ABSTRACT

Modern educational theories, such as collaborative learning, constructivism and inquiry learning, have achieved many successes in real-world applications. Especially, with the development of information technologies, there have been several online collaborative learning platforms in practice. Unfortunately, as these platforms are either too complicated or too expensive, none of them are suitable for us in the practice of STEM+. Moreover, most of these platforms are in English, while we are using Chinese as our teaching language. Using an online collaborative learning platform (OCLP) named Zask, this paper reported our practice in online collaborative learning on course Introduction to Database System. According to the data collected from the first round of our practice, it shows that users’ active participations in Zask could benefit for both teaching and learning, and then provide positive effects in education.

KEY WORDS

online collaborative learning, OCLP, STEM+

1. Introduction

Nowadays, both in-class lectures and online learning pose challenges and limitations in leading students to a deep comprehension of IT education and its real world applications.

In the long term of teaching practice, we have deeply realized that the traditional teaching mode has been encountered larger conflicts and challenges, which have mainly reflected in many aspects, like more teaching contents, rapidly changing technologies, a wider variety of demands from various students, fairly limited in-class hours, etc. It is impossible to achieve all of these instructional objectives merely in class, while students are assumed to take the acquisition and accumulation of knowledge and skills also through learning after class.

Collaborative learning advocates mutual assistance and cooperative learning among students. It is known as to make knowledge and skills accumulated by entire participants, so that students could learn more from information exchanging, problem solving and communication practice. Along with the rapid development of information technologies, like Internet, it is expected to have more platforms which would apply the concept of collaborative learning into practice and explore a successful online educational style. As collaborative learning [1-5] and web-based education [6-11] has attracted many research interests, and many practical experiences have been accumulated [12-18], how to better utilize information technologies and online resources to integrate both classroom instruction and collaborative learning together is fairly an important issue for solving those problems mentioned before and improve teaching and learning effectiveness.

This work has explored how to combine both of these different education forms, in-class lectures and online learning, within a single hybrid course. Through this project, we would like to know how much it would impact students on the problems mentioned before, especially on skills of knowledge accumulating and critical problem-solving. In the practice, teachers would use class time to convey the key and basic points of the curriculum, while students could explore further details and engage in more in-depth study with their classmates in the online society. The ideal environment we want is a suitable and convenient online collaborative learning platform (OCLP) for the participation of teachers and students. However, most of relevant platforms are in English, while we are mainly teaching in Chinese. Besides, they are either too complicated or too expensive for us. As we are mainly focus on improving STEM education, it is supposed to be built and organized mainly based on some of education theories, like collaborative learning, constructivism and inquiry learning, in a clean and clear style. To support this project, we have implemented a succinct OCLP named Zask [19] in Chinese, which is based on an open source Web2.0 framework in PHP, and would like to make it free and share our resources and experiences accumulated with teachers and students all over the world.

The following parts of this paper are organized as below: Providing an overview of related education theories in Section 2, it then describes the design and implementation of Zask, an online collaborative learning platform, in Section 3. The practice of a real world case study is shown in Section 4, while it then reports the results and effective evaluation of this round of practice in Section 5. Finally, Section 6 concludes this practice and discusses future works of the project.
2. Related Education Theories

The objective online collaborative learning is a combination of collaborative learning, experience training, and problem-solving training. It will be achieved by a blended learning of in-class teaching, self-learning, conducted exploring, and project-based exercises. Users could post their problems or answer the others’ questions when having logged into an online collaborative learning platform with a registered account. They could also hold intra-group or inter-group discussions in the platform. Distance mentoring from teachers (including TAs) should also be provided. Here we would like to summarize some of the education theories which have formed the basis of our practice.

2.1 STEM+

The STEM (Science, Technology, Engineering, and Mathematics) fields [20, 21] are those academic and professional disciplines that fall under the umbrella areas represented by this acronym. According to both the United States National Research Council and the National Science Foundation, these fields are collectively considered core technological underpinnings of an advanced society.

