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Scaffolding wiki-supported collaborative learning for small-group projects and whole-class collaborative knowledge building

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Abstract

While educators value wikis' potential, wikis may fail to support collaborative constructive learning without careful scaffolding. This article proposes literature-based instructional methods, revised based on two expert instructors' input, presents the collected empirical evidence on the effects of these methods and proposes directions for future refinements. The instructional methods were implemented by an expert instructor teaching a 12-week 68-student undergraduate design class in Canada. Data were collected from observations, interviews and content analysis of wikis. The findings revealed that in small-group project (SGP), the wiki instructional methods enhanced collaborative learning with most instructional methods derived from cooperative learning, but in whole-class collaborative knowledge building (CKB), the wiki instructional methods failed to turn the class into a self-sustained learning community after the scaffolding faded. We conclude that the genre of wikis should be different for SGP and CKB. While the students easily adopted the 'reproduced' genre of wikis for SGP with familiar tasks, they felt overwhelmed or resistant to the unfamiliar 'emergent' genre of wikis for CKB in massive collaborative constructive learning. Therefore, we propose that future refinements for wiki-supported CKB should focus on providing students scaffolding for intersubjectivity (understanding collaborative constructive learning) and transfer of responsibility (developing autonomy).

Keywords

collaborative knowledge building, collaborative learning, genre of wikis, scaffolding, small-group project-based learning, wikis.

Purpose of the study

Wiki's potential in theory

Wikis, invented by Ward Cunningham and soon adopted in various settings, are considered an Internet genre for quick knowledge construction among massive online users. Wikipedia is a well-known example. Genres are defined as documents categorized by similar forms and purposes to respond to communicative needs within a user community (Campbell & Jamieson, 1978; Crowston & Williams, 2000). As a genre, wikis provide unique

features for collaboration, including the capability to edit, to view the content history of revisions, and to communicate with others. In addition, wikis have an open editing and review structure, and the role of readers and contributors on wikis is interchangeable, requiring lower barriers to entry (micro-content). Consequently, Alexander (2006) called it an opportunity knocking for active student participation and communication. Because an interest in classroom uses for wikis has arisen, several articles have been published on their potential for supporting collaborative and constructive learning (Brown & Adler, 2008; McGee & Diaz, 2007; Staley, 2009), which responds to Reigeluth and Carr-Chellman's (2009) call for advanced technologies to support the learner-centred paradigm of education.

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Wiki's challenges in practice

Given the promise of wikis, a growing number of class wikis have been created and studied. Research has shown that wikis are an effective tool for collaboration and consensus building (Hemmi, Bayne, & Land, 2009), promoting students' collaboration and consensus building (de Pedro et al., 2006) and empowering project collaboration across institutions or countries (Bonk, Lee, Kim, & Lin, 2009); yet, some challenges have been spotted. Kummer (2013) conducted a meta-analysis of 73 articles on wikis in higher-education classrooms that were previously published in peer-reviewed journals. The study found that three barriers – lack of ownership, fear of publicity and poor group climate – hindered optimal wiki collaboration particularly during the learning process. Given that these barriers may reduce the students' confidence in using wikis for collaborative learning, it is not surprising that a content analysis study of 180 000 wikis found that a large percentage of wikis were abandoned or created merely for teacher-centred content delivery (Reich, Murnane, & Willett, 2012). Therefore, a clear gap was identified between the actual application and the theoretical promise of wikis to maximize learner-centred paradigm of education.

Need for systematic design of scaffolding to address problems in learning process

To bridge the gap, we need more investigation into scaffolding for wikis, which echoes Jung and Suzuki's (2014) statement that 'their [wikis'] effectiveness depends upon the use of scaffolding strategies to guide the students in their uses' (p. 1). Scaffolding, which is connected to Vygotsky's (1978) socio-cultural theory and zone of proximal development, is defined as just-in-time support that an instructor (or adult expert) provides to a novice (or a child) in order to help develop competence through meaningful participation in problem solving (Wood, Bruner, & Ross, 1976).

When envisioning a wiki to support the collaborative constructive paradigm of education, we aim to provide a socio-cultural context where learners with appropriate instructional and peer support (i.e., scaffolding) would successfully participate and gain understanding and higher-order thinking skills in problem-solving processes. Recent research on scaffolding wiki-based collaborative learning investigated different types of

scaffolding to support students' small-group projects (SGPs). For example, An (2010) conducted mixed method research on scaffolding students' collaborative ill-structured problem-solving in a wiki environment. Jung and Suzuki (2014) conducted action research developing wiki scaffolding strategies to support collaborative learning in a multicultural Japanese language learning program. Since the researchers were the instructors in both studies, their strategies were designed to best address specific needs and were carefully investigated through implementation to offer insight into similar contexts. However, because of the methodology, such research was more focused on improving local practice, and less intended to generalize for broader contexts or advance theoretical understanding.

Thus, we decided to explore a more systematic approach for the design and development of wiki-based classroom instructional scaffolding, one that is grounded in the literature (reviewed in the design theory section) as well as empirical evidence (presented in the findings section). Design-based research (DBR) was adopted in this project to guide the design, implementation and refinements of instructional methods for wiki-supported collaborative learning.

Research questions

This article reports the process and findings from the literature review and the first implementation of the resulting design theory. In contrast to descriptive theory, which is conclusion oriented, a design theory or design science is goal oriented (Simon, 1996). It offers guidance on methods to achieve a given goal under given conditions (Reigeluth, 1999; Reigeluth & Carr-Chellman, 2009). The following research questions guided the research project.

- What instructional methods could be offered for wiki-supported collaborative learning based on the literature and the practitioners' (the expert instructors') input?
- What instructional methods worked well in the first implementation, what instructed methods should be improved and how should they be improved?

Design theory

The goal

The goal of the instructional theory is to provide evidence-based instructional methods to faculty who

are interested in using wikis for students' collaborative learning. [In this study, collaborative learning is defined from a broader view of the theoretical and practical perspectives of collaborative learning and cooperative learning in higher education: according to Panitz (1996), collaborative learning is a philosophy that believes in active learning in groups with respect for individuals and with shared responsibility to reach consensus in the knowledge-building process.] In addition to support collaborative learning in general, this instructional theory addresses the known barriers that occur during the wiki collaboration process, summarized in Kummer's (2013) meta-analysis on 73 empirical higher-education wiki studies.

