Jigsaw Collaborative Learning in the Large Enrollment Flipped Classroom: A Design-based Research Study

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Abstract

How to promote students' engagement is a challenge facing large enrollment classes. The flipped classroom model, like many other effective learning strategies, faces many challenges when implemented in large enrollment classes in the higher education. Some empirical studies adopt additional strategies to address the challenges in large flipped classrooms. However, most strategies are limited in the effect of promoting large-scale connections between students in large classes. The jigsaw model is a collaborative learning technique. Students in a jigsaw group meet first with students in other jigsaw group who have been assigned the same segment in a temporary expert group. Then the jigsaw group reconvene, and each student act as a tutor on his/her specialty topic. The jigsaw model can promote interdependence, and individual accountability. It has great potential in facilitating connections between students in large classes. In this study, a design-based research method was adopted to explore the integration of the jigsaw model, and the "Explore-Flip-Apply" flipped classroom model. An educational intervention prototype was designed based on these two models, as well as the theory of student involvement and sequences of pedagogical structure. Educational interventions would be revised in successive iterations. Supported by synchronous and asynchronous computer-mediated communication, this jigsaw-based flipped classroom model was finally expected to address the challenges facing the large enrollment flipped classroom, and effectively promote students' involvement in university-level general courses. General design principles of effective collaborative learning environments in large enrollment classes would also be concluded.

Keywords: large enrollment, jigsaw, collaborative learning, flipped classroom, design-based research

1. Background

How to transform traditional education system to adapt to the new century is an issue that all education researchers and practitioners care. Large enrollment classes in higher education are always lecture-based, and tend to lack interaction (Bligh, 2000). Many effective learning strategies face challenges when implemented in these university-level lecture classes. However, large enrollment classes will continue to exist in the higher education due to pinched budgets. Many instructors also tried many strategies to create active and engaging learning experience in large classes, including flipping the class, making use of peer instruction, hiring student assistants, building personal touch with students, adopting interactive technologies, and retrofitting physical space. Among these, the flipped classroom, a popular pedagogical technique in recent years, has been fully adopted to shake up the traditional lectures in large classes.

However, like other effective strategies, the flipped classroom also faces many challenges in large classes like other effective strategies when it extends from secondary education to higher education. The average number of students per teacher in American primary and elementary schools is no more than 17 (Kena et al., 2016). Conversely, in the higher education, there are many introductory courses with large enrollment of students. It is challenging instructors to organize interactive learning activities in these large size classes. However, due to the increasing need in transforming these traditionally lecture-based courses, scholars and practitioners have shown a great interest in how to transform large enrollment classes by implementing flipped classroom pedagogy. Many additional strategies have been adopted to ensure the effectiveness of large enrollment flipped classrooms. A typical one is to integrate peer instruction with the flipped classroom model. The other is to reinvent the physical space of flipped classrooms. However, physical space renewal always requires larger physical space and more financial

pressure, which limits its application. Peer instruction can effectively promote active learning through splitting the lectures into small group discussions. This strategy has been widely adopted in large flipped classrooms and been proved by lots of empirical studies (e.g. Eichler & Peeples, 2016; Jungić et al., 2015). Yet, peer instruction based flipped classroom model can only promote interactions among students sitting near with each other in large classes, but fail to build large-scale connections.

The jigsaw model, a collaborative learning technique, aims to promote interdependence, individual accountability, development of social skills, and promotive interaction (Aronson & Patnoe, 1997). In the higher education, students are always assigned lots of reading materials before class. Yet, the reading effect can hardly be ensured. Neither can instructors have enough time to cover all materials in class. The jigsaw model is effective in dealing with large amount of learning materials through peer instruction. If the jigsaw model could be integrated with the flipped classroom model, it was expected to promote collaborative learning in large enrollment classes, and help link the pre-class and in-class phases of the flipped classroom model. Yet, there is still no such study. Thus, this study will explore whether the jigsaw model is a better additional strategy than peer instruction to help address the challenges facing large enrollment flipped classrooms. The purpose of this study is to address the challenges facing the application of the flipped classroom model in large enrollment classes, provide a new approach to promote students' engagement in general courses, and finally contribute to the transformation of traditional education.

2. Literature Review

2.1 Flipped Classroom

The flipped classroom aims to optimize the face-to-face time by removing the traditional lecture-based instruction out of class, and thus freeing up the class time for interactive student-centered activities (Abeysekera & Dawson, 2015; Bishop & Verleger, 2013). Bergmann and Sams (2014) argues to develop this concept into "flipped learning". Flipped learning is defined as a pedagogical model, in which direct instruction moves from the group learning space to the individual learning space, so as to transform the group space into a dynamic, and interactive learning environment (FLN, 2014). Though the flipped classroom model has become an international popular pedagogical innovation, and there are many anecdotal reports about its success, rigorous peer-reviewed publications are still waiting to increase. Only about 190 peer-reviewed journal articles about flip classroom could be found in educational databases of ERIC until Nov. 28, 2016.

The success of the flipped classroom model lies in the active learning it promotes. Comparative studies on the efficacy of flipped and alternative active learning (e.g., Mennella, 2016) reveal no significant difference between the flipped classroom, and alternative active learning. Implementing interactive and collaborative learning activities and differentiated instruction are critical factors of the flipped classroom model. It is relatively easier to organize collaborative learning in the small enrollment class. Many empirical studies have proved the positive effects of the flipped classroom model in small classes (e.g., Fautch, 2015; McCallum et al., 2015; Schultz et al., 2014; Swart, 2016). On the contrary, it is more difficult to implement active learning strategies in large classes. According to Li and Fu (2015), students who do not have a chance to share group outcomes reported a lower level of evaluation about the flipped classroom. In addition, because a teacher can generally focus on 25 students at most in a class (Wu, Fang & Ren, 2016), students in large classes will easily become outsiders of the course, if

they are neither involved actively nor concentrated by the instructor (Wang Y., 2016). It is also challenging the instructor to organize large number of students, and satisfy their different learning needs (Wang Y., 2016; Wang Z., 2015).

