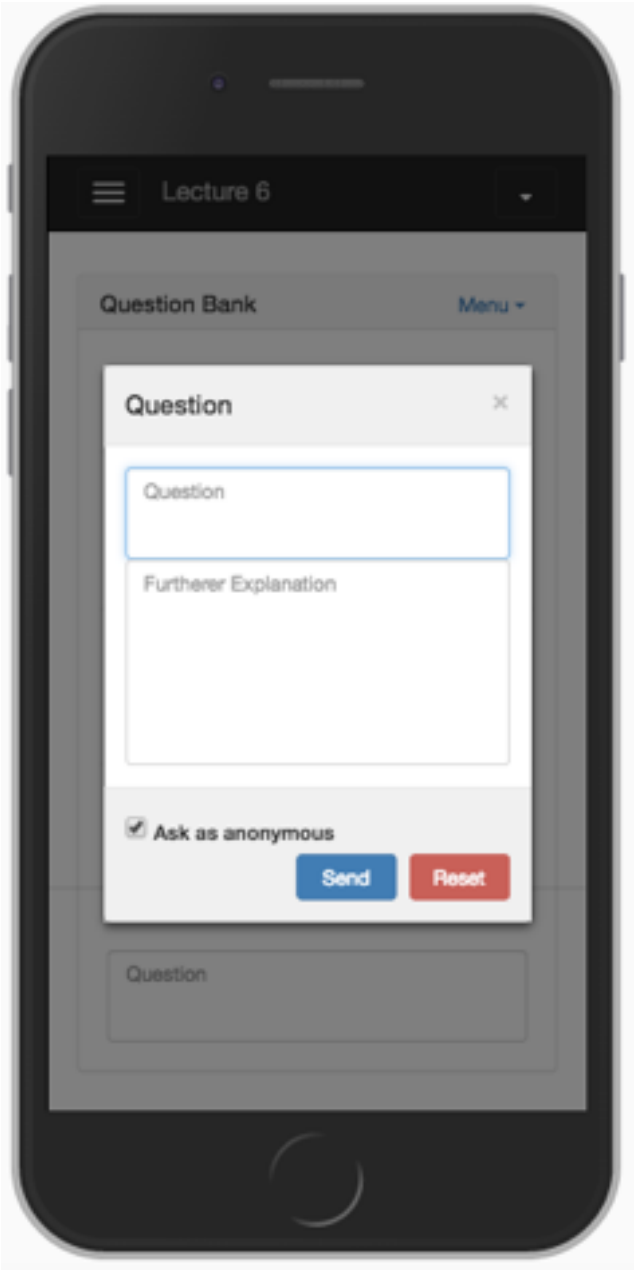

Figure 10. Screen capture of the main screen of the prototype

8. TESTING AND EVALUATION

8.1. System Testing

System tests refers to tests that concerns both hardware and software of the prototype in the current project. The testing processes are conducted on the integrated system using **Black-box Testing** strategy. Various **non-functional requirements** are evaluated in the test.

Table 11. provides a brief summary of different aspects that are evaluated in the test process. More detailed discussions are made in Section 8.2.1. - 8.2.4.

Aspect	Results	Description
Availability	High	• Available 24 / 7.
Reliability	High	• Little effect from deterioration in resource utilization.
Compatibility	High	• Support different operating systems and web browsers on PCs. • Support different operating systems and web browsers on Mobile devices. • The Respond and Delegate Respond are only available on Google Chrome.
Usability	High	• Interactions similar to existing software. • Work on different platforms (PCs and Mobile).
Coding Standard	High	• Support reuse of units. • Support future development.

Table 11. Summary of System Testing.

8.1.1. Availability

Availability refers to whether or not the system perform its function properly and accurately as required when services are demanded.

> ***Availability #1 - High***
>
> Generally, the prototype of the current project is available for access by users **24 hours a day, 7 days per week**.

8.1.2. Reliability

The reliability of the prototype can be describe by its ability to function as stated in the requirement during a specified period.

> ***Reliability #1 - High***
>
> The prototype of the current project can be **run for long period of time** without suffering from deterioration in resource utilisation. The performance remain instant after the server has been running for an entire month.

It should be noted that the prototype has not been evaluated through a **stress test**. However, the condition depends mostly on the server hardware. The prototype should perform with good performance shall the estimation of resources needed is accurate and the adequate server services are purchased.

8.1.3. Compatibility

Compatibility refers to the ability that one or more systems work together without the need of modifying either of them.

Compatibility #1 - High

On personal computers (Desktops & Laptops), the prototype of the current project is accessible by most modern **web browsers**, on major **operating systems**, that are available on the consumers market.

Table 12. contain a list where the prototype had been tested extensively on various combination of operating systems and web browsers.

Case	Status	Operating System	Web Browser
1	✓	Apple Mac OS X 10.11	Apple Safari 9.1.1
2	✓		Google Chrome 56.0
3	✓		Mozilla Firefox 49.0
4	✓	Apple macOS 12.0	Apple Safari 10.0
5	✓		Google Chrome 56.0
6	✓		Mozilla Firefox 49.0
7	✓	Microsoft Windows 7	Microsoft Internet Explorer 11
8	✓		Google Chrome 53.0
9	✓		Mozilla Firefox 47.0
10	✓	Microsoft Windows 10	Microsoft Edge
11	✓		Google Chrome 53.0
12	✓		Mozilla Firefox 47.0

Table 12. Tested environment on personal computers.

Compatibility #2 - High

Apart from personal computers, it is also important that users can access the prototype using various mobile devices. Table 13 listed the combination of

mobile operating systems and **web browsers** where the prototype of the current project had been tested on the following

Case	Status	Operating System	Web Browser
1	✓	Apple iOS 10.2	Apple Safari
2	✓		Google Chrome
3	✓		Mozilla Firefox
4	✓	Google Android 6.0	Google Chrome
5	✓		Mozilla Firefox

Table 13. Tested environment on mobile devices.

Compatibility #3 - Low

Although as describe in ***#1*** and ***#2***, the system is accessible by most modern web browsers running on major operating systems, it must be noticed that the **Respond** and **Delegate Respond** modules will not be able to record instructors' or students' verbal respond and translate them to text, when using web browsers other than Google Chrome.

The compatibility shall be improved should other web browsers begin to support verbal input features.

8.1.4. Usability

The reliability of the prototype can be describe by its ability to function as stated in the requirement during a specified period.

Usability #1 - High

The user interface of the prototype is designed to **look alike to existing chat-room and social networking applications**. This shall improve the **ease of use** of the prototype as it is more connected with systems that target users familiar with in their daily lives.

Usability #2 - High

As previously discussed, it is observed that **mobile devices** are increasingly popular in classroom and replace some of the functionality that personal computers provided to learners and instructors. The prototype provided an user interface that adapt well on mobile platforms, thus improving the **ease of use** of the prototype as targeted users are able to access the system using devices at their convenience.