The process

The design of the initial instructional theory included two phases. First, the researchers drafted a brief version of the instructional theory (please see v1 in Appendix I) based on the literature, including collaborative learning, blended learning and wiki research. The instructional methods used to address barriers (i.e., group climate, publicity and ownership) are marked in Appendix I. Second, during the DBR process, the researchers collaborated with two expert instructors, who had a 5-year experience of using wikis for student collaboration. The initial design theory was simple and brief; this was done purposely to encourage the expert instructors to input their heuristic knowledge [such as rules of thumb, guidelines, causal models and decision-making models (Reigeluth, Lee, Peterson, & Chavez, 2003)]. To revise and enrich the initial instructional theory, the expert instructors were invited to review the instructional methods one-on-one with the researcher in 60-min face-to-face interviews and later to participate in a 120-min focus-group interview to discuss and reach consensus on revisions (v2 in Appendix I) before the first implementation.

Instructional methods from literature (v1) and practitioners' input (v2)

We adopted Vygotsky's (1978) social constructivist framework as the overall pedagogical approach, aligning the goals of the class projects to support collaborative and constructive learning in wiki-based blended learning environments. Seeing the need to address practical

challenges during students' wiki collaboration processes, categorized as group climate, ownership and publicity in Kummer's (2013) meta-analysis of wiki research, we identified the key elements and strategies from relevant literature. The following sections discuss the instructional methods and rationales for each barrier (Appendix I presents the full list of the instructional methods).

Group climate

Group climate is crucial to the success of collaboration, and collaboration on class wikis is no exception. Studies have shown that students can struggle in a difficult group climate, such as those lacking in quality interaction (Bold, 2006) or in trust among group members (Elgort, Smith, & Toland, 2008). The instructional methods derived from cooperative learning and small group learning were drafted, such as starting collaboration with pairs and assigning heterogeneous groups after observing the students' characteristics (Cooper, Robinson, & Ball, 2003; Lyman, 1995). However, these methods in the first version (v1) were later replaced by the new methods in the second version (v2), including helping students form self-organized friendship-based groups. According to the expert instructors in the focus-group interview, the initial methods were not practical, as they would take more time and give less power to students. Other instructional methods to support group climate include providing face-to-face meeting opportunities in early collaboration to build rapport and trust (Garrison & Vaughan, 2008) and to plan communication channels (Bold, 2006); additionally, groups are encouraged to pause, review and discuss their operation and progress (Johnson & Johnson, 1994; West & West, 2009).

Fear of publicity

Empirical research studies have shown that students might feel too intimidated to participate because of the public nature on wikis. For instance, some students felt uncomfortable displaying their works in progress in front of their peers on a class wiki (Beames, Klenowski, & Lloyd, 2010; de Pedro et al., 2006; Lin & Kelsey, 2009). Before addressing students' concerns, there is a need to help students understand 'why wikis?' and 'how openness on wikis benefits learning'. To address 'why wikis?' the literature suggests revealing the connections between wiki projects and academic goals in a course (Cole, 2009); the expert instructors suggested to

explain the different designs between learning management systems (to complete teacher-led tasks) and wikis (to empower learner-initiated activities). To address 'how openness on wikis benefits learning', the expert instructors suggested fostering peer learning by assigning peer feedback and encouraging students to visit past wikis for inspiration. To address students' concerns of making mistakes in public or breaking wiki pages, the expert instructors suggested a sandbox page to encourage experimentation.

Lack of collective ownership

Despite the success of Wikipedia, research has found that college students might not welcome massive edits to enhance quality and could not only hesitate to edit peers' work (Lin & Kelsey, 2009) but also even feel offended if their own work has been edited by peers on class wikis (Alyousef & Picard, 2011) owing to the lack of collective ownership of wiki content. Therefore, the instructional methods focused on empowering students and communicating the constructive wiki behaviours and thinking; the expert instructors recommended providing a framework to guide students' efforts and establish mutual understanding in wiki collaboration. For instance, a class wiki is everyone's space to contribute, as Expert A emphasized in the first class.

To increase the ownership of learning, a wiki framework is provided 'to eliminate some confusions ahead of time, but not all of them', as said Expert B. The expert instructors suggested the following two principles to empower students and help them develop a sense of ownership: First, Students should be encouraged to identify what needs to be done for projects and take action. Choices (e.g., choosing group members, selecting projects and deciding how to approach them) should be offered to increase the students' ownership of learning. Moreover, according to Saunders's (1989) research on collaborative writing and peer interaction, students should actively participate in all stages of the collaborative writing process, including planning, composing, reviewing and correcting, to develop a sense of ownership. Second, when students start making progress and begin mastering wiki tasks, instructors' timely feedback can be helpful to engage learners in collaboration and develop collective ownership of their work on the wiki. For instance, instructors may provide a sense of success when discussing the wiki progress students have made

in class and acknowledge individuals' constructive wiki behaviours [i.e., positive rewards, an element of successful cooperative learning, in Johnson and Johnson's (1994) work]. Timely feedback in class also provides an opportunity for students to learn from their peers and enhance their own self-efficacy, which Bandura (1997) called vicarious learning.

Research methods

Design-based research, a relatively new research genre, has been implemented during the last two decades to sustain innovative development, especially with regard to educational technology. DBR is a collaborative process between researchers and practitioners through which artefacts or effective interventions are developed in iterative cycles that work best in authentic settings (Bereiter, 2002; Design-Based Research Collective, 2003; Wang & Hannafin, 2005). McKenney and Reeves (2012) suggested that theory, empirical findings, inspiration and experience may all become input to create interventions that solve real-world problems, whereas practical solutions and theoretical insights learned from iterative cycled implementations become output for practitioners and researchers. Figure 1 illustrates the process of this research project.

Research site for the first implementation

The instructor

Expert A, the instructor of the first implementation, had been using wikis to support students' collaborative learning for more than 5 years prior to participating in this research project. He was also one of the two expert instructors who commented on the initial instructional theory (v1) and participated in the focus-group interview to revise the theory (v2) before this implementation.

The course and the students

The initial instructional theory was implemented in a three-credit hour course about media and communication in a higher education institution, located in the Greater Toronto Area, Ontario, Canada. The class met face-to-face for 12 weeks. A total number of 68 junior and senior students (36 female and 32 male students; some international students) enrolled in this course. More than half of the students had

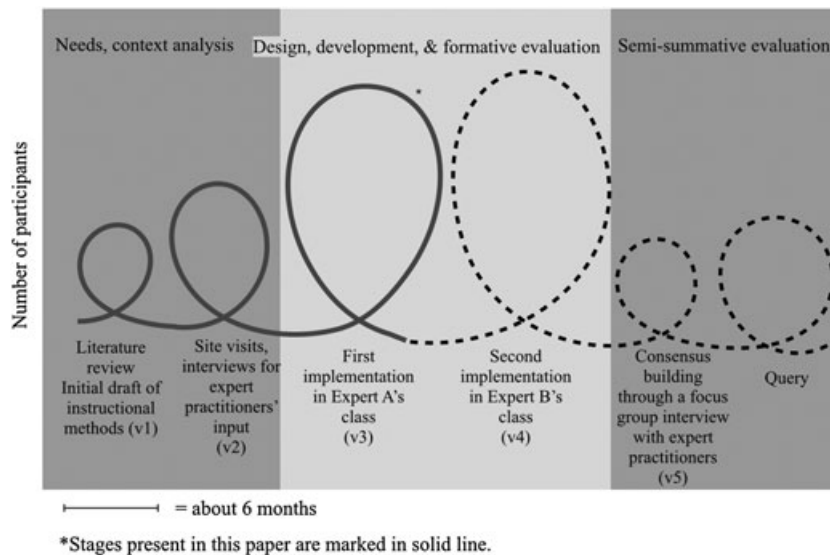


Figure 1 The DBR Process for Developing the Instructional Theory

experience in using the same wiki platform in other courses.

