Abstract

Wikis support collaborative learning in a classroom environment. Nevertheless, the argument of wikis as an unstructured medium for learning and issues concerning security and privacy matters are overshadowed by the full potential benefit it brings to education fields. Educational wikis are very different from the wiki that we know in the biggest online encyclopedia; wikipedia.org. The implementation of wikis in education relies on its pedagogy approach, hence known as wiki pedagogy. The study conducted in Malaysia schools provides the case study for educational wikis to be deployed in school. The approach taken in the study using design experiments managed to formulate a pedagogy for effective use of wikis in education. Findings of the study may provide a new perspective in understanding the current practice of teaching and learning in school. The essence of socialization of learning facilitate by using wikis lead to collaborative knowledge building among students that they are not learning the knowledge but they are involved in the learning process which makes them a distinguish learners.

Introduction

There is much excitement about the potential of “Web 2.0” technologies, or “social software” in education (Gooding, 2008). They can help students develop writing and collaboration skills (Fuchs-Kittowsk & Köhler, 2005; Godwin-Jones, 2003; Wang & Turner, 2004). Being tools for social interaction, they offer opportunities for social learning. Moreover, because young students are familiar with the idea of social software and associate it with being up to date and modern, use of social software for learning can motivate them. Yet, as with any educational medium, obtaining potential benefits from social software is not automatic. Governments and educational institutions have concerns about security; educators, learners (and their parents) can be concerned about safety and privacy. These concerns become more critical when the learners are school students rather than young adults in universities. In addition, as with all educational technology, the simple act of making a wiki available does not ensure that it is adopted or used in such a way that students benefit.

In this paper, we will focus on wikis as social software tools to support collaborative learning. The most well known wiki, Wikipedia.org, is an online encyclopedia. Each entry is written collaboratively by multiple authors who are able to add to, correct or edit a page with a couple of clicks, and (usually) their revisions are incorporated immediately in the entry. Once registered, anyone can contribute to Wikipedia. Wiki software of the type that drives Wikipedia can be used in many other situations (Klobas, 2006) and is particularly valuable for collaborative learning in schools (Forte & Bruckman, 2006). But, wikis themselves are unstructured media and the freedom to create or revise a page, rather than being liberating, can inhibit contributions or result in confusion or chaos among inexperienced users. In this paper, then, we concentrate on what can be done to realise the considerable potential that wikis offer for collaborative learning. We report the results of research on the use of wikis to support collaborative learning in the classroom. The research was conducted in Malaysian high schools and provides a case study of how wikis can be used effectively for collaborative
learning in schools. The research has led us to develop a “wiki pedagogy”, a pedagogical approach to using wikis (and, potentially, other social media) for collaborative learning.

Background
Theories of CSCL are based on the socio-constructivist theory that knowledge is socially produced by communities of people, and each person can gain knowledge if they join knowledge communities (Vygotsky, 1978). People share their ideas, experiences, feelings and information, and within this process of exchange they come to an understanding of what is valuable and acceptable for the other members of the group, and for the group on the whole. From a social constructivist point of view, learning is considered as an active process in which people construct their knowledge by relating it to their previous experiences in complex and real situations in life and through interaction with the social environment.

According to Vygotsky, language and culture play essential roles both in human intellectual development and in how humans perceive the world. These are the frameworks through which humans experience, communicate, and understand reality. As a result, human cognitive structure is essentially socially constructed. Knowledge is not simply constructed but it is co-constructed. The social construction of knowledge through learning is therefore a collaborative process. In general, collaborative learning should be seen as a process of peer interaction that is mediated and structured by teacher.

Activity Theory
Social constructivist theory is often explained in relation to activity based learning theory or activity theory for short (Jonassen & Ronner-Murphy, 1999). The expansion of Vygotsky’s ideas was developed largely under the activity theory banner. Activity theory supports several learning approaches including project based learning, inquiry based learning and problem based learning. In activity theory, the teacher’s role may shift to designing, facilitating and monitoring student activities according to the adopted approach to learning.