8.1.5. Coding Standards

Coding standards of the prototype mainly fostered on 2 aspects: (i) Objected-oriented programming, and (ii) Input and Output.

Coding Standard #1 - High

The prototype of the current project is developed using **object-oriented programming** techniques. They enabled developers and future developers to understand the program logic more efficiently and allowed them to **reuse the existing units** more effectively. Overall, it make maintenance, debugging, and future development much more easier.

Coding Standard #2 - Medium

Although the web platform has already provided universal access from devices on different platforms, the opportunities of **future development of dedicated application** on different platform, or for different context, should not be ruled out. To facilitate such opportunities, the prototype uses ***php*** scripts to process the logic, which receive and return data using ***JSON*** objects. It is supported by Java and Swift for Android App and iOS app development respectively.

8.2. User Evaluation

In order to understand the effectiveness of the proposed solution in achieving its objectives, a preliminary research is carried out to investigate the attitude and perception of target users towards the proposed solution, and the impact of the proposed solution to their learning experience.

8.2.1. Data Collection

The research aimed at students from the Hong Kong Polytechnic University, who studied or are studying courses that teach in mass lecture modes. **5 face-to-face interviews** were conducted. The interviewees include students in different genders, from different academic disciplines, and of different year of study. Interviewees will be showcased the prototype and invited to comment on the questions listed below:

(1) Have you ever attended classes in Mass Lecture format?

(2) Have you ever use online discussion forum(s) for learning? How is your feeling about them?

Under existing context:

(3) How likely it is for you to ask questions during class and after class?

(4) How likely it is for you to answer/discuss questions asked by teachers?

(5) How likely it is for you to answer/discuss questions asked by your peers?

With the proposed solution:

(6) How likely it is for you to ask questions during class and after class?

(7) How likely it is for you to answer/discuss questions asked by teachers?

(8) How likely it is for you to answer/discuss questions asked by your peers?

After trial of the prototype:

(9) What would you like to do most with the proposed solution?

(10) Do you think that it is easy to do *[Answer of 9]* in the proposed system?

(11) What do you think about the interaction with the proposed system?

(12) Do you think the proposed system help you in learning?

(13) Do you have any comments regarding the presented prototype?

8.2.2. Codebook Development

The interview was recorded, transcribed, and translated from Cantonese to English. After the translation, **Open**, **Axial**, and **Selective Coding** were carried out to categorise the collected response. The main categories were defined as the followings:

(1) **Current interactions**, classified as **(i) Method**; **(ii) Timing**; and **(iii) Issues** of communications;

(2) Factors influencing engagement in **existing context**, classified as **(i) Positive**; **(ii) Negative**; and **(iii) Positive or negative**;

(3) Factors influencing engagement in **improved context**, i.e. using the proposed computer-supported solution, classified as **(i) Positive**; **(ii) Negative**; and **(iii) Positive or negative**;

(4) **Most-wanted features** of the proposed solution;

(5) Perceived **usefulness** to the proposed solution;

(6) Perceived **ease of use** to the proposed solution;

(7) **Other comments** to the proposed solution;

8.2.3. Codebook Refinement

The interview confirmed the observations and findings discussed in Section 1. and 2.. Respondents described a handful of scenario where they would initiate communication with their instructors or peers, and various factors that influence them to interact and collaborate with both instructors and their peers.

Notably, a large portion of communication are conducted on ***issues regarding assignments and projects***. In addition to that, most factors described by interviewees, for example ***lack of confidence*** and ***fear of interrupting class***, negatively influence them in interacting and collaborating.