Physical environment

The class met in an auditorium-type classroom with approximately 150 seats. The room was equipped with a projector, speakers, a large projector screen and wireless Internet, which allowed the instructor to connect his laptop. Although there were no public computers available, more than half of the students used their own laptops in class.

Task assignment

The major course assignments contained two individual projects, one SGP and CKB on the class wiki. Because the first two individual projects were conducted offline and designed for the students to acquire basic competencies, this research focused on the latter two projects, which were both conducted on a wiki; these were designed to develop the students' advanced competencies, requiring them to solve complex and authentic problems through collaboration. The next two sections summarize the wiki projects.

The small-group project. The SGP was the final project. It was divided into four stages – planning, group

process, peer feedback and presentation – to assist the students' project management skills and maximize the students' learning from collaboration. The project aimed to develop the students' understanding of Internet media by their application of knowledge and skills in authentic settings. The syllabus stated the goals of the authentic project, stating 'Prepare a group plan to create viral Internet content dissemination', 'Critique the work of student groups in a productive and empathetic manner' and 'Present the results of the project in both a written and oral presentation'.

The collaborative knowledge-building project. Unlike administration-oriented learning management systems, the class wiki featured user-centred and flat-structured environments for student content creation. The intention of the class wiki was not to achieve instructors' administrative goals but to extend, enrich or transform the student learning experience by focusing and fulfilling the students' needs, interests and goals through peer support on a class wiki. The ultimate goal was to foster a peer-supported learning community with the students' development as autonomous learners through active participation. The instructor encouraged various forms of wiki participation, such as seeking help, answering questions, adding class notes, sharing resources, managing wiki pages and other related tasks. The

purpose of CKB was introduced in the first class along with examples from past wikis. The CKB project continued throughout the semester.

Data collection and analysis during the first implementation

We used several data collection methods to document evidence during the first implementation.

- Class observations: the weekly classes were observed and audio recorded to document how the instructor scaffolded learning and how the students responded.
- Content analysis: the content on wikis was closely monitored and analysed to study the students' behaviour patterns.
- Student focus-group interviews: three student focus-group interviews were conducted to understand the students' thoughts behind their behaviours. A total number of 11 students (seven female and four male students) were interviewed, three to five students each time. The participants were recruited on site and interviewed for 20 min after the classes dismissed. Their participation was voluntary. The interview questions can be found in Appendix II.
- Frequent instructor interviews: we conducted weekly or biweekly discussions with the instructor to understand factors influencing his decision-making process during instruction, which was expected to reflect changes for the scaffolding design. A sample of the interview questions can be found in Appendix II.

We conducted qualitative analysis to address the second research question regarding how instructional methods worked in the local context, including whether the group climate, publicity and ownership issues were revealed or resolved. Data were frequently analysed as collected and triangulated among sources. The findings were also synthesized from multiple data sources. In addition to findings from the interviews with the instructor and the students, we included findings from the class observations (e.g., how the groups worked during class in 'Small-group project stage 1: planning' and 'Small-group project stage 4: project presentation') and the wiki content analysis (e.g., students' SGP behaviours in 'Small-group project stage 2: group process' and CKB edits in 'Collaborative knowledge building stage 2: guided participation' and 'Collaborative knowledge

building stage 3: outcome, a self-sustained knowledge community, or not yet'). We triangulated and presented findings from more than one data source when available. For example, after we analysed the students' peer feedback on the wiki and found that some comments were intensive, while some were general and brief, we interviewed the students to find out what they thought and why some comments were not helpful (see 'Small-group project stage 3: peer feedback'). Additionally, we carefully examined and presented findings regarding their levels of consistency during triangulation. For example, we discuss the inconsistent students' thoughts on wikis for peer feedback ('Small-group project stage 2: group process') and their views on the wikis' publicity (see 'Collaborative knowledge building stage 2: guided participation'). The final report was member-checked by the instructor.

Findings

Part 1: wiki-supported small-group project-based learning

Small-group project stage 1: planning

In this stage, the instructor introduced the SGP project and prepared the students for working in small groups.

Self-organized groups. As the literature-based methods for assigning groups were modified based on the expert instructors' input in v2, the instructor allowed the students to form self-organized groups, mostly friendship based and some academic interest based. He created a wiki page for listing group members or finding group members based on topics and allowed three weeks to form self-organized groups. During an after-class interview, the instructor explained that for large classes, self-organized groups often work better than randomly assigned or instructor-formed groups. According to him, students in a large lecture class, working in a newly assigned group, have difficulty establishing trust, rapport and effective collaboration strategies within the limited project timeframe. Trust does affect group processes and their performance.

Effective communication. In addition, the instructor offered time for face-to-face discussions at the beginning of the project and discussed media use to support group collaboration, via wikis and other social media, such as Facebook group pages. During our class observation,

the instructor allocated 10 min for group brainstorming prior to some 15-min breaks. Moreover, most groups stayed 15–30 min after class or met online later for more discussion. During the focus-group interviews, that students confirmed that, even though their self-organized groups were friendship based, face-to-face interaction was necessary to build consensus.

Choices. The students were invited to make choices, ranging from topics to strategies to media for presentations; meanwhile, creative and critical thinking skills were encouraged in groups. The key here was to call the students' attention to open opportunities in the complex, real-world project, without telling them what to do. By promoting the students' higher-order thinking, the instructor intended to help the students develop ownership of their learning and challenge their thinking by activating their groups' decision-making process. From our class observations, when the class was dismissed, there were always groups lining up to talk with the instructor about their new progress and new possibilities. The students looked excited after meeting with their instructor and continued their group discussions afterwards.

Methods worked well. Given that no issues were identified from our interviews with the instructor and students, SGP stage 1 seemed successful.

Small-group project stage 2: group process

In this stage, the instructor supported the groups' learning during the project.