Computer Supported Collaborative Learning (CSCL)
The basic underlying concept of CSCL is the word ‘collaboration’. Collaboration is a basic human activity, particularly for cultural development (Bruner, 1996; Engeström, 1987; Mead, 1934; Tomasello, 1999; Vygotsky, 1978). Lipponen (2002) describes collaboration as a process of participating in knowledge communities. Similarly, Scardamalia and Bereiter (1994) speak about knowledge-building communities where knowledge building is a special form of collaborative activity oriented towards the development of conceptual artifacts, and towards the development of collective understanding. Brown (1994) added that, "Learning and teaching depend on creating, sustaining, and expanding a community of research practice. Members of the community are critically dependent on each other. No one is an island; no one knows it all; collaborative learning is not just nice, it is necessary for survival" (p.10)

Since knowledge is a social phenomenon (Brown et. al.,1989), it involves people coming together and sharing their thought processes. By using information and communication technology to enhance individual and group learning, this social knowledge could be used, captured, shared and expanded further in the collaborative system commonly known as CSCL. CSCL promotes interaction and facilitates the sharing and distribution of knowledge and expertise among a group of learners (Lipponen, 2002). Collaborative learning exercises are student-centred and enable students to share authority and empower themselves with the responsibility of building on their foundational knowledge (Collins et. al.,1989). Wikis can be used to facilitate CSCL where students can create a set of documents (conceptual artifacts)
that reflect the shared knowledge of the learning group or knowledge community (Augar, Raitman, & Zhou, 2004; Wang & Turner, 2004)

**Wikis as Collaborative Tools in School**

Wiki is an interesting tool for enhancing social constructivist learning environments. Wikis are increasingly being accepted as a new breed of collaborative technology. A wiki allows a group of users to quickly initiate and evolve a hyper-linked set of web pages using a simple markup language.

Wikis are easy-to-use collaborative technologies. They are people-centred tools (Brereton, Donovan, & Viller, 2003) that can impact knowledge management, and can support knowledge creation and sharing (Lamb, 2004; Leuf & Cunningham, 2001; Wagner, 2004) within both the corporate and the academic environment. They can be used to support teaching and learning activities in school where they can be adopted to facilitate student collaboration in construction of meaning and knowledge (Richardson, 2006).

Previous studies have shown that wikis have been used successfully in higher education (Bergin, 2002; Bold, 2006). Early implementation of wikis in educational settings have shown that the more autonomy teachers give to students in terms of negotiating the scope and quality of the content they are creating, the better. In using wikis, students are not only learning to write collaboratively and publish content; they are also learning how to develop and use all sorts of collaborative skills, negotiating with others to agree on correctness, meaning, relevance, and more (Fuchs-Kittowsk & Köhler, 2005; Godwin-Jones, 2003; Wang & Turner, 2004). In essence, students begin to teach each other. Research has shown that teachers and students can get very creative and develop innovative and useful activities for learning (Honegger, 2005; Synteta, 2002). For some, wikis become objects to think with, for others, wikis can help build an understanding of a community’s shared knowledge (Schwartz, Clark, Cossarin, & Rudolph, 2004).

Wikis encourage knowledge building with and for others. The focus is on the knowledge community rather than on the individual learner (Holmes et. al., 2004). The implication of co-construction in the school context is important. In the words of Holmes et al. (2004), "What we argue for is a communal constructivism where students and teachers are not simply engaged in developing their own information but actively involved in creating knowledge that will benefit other students. In this model students will not simply pass through a course like water through a sieve but instead leave their own imprint in the development of the course, their school or university, and ideally the discipline. (p.4)"

**Key factors associated with knowledge sharing using wikis**

In order for wiki to be successfully integrated in school activities, several important factors need to be investigated. Research conducted on wikis has identified openness and transparency (Klobas, 2006); non-anonymous participation, recognition of individual participants in the reward structure (Banerjee, Bolloju, & Ma, 2004); current user page locking mechanism, owner and modifiable wiki page, archival wiki page (Wang & Turner, 2004); anarchistic, connected pages, lack of control, self-healing, based on trust (Spek, 2006), egalitarian structure of wikis (Ebersbach & Glaser, 2004; O’Neill, 2005), familiarity with wiki technology (Augar et al., 2004), careful planning for implementation and use, appropriate class size (Holmes et al., 2004) and student creativity (Synteta, 2002), empowerment and motivation of students to engage in collaborative learning. Most importantly, the earliest research on wikis in education, the CoWeb project; concluded that the culture of the classroom and the discipline needs to be compatible with the medium for CSCL to be effective (Rick & Guzdial, 2006)
Method
In order to identify how wikis can effectively support computer supported collaborative learning and knowledge sharing in schools, a study was developed to answer two questions:

1. What learning approaches are appropriate for online collaborative learning using wikis in school?
2. What are the key factors that contribute to effective use of wikis in school?