Though, theoretically and empirically, the flipped classroom model is easier to be applied in small enrollment classes, there are increasing successful applications in large ones (Albert & Beatty, 2014; Eichler & Peeples, 2016; Jungić et al., 2015; Winquist & Carlson, 2014). Given the additional challenges of applying the flipped classroom model into large enrollment classes, new design principles are usually used to ensure the quality of in-class activities. For example, involve assistant instructors or peer tutors to help organize and guide the group discussions (Wang, Shi & Ma, 2016), and adopt stratified group rules, to ensure the engagement of each student (Li & Fu, 2015). Peer instruction is a commonly used additional strategy in large enrollment flipped classrooms. Eichler and Peeples (2016) designed in-class clicker questions to help reveal the misconceptions, increase active learning, and improve student grades in large enrollment general chemistry courses. Jungić et al. (2015) applied peer-instruction strategy to ensure differentiated instruction in large first year calculus courses. Another popular instructional innovation comes from large classes in the higher education is called “SCALE-UP”, which stands for “Student-Centered Active Learning Environment with Upside-down Pedagogies”. It was originally “Student-Centered Activities for Large Enrollment Undergraduate Physics” put forward by Beichner & Saul (1999). The SCALE-UP classroom integrates the flipping concept with a renovated physical space to promote collaborative learning in large classes. These additional strategies can help address the above challenges facing the adoption of the flipped classroom model in large enrollment classes to some extent. However, reinventing physical

space is always expensive. Most strategies are limited in promoting large-scale of connections between students with fixed sittings.

2.2 Cooperative and Collaborative Learning (CL)

Cooperative and collaborative learning are common instructional strategies in the higher education. Sometimes they are used interchangeably. However, cooperative learning is more structured with close-ended group task than collaborative learning (Rockwood, 1995a, 1995b). There are also many other terms used in conjunction with these two strategies, including team learning, problem-based learning, simulations; peer instruction, learning communities and so on (Cooper and Robinson, 1998). Many techniques of CL have been developed (see table 1).

Table 1

Cooperative and collaborative learning strategies

Strategy	Brief Explanation
Teams-Games-Tournaments (TGT)	Students join in a heterogeneous group first and help each other answer the questions they select. Then they come to homogenous groups and compete with each other. Finally, they return to their former group, and team scores will be calculated (De Vries & Slavin, 1978).
Learning Together	Students working in heterogeneous groups on assignment sheets, and will receive praise and rewards based on the group product (Johnson & Johnson, 1987).
Group Investigation (GI)	Instructor identifies the topic to be investigated, and organize students into heterogeneous research groups. Students investigate their subtopic in-group, present the final report, and receive evaluation

	from their peers and teacher (Sharan & Sharan, 1992).
Team Assisted Individualized (TAI)	Students work on individualized learning material at their own pace in a mixed ability group. Students in the group will help each other and take responsible for all members' individualized program. "High performing" team will be awarded in the end. (Slavin, 1985)
Jigsaw	Students in a jigsaw group meet first with students in other jigsaw group who have been assigned the same segment in a temporary expert group. Then the jigsaw group reconvene, and each student act as a tutor on his/her specialty topic (Anderson, 1978).
Student Teams-Achievement Divisions (STAD)	Students are responsible for their teammates' learning as well as their own. Team goals are dependent on the learning of all group members (Slavin, 1980)
Complex Instruction (CI)	CI targets equity in the classroom. It invites more equitable student participation by assigning competence to students that helps to equalize status issues. It has three major components: "Multiple ability curricula," "Using special instructional strategies" and "Treat status problems" (Cohen & Lotan, 1997).
Think-Pair-Share	Students reflect on the question posed individually and then discuss with paired partner or in a small group. Teachers expand the "share" into a whole-class discussion (Lyman, 1987).
Fishbowl	A team works on a problem or exercise and thinks aloud the process. Other teams will observe the first team. Then rotate the groups or the class discuss together about the procedure (Cowan, 1984).

Paired Annotations	Students pair up to review or learn the same material, and submit a composite annotation of the material to the teacher (Millis & Cottell, 1998).

Kagan (1989) put forward cooperative learning structures to classify different techniques into teambuilding, class building, communication building, mastery, concept development and multifunctional. Lawrie et al. (2014) concluded five core attributes of constructive CL environments based on existing research: positive interdependence, individual accountability, social interaction, group processing, and communication. In the above CL techniques, the jigsaw model is a well-developed multifunctional group learning strategy. It gives each group member an essential part. All group members must work together. Otherwise, they could not accomplish a common goal. The jigsaw process can promote equal sharing of responsibility of group members, and develop a high level of interdependence (De Jong & Hawley, 1995). This technique can enhance differentiated instruction by allowing each student to choose different segments of the task. It also allows each student a chance to be peer tutor. The idea of learning by teaching (LBT) has yielded strong results across a broad range of educational practices (e.g. Okita, 2013). In large classes' contexts, the jigsaw model has a great potential in connecting more students by combing fixed home groups and temporary expert groups. It is also appropriate for handling the large amount of assignments out of class in the higher education.

Along with the development of technologies, CL can also be fulfilled in online learning environments. Computer-mediated communication (CMC) has provided valuable alternative spaces for collaboration, and opportunities for learner autonomy. Asynchronous and synchronous CMC modes can be used in combination and create more affluent CL opportunities. In addition,

it has been a common form of social interaction between students in colleges or universities. Its advantages in promoting collaborative learning have been evidenced (e.g., Fisher, Thompson, & Silverberg, 2004). In Althaus's study (1997), CMC was used as an effective way to supplement the face-to-face interaction in class. There are also some disadvantages such as its text-only form, which would prevent effective group transactions (Brignall and Valey, 2005). In the existing studies on large enrollment flipped classrooms, most researchers focus on how to promote face-to-face interactions, but seldom focus on interactions before class. CMC will be an effective way to extend the interaction spaces, and provide an alternative channel for interactions in large enrollment face-to-face environments.