Group reflection. In addition to allocating time for group interaction, group reflection was encouraged during class. The students were invited to share their thoughts and feelings on the topics, such as what strategies were used to pursue objectives, how well the strategies worked and what other strategies could have been considered. In this way, the students were given opportunities to share their tacit knowledge, raise questions, learn from other groups and reflect on their own progress.

Timely feedback. Given the openness and timeliness of wikis, the instructor observed and monitored the groups' and individuals' collaborative learning behaviours on wikis, which enabled him to support real-time learning as it progressed. He offered frequent feedback to foster cognitive development. Firstly, informal feedback was provided by his comments posted on wikis or social media and face-to-face meetings with individual groups.

Secondly, formal feedback was offered at project milestones, including written feedback for proposals and oral feedback after presentations. He praised the groups' progress and challenged their thinking by addressing potential problems, requesting clarifications or suggesting alternate approaches to excelling in the end.

Students experienced more flexibility, more participation and collaboration. In order to understand how wikis support SGP, we also interviewed the students. The students used wikis as their central place for work and communication during group projects. According to them, wikis allow for more control, more participation and closer collaboration during group projects. One student shared how his group used the wiki for consensus building via individual contributions to the wiki and then face-to-face meetings: 'The wiki functioned as a "Cloud" to store individual thoughts when we couldn't meet as a group, and then we'd pull off unwanted stuff when we met as a group [after reaching consensus]' (Student A).

Content analysis of students' SGP behaviours on wikis. The wiki content was analysed to investigate collaboration behaviours. At the end of the semester, we randomly selected 5 groups (by using the random number generator on <http://www.random.org/>) out of a total of 23 groups. A coding scheme was created to code each group page for its purpose, number of edits, number of contributors, number of messages, number of messages excluding peer feedback and period of major contributions. The analysis showed that all groups processed and posted required written deliverables, including project proposals and final papers, on their wikis; four out of five groups frequently and actively used their wikis, even when they were not asked to do so – four groups brainstormed and analysed strategies to pursue objectives, three groups shared web resources for inspirations, the three groups that chose to produce videos for their projects created scripts and scenes, three groups tracked and analysed their results and one group summarized feedback from the public; and all wikis showed that most students took equal responsibility in the collaboration process.

Methods worked well. In this stage, learning responsibility was successfully transferred from the instructor to the student groups, who actively identified what needed to be done and took action. Several methods were implemented. Students found the instructor's frequent, timely and informative feedback particularly helpful. 'I think one of the good things about wikis is that you can

network with your prof. You have the professor more reachable' (Student A). In addition, the wiki itself also provided students a unique, flexible and diverse environment to conduct accountable, participatory and collaborative learning experiences throughout their group project.

Small-group project stage 3: peer feedback

To encourage constructive peer feedback, each student was asked to post three substantial comments to three self-selected group projects within 2 weeks. The groups were also encouraged to consider integrating peers' suggestions to improve their projects. The instructor offered the students guidance for writing peer feedback after a discussion on good feedback, which should be specific, constructive, timely, actionable and empathetic.

Peer feedback on wikis. The peer feedback stage seemed ambivalent regarding its success. On the wikis, we found that some students posted well-written feedback and those receiving this feedback expressed their appreciation, whereas some students made less helpful, brief comments. *Some unsatisfied with received feedback.* On the one hand, when asked 'what do you think about the peer feedback your group received?' several students stated that it was not so helpful. First, they found the feedback too general and unreliable. As one student said, 'We got some feedback, but it's not like profound, you know. I mean it wasn't like ground-breaking. It was just like, 'yeah, good idea'. It's something like everyone can easily do' (Student C). Another student said, 'I thought it wasn't that helpful because everyone had different ideas of what viral content should be. We're doing a very serious topic. It was a great issue. It definitely got a lot of responses back [from the public]. But some [peers] might think it wouldn't go viral because it's not funny or entertaining' (Student D).

Some hesitated to offer best advice. On the other hand, some students admitted that they intended not to give their best feedback. The follow-up interview question, 'what do you think about the peer feedback that you created for other groups?' triggered an interesting discussion. Several students genuinely described their reaction against offering advice to peer groups, whom they considered competitors. One student said, 'I thought that I didn't want to give my best advice just because (laughed embarrassingly) sort of the competitive thing' (Student C). That is, despite the goal of this stage being to help each other by offering suggestions, the students might have considered peers more as competitors and less as supporters.

Needs improvement. This stage failed to promote a culture of peer coaching. Although the students were given instruction regarding composing peer feedback, they were not so motivated to help other groups (their competitors). Therefore, some peer feedback turned out to be too general and superficial to be helpful.

Small-group project stage 4: project presentation

The last stage of SGP was to present learning outcomes. *Learning from peers.* All groups posted deliverables on group wikis and, on the presentation day, the groups made oral presentations in a setting similar to a science fair – the students walked around to interact and share their projects with other groups. Each group presented for 5–7 min to the instructor with their choice of media (varying from a poster with an iPad inserted for demonstration, photo albums, slide and videos to role playing). The instructor took notes, asked questions and gave feedback. The researcher also walked around to interact with student groups. Most groups were confident and excited when sharing their learning outcomes. At the end of the class, the instructor shared what he learned from their projects with the class, celebrated their learning achievements and addressed issues for future projects. That class provided a sense of success to the students and opportunities for vicarious learning.

Summary of wiki-supported small-group project. With the scaffolding provided, the student groups gradually took responsibility for their own learning and later presented their outcomes independently. In short, most stages of the SGP were supported successfully with no issue except for the peer feedback stage.

Part 2: wiki-supported whole-class collaborative knowledge building

Collaborative knowledge building stage 1: introduction

When introducing the CKB project to students, the instructor emphasized the nature of the wiki environment and that learning should be collaborative and constructive.

Explaining collaborative knowledge building. The instructor explained CKB and gave CKB examples to the class.

The course wiki is your space, my space, everyone's space together The whole idea of wiki is that it's not 'me' who controls everything, it's 'us' who control our space.

We can all contribute to it. I encourage you to do [so].... The space really works when everyone kind of makes it work together. So it's usually a good place to ask questions about the assignments; it's a good place to find the information about the assignments, course outline and syllabus. So there are many types of things we can use this for. (Expert A, lecture)

Offering choices. Additionally, the instructor described various actions that students might take to participate in CKB, such as asking questions, organizing materials and posting relevant resources. The intent was to give freedom, so that the students would develop a sense of ownership of the project and the co-created content on the wiki.

Students looked forward to collaborative knowledge building. Expressing interest and expectations, students seemed positive about this stage. Student B shared: 'I noticed that on the past wikis, students were more involved. Maybe it's because we haven't done much yet with the wiki.... Maybe in a couple of weeks it [our class wiki] will start to look, you know, more colorful.'