As mentioned in HP Catalyst Initiative [22], this work would like to explore new and more effective approaches for preparing students to use their technical, creative, and collaborative ingenuity to address significant social challenges in their community and around the world. The first breakthrough is to think beyond the traditional definition of STEM education, and think about STEM+, where the plus represents: existing and emerging disciplines that were not originally included in the acronym, such as computer science, and skills and attributes that students must develop to be effective and innovative.

2.2 Collaborative Learning

Collaborative learning [1, 3, 5] is a strategy of organizing students to learn knowledge in the form of a group or team. In the process of collaborative learning, learners could get a full discussion of issues through different ways, including dialogues, discussions, debates, etc. Online Collaborative Learning (OCL) [12, 14, 15, 23] is a process which is based on a collaborative learning environment established by computers and networks. With OCL, discussions become much easier among teachers and students. Learners could collaborate with each other within the online platform and reach a deep understanding and mastery of the teaching content, while teachers could also participate into discussions and give some helpful advices and necessary guidance. Then online collaborative learning could have a positive effect on improving learning efficiency by reducing the complexity of searching for useful information and online resources, which would shorten the time of acquiring information and knowledge exactly wanted.

Besides Collaborative learning, this work also absorbed the other education theories, like inquiry learning and constructivism, to have a better impact during the practice.

2.3 Inquiry Learning

Inquiry learning [24, 25], which is also known as Inquiry-based learning, is proposed by Klaus Schwab. It is named as opposed to the traditional concept “reception learning”, which thinks that students’ learning process is essentially the same as the researching process by scientists. It believes that students should find and solve problems like scientists. What’s more, during the process of exploration, a student would be impacted to figure out how to mesh their scientific view of the mind with these humanist values they might want to preserve. He could give full play to the initiative and autonomy during learning to acquire professional knowledge, build specialized skills and improve personal ability, especially in creativity.

Different from the traditional ways of imparting information and knowledge to students directly, teachers are demanded to change their roles from knowledge imparters into learning facilitators. They would like to help students draw their own conclusions through a variety of exploration activities. Regardless of the constraints of time and space, an internet-based teaching platform could offer fast learning feedbacks, implement various forms of teaching, open up a wider world of education, and provide students with a multi-channel, multi-perspective, multi-level learning environment. Therefore, the inquiry learning would undoubtedly make a greater progress with the rapid development of information technologies, especially with internet.

2.4 Constructivism

Constructivism [26, 27] is first proposed by Jean Piaget, which believes that knowledge is not only taught by teachers, but also obtained by learners during the learning process in certain situations. In brief, constructivism encourages learner-centered learning under the guidance of teachers, and emphasizes that students should actively explore discover knowledge and construct the meaning of obtained knowledge. On the contrary, the traditional teaching only transports knowledge from teachers’ minds to students’ notebook. During this practice, there are 2 kinds of constructivism related: cognitive constructivism, where the learner builds their unique neural network of understanding based on the stimulus they receive and their cognition, and social constructivism, where as a group we create shared understandings. We have both of them while the latter would be more powerful in this work. Thus, we would also consider looking at intersubjectivity, or shared understanding among those in collaborative online education.
Constructivism encourages students to identify problems under the guidance from teachers with initiative interests. Inquiry learning requires students to study in-depth while focusing on the nature of things. Collaborative learning is more beneficial for students to discuss learning contents in-depth during the process of collaboration and enhance the learning efficiency. These three theories together could make full use of IT technology and open up broad prospects for the students to improve learning efficiency and in-depth study. It is important to develop an online collaborative learning platform (OCLP) by integrating constructivism and inquiry learning together while combining the rapid development of information technology for STEM+. That is because this could create spaces for students to find their interested questions and solve problems initatively when they are provided a communication environment to work together during this process. The courses will not only help for further teaching and learning, but also help for communications and discussions without limits of time and spaces.