Flipped classrooms are typical blended learning environments. They can be well supported by combination of CMC modes. The jigsaw model has also been proved effective in online learning environment through CMC (Weidman & Bishop, 2009). Thus, it is possible to integrate the flipped classroom model and the flipped classroom model with support of CMC.

2.3 The Theory of Student Involvement

According to Astin (1984, 1999), student involvement is the amount of physical and psychological energy that is invested in a student's academic and social experience. The theory of student involvement is an effective guidance for learning environment design. McCallum et al. (2015) focused on three components of student involvement: academic involvement, student-faculty involvement, and peer-peer involvement, to explore learning experience in the flipped classroom.

2.4 Sequences of Pedagogical Structure

Pedagogical structure is the approach or sequence of the spatial and temporal combination and interaction of different elements in a pedagogical system. It depends on elements' category,

number, proportion, and combination modes (Hu, 2016). Jacobson (2016) put forward a framework of sequences of pedagogical structure to categorize different sequencing structures for learning and problem-solving activities. He defined two different structures. One is high structure referring to direct instruction approaches, typically a lecture; the other is low structure referring to the minimally guided approaches. In teaching practice, there were different sequences of structure including high-to-high (HH), high-to-low (HL), low-to-low (LL), and low-to-high (LH).

Different sequences can lead to different learning effects. Edelson (2001) suggested not using mini-lecture or benchmark lesson presenting key information to students until they understand the necessity of that information, and its relevance to their problem-solving, and investigational practices. This just-in-time direct lecture was presented as scaffolding for inquiry, but not as direct instruction that could promote meaningful learning. Schwartz and Martin (2004) also found that ninth graders, who initially learned through exploratory problem solving employing statistical principles, learned more from a subsequent lecture than students, who had initially learned from a worked example that the instructor explained in class. Therefore, the sequences of pedagogical structure from low to high can achieve better learning effect. Recent impressive research findings such as productive failure (Kapur & Bielaczyc, 2012), and desirable difficulties (Bjork & Linn, 2006) can all be classified as this kind of sequence.

Many different flipped classroom models have different sequences of pedagogical structure (Hu & Zhang, 2016). The typical Robert Talbert model starts from a high structured video lecture and followed by low structured in-class exploratory activities. It belongs to “HL” sequence. On the contrary, the “Explore-Flip-Apply” model put forward by Musallam is based on constructivism. It adopts inquiry-based instruction in class first, and then requires students have

independent learning through video lectures at home, and implement concept tests, material extension, and evaluation guided by the instructor in class at last. This flipped classroom model belongs to "LHL" sequence. Thus, in this study, the "Explore-Flip-Apply" flipped classroom model will be adopted, instead of the typical one.

3. Operational definitions

3.1 A Jigsaw based Flipped Classroom (J-FC) model

The J-FC model in this study integrates the "Exploration-Flip-Apply" flipped classroom model and the jigsaw model with support of asynchronous and synchronous computer-mediated communications in online, as well as face-to-face environments.

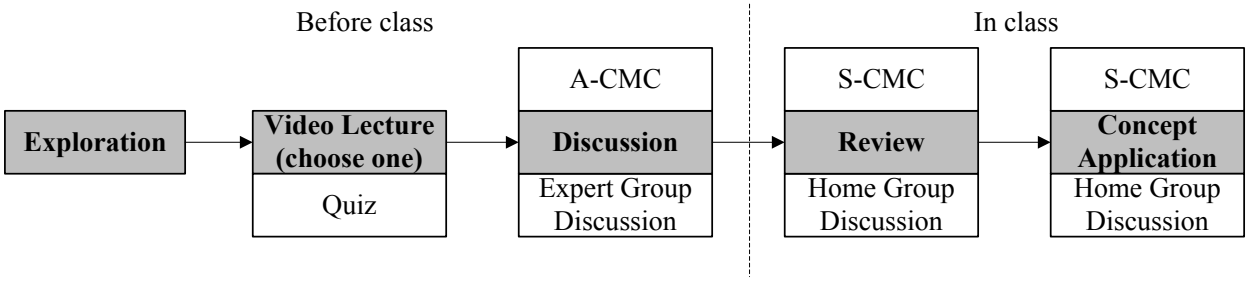

Figure 1. A jigsaw based flipped classroom model

Before class, home group will receive a comprehensive problem-solving task. Students should firstly try to solve this problem individually. Then home group members choose different video lectures and finish relevant short quiz. After finishing the quiz, they are allowed to join in the expert group learning space, and participate in the group exploration through constructing expert group wiki, sharing viewpoints, or discussing problems. In class, instructor will allow some time for home group discussion online (or face-to-face if it works in the classroom). One or two groups will be selected to share their answers to the initial problem-solving task. The instructor gives an in-time lecture based on their work. Then the high level learning objectives will be focused through application activities.

3.2 The Sense of Classroom Community (SCC)

The sense of classroom community represents to what extent students perceive themselves as part of the group. Students with low-level sense of classroom community are likely to feel they are isolated from the group and tend to drop the course. On the contrary, a strong classroom community will facilitate the interactions in class (Yapici & Ümit, 2016). Bielaczyc and Collins (1999) described an authentic classroom community as one that embodies a "culture of learning in which everyone is involved in a collective effort of understanding".

3.3 The Student Approaches to Learning (SAL)

This theory derives from a classic study conducted by Marton and Säljö (1976). They had an in-depth qualitative interview with students about their learning strategies when reading texts, and found two different approaches to process the texts: deep and surface. A deep approach focuses on fundamental idea or message, while a surface approach concentrates more on the surface features of texts. A third approach called strategic or achieving refer to students who work hard to achieve good grades. Existing studies have supported the association between a deep approach and better learning outcomes, and the positive relationship between the achieving approach and academic achievement (Watkins, 2001).