The study took place in 11 schools in Malaysia. Both “Smart” schools (N= 6 government led school initiative under Multimedia Super Corridor projects embraces ICT as an integral part of their school systems) and normal schools (N = 5) participated. Schools in both urban and rural settings were selected in each category.

The participating students were 16 year olds taking the 6 modules Information and Communication Technology (ICT) course which, at the time of the study, was offered in English. Activities were designed to use wikis for learning in two modules: ICT and Society, and Multimedia. A total of 169 students (74 male and 95 female) and their (N = 11) teachers participated across the 11 schools.

A key feature of this study was adoption of design based research (Brown, 1992; Collins, 1992; Design-Based Research Collective, 2003). DBR is the study of learning through systematic design of instructional strategies and tools. In this study, activities for learning the curriculum for the selected modules using wikis were designed in the (rough) series of steps outlined by Collins et. al. (2004) and illustrated in Figure 1. An initial design of the activities was prepared (stage 1), based on the researchers’ knowledge of students who study the ICT course in Malaysian schools and the curriculum. The design included four different types of group learning activity:

- a pre-course Ice Breaking Session (IBS) that introduced students to group work, wikis, the wiki they would be using (two different hosted wiki platforms, PbWiki - now pbworks.com - and wikispaces.com, were used to ensure results were not specific to a specific wiki technology), the learning activities, the tasks they would be asked to perform, and the methods and tools available for these tasks, and in many cases, set up students with their first email address;
- an inquiry-based learning activity (“Wiki 1”) in which students gathered materials and collated information in a wiki about an aspect of ICT and Society of their choice;
- a problem-based learning activity (“Wiki 2”) which posed a problem associated with application of multimedia to ICT and Malaysian society and asked students to prepare a wiki that recorded their understanding of the problem and potential solutions.
- a project-based learning activity (“Wiki 3”) in which students were required to research a form of multimedia (chosen by the group) and, as a group, produce a wiki project that described a chosen topic in the ICT and Society modules.

All of the activities involved a form of blended learning in which one of the two weekly classroom sessions for the ICT course was devoted to group work in the school’s computer laboratory. Students were free to work on their wikis outside class time, if they wanted, although this was not a requirement.

Different teachers chose to incorporate all or some of the four activities in their courses. Activity completion rates were as follows:

- 100% of students participated in Ice Breaking Session
- 87% completed Wiki 1 (inquiry-based)
- 62% (all in normal schools) completed Wiki 2 (problem-based)
- 25% (two smart schools and one normal school) completed Wiki 3 (project-based)

The activities were modified after interviewing a sample of teachers and discussing the design; tasks were simplified and provision was made for individual assessment (stage 2).
They were revised further simplified after the IBS (stage 3) when it was realized that students had no previous experience of group work, not all had the level of IT literacy that had been assumed and a relatively high proportion had not previously used email or the World Wide Web. The fourth stage of the design consisted of the activities as they were conducted in the classroom, along with assessment and evaluation.

Figure 1. Schematic of application of DBR to design of activities for learning using wikis

The final (stage 4) design was evaluated with information and data gathered from students, teachers, and review of the content of the wikis created by the students. Students completed an online questionnaire and participated in group interviews after completion of the activities chosen by their teachers. The questionnaire contained a set of items which asked students to rate the quality of their experience of using wiki for collaborative learning and knowledge sharing in their school on a five point scale, as well as open-ended questions about their response to each activity. Ten teachers (five each from normal and smart schools) were interviewed individually. The contents of the wikis were evaluated in three ways and scored for: evidence of collaboration, evidence of knowledge sharing, and quality of the content of the final wiki produced for each activity relative to the requirements of the assignment.

Factor analysis was used to identify six aspects of students’ quantitative evaluations of their experiences. The students’ answers to the open ended questions, their responses to questions posed in the group interviews, their guided reflections on the extent to which participation in the wiki activities contributed to their learning, and the teachers’ responses to interview questions were classified into common topics. To identify appropriate learning approaches, the evaluations collected from students, teachers and independent assessment of wiki content were examined for students who had completed each activity. Key factors that contribute to effective use of wikis in school emerged from this work.