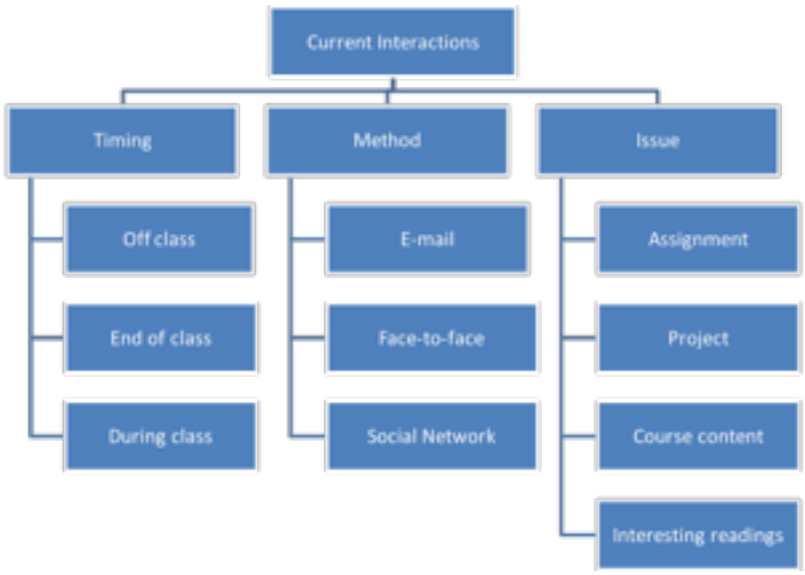

Figure 11. Current student-teacher and peer interactions

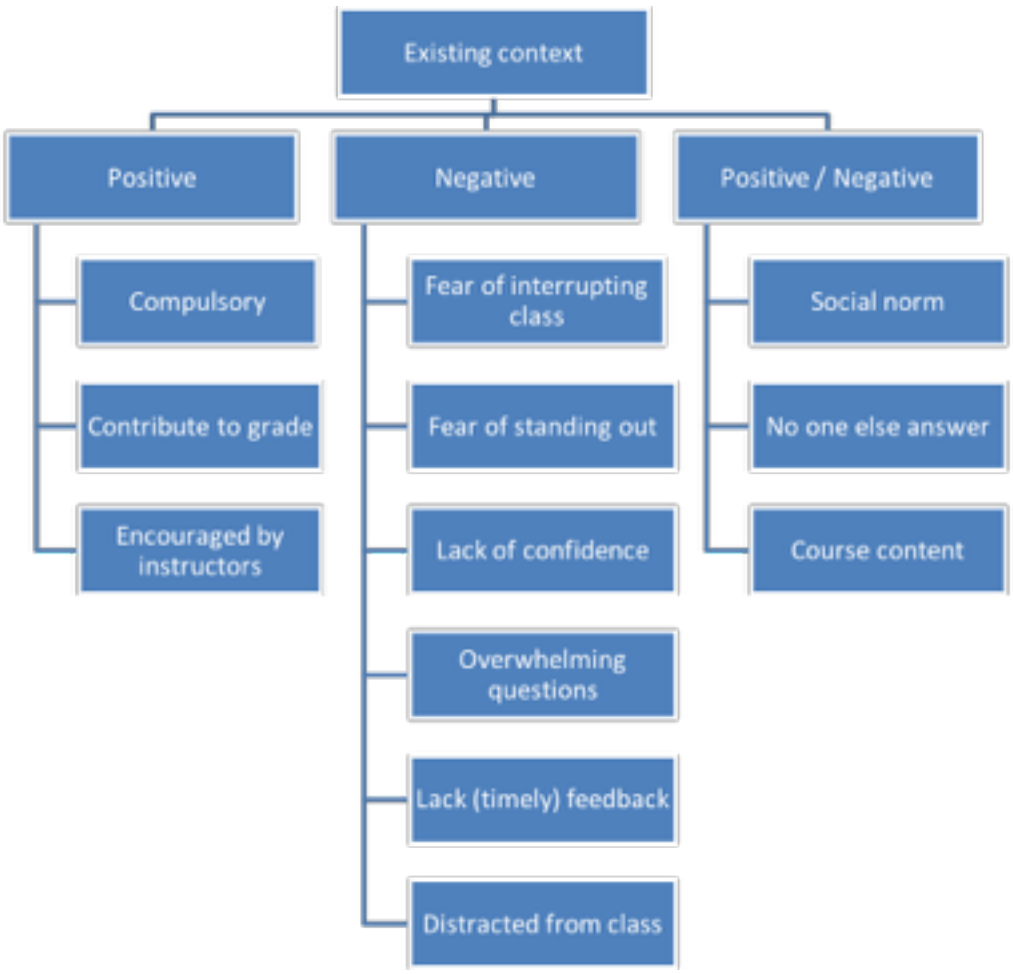

Figure 12. Factors influencing engagement in existing context

On the other hand, when respondents described the factors that influence them to engage in interaction and collaboration, they stated more positive factors and fewer negative factors. Notably, about half of them reported that the ***Anonymous feature*** contribute to their willingness to interact. ***Seeking support from peers***, ***receiving feedback from instructors***, and ***elaborating in advance*** also positively affect them to interact with other stakeholders. However, as pointed out by one interviewee, it would also be important for ***instructors to make use of the technology*** and really responding to questions.

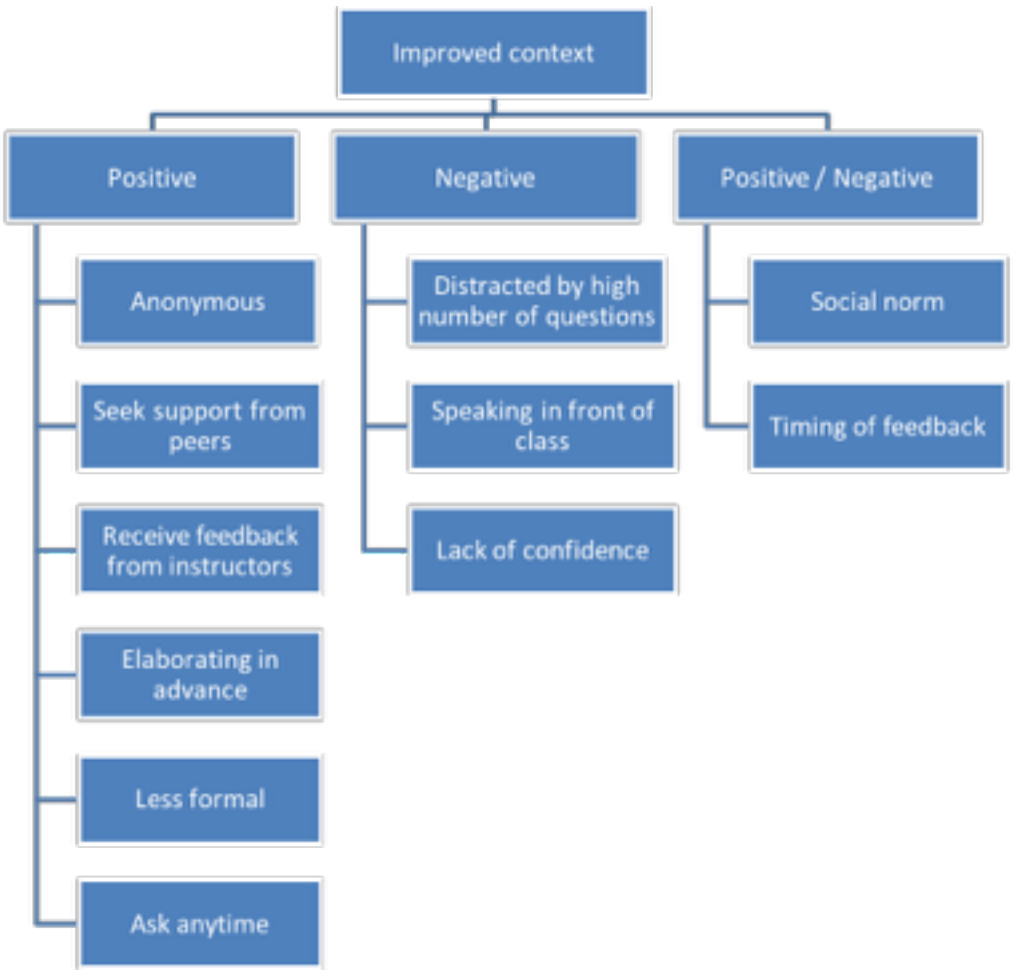

Figure 13. Factors influencing engagement in improved context

Given that respondents reported positive factors to engagement in interactions, their intention with and perception towards the proposed solution is also investigated. Majority of students are interested in ***asking or upvoting questions***, while about half of them indicated that they would ***respond to questions*** or ***participate in discussion***. In addition, interviewees generally have ***positive perception*** towards the proposed system.