4. Study Design

4.1 Design-based Research

This study adopts design-based research (DBR) paradigm. DBR is a collection of approaches with dual goals of advancing theory and affecting practice (Barab, 2014). It can help improve educational interventions, and find generalizable effective design principles. It derives from design experiment put forward by Allan Collins and Ann Brown (Cobb et al., 2003). Reeves (2006) concluded the DBR framework as four steps: problem analysis, create

intervention, iterative process, and reflective conclusion. This study will follow these four steps to continuously revise the interventions, improve practice, and finally contribute to theoretical development.

3.1.1 Design of Intervention Prototype

In the intervention prototype (see Fig. 2), the J-FC model is detailed in procedures and supported with some additional instructional techniques.

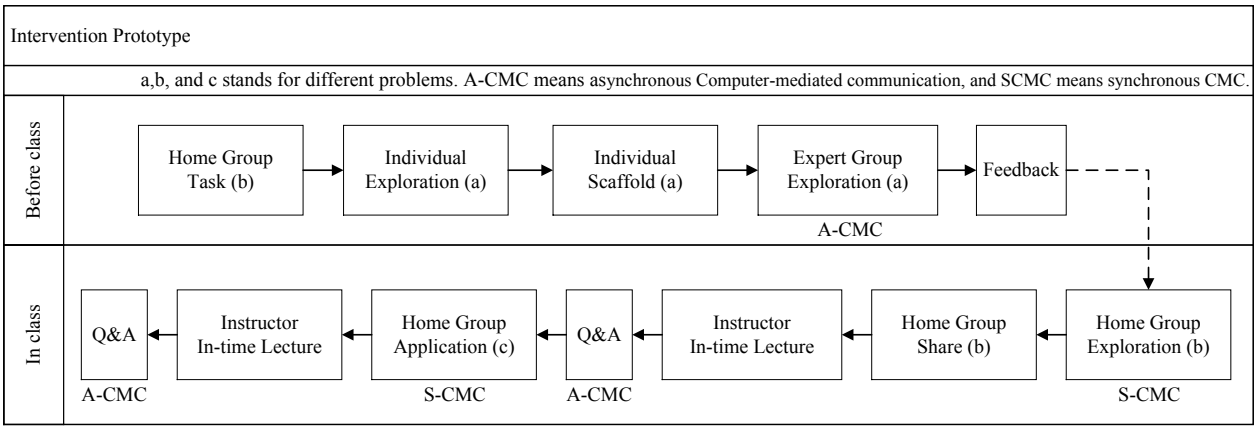

Figure 2. Intervention prototype

Allowing students to choose their preferred scenario and group membership can enhance their investment in the group task (Lawrie et al., 2014). Thus, in the first iteration, all students will be divided into fixed home group according to their choice. To balance the number of group and group member, group size of ten or so will be considered first. At least two experts of each task will be ensured in each home group.

As the main principles of J-FC model, the home group will receive a comprehensive problem-solving task before class. This task is closely related to the lesson objectives. Along with this task, different forms of scaffolds will be provided in the first iteration, including video lectures, animations, simulations, or reading materials. Group members choose different scaffolds, and enter different scenarios. The scaffolds will be locked until students finish the relevant ill-structured problems (a) individually. After learning the scaffolding materials, they

are allowed to join in the expert group learning space, and participate in the group exploration through constructing expert group wiki, sharing viewpoints, or discussing problems. In the first iteration, the expert group needs to work together, and is required to submit the final answer to the problems (a). They will get the feedback after submission. After expert group exploration, students are encouraged to continue working together on the home group task if time available.

The in-class procedure is almost the same with the main J-FC model. One additional design is that students are encouraged to post or answer any questions in the online course space (it can be anonymously) during class. In the middle and at the end of the class (after lectures), the instructor will select the most frequently asked questions, and explain further.

In addition, to improve the intervention design, students will be allowed a few minutes at the end of the class, and be encouraged to post at least one suggestion on curriculum design in the course space. They can also post anytime during the class, or choose to be anonymous.

3.1.2 Improvement of Iterative Interventions

Intervention prototype will be continuously revised according to the data analysis in each iteration. In terms of the jigsaw model, grouping principles and time allocation will be possibly adjusted. The CMC effect in class will be compared with face-to-face interaction (if any), and be further revised. As to the flipped classroom model, one possible variable needing to be evaluated is the form of scaffold. How to design problems will also be considered in the successive iterations. In addition, other possible adjustments from students' feedback will be thoroughly evaluated through collaboration with relevant stakeholders.

3.2 Settings and Participants

This study will be implemented in a large enrollment (more than 100 students) general course in college/university. Participants will be selected through a convenience sample strategy.

The instructor, who has a large enrollment class and who is easily accessed, will be recruited as the research collaborator. This course should better have mature curriculum resources and easier to adapt to the flipped classroom model. The instructor with experience of the flipped classroom is much preferred. Online platform should support material upload, group space, instant messaging, bumping up and ranking threads.

3.3 Study Procedure

In this study, there will be two iterations in a semester (see Fig. 3). Students will receive the traditional lectures in the first four weeks of the semester. This can avoid the confounding variable of time that could make students in this course familiar with each other, and accordingly lead to a stronger sense of classroom community. This also allows having the final list of students who decide to select this course if it is not compulsory. Then students will have the pretest including sense of classroom community, learning approaches, and the achievement test of the first iteration. All the pretests are not anonymous and not prepared. In the following four weeks, the intervention prototype will be implemented. Students will be required to bring their tablet or laptop to communicate in the class. In the posttest after the first iteration, they need to finish the same instruments. All data will be analyzed to support the revise of intervention prototype. Before the second iteration, students will only need to have a new achievement test covering the new topics, and receive the same tests after the new iteration. The tracing test of the first iteration will also be implemented after the second iteration. The tracing test of the second iteration will be implemented four weeks later. A new session of iterations will be conducted in a new semester based on the data analysis of the two iterations.