Through the implementation of this project, we would like to achieve several objectives as listed below:

1. Study how to apply the collaborative learning mode in an online platform, and improve teaching effectiveness.
2. Put collaborative learning into the student achievement evaluation system to improve their participation and interests.
3. Get a balance between classroom instruction and collaborative learning to achieve an optimal teaching effect.
4. Evaluate the effect of collaborative learning mode based on this case study.

3. Solution Design and Implementation

3.1 Solution Design

Researchers suggest that collaborative learning bring positive results [1, 3, 5] such as deeper content understanding, increased overall achievement in grades, improved self-esteem, and higher motivation on tasks. Generally, there are two critical considerations when designing an online learning platform: advanced features and successful usage, in which the latter one is supposed to be more important.

There has been abundant of paid or free online learning platform software, all of which is rich in collaborative learning supported features, but our teaching practice shows that the key to success is how to effectively bring this software into specific courses and fully arouse the interest and enthusiasm of teachers and students. The approaches that users use for interactive communications in the platform are supposed to be as shown in Figure 1.

![Figure 1. Interactive Communications in OCLP](image)

All we want to have is a clean and clear OCLP that could simply help students to be active and constructive during their participating, take ownership of their own learning, resolve group conflicts, and improve teamwork skills. Therefore, the designed workflow of a supposed classical user learning model would like to be that: users visit an OCLP for information sharing and extract useful or interested things during this process; during the progress of digesting, they may obtain new knowledge, skills and experiences, which would also have impact of affection and modification in their mind; then, it is possible for them to have new ideas or thoughts after thinking and innovating. Some of them may then share their learning experiences and thoughts online and begin a new circle of this workflow.

3.2 Platform Implementation

Under the guidance of education and learning theories, we have designed and implemented an OCLP to support this project. This OCLP is based on an open sourced PHP framework and implemented by a development team composed by a group of undergraduate students from our university. The basic implementation information has been listed in Table 1.

<table>
<thead>
<tr>
<th>Table 1. The Implementation Information of Zask</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Item</strong></td>
</tr>
<tr>
<td>IDE</td>
</tr>
<tr>
<td>Database</td>
</tr>
<tr>
<td>Language</td>
</tr>
<tr>
<td>Other Tools</td>
</tr>
<tr>
<td>Server</td>
</tr>
<tr>
<td>URL</td>
</tr>
</tbody>
</table>
The Platform is named Zask [19]. Its name is obtained through combining both ‘Z’ and ‘ask’ together. Here, ‘Z’ stands for ‘知道’ and ‘知识’ in Chinese, which means know and knowledge respectively in English. The term ‘ask’ is to encourage students to throw out more doubts and problems, help to answer plenty of questions from the others, and more importantly, take part into various kinds of activities online. Since the selected experimental course is taught in Chinese, the system only has Chinese version published by now.

![Figure 2. Homepage of Zask](image)

![Figure 3. Hot Tags in the Tag List](image)

![Figure 4. User List](image)

Table 2. Channels in Zask

<table>
<thead>
<tr>
<th>Channel</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newest Activities</td>
<td>List all the activities in the platform by temporal sequence (newest first).</td>
</tr>
<tr>
<td>All Questions</td>
<td>List all the questions that have submitted in the course by temporal sequence (newest first).</td>
</tr>
<tr>
<td>Questions Waiting for Answers</td>
<td>List all the questions that do not have any reply by temporal sequence (newest first).</td>
</tr>
<tr>
<td>Question List by Tags</td>
<td>List questions by tags. All the tags that have registered have been listed in Figure 3.</td>
</tr>
<tr>
<td>Question List by Categories</td>
<td>List questions by knowledge categories. All the categories that have registered would be listed.</td>
</tr>
<tr>
<td>User List</td>
<td>List all the users that have registered in this course, as shown in Figure 4.</td>
</tr>
<tr>
<td>Question Post</td>
<td>The main box is as shown in Figure 2 without any question or activity listed below.</td>
</tr>
</tbody>
</table>

For statistical information collection and system safety guarantee, users could only post their activities, questions and answers after logging into Zask with a registered account.