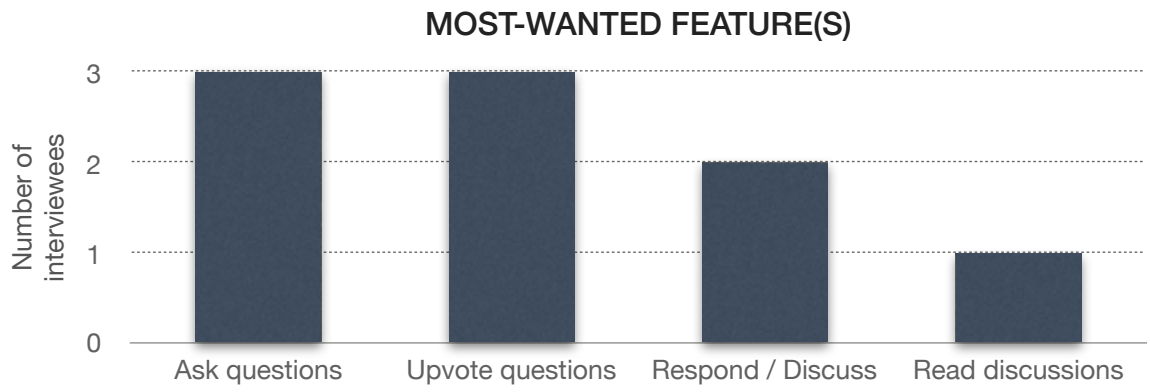

Figure 14. Most-wanted features of the proposed solution

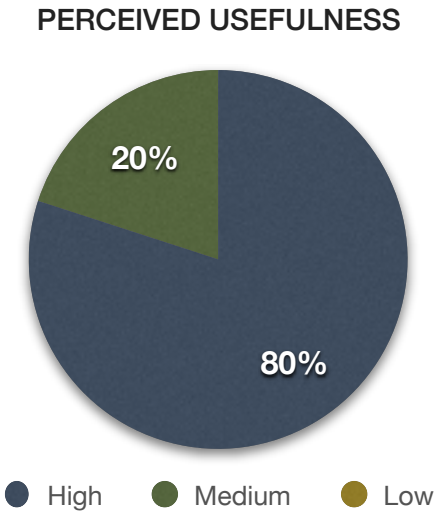

Figure 15. Perceived usefulness to the proposed solution

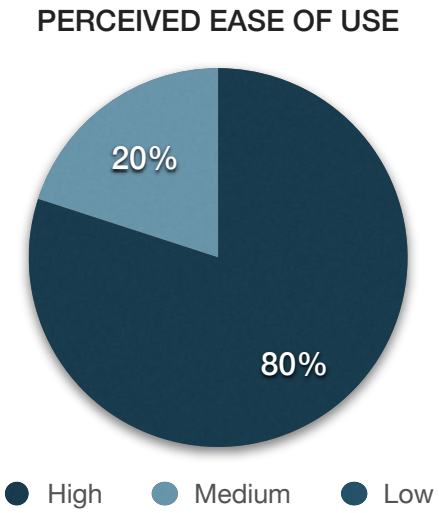

Figure 16. Perceived ease of use to the proposed solution

8.2.4. Findings

Using the information obtained from various interviews, it is evidenced that the proposed solution should be **effective** in encouraging student-initiated student-teacher and peer interactions. Students are found to be more willing to ***raise questions during class***, ***upvote questions*** raised by peers, and ***participate in discussion*** of questions. By engaging in such interactions, students increase cognitive engagement in the learning process and promote themselves from passive or active learners to ***constructive*** or ***interactive learners***.

In addition to the direct influence made by the proposed solution, the user-friendly human-computer interface of the prototype contributed to the positive attitude indirectly. According to the Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989), ***high perceived usefulness*** and ***high perceived ease of use*** are positively related to the attitude and intentions towards using an application. Hence, such attributes ***improve the actual***

system use (Figure 17). From the current research, it can be concluded that a good user interface could be important in promoting the use of technology in learning process. Such factors should not be ignored in future projects.

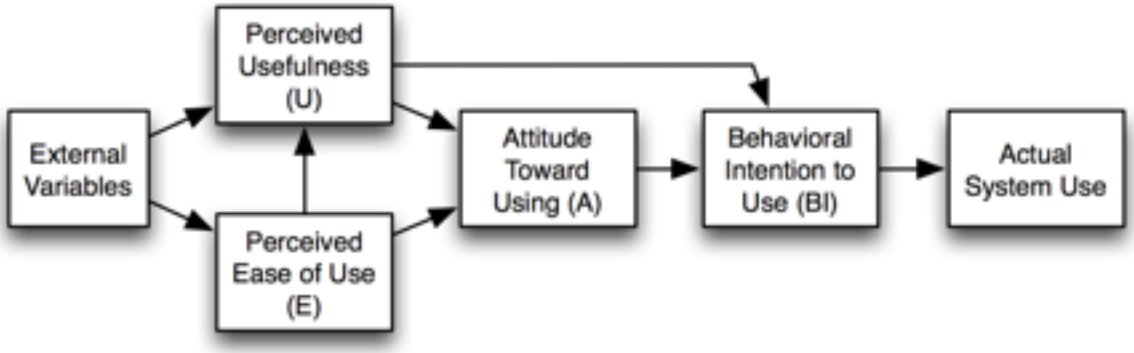

Figure 17. Technology Acceptance Model

9. DISCUSSION

9.1. Discussion

Evidenced by the result of interviews, the proposed solution is considered effective in promoting student-initiated interactions and collaborations. However, as pointed out by some interviewees, apart from motivational factors, there might be other factors there would contribute to learners' attitude towards the proposed solution.

9.1.1. Other Factors to the Actual Use of System

(1) Awareness and Application of Technology

The current research focuses on the use intention of students to the proposed solution. However, it must be noted that the **instructors' awareness towards technology** is also essential to a successful implementation of collaborative learning classroom. For instance, instructors should devote class time in addressing the online inquiries made by learners. **Timely feedback** can **establish students' sense of relatedness** with the class activities, thus contributing positively to the iterative process of motivation. Furthermore, **perceived usefulness** is enhanced as timely feedback is provided, hence improve leaners' attitudes and actual system use of the solution.

9.2. Contribution

In the current project, a software prototype is developed to facilitate collaborative learning in mass lectures. The prototype serves as a solution to **encourage student-initiated interactions or collaborations between students-instructors and students-students**. The solution incorporate a real-time question raising system, a social-network-

like interaction experience, and respond and collaboration mechanism. It motivate learners to initiate interactions or collaborations by ***mitigating the some of the potential barriers***.

Although a great number of past researches investigate different mechanisms to support interactions and collaborations in distanced e-Learning environment, there is little knowledge concerning if such mechanisms can be applied with students and teachers are situated face-to-face, in an actual classroom. Preliminary research conducted in this project proved that ***learners have positive attitudes towards the proposed ideas***.

Educators may reference to this project to gain insights on supporting collaboration in classroom with computer aid. The proposed ideas enabled **instructors** to ***provide a more interactive learning experience to learners***, while ***instantly receive feedback*** that help them to dynamically alter course content or class activities to better engage current and future learners. Hence, **students** may be benefited by their ***enhanced cognitive engagement***, thus generate greater interests, develop better understanding, and ***achieve better learning outcomes*** in respective disciplines.

9.3. Limitation

One must realised that there are no perfect methods for any researches. In the current project, a number of limitations are identified.

9.3.1. Small Sample Size of Evaluation

Since progress of the development falls behind of estimation, the prototype was not able to put in use in real-life classes for testing and evaluation. Alternatively, a small number of interviewees are selected and showcased the prototype. Comments are collected from interviewees based on their past experience of taking mass lectures. As a result, the sample population may not be

representative in a wider cultural, educational, and academic context. Reliability and validity of the evaluation should be improved with further researches.

9.3.2. Lack Integration with Existing Platforms

A weakness of the current prototype is that it is not integrated with existing Learning Management Systems, such as Blackboard, Moodle, or OpenEdX. The lack of integrated with existing platforms increase the effort required for instructors to adopt the technology in classrooms. As a result, the perceived ease of use and intention of instructors to use the proposed solution may be lowered.