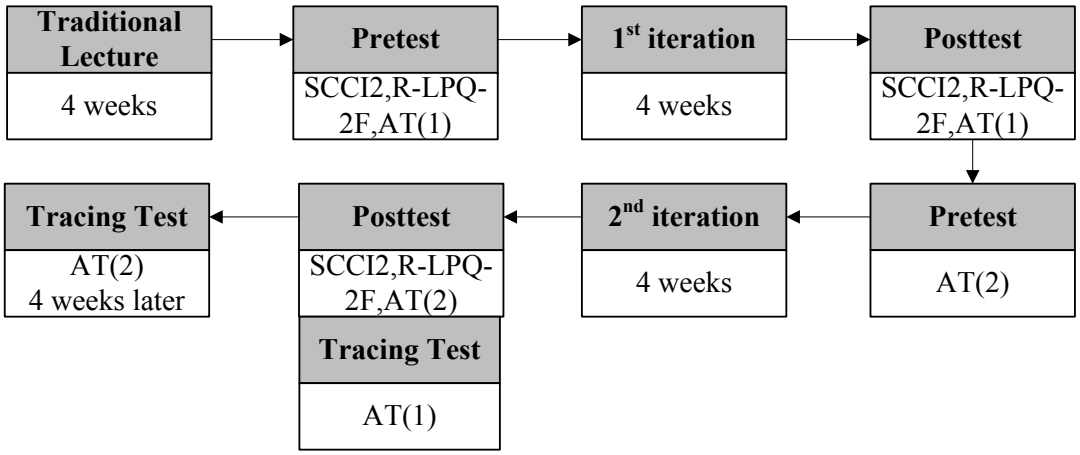

Figure 3. Study procedure of the first two iterations

3.4 Instruments

3.4.1 The Sense of Classroom Community Index, second edition (SCCI 2)

The SCCI2 was used to measure sense of classroom community. It consists of a self-report questionnaire of 40 items, 10 items each for the subscales of spirit, trust, interaction, and learning. The SCCI2 possesses high face validity. An examination of items reveals that on face value they appear to measure what is needed to assess sense of classroom community. Existing studies show that coefficients of internal consistency were 0.95 for the overall SCCI2 score, 0.87 for the spirit subscale, 0.83 for the trust subscale, 0.87 for the interaction subscale, and 0.80 for the learning subscale (Rovai, 2001).

3.4.2 A revised two-factor version of the Learning Process Questionnaire (R-LPQ-2F)

A revised two-factor version of the Learning Process Questionnaire (R-LPQ-2F) (Kember, Biggs, & Leung, 2004) will be adopted to test students' learning approaches in the course. This instrument has very good psychometric properties, and as well offers new insights into the constructs of deep and surface approaches to learning. Cronbach alpha of Deep Approach is 0.82; Surface Approach is 0.71. Cronbach alpha of subscale Deep Motive is 0.75; Deep Strategy is 0.66; Surface Motive is 0.58; and Surface Strategy is 0.68.

3.4.3 The Achievement Test (AT)

An achievement test will be designed to test students' academic performance. It will include questions on declarative knowledge as well as procedural knowledge, and have an appropriate difficulty distribution. In addition, the achievement test will also be examined by experts in this course. The Cronbach's Alpha internal consistency coefficient, average item difficulty, and item discrimination indices will all be provided.

3.5 Data Collection

This study will mainly focus on students' academic involvement and peer-peer involvement. According to Astin (1984, 1999), academic involvement could be indicated by behaviors like attending class, completing homework, and submitting assignments on time. Attendance is a critical problem in large enrollment classes. To analyze academic involvement, students' attendance, and evaluations on their homework will be collected. Additionally, no prepared pretest, posttest, and tracing test with similar items will be implemented to test academic performance improvement, as well as long-term knowledge retention.

Peer-peer involvement can affect the quality of collaborative learning. Students' online discussion texts in expert group, home group, and course space will be collected. Students will be required to help record their face-to-face interactions in class (if any). Collaborative learning of some focused group will be recorded through structured observation by the researcher.

In brief, other than the data collected from above instruments, some qualitative data on students' academic and peer-peer involvement will also be collected. Additionally, students' demographical data including their age, gender, nationality, major, and GPA will be collected directly from relevant student database. The attendance in each iteration will be self-reported by students themselves in the posttests. These possible confounding variables will be adjusted

through linear regression analysis. To promote the improvement of learning environment design, students' feedback on curriculum design will also be collected through interview, questionnaire and online platform (see table 2).

Table 2

Data collection

Data type	Data source	Collection time
Academic Involvement	The Achievement Test	Pre-test, post-test, & tracing test.
	Learning Approach	Pre-test & post-test
	Attendance	Post-test
	Evaluations on homework	Before class (individual and expert group) After class (home group)
Peer-peer Involvement	Sense of Classroom Community	Pre-test & post-test
	Online discourse	Throughout the study
	Face-to-face interaction audio	In class (if any)
	Focused group observation	In class (if any)
Curriculum Design Suggestions	Online posts	Throughout the study
	Semi-structured interview	Post-test
	Student satisfaction questionnaire	Post-test
Other	Depends on the process	Depends on the process

4. Data Analysis

For the quantitative data, the IBM statistical package for the social Science (SPSS) predictive analytics package will be used to examine the change of SCC, SAL and AT in each group through descriptive statistics, and paired t-test, and to compare the changes between groups through independent t-test, and the multiple regression analysis. All alpha level will be set at $p < 0.05$. For the qualitative data, ground theory coding technique will be mainly adopted.