Results
Students’ response to wikis, as measured on the quantitative scales could be classified into seven themes. Table 1 shows the themes and the mean score for all students on each theme. It also highlights differences between students’ rating of their experience of learning with wiki by student background for each theme. In addition to the detail shown here, female students felt more strongly than males that using wiki enhances knowledge building community.
Table 1. Students response to wikis – Differences by theme and background

<table>
<thead>
<tr>
<th>Theme</th>
<th>Mean score</th>
<th>School type</th>
<th>Wiki 1</th>
<th>Wiki 2</th>
<th>Wiki 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-requisites for learning with wiki</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quality of access to computing facilities</td>
<td>2.95</td>
<td>n.d.</td>
<td>not complete</td>
<td>not complete</td>
<td>not complete</td>
</tr>
<tr>
<td>Participated in co-construction of wiki</td>
<td>2.82</td>
<td>smart &lt; normal</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Experience of learning with wiki</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wiki promotes collaborative learning</td>
<td>3.77</td>
<td>smart &lt; normal</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Wiki enhances knowledge building community</td>
<td>4.02</td>
<td>smart &lt; normal</td>
<td>n.d.</td>
<td>n.d.</td>
<td>n.d.</td>
</tr>
<tr>
<td>Learnt more with wiki activities than alone</td>
<td>3.32</td>
<td>n.d.</td>
<td>not complete</td>
<td>not complete</td>
<td>not complete</td>
</tr>
</tbody>
</table>

Notes: n.d. = no differences. All differences statistically significant at $p < .01$.

Table 1 shows that the quality of access to computing facilities was less than ideal (mean score of 2.95 on the 5 point scale). Students strongly agreed (4.26) that the IBS was a valuable aid to their using wiki for the learning activities. Not all students participated in co-construction (editing of each others’ work) in completing the wiki activities (2.82), reflecting the fact that not all students had the opportunity to participate in Wiki 2 and Wiki 3, the activities designed to encourage co-construction.

Scores for all themes associated with learning with wikis were above the mid-point of the scale, for students in both type of school, but higher for students in the normal schools, where more students completed Wiki 2 and Wiki 3. Although not shown in the table, the results also show that the more time students spent on the wiki activities, the more they agreed that wiki enhances knowledge building community. These results show that the students associated use of wiki with collaborative learning and knowledge community.

The last three columns of Table 1 allow us to compare the different approaches to learning in Wiki 1, Wiki 2 and Wiki 3. Fewer students with poor access to computing facilities completed the activities. Those students who completed the activities reported that they learnt more using wiki than alone. The specific learning approach incorporated in the wiki activity had no effect on students’ (positive) experience of learning with wiki, with the exception that the real-life problem posed in Wiki 2 was recognised as valuable.

Analysis of the wikis completed by students confirmed that all of the activities resulted in knowledge sharing and collaborative learning. Wiki activity statistics are available only for the 103 students in 9 schools that used WikiSpaces software. These students made an average of 14.7 edits each while having an average of 179.07 page views. Students who completed Wiki 2 and Wiki 3 had a higher average number of edits per activity than students who completed only Wiki 1, confirming that the two activities designed for development of a single group wiki generated more collaboration than the activity that required each student to present a wiki. There was little difference between the three activities when the quality of the wikis produced and students’ reflections on the knowledge they gained through participation in the wiki activities was compared, although the Wiki 2 scores were slightly higher.

The edits made by students in groups that completed Wiki 2 and Wiki 3 were given a collaborative learning score on a scale of 1 – minimal (punctuation, title, less than 3 words
added or deleted); 2 – addition of substantial content without significant alteration of existing content; 3 – change of structure leading to new ideas and contributing one’s own knowledge.

Few schools completed Wiki 3 so comparison of these scores must be qualitative. They suggest that the problem-based learning activity of Wiki 2 resulted in more collaboration. (Mean score for Wiki 2 was 18.3, while mean score for Wiki 3 was 8.3. At the one school that completed both Wiki 2 and Wiki 3, the Wiki 2 score was 26 compared to 16 for Wiki 3.)

Students’ open-ended and interview responses provided more detail. Through Wiki 1, they noted they learnt new IT skills, knowledge discovery and how to present and share their knowledge with others. They appreciated the recognition that sharing their work can bring. In commenting on Wiki 2, they were more specific about the knowledge and skills that they obtained, and also noted how much they enjoyed the assignment. They also appreciated the teamwork on this project, and noted it was easy to work with group members through the wiki. Comments on learning through Wiki 3 were similar to those on Wiki 2, but there were fewer comments on group work; one student commented that the group cooperated better in Wiki 2 than Wiki 3. These comments confirm that all three approaches resulted in learning and that activities designed for collaboration result in teamwork, again with a hint that the problem-based activity of Wiki 2 worked slightly better.