9.4. Future Development

Concerning the limitation discussed in Section 9.3., proposals of future development is recommended. In addition, proposals to enhance the functionality of the currently proposed solution is suggested.

9.4.1. Evaluation in Real-life Mass Lectures

Considered that the reliability and validity of the evaluation in this project, it is proposed that future researches should be carried out to implement the prototype in a real-life mass lectures. For instance, within the Hong Kong Polytechnic University, there are numerous classes that deliver in mass lecture mode. Accompanied with higher number of students and a more diversified cultural and educational background, researchers will be enabled to conduct a more precise and accurate evaluation on effectiveness of the proposed solution.

9.4.2. Integration with Existing Platforms

Regarding the integration with existing computer-supported learning applications, a potential advantage is that the proposed system can retrieve the learning directly from them rather than requiring instructors to upload twice. Furthermore, the authentication will be simpler for users (both instructors and learners), learning curve of the new technology is less demanding.

9.4.3. Enhancement in Automatic Tag Generation

As per previous discussion in Section 7.2.4., current Rapid Automatic Keywords Extraction (RAKE) algorithm is selected for quick implementation of automatic tag generation. However, the algorithm produces output with limited accuracy.

In order to enhance accuracy and thus the functionality, an alternative to the RAKE algorithm would be following the modelling process proposed by Kim and Shaw (2012). The process required additional input, such as scanning the Term Glossaries from textbook, from instructors, so that the application can create a list of important words from course content and conduct more effective extraction of students-initiated questions. Although the ease of use might be reduced, the improved accuracy should enhance the perceived usefulness of the solution. Such alternatives shall be studied in future projects.

9.4.4. Increase Opportunities of Collaborations

Despite the current project had put emphasise in the term **Collaboration**, the proposed solution only provide 1 mean of collaboration — by responding or discussing the questions posted by peers. With an increasingly popular trend in collaborative learning, feasibilities of different innovative ideas, such as integration with ***Social Networks***, introduction of ***Gamification elements***, addition of

Social Annotation features, could be studied and applied to classroom settings. They provided alternative means of collaboration, hence enabling an increase in cognitive engagement of students and prompting them to enjoy the benefits of collaborative learning.

10. CONCLUSION

The current project aimed at facilitating collaborative learning in mass lectures with the aid of computer software. A solution that incorporate various features is proposed and evaluated using a workable prototype. The potential barrier to motivation of engagement had been mitigated. In addition, learners reported a positive attitude towards the proposed ideas.

Concerning the problems stated in Section 1.3., problem ***P1: Learners unable to seek assistance*** is resolved by the proposed **Real-time Question Raising feature**. The feature encourage students to initiate interactions with instructors or collaborations with peers. **Social Network-like Interactions** also contribute in helping learners with low sense of autonomy or competence to adapt to the collaborate culture in class.

Regarding problem ***P2: Lack of collaboration between learners within large class***. The **Real-time Question Raising feature** contributes in mitigating the problem. Social Network-like interaction such as the **"Raise-your-hand" feature** enable instructors to foster exchange of opinions and ideas during class. Thus, achieving the real meaning of collaboration.

Considering problem ***P3: Teachers unable to receive feedbacks***, with the proposed solution, teachers can interpret the questions in the **Real-time Question Raising feature** as feedback to the effectiveness of teaching activities. The decisions to altering activities to satisfy learners' interests are also better supported with adequate data, helping instructors to deliver a positive learning experience.

As described in Section 9.2., the current study created a tool to enable instructors to foster collaboration in mass lectures. Students will be benefited from the better learning experience. Perhaps with the adequate application of technology, their frustration during

boring, lengthy mass classes could be relieved, and instead, they would be engaging in class, initiating interactions, and enjoying the collaborative processes.

APPENDIX

(i) Fieldwork 1 - Face-to-Face Interview

Date: 8th April 2017

Venue: Project Lab, Department of Computing, the Hong Kong Polytechnic University

Interviewee: Male; Final-year students; Department of Computing

No	Field Notes	Analytic Codes / Memo
1	• Yes. Courses of our department follows "Lecture + Tutorial" structure. I have plenty of lectures every semester.	
2	• No. My courses did not use them.	
3	• I would say … seldom. It is awkward to ask a question when the classroom is almost client. • Though sometimes I ask about assignment and project using e-mail.	Existing context: • Awkward to break silence Current student-teacher interactions: • Assignment • Project • Email
4	• I would also say seldom. When I am 100% sure of the answer I might do that.	Existing context: • Lack confidence
5	• I think I never did that. Most lecturers explain the query quite well and did not ask us to participate in discussion.	Existing context: • Addressed by instructors
6	• I think it will be more likely than currently. • At least I might submit into the system first, and see what will happen.	Improved context: • Lack confidence
7	• If it is asked as a poll, I will have a try.	

8	• If it is not formal in-class. Perhaps I will have a try. • If it is not formal in-class, I might not use the function, except when I am very sure about the answer.	Improved context: • Informal Improved context: • Lack confidence
9	• Ask a question! Sometimes I really like to ask furtherer on the topic but I have no chance.	Want to do: • Ask questions Existing context: • Interrupting Class
10	• It will prompt me to raise a question. • I doubt that my kind of question will be voted by others. It is like a lottery, you would not know if others also concern this. • But at least I will have a chance to ask. If the teacher can answer that after class, it will be even better.	Improved context: • Receive Feedback
11	• It is fine. Just like any other website. • … better than Blackboard discussion board. Save the hassle of switching between webpage.	Ease of use: • High
12	• I think this is a good idea. I am not those attentive in a class, so this system at least make me know what is happening in class, if not entirely remove me from other websites.	Existing context: • Distracted Improved context: • Aware of class
13	• No.	

(ii) Fieldwork 2 - Face-to-Face Interview

Date: 8th April 2017

Venue: Project Lab, Department of Computing, the Hong Kong Polytechnic University

Interviewee: Male; Third-year students; Department of Computing

No	Field Notes	Analytic Codes / Memo
1	• Yes. Most of my courses includes weekly lectures. • Usually 80 people attend them, that is about 50%-60% of those registered.	
2	• Yes. My CAR subjects have those. But that's the only one subject which uses the feature on Blackboard.	
3	• I tried a handful of times. But it is difficult to find the right timing to do so. • … usually when I have questions regrading projects, we draft e-mail carefully and ask our professor.	Existing context: • Interrupting Class Current student-teacher interactions: • Project • Email
4	• Seldom. I hate being wrong so I rather wait somebody else to answer, or let the lecturer make explanation himself/herself.	Existing context: • Lack confidence
5	• No. Most of the time the lecturer answer them quite well. • And in fact very few of my classmates ask questions.	Existing context: • Addressed by instructors • Social Norm

6	• I will evaluate hardly if my questions are silly first. If not then I will post (onto the system). • … (Anonymous feature) helps me in the process. And if my question is silly then others might not see it. • However, I will certainly look at others' and upvote them.	Improved context: • Anonymous • Lack confidence
7	• I will make a vote on the question. • But not answering / discussing it extensively.	
8	• Most likely not. • If I am interested in that question / topic, then I might read the thread. In the process if I had a question I might drop it in the discussion.	Improved context: • Interests
9	• I think reading others' posts that interest me. • … upvoting the questions I have in my mind.	Want to do: • Read discussions • Upvote questions
10	• I believed that it will be easy. • But too many questions may distract me from listening to the lecturer.	Comments to solution: • Distracted by amount of questions
11	• Yes. Everything looked like modern websites.	Ease of use: • High
12	• I think so. You can have more time to process the knowledge than absorbing them all during class.	Usefulness: • High
13	• No.	