Collaborative knowledge building stage 2: guided participation

The goal of this stage was to encourage all students' active participation on the wiki, so that they would develop collective ownership and leadership of the project.

Offering guidance: basic structures and suggested tasks. The instructor observed the students' progress and needs. The instructor first created basic structures for a few pages. 'A blank page is something that takes a while for people to get to know it's there and they can do things with it' (Expert A, interview). Additionally, our class observation and interviews found that when the instructor detected the students' slow progress or low participation, he suggested tasks to guide participation. The tasks included a class contest for designing wiki page banners (in exchange for 1-week's assignment credits) and a sharing activity of the self-selected comics from a previous individual project. The instructor's suggested tasks during low participation were not in the original plans (v1 or v2). The following section explains how the idea emerged.

Addressing the issues of group dynamics and ownership. In order to help the students develop leadership and take initiative on the wiki, which was strongly desired in CKB, the instructor explained his careful stance on providing guidance.

I let it [wiki] go to the community [i.e., the class] and find out whatever particular group is running things, and they will come up with new ideas. And so, some classes were really creative and really kind of over populating and organizing everything; and some, for whatever reason, just the dynamics in the class don't work, that kind of reflects in the wiki a little.... It's an indication for me a little bit, though, kind of the nature of the class.

But when there were few students participating in CKB, the instructor tried to encourage participation.

So I was looking at it [wiki] and I was like, 'OK, there was no one doing it.' I remember when one of my students in 2006 did these really nice banners, and so I was like 'how do I get that?' It [the banner contest] is an experiment. I have never done it before. And I think it *will* kind of.... It's one of those things to give people some incentive to create and share their talents in the first place, and once people get started, then content [creation], it just happens. But sometimes, to me, it needs a little kick. (Expert A, interview)

Student: a community space. The findings from early student interviews showed the students' positive attitudes. For example, Student E said, 'I think it's also interesting to have a banner contest. We can actually be more involved with the content and the work of wiki. It's not just like a space where you submit work to the professor, but it's also a community space.'

Mixed views on publicity. As the CKB project proceeded, several students expressed their concerns, in a focus-group interview, about posting a mistake or imperfect work on the class wiki, despite a sandbox page for experiments: 'I'm pretty good on the computer, I would say. But it's [the wiki] kind of intimidating because when you post something, others would see it, in a case that we make a mistake or we post something that is incorrect' (Student F). The issue, in fact, may have less to do with technical difficulties but more to do with students' feeling incompetent or holding onto the traditional view of learning as product oriented, not process oriented, as the instructor indicated later in an interview. However, one of the students thought that the open nature of the class wiki could reduce the stress of the learning process because what other people think and how they learn could become transparent. According to her, 'You know what everyone is thinking. You are not lost. It [the wiki] sometimes helps with clarification, too' (Student G).

Students' progress on making the collaborative knowledge building edits. To observe the students' CKB progress, all students' contributed wiki activities for the CKB project

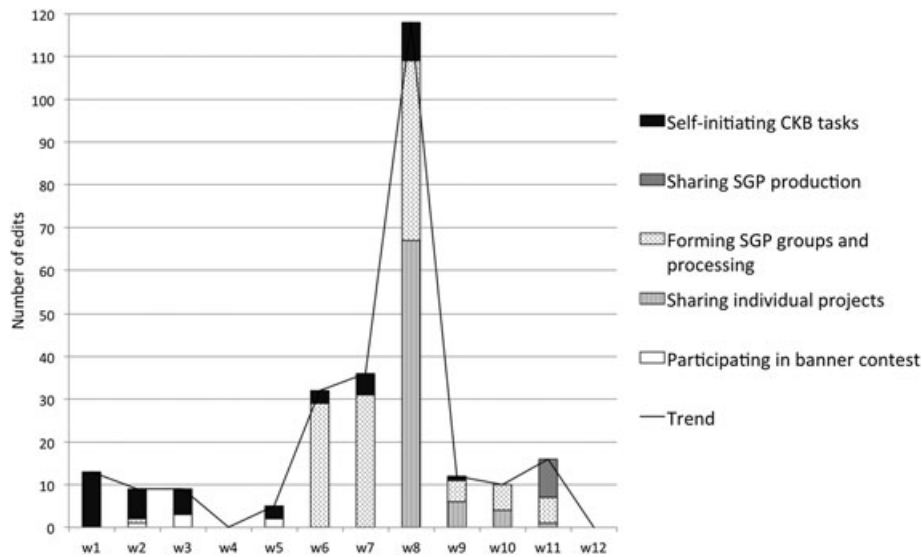


Figure 2 Students' CKB Contributions Throughout the Semester

were analysed. We first identified the wiki pages containing the CKB activities, categorized the types of wiki activities emerging from the data, pulled out the revision history of these pages and counted the number of edits students made in each category, every week. Figure 2 presents the number of edits and types of edits made by students for the CKB project throughout the 12-week course.

To explain the influence of CKB stage 2 instructional methods on the students' behaviours, one may find that students' edits increased when they participated in the suggested activities. However, very few students showed further self-initiated contributions to the CKB project. In other words, the instructor's efforts in observing progress and guiding participation did increase students' editing behaviours, but the class did not take leadership of the CKB project afterwards.

Collaborative knowledge building stage 3: outcome, a self-sustained knowledge community, or not yet

The goal of this stage was to foster (or observe) the self-sustained learning community on the wiki developed in the CKB project, ideally with most scaffolding faded away. In this section, we present the findings regarding the students' overall participation in this project based on the content analysis of the class wiki.

Students' overall collaborative knowledge building behaviours on wiki. As per the analysis described in the previous stage, five types of edits were identified out of the total of 260 CKB edits made by students (see Figure 2):

- participating in the banner contest (guided participation): 2%;
- sharing individual projects (guided participation): 30%;
- updating the SGP group list, including listing or finding group members, and editing the links to group wikis: 46%;
- sharing the final production from SGP with the class: 3%;
- other students' self-initiated CKB tasks, such as editing the FAQ page, navigation and summaries of lectures: 18%.

Self-initiated edits? long-tail effects. When looking at students' self-initiated CKB edits over time, we find, at the beginning, self-initiated edits were made to organize the class wiki. The number of edits became steady, which reflects regular activities, such as posting class notes. However, we realized that most contributions came from only a few students in the beginning. Figure 3 presents the number of edits made by individual students. The top (most active) 20% of students contributed to over 50% of CKB edits. This illustrates the long-tail effect, which reflects that a small number of students made the majority of the contributions and a large number of students made minimal contributions.