Overall, students commented that the wiki activities helped them to understand the ICT syllabus better and to learn specific content that they would not otherwise have discovered. They felt that they were able to gain more knowledge through sharing, and they reported a sense of community in their groups as well as learning to work as a group and complete a project together. They enjoyed using the Internet for learning and reading what others’ produced as well as the recognition of being able to publish their own work, and several appreciated the ability it offers for working together outside the classroom. Some comments:

“...to do wiki is better because I don’t have to listen to the teacher who talks boring stuff”
“Get some idea, get the best idea from other people, put it inside wiki”
“Wiki allows us to share information... when doing the ... project, we can help each other”
“What I didn’t know, my friends can teach me, explain it to me”

Negative comments were mostly associated with lack of access to suitable computing activities. Some students would have liked the wiki interfaces to be more sophisticated and others would have liked more detailed instruction for the wiki assignments. Less common were problems with English (although the language of instruction for the course is English) and complaints that too little time was available for the activity. A subset of comments was related to the amount of time devoted to the two modules addressed by the wiki activities relative to the total syllabus; students picked up on the attitudes of some teachers that the learning approach used in the wiki activities took too long relative to traditional delivery:

“The teacher told us we don’t have time. Do it [the wiki project] next time...”

**Teachers’ observations**

Teachers’ responses confirmed the value of the wiki activities for learning in schools. Some teachers pointed to the specific functionality of wikis, which enable students to read and immediately edit their own and others’ work. The teachers were also able to observe students learning collaboratively and sharing their knowledge to learn.

“Sometimes, they are not clear of what they have to do. When they do it individually, they are blank. When in a group, they can discuss among the group... Maybe things are not clear, their friends can explain it to them. Their friends who are not clear on the other parts, [now] understand it. So, they can help each other to understand”

“In group work, each student searches for information and shares the information. From here they get more knowledge than learning individually.”
Even though prompted to distinguish between the three different learning approaches used in the different activities, the teachers treated all three as a one common collaborative learning approach:

“...If we use a multiple approach, we can cover all the students’ [learning styles]”

The teachers also provided more detail about the factors that acted as barriers to effective use of wiki for learning in schools. The four main barriers were:

1. Limitations of the technical computing laboratory infrastructure in the schools, including Internet access and access to up-to-date and working computers – this was a particular problem for students who did not have Internet access at home;
2. Limited availability of administrative and technical support for teachers and students using the laboratories;
3. Relatively little classroom time available for the ICT subject, which is an elective and has relatively few available teaching hours, combined with the demands on students to undertake other school-related activities outside the classroom;
4. The amount of time ICT teachers needed to spend outside the school to update their own knowledge, given the subject was introduced only the year before the study.

**Discussion**

The first conclusion of this study relates to the use of wiki as a CSCL tool in school. The literature suggested wikis are potentially the best online collaborative tools to facilitate learning among students in school (Banerjee et al., 2004; Bergin, 2002). However, most studies about the learning with wikis have been conducted in universities (Guzdial, Rick, & Kehoe, 2001) and not in school. In turn, the findings of this research demonstrate that wiki can be used as a CSCL tool in school environment, agreeing with the literature noted above. Nonetheless, the research on wikis in the education context is relatively new (Augar et al., 2004; Baur, 2005).

The second conclusion relates to the use of wiki for knowledge sharing in school. The students’ rating of their wiki experience shows that they perceive that using wiki enhances their knowledge. In their interviews, they confirmed that wikis can be tools for knowledge sharing which extend physical class hours to outside class time. On a similar note, teachers saw wiki as a platform for students to learn not only as individuals, but most importantly through groups. Because wikis support information sharing where students can add, edit and modify content of their group right there in the wiki itself, they offer functions that permit them to be knowledge sharing tools in the classroom.

Thirdly, the study confirmed that wikis can be used effectively for the three types of learning activity that were designed for this study. All seem to support collaborative learning and knowledge sharing. All of the learning approaches relate back to the social constructivist theory proposed by Vygotsky (1978). Even the teachers found it hard to decide which learning approaches the best after observing the students wiki activities. However, in all three learning approaches, teamwork was highlighted consistently by the students. They also made the point that learning with wiki, regardless of approach, made their learning both exciting and fun and they gained considerable knowledge by working together in a group – personally, skill wise and content wise. Thus, this study supported all three collaborative learning approaches, inquiry-based learning, problem-based learning and project-based learning as appropriate to be used in a wiki learning environment.