(iii) Fieldwork 3 - Face-to-Face Interview

Date: 8th April 2017

Venue: Project Lab, Department of Computing, the Hong Kong Polytechnic University

Interviewee: Male; Final-year students; Department of Accounting and Finance

No	Field Notes	Analytic Codes / Memo
1	• Yes. Approximately half of my registered courses have lectures. • Some are larger lectures with more than 100 students. Some are smaller with about 40.	
2	• Yes, during my CAR subjects. It was not very good. Everyone tried to "discuss" just before the deadline.	Current student-student interactions: • Compulsory • Occur before deadline
3	• Sometimes, but usually at the end of the class or during a break. • … it seems like a "too-good" students if everything is asked by raising the hand and interrupt the class.	Existing context: • Interrupting Class • Standing out Current student-teacher interactions: • End of Class
4	• Often. Particularly when participation is a contributor to the final grade.	Existing context: • Contribute to final grade
5	• Seldom. Only a few of my classmates tend to ask publicly during classes.	Existing context: • Social Norm
6	• It will be more likely (to ask in front of the whole class). I think I would make those questions posted rather than ask my lecturers individually.	Improved context: • Seek support from peers
7	• It will be similar as currently.	

8	• I think it will be more likely. You can see the question and have a thought first. • But if the question is reviewed after a long period of time, then it will become difficult to recall and organise an answer in a short period of time.	Improved context: • Time for elaboration • Timing of feedback
9	• Ask a question, most likely. • It will be interesting to see how many peers have similar questions.	Want to do: • Ask questions
10	• I think it will be easy. Sometimes even you want to ask at the end or during break, you need to "queue up" and wait!	Comments to solution: • Unlimited questions Existing context: • Overwhelming questions
11	• It is easy to learn. • Everything pop up and show in the same window is better than click "Last page" and wait the Internet to load. • Try to simulate the interface on "LIHKG" (A local online forum in Hong Kong). Show the thread list and the message side by side.	Ease of use: • High
12	• I think it is all depending on the lecturer. If he/she devote time to answer the questions, then your system will be successful.	Usefulness: • Medium Comments to solution: • Instructors adapt to technology Improved context: • Timely feedback
13	• Not at all.	

(iv) Fieldwork 4 - Face-to-Face Interview

Date: 9th April 2017

Venue: Media Resources Centre, Department of Management and Marketing, the Hong Kong Polytechnic University

Interviewee: Female; Final-year students; Department of Management and Marketing

No	Field Notes	Analytic Codes / Memo
1	• Yes. The elementary courses are in mass lecture mode, with about 120 students in one class. The more advance course are in seminar mode, varying between 30-50 students in one class.	
2	• Yes. A handful of classes have discussion on Blackboard. One even have discussion on Facebook. • I think that they are pretty useless. Everyone tend to make response when deadline approaches. • Though I observed some active students share readings (articles) on Facebook. Generally speaking, in that course we students have more off-class online interactions. • … Clickers are also used during class for several times. But it always take time for students to get their device, login, and vote.	Current student-student interactions: • Mostly compulsory • Occur before deadline • Articles • Clickers • Time-consuming

3	• Quite often! We are encouraged to do so from time to time, especially in class with fewer students. • I did not ask questions public in classes with larger number of students. But that was just because there was not much to ask about. • It is also common to communicate with the lecturers regarding my essay by e-mail.	Existing context: • Being encouraged Current student-teacher interactions: • Assignment • E-mail
4	• A lot. Lecturers always ask questions so we are actually encouraged to do so.	Existing context: • Being encouraged
5	• A lot, too. When someone asked a question and after instructors address it briefly, there are always some active students making comments about them. • Also our lecturers will ask our opinion from time to time, too.	Existing context: • Social Norm • Fostered by instructors
6	• I think it will make me ask more. • It is like writing notes. When you have some points, you jog them down first.	Improved context: • Without time constraints
7	• I think it will be more or less the same. There are many responses even now.	
8	• I think yes. Part of the reason is because I am not a fast thinker, so usually I cannot react a question / topic immediately. If we saw a question and think it is interesting in advance, then surely you build up some idea in your mind and express them publicly.	Improved context: • Time for elaboration
9	• Ask a question! To be honest, I sometimes forgot what I was going to ask after the lecturer finish one section. So it would help me to ask instantly.	Want to do: • Ask questions Improved context: • Ask anytime

10	• Sure. Just typing some words!	Ease of use: • High
11	• Generally easy. I think you do not even need instructions to know where to click.	Ease of use: • High
12	• Ummm… I think it will. It will gather more questions from the class. • Perhaps it would also enable me to review a discussion when I recall them during revision.	Usefulness: • High
13	• Maybe there should be options to let me delete my questions. You know, sometimes you made a question just because the lecturer are not there yet. • There should also be a search function. It is difficult to read when there are lots of questions!	Comments to solution: • Edit / delete questions • Search questions

(v) Fieldwork 5 - Face-to-Face Interview

Date: 9th April 2017

Venue: Project Lab, Department of Computing, the Hong Kong Polytechnic University

Interviewee: Male; Third-year student; Department of Applied Biology and Chemical Technology

No	Field Notes	Analytic Codes / Memo
1	• Yes. Some courses come with lectures, and also the common courses like CAR subjects.	
2	• Not at all. I cannot remember any of my courses uses them.	
3	• Sometimes. • Most occasion about the projects.	Current student-teacher interactions: • Project
4	• I would say often. When there are no one in the class answer them and I know something, I speak and make my little opinion on the question.	Existing context: • Break slience
5	• Maybe sometimes? I honestly cannot remember. On most occasions our teachers are kind enough to explain the concept / issues detailedly.	Existing context: • Addressed by instructors
6	• If about the concepts / content, then it is more likely. It is good to have somewhere to ask and see if someone else have similar questions. • I think questions about projects will remain asked privately.	Improved context: • Seek support from peers • Timely feedback
7	• I would say a little more likely. It depends on how it is asked.	