4.1 Academic involvement

Paired t-test will be implemented to analyze the achievement test in pretest, posttest, and tracing test. Detailed change of declarative knowledge and procedural knowledge will also be analyzed. The paired t-test will be used to compare whether there is significant difference between the LA scores in pre-test and posttest. In addition, change in subscales of LA including deep motive, deep strategy, surface motive, and surface strategy will be compared separately. Attendance of each lesson will be graphed to see the change along with time. It will also be compared with historical attendance data (if any). A multiple regression model will also be used to measure whether the LA scores and achievement test scores between pre-test and post-test (and tracing test) differ significantly, while holding constant students' GPA, nationality, major, and course attendance. Evaluations on individual homework and group homework will be separately graphed. Comparison between evaluations of individual homework and expert group homework will also be included, which can reflect the effect of expert group learning.

4.2 Peer-peer involvement

For the SCC scores, the paired t-test will also be used to compare whether there is significant difference between pre-test and post-test. Scores in subscales of SCC including spirit, trust, interaction, and learning will be compared separately. A multiple regression model will

also be used to measure whether the SCC scores between pre-test and post-test differ significantly, while holding constant students' GPA, nationality, major, and course attendance.

Lawrie et al. (2014) concluded five core attributes of constructive cooperative and collaborative learning environments based on existing research: positive interdependence, individual accountability, social interaction, group processing, and communication. Peer-peer involvement data will all be coded and classified mainly based on these five attributes. Radar maps on these attributes of online collaborative learning before class, face-to-face and online collaborations in class, will be separately depicted to show the characteristics of collaborative learning in different phases and different forms. Whether CMS is an effective supplemental way for collaborative learning in large enrollment classes will also be analyzed through comparison with face-to-face interaction.

4.3 Curriculum design suggestions

All suggestions data will be coded according to their types. For example, they can be about the flipped classroom, collaborative learning, online platform, curriculum content, homework, instructor, evaluation and so on. Descriptive statistical analysis will then be implemented to help synthesize effective improvement approaches of educational interventions.

5. Outcomes and Value

In this study, the proposed jigsaw-based flipped classroom model is expected to improve students' score in the achievement test, promote a deep learning approach, more and deeper connections with each other, and a stronger sense of classroom community. Through the iterations, the intervention prototype is expected to be revised and developed into a more effective and feasible model. In addition, the general design principles of effective collaborative learning in the large enrollment flipped classrooms will also be concluded in the end. These

outcomes are expected to address the challenges facing the adoption of the flipped classroom model in large enrollment classes, provide a new approach to promote students' engagement in general courses, and finally contribute to the transformation of traditional education. This research proposal aims to convince the instructors of large classes to collaborate in developing a new and better approach to shake up the traditional lectures, the educational administrators to support a teaching innovation in the higher education. The outcomes of this study comes from an authentic educational context and will be tested and revised through successive iterations. Therefore, the outcomes will be very feasible and easily generalized into more contexts by more instructors who are interested in teaching innovations.

6. Limitations

This study design still has several limitations in the following aspects. First, due to the convenience sample technique, it cannot be ensured there is no significant difference in the depending variables. Therefore, both pretest and posttest are included. However, in order to have the change score between pretest and posttest, all participants are required to report the SCC and SAL in real names, which are usually reported anonymously. Therefore, this will pose a caveat to the interval validity of the self-report. To alleviate this, participants should be made safe to give an accurate report of their true experience. For example, it should be emphasized that the score will not affect their grades, nor will be used to evaluate their instructor. An alternative design is to allow students report the score in a consistent pseudonym. Secondly, the course attendance is a significant confounding variable. It is collected through self-report in the posttest to avoid the manipulative effect on the attendance. Similar with the first aspect, the accuracy of this report is also a threat to the design. Thirdly, there are some possible contaminations to the design. For example, it cannot be ensured all students finish the inquiry problem and video

lectures in the designed sequence if they share materials with each other before class. Finally, the generalizability of the findings is also a limitation. Different subjects or instructors might yield out different results. The representativeness of the convenient sample is also not ensured. It could not completely rule out the possible effect of students' difference, such as students' motivation, and background knowledge. What's more, even the size of large classes can range from 50 or so to more than 400, which might affect the effectiveness of the model greatly. Yet, this study only chose one middle size of large classes. Therefore, more studies are needed to test the generalizability of the findings.

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8. Appendix

8.1 Sense of Classroom Community Index

Developed by Alfred P. Rovai, PhD, Robert A. Lucking, PhD, and Dean Cristol, PhD

Directions

The survey you have in front of you consists of two pages and should only take you a few minutes to complete. You may use either a pen or pencil. It pertains to: *[Identify specific course, cohort, or school]*

This survey is voluntary. Its purpose is to conduct research in order to help improve teaching and learning. Your honest responses to each item will help us achieve this purpose. It will not be used to evaluate your teacher. Taking or not taking this survey will have no affect on your course grade.

[If students are to provide an ID read the following paragraph]

The first page includes some information about yourself. Let me assure you that your responses will remain confidential should you choose to complete this survey. Under no circumstances will your responses be revealed to anyone. Results will be reported in group form only. Near the top of the survey you will see fill-in-the-blank items marked ID, A, B, C, and D. In the space next to ID write the last four digits of your student ID now. Leave the spaces next to A, B, C, and D empty. *[or specify contents]* Also answer the three questions about yourself. *[Pause]*

[If students are not to provide an ID read the following paragraph]

The first page includes some information about yourself. Let me assure you that your responses will remain anonymous should you choose to complete this survey. Near the top of the

survey you will see fill-in-the-blank items marked ID, A, B, C, and D. Leave these spaces blank. *[or specify contents for A, B, C, and/or D]* Answer the three questions about yourself now. *[Pause]*

The survey also includes a number of statements with each statement followed by a scale. Examine one of the items on the first page of your survey.

[PAUSE for a moment or two]

You will note that each item consists of a statement followed by a scale represented by five pairs of parentheses. Carefully read each statement and place an "X" in the first pair of parentheses if you strongly agree with the statement, mark the second pair if you agree with the statement but to a lesser degree, mark the third pair if you neither agree nor disagree with the statement or are uncertain about how to respond, mark the fourth pair if you disagree with the statement, or mark the last pair of if you disagree strongly with the statement. Only mark one pair of parentheses for each statement. The letters between the parentheses are there to help you identify the scale. As you complete this survey please make sure you place an "X" in the appropriate space for all items. Do not skip any items. You may now start.