Guiding activities? different results. Because the instructor wanted to involve all students, he suggested the 'banner design contest', which increased only 2% of all total contributions. The instructor then encouraged students to share their individual projects on the class wiki at week 6, which added 30% to the total contributions.



Figure 3 The Total Number of CKB Edits Made by Individual Students

The task difficulties could have influenced the students' choice of participation. Posting previous projects was a quick and easy task compared with designing a web page banner. Moreover, the constructive discourse (e.g., building on each other's ideas) was rarely observed in students' CKB contributions.

Needs improvement. The line connecting students' weekly edits in Figure 2 suggests that most students' contributions increased as the instructor provided a clear instruction on what information to post and dropped when the guiding activities faded away. In other words, a self-sustained CKB community was not observed in this stage. Issues such as group dynamics and publicity may have contributed to the students' low participation. We envisioned that effective CKB scaffolding would develop the students' autonomy, leadership and ownership in the project. Therefore, Figure 2 would have shown the students' gradual growth and steady participation over time with a variety of community-identified tasks aimed to support meaningful, collaborative learning. Additionally, in contrast to the long-tail effect shown in Figure 3, we believe that a successful wiki-supported CKB would require more active student participation.

Conclusion and discussion

This article proposes an initial instructional design to support higher-education students' collaborative learning on wikis and reports the first implementation to generate empirical evidence for future revisions. The wikis were used for two major practices of collaborative learning: SGP-based learning and whole-class CKB. In this section, we summarize the findings, propose relevant literature to explain the difficulties and suggest possible directions for future revisions.

Summary of the small-group project and collaborative knowledge building scaffolding

We created Table 1 to summarize the findings and assist the discussion that follows. Table 1 lists what instructional methods were implemented to scaffold SGP and CKB, how students perceived their experience and whether the methods met scaffolding goals for the stage or needed improvement.

According to the findings, most SGP stages succeeded. The students expressed satisfaction with their learning supported on wikis, engaged in group processing and demonstrated cognitive development. Besides common strategies for small-group learning, the

Table 1. Summary of the Implemented Instructional Methods for Wiki-supported SGP and CKB

| Stage no. | Scaffolding goal | Implemented scaffolding design | Results | Direction for future changes |
|---|----------------------------|---|--|---|
| SGP stage 1: planning | Intersubjectivity | <ul style="list-style-type: none"> • Established milestones [G] • Allowed student self-organized groups [G] [O] • Helped effective communication [G] • Offered choices [O] | Worked | N/A |
| SGP stage 2: group process | Transfer of responsibility | <ul style="list-style-type: none"> • Encouraged group reflection [G] • Observed students' progress and needs [P] • Offered timely feedback [P] | Worked | N/A |
| SGP stage 3 (optional): peer feedback | Transfer of responsibility | <ul style="list-style-type: none"> • Requested peer feedback [P] | Undecided (uneven quality) | Mind-set change (culture of peer coaching) |
| SGP stage 4: outcome: presentations | Scaffolding removed | <ul style="list-style-type: none"> • Provided a sense of success, reward through recognition and opportunities for vicarious learning [O] | Worked | N/A |
| CKB stage 1: introduction to CKB | Intersubjectivity | <ul style="list-style-type: none"> • Explained the purposes of using wikis [P] [O] • Offered choices [O] • Created a sandbox page [P] • Examples on past wikis [P] | Worked | Mind-set change (knowledge about the collaborative and constructive nature of learning) |
| CKB stage 2: guided participation | Transfer of responsibility | <ul style="list-style-type: none"> • Observed students' progress and needs • Offered a template or skeleton for pages and allowed students to identify what needs to be done [O] • Suggested activities when participation was low [O] [G] | Undecided (low self-initiated participation) | Increase confidence and motivation |
| CKB stage 3: outcome: Self-sustained knowledge community or not | Scaffolding removed | N/A | Failed, unsatisfied | N/A |

[G] = methods for group processing; [O] = methods for ownership; [P] = methods for publicity; N/A = not applicable.

instructor made efforts to empower their students and value their expertise by having the students self-organize into groups and adding a stage for peer feedback. On the one hand, the students' self-organized groups went well, resulting in positive group dynamics by eliminating the trust-building issue, which could have been challenging for SGP in large classes. On the other hand, the success of peer feedback was questionable given that some students did not find the feedback helpful or refused to offer their best advice to other groups. It drew our attention to the need for helping students transform

their mind-set from a traditional view with norm-referenced assessment (i.e., competing with peers; product oriented) to a collaborative, constructive learning mind-set with criterion-referenced assessment (i.e., helping each other by offering perspectives and expertise; process oriented).

Unlike the success of SGP, the findings from analysing the students' 12-week behaviours (Figures 2 and 3) failed to support the ultimate goal of the CKB project: the sustainability of the learning community with the students' development as autonomous learners. At

the beginning, a conceptual framework and a basic skeleton of the class wiki was offered to allow the development of the learners' autonomy based on the class's interests and strengths. When the instructor observed low student participation in CKB, he proposed guiding activities, including the banner contest and the submission of individual projects, hoping to engage more students after the scaffolding faded away. However, after guided participation, most students were still unable or unwilling to self-identify and contribute to tasks for CKB. The issues, such as publicity and group dynamics, still exist.

Why difficult for collaborative knowledge building? a new genre and autonomy

Although CKB failed, it brought us one step towards success, by suggesting an explanation and an opportunity to re-examine the relevant literature for designing scaffolding in future implementation.

First, it appears that the genre of wiki for SGP and the genre of wiki for CKB should be distinguished, given the results of this study. Genres often refer to a combination of particular forms and purposes (Campbell & Jamieson, 1978), helping both genre creators and users easily recognize them and determine how to proceed. Therefore, wikis should not be viewed as one genre here but two different genres for two practices (i.e., same forms but different purposes). On the one hand, we found an effective wiki for SGP to be a reproduced genre to the students, which is similar to an online news site reproduced to the reflect readers' experience with traditional newspapers (Vaughan & Dillon, 2006). Given that most students had prior experiences in their SGP, they easily adopted a genre of wiki for SGP that offered features to perform collaborative tasks they had already mastered.

A wiki for CKB, on the other hand, was a completely new (emergent) genre for students. Although the students had heard of wikis and Wikipedia, they had neither experience in using them for massive collaborative knowledge construction (contributing rather than consuming) nor experience in face-to-face, student-led, whole-class knowledge building. Therefore, this genre of wiki for CKB was unrecognized. With no adequate scaffolding to help reduce cognitive overload, the students were uncertain about how to proceed. More importantly, the genre of wiki for CKB required students to

develop a new mind-set of learning (i.e., constructive and collaborative rather than individualized and competitive) in order for them to successfully adopt it. Second, because the findings on CKB contradicted our instinct that wiki-supported CKB would require few interventions for group dynamics to allow autonomy, we plan to redesign the scaffolding to focus on strategies for developing the students' autonomy in CKB in future implementation.