8	• Probably will be more frequent. This is something new to me. So I am not sure. • If everybody else contribute to discussion, then I will join. It will be awkward if there are only few students talking to each other.	Improved context: • Social norm
9	• Ask / Upvote a question. Posting online is somewhat less “stand out” from the class than raising hand and standing up.	Want to do: • Ask questions • Upvote questions Improved context: • Lower barrier
10	• Yes, especially with the anonymous feature.	Improved context: • Anonymous
11	• Intuitive. It like nothing more than, say, Whatsapp. • Except the sorting feature. It would be unnoticed if there is no instructions.	Ease of use: • Medium
12	• Yes. I think the anonymous function will help to mitigate the bad feeling of asking.	Usefulness: • High
13	• Not much.	

REFERENCES

Automattic (2017). How to use. *Socket.IO*. Retrieved 16 April 2017, from: https://socket.io/docs/

Baghaei, N., Mitrovic, A., & Irwin, W. (2007). Supporting collaborative learning and problem-solving in a constraint-based CSCL environment for UML class diagrams. International Journal of Computer-Supported Collaborative Learning, 2, 159–190.

Barros-Castro R., Córdoba-Pachón J., Pinzón-Salcedo L. (2013). A Systemic framework for evaluating Com- puter-Supported Collaborative Learning-Mathematical Problem-Solving (CSCL-MPS) Initiatives: insights from a Colombian case, Systemic Practice and Action Research, doi: 10.1007/s11213-013-9279-7

Barros-Castro, R., Córdoba-Pachón, J., & Pinzón-Salcedo, L. (2014). A systemic framework for evaluating computer-supported collaborative Learning—Mathematical problem-solving (CSCL-MPS) initiatives: Insights from a Colombian case. Systemic Practice and Action Research, 27(3), 265-285.

Blackboard, Inc. (2014). Flipped Classroom. Accessed 6 November, 2016, from: http://images.email.blackboard.com/Web/BlackboardInc/%7Ba87fffa3-375e-422f-a08b-1e2a4f891f8e%7D_Bb_FlippedClassroom.pdf

Blackboard, Inc. (2016). Blackboard Collaborate: Feature Showcase. Accessed 6 November, 2016, from: http://www.blackboard.com/online-collaborative-learning/blackboard-collaborate-features.aspx

Blasco-Arcas, L., Buil, I., Hernandez-Ortega, B., & Sese, F. J. (2013). Using clickers in class. The role of interactivity, active collaborative learning and engagement in learning performance. Computers & Education 62 (2013) 102–110

Blumenfeld, P. C., Marx, R. W., Soloway E., Krajcik J. (1996). Learning with peers: From small group cooperation to collaborative communities. *Educational Researcher* 1996;25:37–40.

Blumenfeld, P. C., Kempler, T. M., Krajcik, J. (2006). Motivation and Cognitive Engagement in Learning Environment. The Cambridge Handbook of the Learning Sciences.

British Columbia Institute of Technology (2017). CodeIgniter URLs. *Docs*. Retrieved 16 April 2017, from: https://www.codeigniter.com/userguide3/general/urls.html

Capdeferro, N., & Romero, M. (2012). Are online learners frustrated with collaborative learning experiences?. The International Review of Research in Open and Distributed Learning, 13(2), 26–44.

Caswell, T., & Harband, J. (2017). Installation. *Node Version Manager*. Retrieved 16 April 2017, from: https://github.com/creationix/nvm/blob/master/README.markdown#install-script

Chi M. T., (2009). Active–constructive–interactive: A conceptual framework for differentiating learning activities. *Topics in Cognitive Science* 2009;1:73–105.

Chi, M. T., Wylie, R. (2014). The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes, Educational Psychologist, 49:4, 219-243, DOI: 10.1080/00461520.2014.965823

Cohen, E. G. (1994). Restructuring the Classroom: Conditions for Productive Small groups. Review of Educational Research, 64(1), 1-35.

Collins, A. (2016). A brief history of mass collaboration: How innovations over time have enabled people to work together more effectively. In Mass collaboration and education (pp. 31–42). Cham, Switzerland: Springer International.

Dillenbourg, P. (1999). Collaborative learning: Cognitive and computational approaches. New York: Emerald Group.

D. Dolmans, W. Grave De, J. Wolfhagen, and C. Van Der Vleuten, "Problem based learning: Future challenges for educational practice and research," Med. Edu., vol. 39, pp. 732-741, 2005.

Fisher, Lucas, & Galstyan (2013), The Role of iPads in Constructing Collaborative Learning Spaces. Tech Know Learn, 2013(18), 165-178.

Fredricks, J. A., Blumenfeld, P. B., Friedel, J., & Paris, A. (2002). Increasing engagement in urban settings: an analysis of the influence of the social and academic context on student engagement. In Paper presented at the annual meeting of the American Educational Research Association. New Orleans.

Gallini, S. M., & Moely, B. E. (2003). Service-learning and engagement, academic challenge and retention. Michigan Journal of Community Service Learning, 5–14, Fall.

Go-Globe (2015, May 16). Social Media Usage in Hong Kong — Statistics and Trends [Web Blog Post]. Retrieved from http://www.go-globe.hk/blog/social-media-hong-kong/

González, M. G., Burke, M. J., Santuzzi, A. M., & Bradley, J. C. (2003). The impact of group process variables on the effectiveness of distance collaboration groups. Computers in Human Behavior, 19(5), 629–648.

Google, Inc. (2012). Web Speech API Specification. Retrieved 16 April 2017, from: https://dvcs.w3.org/hg/speech-api/raw-file/tip/speechapi.html

Google, Inc. (2017). Cloud Compute Products. Retrieved 16 Apr 2017, from: https://cloud.google.com/products/compute/

Haseman, W. D., Polatoglu, V. N., & Ramamurthy, K. (2002). An empirical investigation of the influences of the degree of interactivity of user-outcomes in a multimedia environment. Information Resources Management Journal, 15(2), 31–48.

Hickey, D. T. (1997). Motivation and Contemporary Socio-constructivist Instructional Perspectives. Educational Psychologist, 32(3), 175-193.

The H.K.F.Y.G. Youth Research Centre (2014). Youth and Information Technology: Youth Poll Series, 208, 7-13. Retrieved 2016-12-05, from: http://yrc.hkfyg.org.hk/files/yrc/New%20Poll%20since%202013/P208%20Full%20Report%20for%20Web_chi_20150321.pdf

Handley, K., & Williams, L. (2011) From copying to learning: Using exemplars to engage students with assessment criteria and feedback, Assessment & Evaluation in Higher Education, 36:1, 95-108, DOI: 10.1080/02602930903201669

Holbrrok, J., & Kolodner, J. L. (2000). Scaffolding the Development of an Inquiry-based (Science) Classroom. In B.Fisherman & S. O'Connor-Divelbiss (Eds.), Proceedings of the Fourth International Conference of the Learning Sciences (pp. 221-227). Yahweh, NJ: Lawrence Erlbaum Associates.