4. Practice of Online Collaborative Learning

Traditional teaching mode faces great challenges as aforementioned. In general online learning community, the interactive mode among teachers and students are mainly in the form of free discussion. This work plans to apply the concept of collaborative learning into teaching practice with the supports of an online learning platform. The whole teaching and learning workflow in an OCLP is as shown in Figure 6.

In order to make most of the students participate into online collaborative learning, we have designed many online activities, including self exploration, online mentoring, online education, group practice, exchange of feedbacks, and online discussion. This work tries an online teaching and collaborative learning mode that is supposed to better meet the needs of students and highlights the online collaborative learning features, including mutual help, autonomy and exploratory.

In the past year, we applied course Introduction to Database System into practice. It is selected as one of the most welcome and famous courses in Renmin University of China. In the following parts, the activities, which we have been listed in Table 2. Below the channel bar is the content field. The content panel on the left of this field is for questions and activities that to be posted and listed, while a notice board is on the right for news and notices to be published.
held in the first round of Zask practice, would be introduced in detail. Since both items of Online Teaching and Online Discussion are just as them in the traditional way, this section will skip both of these two parts.

4.1 Self Exploration

Inspiring questions during the learning process is a critically important section that is insurmountable and should not be skipped. One of our original intentions in this project is to have students raise concerns and questions and encourage them to get troubles shot during the communication with other students or under the guidance of teachers (including TAs). This is the partly progress of cognitive constructivism, where the learner builds their unique neural network of understanding based on the stimulus they receive and their cognition. Online collaborative learning could offer students 7*24 services so that it could satisfy the requirement of post any questions anywhere they are and take part into discussions any time it is.

Meanwhile, at the very beginning of the semester, we set an activity for all students on paper reading. All of the students were asked to read, think and discuss a classic paper in database domain, which is named A Relation Model for Large Shared Data Banks [28] by F. Codd. This activity was based on both of the problem scenarios and conceptual architecture that have been raised and built in their mind. We would like to guide the students to the learning objectives, and guide them to achieve common progress during the process of collaborative exploration and inquiry learning. The practice response showed that students had more interest in interesting questions and confused fields they found in the paper, and would like to concentrate on learning when teachers gave instructions in-class or online. Students then started to build the interest in this course, and would like to find more in their spare time.

4.2 Online Discussion

To enable students to consolidate knowledge and further expand their horizons, teachers also arrange online discussions based on the actual progress of teaching contents. Exploration is first inspired by lecturers, and then students are sent to analysis all they want in this domain by themselves. During this process, the teachers should give guidance tips and help students solve problems timely along with the conceptual framework.

For example, when learning the concept of Database Integrity [29], a lecturer could organize students to have online discussions, e.g. ‘in the actual database system, in order to ensure its integrity, what kind of design and implementation you would like to have?’ Students are required to express their points of view, and make appropriate research on it. In order to make their answers reasonable, students need to actively search for relevant issues. Meanwhile, in this process, teachers could guide students to explore and discover new questions and help them to solve problems.

4.3 Group Practice

Group consultation and discussion is a very important part of collaborative learning and inquiry learning. It is an important training for students - not only in knowledge and technical skills, but also for their team work spirits and communication skills. This is the partly progress of social constructivism, where as a group they create shared understandings.

In the first round of practice of Zask in course Introduction to Database System, in addition to the single small set of pilot projects, we had also asked students involved to implement a prototype system by team. All of the students were divided into small groups, which only had 3 - 5 members each, and together finished a project given or selected by themselves. Different teams had different topics. Each member in a team had a different role and tasks from the others. They should cooperate with each other to design and implement the project, record all of this process in documents and project source code, and finally, achieve and summit the complete project work together by team before the course finished. Their discussion, schedule and documentations should be recorded and shared in the platform, so that the other users could visit them via either the target user name or their interested record tags.