Future directions to refine the scaffolding for collaborative knowledge building

The redesign for CKB requires supporting the two following aspects – intersubjectivity and transfer of responsibility [which Belland (2014) called for future directions of research in reviewing scaffolding published in the most recent handbook of research on educational communications and technology]. Intersubjectivity in stage 1 focuses on reducing cognitive overload and resolving mental conflicts, whereas transfer of responsibility in stage 2 emphasizes developing methods to support students' self-sustained CKB by integrating Littlewood's (1996) model of autonomy into the collaborative learning literature.

Scaffolding for intersubjectivity, the goal of collaborative knowledge building stage 1

Scaffolding for intersubjectivity refers to communication between the instructor and students about the goals of upcoming tasks, similar to Rogoff's (1990) example of intersubjectivity as a mother introducing a new toy to an infant by drawing her attention and showing her how to play with it. Given that wikis for CKB appear to be a new genre to most students and that collaborative and constructive learning conflicts with prior school experience, students are likely to face mental conflict and cognitive overload at the beginning of the project. Students need assistance to transform their mind-sets from the traditional learning model (i.e., teacher-directed, product-oriented learning and norm-referenced assessment) to the constructive, collaborative learning model (also student-directed, process-oriented learning and criterion-referenced assessment). Moreover, Stahl's (2000) model of CKB may help students come to a new understanding of learning, which involves resolving cognitive conflicts or filling in gaps to arrive at a new comprehension in the cycle of personal and social knowledge building. In the wiki-supported

CKB, using Piaget's model of equilibration, Cress and Kimmerle (2008) stated, 'people engage in knowledge building by contributing new information to wikis and by restructuring existing articles because of cognitive conflicts'. Thus, a wiki-supported CKB project should aim to support learning by giving opportunities for all to actively identify knowledge problems and resolve cognitive conflicts by having students internalize the class's shared understanding and externalize personal beliefs as their contributions to the collective knowledge.

Scaffolding for transfer of responsibility, the goal of collaborative knowledge building stage 2

Scaffolding for transfer of responsibility refers to the process of helping students take more responsibility and leadership from instructors and become more autonomous learners [aligning with the paradigm shift in education from teacher-directed to learner-directed learning (Reigeluth & Karnopp, 2013)]. The findings, especially the lack of student participation in self-identified meaningful CKB tasks, not only echo previous research in the need to develop a 'give-and-take' culture (Ebner, Kickmeier-Rust, & Holzinger, 2008) but also indicate the urgent need for investigating effective instructional methods to support the transfer of responsibility in such projects.

Littlewood (1996) proposed two main components of autonomy – ability (i.e., skills and knowledge) and willingness (i.e., confidence and motivation). This model of autonomy may help design future revisions for the instructional methods. After learners acquire CKB-related knowledge and skills during an instructor's scaffolding of intersubjectivity in CKB stage 1, the instructional focus need to shift to learners' confidence and motivation in stage 2. Instructors may reinforce the constructive and collaborative nature of learning through constant practice, frequent feedback and discussions, as mastery experiences and social persuasion (Bandura, 1997), to help learners become intrinsically motivated.

But how to facilitate CKB during discussions with students? Hmelo-Silver and Barrows (2008) studied the strategies to facilitate CKB, and they recognized that asking metacognitive questions was the key. In their successful CKB case, 75% of the instructor's questions (and 41% of the students' questions) fell into this category. These task-oriented and monitoring questions, such as 'Um, so what did you want to do next?' 'So that might

be a learning issue we can take a look at?' (p. 62) helped the students reflect on their progress and become self-directed learners. Therefore, the next implementation of wiki-supported CKB should include metacognitive questions when planning discussions with students, such as 'What do you think of Shenna's post on the wiki? Was it helpful? How do posts like this help you learn?' 'What can be done next?'

To conclude, this article proposes an instructional theory to support collaborative learning on wikis with suggestions for future implementation (please see Appendix I) and provides a lens to understand how students behave on wikis and how experienced instructors design their use of wikis for collaborative learning. Future research needs to investigate how the instructional methods may be improved based on the suggested directions for their redesign and to offer empirical evidence from various contexts to increase the generalizability. We look forward to further explorations of the effectiveness of wiki-supported collaborative learning to help align students' mind-sets and practices with the collaborative and constructive nature of learning in the 21st century.

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Appendix I: The instructional methods

| Instructional methods | v1 | v2 | v3 |
|---|----|----|----|
| M1: prepare the course objectives, the collaborative projects and the class wiki site | v | v | v |
| • Identify the course objectives and other conditions, such as learners' backgrounds | v | v | v |
| • Plan collaborative projects or tasks for helping students achieve course objectives | v | v | v |
| ♦ Decide on individual small exercises, group projects or both | | v | v |
| ♦ Establish multiple project stages or milestones for complex tasks [G] | | | v |
| • Prepare the materials and the class wiki site based on the objectives and needs of the collaborative projects | v | v | v |
| ♦ Create a framework and skeletal structure on wiki to foster mutual understanding and encourage leadership [O] | | v | v |
| M2: Introduce wikis to students and build their confidence in using wikis | v | v | v |
| • Explain the purposes of using wikis [P] | v | v | v |
| ♦ Explain connections between wiki projects and academic goals [P] | v | v | v |
| ♦ Explain the advantages of using wikis compared with using learning management systems [O] | | v | v |

(Continues)