Jeong, H. and C. E. Hmelo-Silver (2010). Technology Use in CSCL: A Content Meta-Analysis. In Proceedings of the 43rd Hawaii International Conference on System Sciences - 2010. IEEE.

Jeong, H. and C. E. Hmelo-Silver (2016). Seven Affordances of Computer-Supported Collaborative Learning: How to Support Collaborative Learning? How Can Technologies Help? Educational Psychologist.

Johnson, D.W., Jonson, R. T., Smith, K. (1991) Active Learning: Cooperation in the college classroom. Edina, MN: Interaction Book Company.

Jones, C., & Hosein, A. (2010). Profiling students' use of technology: Where is the net generation divide? *International Journal of Technology, Knowledge & Society*, 6(3), 43-58.

Kafai, Y. B., & Peppler, K. A. (2011). Beyond small groups: New opportunities for research in Computer-Supported Collective Learning. In H. Spada, G. Stahl, N. Miyake, & N. Law (Eds)., Connecting Computer- Supported Collaborative Learning: CSCL2011 Conference Proceeding Volume I—Long papers (pp. 17–24). Hong Kong, China: International Society of the Learning Sciences.

Kim, J., & Shaw, E., (2014). Scaffolding student online discussions using past discussions: PedaBot studies. Artif Intell Rev (2014) 41:97–112 DOI 10.1007/s10462-011-9300-4

Laurie, G. A., Gahan, L. R., Matthews, K. E., Weaver, G. C., Bailey, C., Adams, P., Kavanagh, L. J., Long, P. D., Taylor, M. (2014). TECHNOLOGY SUPPORTED FACILITATION AND ASSESSMENT OF SMALL GROUP COLLABORATIVE INQUIRY LEARNING IN LARGE FIRST-YEAR CLASSES. *Journal of Learning Design*, 7(2), Science and Education.

Lee, O. (2003). Equity for Linguistically and Culturally Diverse Students in Science Education: A Research Agenda. Teachers College Record, 105(3), 465-489.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukko- nen, H. (1999). Computer-supported collaborative learning: A review. Retrieved 2016-11-05, from http://www.kas.utu.?/clnet/clnetreport.html

Liu, C. C., Chung, C. W., Chen, N. S., & Liu, B. J. (2009). Analysis of peer interaction in learning activities with personal handhelds and shared displays. Educational Technology and Society, 12(3), 127–142.

Liu, T., Liang, J., Wang, H., Chan, T., & Wei, L. (2003). Embedding educlick in classroom to enhance interaction. In Proceedings international conference computers in education (ICCE) (pp. 117–125). Hong Kong, China.

Monteiro, E. & Morrison, K. (2014) Challenges for collaborative blended learning in undergraduate students, Educational Research and Evaluation, 20:7-8, 564-591, DOI: 10.1080/13803611.2014.997126

The Nielsen Company (2014-05-09). Mobile Millennials: Over 85% of Generation Y Owns Smartphones. Retrieved 2016-12-05, from http://www.nielsen.com/us/en/insights/news/2014/mobile-millennials-over-85-percent-of-generation-y-owns-smartphones.html

Node.js Foundation (2017). Installing Node.js via package manager. Retrieved 16 April 2017, from: https://nodejs.org/en/download/package-manager/

Nokes-Malach, T. J., Richey, J. E., & Gadgil, S. (2015). When is it better to learn together? Insights from research on collaborative learning. Educational Psychology Review, 1–12.

Oracle Corp. (2017). Installing MySQL on Linux. Retrieved 16 April 2017, from: https://dev.mysql.com/doc/refman/5.7/en/linux-installation.html

Padlet (2015). What is Padlet?. Retrieved 2016-11-05, from: http://jn.padlet.com/article/57-what-is-padlet

Palincsar, A. S. (1998). Social Constructivist Perspective on Teaching and Learning. Annual Review of Psychology, 49, 345-375.

Persico, D., Pozzi, F., & Sarti, L. (2010). Monitoring collaborative activi- ties in computer supported collaborative learning. Distance Education, 31(1), 5–22.

Peters, V., & Slotta, J. D. (2010). Scaffolding knowledge communities in the classroom: New opportunities in the web 2.0 era. In M. J. Jacobson & P. Reinmann (Eds.), Designs for learning environments of the future: International perspectives from the learning sciences (pp. 205–232). New York, NY: Springer.

Pifarre, M., & Staarman, J. K. (2011). Wiki-supported collaborative learning in primary education: How a dialogic space is created for thinking together. International Journal of Computer-Supported Collaborative Learning, 6, 187–205.

Pluta, W., Richards, B., & Mutnick, A. (2013). PBL and beyond: Trends in collaborative learning. Teaching and Learning in Medicine, 25, 9-16.

Rummel, N., & Spada, H. (2005). Learning to collaborate: An instructional approach to promoting collaborative problem solving in computer-mediated settings. The Journal of the Learning Sciences, 14, 201–241.

Sikarwar, A. S. (2015). Flipped Classroom with Poll Everywhere: Engaging Students with Active Learning in Large Group Settings. Journal of Asian Scientific Research, 2015, 5(2):111-119

Sinha, S., Rogat, T. K., Adams-Wiggins, K. R., & Hmelo-Silver, C. E. (2015). Collaborative group engagement in a computer-supported inquiry learning environment. International Journal of Computer-Sup- ported Collaborative Learning, 10, 273–277.

Springer, L., Stanne, M. E., & Donovan, S. S. (1999). Effects of small-group learning on undergraduates in science, mathematics, engineering, and technology: A meta-analysis. Review of Educational Research, 69(1), 21–51.

The PHP Group (2017). Installation and Configuration. Retrieved 16 April 2017, from: http://php.net/manual/en/install.php

Tudge, J. R. H., Winterhoff, P. A., & Hogan, D. M. (1996). The cognitive consequences of collaborative problem solving with and without feedback. Child Development, 67(6), 2892–2909

Wang, S. L., & Hwang, G. J. (2011). The Role of Collective Efficacy, Cognitive Quality, and Task Cohesion in Computer-Supported Collaborative Learning (CSCL). Computers & Education, 58 (2012), 679-687.

Webb, N. M., & Palincsar, A. S. (1996). Group Processes in the Classroom. In D.Berliner & R. Calfee (Eds.), Handbook of educational Psychology (pp. 841-873). New York: Macmillan.

Wentzel, K. R. (1997). Student Motivation in Middle School: The Role of Perceived Pedagogical Caring. Journal of Educational Psychology, 89(3), 411-419.

Yackel, E., Cobb, P., & Wood, T. (1991). Small-group Interactions as a Source of Learning Opportunities in Second-grade Mathematics. Journal for Research in Mathematics Education. 22, 390-408.