Strongly Agree (SA)

Agree (A)

Neutral (N)

Disagree (D)

Strongly Disagree (SD)

SURVEY

Please complete the following based on verbal instructions you receive:

ID: _____ A: _____ B: _____ C: _____ D: _____

Next, please check the categories that apply to you:

1. Age: **(** 1 **)** 25 or less (2) 26 - 30 (3) 31 - 40 (4) 41 - 50 (5) over 50

2. Gender: **(** 1 **)** Male (2) Female

3. Race or ethnic group: **(** 1 **)** White (includes Arabian) (2) Black (3) Hispanic

(4) Asian (includes Pacific Islanders) (5) Native American (6) Bi-racial

DIRECTIONS:

Below you will see a series of statements concerning a specific course or program you are presently taking or recently completed. Read each statement carefully and place an X in the parentheses to the right of the statement that comes closest to indicate how you feel about the course or program. You may use a pencil or pen. There are no correct or incorrect responses. If you neither agree nor disagree with a statement or are uncertain place an X in the neutral (N) area. Do not spend too much time on any one statement, but give the response that seems to describe how you feel.

Please respond to all items.

1. I feel excited about this course ..... (SA) (A) (N) (D) (SD)
2. I feel that others in this course are concerned about my well-being ... (SA) (A) (N) (D) (SD)
3. I feel that there is not much interaction with the teacher ..... (SA) (A) (N) (D) (SD)
4. I feel that this course is not learner-centered ..... (SA) (A) (N) (D) (SD)
5. I feel that there is no group identity ..... (SA) (A) (N) (D) (SD)
6. I trust other students ..... (SA) (A) (N) (D) (SD)
7. I feel that I am encouraged to ask questions ..... (SA) (A) (N) (D) (SD)
8. I feel that I learn useful skills in this course ..... (SA) (A) (N) (D) (SD)
9. I feel a sense of cohesion with other students ..... (SA) (A) (N) (D) (SD)
10. I feel that I receive insincere feedback ..... (SA) (A) (N) (D) (SD)
11. I feel that I learn a lot from other students ..... (SA) (A) (N) (D) (SD)
12. I do not feel in control of my learning process ..... (SA) (A) (N) (D) (SD)
13. I do not feel connected to my teacher ..... (SA) (A) (N) (D) (SD)
14. I feel that I can rely on others in this course ..... (SA) (A) (N) (D) (SD)
15. I feel that the learning environment facilitates discussion ..... (SA) (A) (N) (D) (SD)
16. I feel that our discussions promote learning ..... (SA) (A) (N) (D) (SD)
17. I feel important in this course ..... (SA) (A) (N) (D) (SD)
18. I feel uneasy exposing gaps in my understanding ..... (SA) (A) (N) (D) (SD)
19. I feel that this course offers limited resources to work with ..... (SA) (A) (N) (D) (SD)
20. I feel that we build knowledge in this course ..... (SA) (A) (N) (D) (SD)
21. I do not feel a spirit of community ..... (SA) (A) (N) (D) (SD)
22. I feel that members of this course are loyal to each other ..... (SA) (A) (N) (D) (SD)
23. I feel that a few students dominate this course ..... (SA) (A) (N) (D) (SD)
24. I feel that this course provides valuable skills ..... (SA) (A) (N) (D) (SD)
25. I feel close to others in this course ..... (SA) (A) (N) (D) (SD)
26. I feel reluctant to speak openly in this course ..... (SA) (A) (N) (D) (SD)
27. I do not feel comfortable speaking openly ..... (SA) (A) (N) (D) (SD)
28. I feel that there is no need to think critically in this course ..... (SA) (A) (N) (D) (SD)
29. I feel isolated in this course ..... (SA) (A) (N) (D) (SD)
30. I distrust my teacher ..... (SA) (A) (N) (D) (SD)
31. I feel that my teacher is responsive to me ..... (SA) (A) (N) (D) (SD)
32. I feel that this course does not meet my educational needs ..... (SA) (A) (N) (D) (SD)
33. I feel that I am recognized for my participation ..... (SA) (A) (N) (D) (SD)

34. I feel uncertain about others in this course ..... (SA) (A) (N) (D) (SD)

35. I feel that discussions are one-way .... (SA) (A) (N) (D) (SD)

36. I feel that I learn a lot in this course ..... (SA) (A) (N) (D) (SD)

37. I feel out of place in this course ..... (SA) (A) (N) (D) (SD)

38. I feel secure in this course ..... (SA) (A) (N) (D) (SD)

39. I feel that discussions are high quality ..... (SA) (A) (N) (D) (SD)

40. I do not value all the material that the instructor covers ..... (SA) (A) (N) (D) (SD)

Scoring Key

Overall SCCI Raw Score

SCCI raw scores vary from a maximum of 160 to a minimum of zero. Interpret higher SCCI scores as a stronger sense of classroom community.

Score the test instrument as follows to obtain the overall SCCI score:

For items: 1, 2, 6, 7, 8, 9, 11, 14, 15, 16, 17, 20, 22, 24, 25, 31, 33, 36, 38, 39

Weights: Strongly Agree = 4, Agree = 3, Neutral = 2, Disagree = 1, Strongly Disagree = 0

For items: 3, 4, 5, 10, 12, 13, 18, 19, 21, 23, 26, 27, 28, 29, 30, 32, 34, 35, 37, 40

Weights: Strongly Agree = 0, Agree = 1, Neutral = 2, Disagree = 3, Strongly Disagree = 4

Add the weights of all forty items to obtain the overall SCCI score.