4.4 Exchange of Feedbacks

During the achievements in practice, students could obtain many valuable experiences and find some problems from independent explorations. The instructor can then select representative issues, give feedbacks, and further inspire students to absorb and master all kinds of knowledge.
When corresponding online discussions come to an end, the students can organize the information online and cumulate their own learning. At the same time, teachers could also choose typical problems and explain them in the classroom. Also, they could specify the focus and main points of knowledge and skills in order to facilitate the consolidation and increase of knowledge.

This practice is expected to overcome the problems encountered in teaching and improve learning effectiveness, while the OCLP is expected to cover more and more students for their accessing and utilizing of these resources.

5. Discussions

We hope to apply the collaborative learning concept into IT teaching practice to solve the problems encountered in education and improve the teaching effectiveness. This work is expected to provide evidences of benefits and area for improvement from online collaborative learning, share our experiences of activity organizations and participants’ behaviours, meet students' learning-to-know demand, and highlight its features of Cooperation, Autonomy and Thought.

During the last school year, we have applied online collaborative learning into teaching and learning process of Course Database Technology and Application with the support of Zask. There have been 4 teachers and 61 students involved in this practice. The overall information about the practice has been listed in Table 3. In this process, we encouraged students to think more about the content in-class and asked them to learn and release curriculum questions online, discuss with each other and actively participate in online communication and activities.

<table>
<thead>
<tr>
<th>Item</th>
<th>Basic Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>School(s)</td>
<td>School of Information, Renmin University of China</td>
</tr>
<tr>
<td>Involved Teachers</td>
<td>4 (including 2 in-service and 2 teaching assistances)</td>
</tr>
<tr>
<td>Involved Classes</td>
<td>2</td>
</tr>
<tr>
<td>Course Name</td>
<td>Introduction to Database System</td>
</tr>
<tr>
<td>Involved Students</td>
<td>61</td>
</tr>
<tr>
<td>Students Gender</td>
<td>56.3% male and 43.6% female</td>
</tr>
<tr>
<td>Students Age Range</td>
<td>19 – 21 (19.5 on average)</td>
</tr>
</tbody>
</table>

We have used several data collection methodologies for different target populations (teachers and students), examine the efficiency and effectiveness of the applied collaborative learning solution and the effective use of Zask, including interviews, observations, questionnaires, tests, activity records, etc. Data from experiments, course examinations, post-questionnaires, and inquiries from teachers has also been collected.

5.1 Analysis of Learning Effects

1. Correlation Analysis between Course Scores and Online Participation

We give each student a participation score in Zask and transform it into the corresponding percentile data as his/her participation value in Zask. Each of them also has a final grade in course Introduction to Database System. We sorted their course grades in descending order with corresponding Zask score. Based on the comparison analysis of these data, we have found that: Among the top 10 students with the highest academic scores, there are 7 of them plays an active role in Zask, which shows that they are also involved in the top 10 group in Zask ranking system; at the same time, there are eight students in the group of 10 lowest course grade also in the group of 10 lowest Zask scores. As an aspect, this shows the good efforts of Zask platform in online collaborative learning for students to master theoretical knowledge and improve their professional skills. It also gives a certain significance that students with higher level of participation could benefit more due to their better performance.

2. Analysis of Course Grades

Theory examinations are very important for teachers to know the first hand information of students' learning about basic concepts and methods of database systems in course Introduction to Database System. According to the comparison of students' exam results in both midterm and final examinations, we found that, in accordance with the sorted individual scores in descending order, up to 3/5 students’ final examination scores are higher than their mid-term scores. This partly shows that the practice of online collaborative learning has a promotion for students to master knowledge and improve skills during their learning process.

5.2 Questionnaires

To further understand the students' attitudes and perceptions on online collaborative learning, we conducted a survey for all of the 61 students involved in this round of practice. This survey is divided into two parts: Online Collaborative Learning Questionnaire and Online Collaborative Learning Effectiveness Evaluation Form.