| | | | |
|--|---|---|-----|
| • Introduce wiki concepts | v | v | v |
| ♦ Explain the expectations of learners on wikis with examples about constructive and unconstructive wiki behaviours [P] [O] [G] | v | v | v |
| ◇ <i>Future consideration: help overcome the fear of posting in public by rethinking about wikis as a space for sharing and facilitating learning process, rather than turning in results for evaluation</i> [P] | | | n |
| • Help students develop wiki skills | | v | v |
| ♦ Give a tour of class wiki, including its features | | v | v |
| - Offer one-on-one face-to-face tutorials to students who are new to wikis or have technical difficulties | | | v |
| ♦ Explain wikis' limitations, anticipated problems and potential solutions | | v | v |
| ♦ Create a sandbox and encourage experiments [P] | | v | v |
| ♦ Assign tasks as soon as wiki skills are introduced for practicing skills and discussing concepts | | | v |
| • Show previous examples of wikis | | v | v |
| ♦ Discuss various examples from past wikis (e.g., success of community building, diversity of projects, exemplary activity logs) [P] | | | v |
| M3: foster a learning community | v | v | v |
| • Introduce knowledge co-construction on wikis for community building [O] | | v | v |
| ♦ Initiate and discuss spaces for whole-community collaboration | | v | v |
| - Define wikis as learner-centred for co-constructing learning experiences [O] | | | v |
| ◇ <i>Future consideration: include diverse examples of community building tasks on wiki and explain the concept learning through CKB</i> [O] | | | n |
| ♦ Structure activities in which individuals are responsible for their own and peers' learning [G] | v | v | v/p |
| ◇ <i>Future consideration: require all students to participate in community building</i> | | | n |
| ◇ <i>Future consideration: discuss individuals' contributions to peer learning (i.e., intrinsic motivation, internalization)</i> | | | n |
| • Maximize participation and develop ownership of work on wiki | v | v | v/p |
| ◇ <i>Future consideration: remove the instructional method "guide participation by hosting a contest (e.g. wiki banner design)"</i> | | | v |
| ♦ Allow students to identify what needs to be done on the wiki and take action [O] | | v | v/p |
| ♦ Ensure students' active participation in all stages of the collaborative writing processes, including planning, composing, reviewing and correcting, (i.e., all levels of contributions) to develop the sense of ownership [O] | v | v | v/p |
| M4: prepare collaborative learning in small groups | v | v | v |
| • Help students form cooperative project groups [G] | v | v | v |
| ◇ <i>Remove the instructional methods, "start with pairs, assign heterogeneous groups, and form groups of four to six"</i> | v | | |
| ♦ Allow students' self-organized groups, which may be based on friendship or academic interests [G] | | v | v |
| ♦ Recommended group size varies depending on the level of project complexity and instructional needs (e.g., groups of two to three in a small class, three to five in a large class) | | v | v |
| ♦ Encourage students to organize groups on wiki (list or find a group on a group listing page) [G] | | | v |
| • Prepare students with group skills | v | v | v |
| ♦ Allow face-to-face interaction to build trust [G] | v | v | v |
| ♦ Plan effective communication and interaction [G] | v | v | v |
| M5: scaffold collaborative learning and cognitive development | v | v | v |
| • Facilitate collaborative learning process | v | v | v |
| ♦ Observe collaborative learning behaviours (i.e., interaction and edits), and pay close attention to student progress and needs. Subscribe to RSS feeds to monitor activities on wiki [G] | v | v | v |
| ♦ Encourage groups to pause, review and discuss their operations and progress frequently or in each project stage [G] | v | v | v |
| ♦ Help groups recognize and resolve conflicts independently (e.g., remind to communicate within groups before reporting to instructors) [G] | v | v | v |
| ♦ Provide a sense of success, reward through recognition and opportunities for vicarious learning by making group projects available on the wiki and giving all students opportunities to present their projects [O] | v | v | v |

(Continues)

| | | | |
|---|---|---|---|
| • Promote critical and creative thinking | v | v | v |
| ♦ Advocate creative thinking by offering choices (e.g., topics, strategies and media for presentations) and scaffolding decision-making processes [O] | v | v | v |
| - Encourage students to browse projects on previous wikis for inspiration to learn different approaches, generate new ideas or improve existing projects [P] | | v | v |
| ♦ Advocate critical thinking in projects, especially through peer-coaching and peer feedback processes [P] | v | v | v |
| - Discuss and post guidelines for writing effective peer feedback [P] | | v | v |
| - Allow students to select projects to which they will give feedback [P] | | v | v |
| ◇ <i>Future consideration: emphasize value of collaboration, peer coaching and collaborative relationships in a new model of learning in CKB during weekly discussions to eliminate the resistance from an old mind-set [P]</i> ◇ <i>Future consideration: during discussions, use metacognitive questions to help students reflect group progress and become self-directed [O]</i> | | | n |
| ♦ Provide formal and informal feedback to encourage or challenge students [O] | v | v | v |
| M6: assess learning outcomes with formative feedback | v | v | v |
| • Before assessments, provide clear guidelines | v | v | v |
| ♦ Offer no rubrics to encourage creativity [O] | | v | v |
| ♦ Assess projects at multiple project stages and offer informative feedback to proceed [G] | | | v |

Note. 'v' indicates existence of a method (remained, implemented or added). 'v/p' indicates partial implementation of a method: in SGP but not in CKB. 'n' indicates the need to add a method. A blank cell indicates non-existence of a method (deleted or not implemented). Text in italics indicates future consideration for refinement based on the implementation. [] indicates the issue addressed in the method: [G] for group climate, [P] for publicity and [O] for ownership.

Appendix II: The interview questions

| Interview questions (students) | SGP/CKB | Note |
|---|-------------|---------------|
| 1. Could you tell me about your group's progress so far on the final project? | SGP | Group climate |
| 2. What role does the wiki play during your collaboration with teammates? | SGP | |
| 3. How does the class wiki help your personal learning in this course up to this point? | CKB, SGP | |
| 4. Based on your experience, what would be the benefits of using a class wiki to support learning? What would be the challenges? Follow-up: How do you feel about the openness on a class wiki? | CKB, SGP | Publicity |
| 5. I looked at the peer feedback on your projects. I am curious about what you think of the peer feedback you received from your classmates. How about the peer feedback you offered to other groups? | SGP | |
| 6. Have you visited the past class wikis that your instructor showed in class? If yes, what did you think of them? If not yet, what would you expect to find? How do you plan to contribute to your class wiki? | CKB | Ownership |
| 7. Are you aware of the recent activities on the wiki? Did they help you become involved in collaborative knowledge building with your classmates? | CKB | |

| Interview questions (instructor) | SGP/CKB | Note |
|--|---------|---------------|
| 1. I saw that students have begun listing their names and topics on the class wiki for the final project. How well did it work for the students' self-organized groups? Did anyone ask for your help, such as saying I can't find a group? | SGP | |
| 2. For a complex project, like this final project, what kind and how much scaffolding is needed to help students' time management, group processing, cognitive thinking and so on? | SGP | Group climate |
| 3. When you showed the past wikis to the class, I noticed that they all looked different. Did you have certain expectations on each of them or on the current class wiki? | CKB | Ownership |
| 4. I found that a couple of students started editing the wiki for collaborative knowledge building since last week [second class]. Did you encourage this by sending an email to the class and asking for contributions? | CKB | |
| 5. What do you think about students' participation in the wiki activities so far? What do you do if the participation is low? | CKB | |
| 6. I noticed that you announced a new activity, the wiki page banner contest, in class today. That is interesting! How did you come up with the idea and why? | CKB | |
| 7. I interviewed students last week. A couple of them said they were hesitant to present the still-on-progress work in front everyone by posting it to the wiki. What do you think? What can we help them overcome this challenge? | CKB | Publicity |