SCCI Subscale Raw Scores

SCCI subscale raw scores vary from a maximum of 40 to a minimum of zero. Calculate SCCI subscale scores as follows:

Spirit: ---------- Add the weights of items 1, 5, 9, 13, 17, 21, 25, 29, 33, 37

Trust: ---------- Add the weights of items 2, 6, 10, 14, 18, 22, 26, 30, 34, 38

Interaction: -------- Add the weights of items 3, 7, 11, 15, 19, 23, 27, 31, 35, 39

Learning: ---------- Add the weights of items 4, 8, 12, 16, 20, 24, 28, 32, 36, 40

8.2 Revised Learning Process Questionnaire (R-LPQ-2F)

Developed by John Biggs and David Kember

This questionnaire has a number of questions about your attitudes towards your studies and your usual way of studying.

There is no *right* way of studying. It depends on what suits your own style and the course you are studying. It is accordingly important that you answer each question as honestly as you can. If you think your answer to a question would depend on the subject being studied, give the answer that would apply to the subject(s) most important to you.

Please fill in the appropriate circle alongside the question number on the ‘‘General Purpose Survey/Answer Sheet’’. The letters alongside each number stand for the following response.

A — this item is *never* or *only rarely* true of me

B — this item is *sometimes* true of me

C — this item is true of me about *half the time*

D — this item is *frequently* true of me

E — this item is *always* or *almost always* true of me

Please choose the *one* most appropriate response to each question. Fill the oval on the Answer Sheet that best fits your immediate reaction. Do not spend a long time on each item: your first reaction is probably the best one. Please answer each item. Do not worry about projecting a good image. Your answers are CONFIDENTIAL.

Thank you for your cooperation.

(1) I find that at times studying makes me feel really happy and satisfied.

(2) I try to relate what I have learned in one subject to what I learn in other subjects.

(3) I am discouraged by a poor mark on a test and worry about how I will do on the next test.

(4) I see no point in learning material that is not likely to be in the examination.

(5) I feel that nearly any topic can be highly interesting once I get into it.

(6) I like constructing theories to fit odd things together.

(7) Even when I have studied hard for a test, I worry that I may not be able to do well in it.

(8) As long as I feel I am doing enough to pass, I devote as little time to studying as I can. There are many more interesting things to do.

(9) I work hard at my studies because I find the material interesting.

(10) I try to relate new material, as I am reading it, to what I already know on that topic.

(11) Whether I like it or not, I can see that doing well in school is a good way to get a well-paid job.

(12) I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra.

(13) I spend a lot of my free time finding out more about interesting topics that have been discussed in different classes.

(14) When I read a textbook, I try to understand what the author means.

(15) I intend to get my A Levels [or equivalent qualification] because I feel that I will then be able to get a better job.

(16) I find it is not helpful to study topics in depth. You do not really need to know much in order to get by in most topics.

(17) I come to most classes with questions in mind that I want answering.

(18) I learn some things by rote, going over and over them until I know them by heart even if I do not understand them.

(19) I find I am continually going over my schoolwork in my mind at times, like when I am on the bus, walking, or lying in bed, and so on.

(20) I find the best way to pass examinations is to try to remember answers to likely questions.

(21) I like to do enough work on a topic so that I can form my own conclusions before I am satisfied.

(22) I find I can get by in most assessment by memorizing key sections rather than trying to understand them.

Scales in the Revised Learning Process Questionnaire (R-LPQ-2F)

The number in parentheses is the item number in the questionnaire.

Deep approach

Deep motive

Intrinsic interest

I find that at times studying makes me feel really happy and satisfied. (1)

I feel that nearly any topic can be highly interesting once I get into it. (5)

I work hard at my studies because I find the material interesting. (9)

Commitment to work

I spend a lot of my free time finding out more about interesting topics which have been discussed in different classes. (13)

I come to most classes with questions in mind that I want answering. (17)

I find I am continually going over my school work in my mind at times like when I am on the bus, walking, or lying in bed, and so on. (19)

I like to do enough work on a topic so that I can form my own conclusions before I am satisfied. (21)

Deep strategy

Relating ideas

I try to relate what I have learned in one subject to what I learn in other subjects. (2)

I like constructing theories to fit odd things together. (6)

Understanding

I try to relate new material, as I am reading it, to what I already know on that topic. (10)

When I read a textbook, I try to understand what the author means. (14)

Surface approach

Surface motive

Fear of failure

I am discouraged by a poor mark on a test and worry about how I will do on the next test. (3)

Even when I have studied hard for a test, I worry that I may not be able to do well in it. (7)

Aim for qualification

Whether I like it or not, I can see that doing well in school is a good way to get a well-paid job. (11)

I intend to get my A Levels because I feel that I will then be able to get a better job. (15)

Surface strategy

Minimizing scope of study

I see no point in learning material which is not likely to be in the examination. (4)

As long as I feel I am doing enough to pass, I devote as little time to studying as I can. There are many more interesting things to do. (8)

I generally restrict my study to what is specifically set as I think it is unnecessary to do anything extra. (12)

I find it is not helpful to study topics in depth. You don't really need to know much in order to get by in most topics. (16)

Memorization

I learn some things by rote, going over and over them until I know them by heart. (18)

I find the best way to pass examinations is to try to remember answers to likely questions. (20)

I find I can get by in most assessment by memorizing key sections rather than trying to understand them. (22)

To calculate scores on the scales use the following response scores.

A = 1, B = 2, C = 3, D = 4, E = 5

Scores for the two main scales, deep approach (DA) and surface approach (SA), can then be calculated by adding the following item scores:

DA = 1 + 2 + 5 + 6 + 9 + 10 + 13 + 14 + 17 + 19 + 21

SA = 3 + 4 + 7 + 8 + 11 + 12 + 15 + 16 +18 + 20 + 22

Each contains identifiable strategy (DS and SS) and motive (DM and SM) subscales. The subscale and scale scores can be calculated by adding item scores as follows:

DM = 1 + 5 + 9 + 13 + 17 + 19 + 21

DS = 2 + 6 + 10 + 14

SM = 3 + 7 + 11 + 15

SS = 4 + 8 + 12 + 16 +18 + 20 + 22