Through the collection and analysis of the questionnaire data and collation of information, we have found that:

1. Participating in online collaborative learning, almost all of the students are satisfied with the well working of the platform, which relies on the provided service of 7 * 24 hours well running of Zask. 78.33% of the students think
that their discussion in OCLP make senses, and up to 76.67% of them indicated a wish to further participate in online discussions. But half of them think the online time is limited and is difficult to be guaranteed.

2. After the practice of collaborative learning, 90.00% of the involved students think that it could enhance knowledge learning and skill mastering while improving emotional communications; 83.33% of them could adapt and accept the combination style of both online collaborative learning with traditional teaching; 91.67% of them consider that it could expand the amount of shared information and their own knowledge.

3. For the factors that may impacting online collaborative learning, up to 96.67% of the involved students affirmed the importance of participation of teachers (including TAs), while 98.33% of them think that other active participations and timely feedbacks could make it easier to capture great perception of affection and affiliation. 95.00% of them believe that collaborative learning activities contribute good efforts for them to master relevant knowledge and skills better.

In addition, as students involved in the project are all belong to the same college in the same grade, which indicates that they would spend a lot of time together in life, thus 68.33% of the students are more inclined to discuss directly with classmate or roommates. In the process to further expand the range of applications and improve systems, proper courses that are more fit for online collaborative learning should be selected carefully and how to better attract users to participate into online activities and discussions is a question worth to be explored.

5.3 Interviews

At the end of the semester, we have random selected 9 of the students in involved in the practice of this project, which is 15% of the whole, and taken a face to face interview for this round of practice.

Evaluating from the interview for course Introduction to Database System, we could see that methods and activities used in this project worked effectively for educational purposes. Analyses were conducted based on these collected data from various sources, while positive results have been observed from some basic analyses:

1. All of the students have their accounts in Zask and over 98% of the students have taken part into online discussion and activities.
2. More than half of the information discussed in Zask are supposed to be meaningful and helpful.
3. The knowledge acquired in Zask is effectively applied in discussions in class.
4. The final examination results indicate that it was effective for students' learning, and have a obvious positive correlation with students' activities in Zask.

We also have learnt that the conduct role of teachers and TAs should be enhanced. Although the research focus of this project is on individual collaborating with their peers among students, teachers still have a vital role in facilitating learning. At the very beginning, we would like to encourage students discussing topics and exploring problems all by themselves, but the depth of discussion usually just stayed on the surface level. It then turns to be rather obvious that it would be fairly benefit and helpful to the students when teachers could introduce the online collaborative learning activities in a thoughtful way and offer necessary guidance.

Besides, we have collected advices from teachers and students for how to improve this OCLP with more features, including usability, adaptation and internationalization, which are under discussion. Based on the feedbacks and analysis from questionnaires, interviews and test results, we will continue to refine the functions in the system, improve the teaching and learning methods applied in this practice and extend the solution to the courses taken by graduate students in the following semester.

6. Conclusion

In the past year, we have designed a specific collaborative learning solution for STEM+, implemented online collaborative learning in course Introduction to Database System under the support of an online platform named Zask, and evaluated the effect of this practice as the course goes on. From the review of the practice in the past semester, we have found that this practice has not only helped students consolidate and broaden their knowledge and skills obtained in and out of classroom, but also developed their abilities in independent thinking, innovation, team working, and solving problems. We also found that during the process of online collaborative learning, teachers should play a conduct role in the whole practice while some of the functions in Zask are also needed to be enhanced and improved.

The research in online collaborative learning in STEM+ is fairly an active information technology application domain. This work has just taken an elementary exploration on general online collaborative learning pattern based on the study process and instance analysis. In the future, we would like to adjust teaching methods and schedule, choose some of the other appropriate courses to be applied into the optimized collaborative learning pattern, have more practices in this field, and share our experience and lessons in it to the others. Also, interactions are social, and thus are governed by one's cultural framework for social interactions. As all of this practice is held in China, the social interactions within this environment might be different from social
interactions from some other cultures. How to have the platform with the feature of internationalization, better sharing our experiences in online collaborative learning with the others, and evaluate its success is the issues need to have a research and discussion.

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