Finally, this study was able to identify several key factors for effective use of wikis in school. They concern context, method and pedagogy and method. In terms of context, the factors that emerged can be classified as related to the students, the teachers, the schools, and national infrastructure. They key factors in each of these areas are listed in Table 2.
Table 2. Key contextual success factors for wiki in school

<table>
<thead>
<tr>
<th>Student</th>
<th>Teacher</th>
<th>School</th>
<th>Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT literate students</td>
<td>Openness to embrace Internet</td>
<td>Recognition importance of ICT subject</td>
<td>High speed broadband</td>
</tr>
<tr>
<td>High calibre students</td>
<td>Ready to shift role from instructional to moderator</td>
<td>Supports ICT teachers</td>
<td>Fully functional computer with latest OS</td>
</tr>
<tr>
<td>English proficiency</td>
<td>Encourage collaborative culture among students</td>
<td>Create IT lab assistant position</td>
<td>No censorship of web content</td>
</tr>
<tr>
<td>Trained in wiki culture</td>
<td>Introduce wiki at early school years</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group members between 3 to 5</td>
<td>Dedicated time for wiki learning</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In terms of pedagogy, attention must be paid to the context, including infrastructure limitations and other barriers, in designing pre-wiki experiences, course activities and post-wiki experiences. These are all held together by design. Three important factors need to be considered. First, when designing a course syllabus, class activities in the wiki environment need to be designed around the syllabus. It is essential that the activity follows the course syllabus while wiki acts as the learning environment. Secondly, it is crucial for the teachers to know how to use wiki to make the students feel more comfortable as they work using wiki. An introductory course can achieve this where wiki technology is new. This was first suggested by Aagar et al. (2004) and it was successful in this study. Lastly, when designing a course activity, the teachers always need to think of it as a group collaboration and not so much on an individual basis. It is clearly shown in this study that it is the group’s collaborative effort that distinguishes wiki from other web applications as it is a social learning application rather than tailored for individual learning.

In terms of the pre-wiki experience, the wiki software needs to be selected with the students and activities in mind; this includes editable wiki pages, an embed object function for activities that involve more than writing with text, and simple interface. Where students are not already familiar with wikis, an introductory course (again, keeping the educational goals of the wiki activities in mind) is necessary.

Wiki course development is a second moment for wiki pedagogy. The focus turns to the evolving stages of integration of wiki in teaching and learning, from initiation of the course through ongoing course development and completion. In this study, students pointed out several success factors such as integrating real-life learning scenarios in wiki assignments, creating a wiki editing culture, encouraging teamwork among students, providing clear instructions, allocating of specific and sufficient time for wiki projects, groups of between 3-5 students, teacher attention in the wiki project and good functional lab. Teachers echoed the value of real-life learning scenarios, and additionally indicated the need for a well planned design study prior to the start of the school term, activity type based learning, good students discipline, IT literate students with Internet at home, introduction of wiki very early in the school year, students’ openness to embrace the Internet for learning or education, and a balanced mix of group members determined by the students.

Post-wiki experience is the last moment that relates directly to teaching and learning in the wiki pedagogy. In this moment of reflection, teachers interviewed in this study addressed the
flexibility of wiki to cater different individual learning styles, extension of classroom beyond school hours, shorter learning curve, anonymity in wiki, integrity of wiki and lastly the teachers’ changing role from instructor to facilitator of learning.

Turning back to the critical role of design in bringing the wiki pedagogy together, several design success factors emerge from this study:

- Use of a design science approach to iteratively design activities that fit the emerging context of the educational institution, teachers and students;
- The importance of designing activities around the content defined in the course syllabus
- Design for active and collaborative learning among students working in teams
- The value of real-life learning scenarios

Thus, in addition to confirming the literature about the key factors that contribute to effective use of wiki in education, this study has extended our understanding of the key factors to demonstrate how context, pedagogy and design work together to enable students to learn collaboratively and share knowledge as they learn with wiki in school. This issue has not yet been emphasized enough in the wiki literature. The relationship between these key factors is illustrated in Figure 2, which summarises our proposed “wiki pedagogy”. The phases on the left-hand side refer to the four phases of design research introduced in the methodology section of this paper, while the moments in which they are applied appear in the triangle.

<table>
<thead>
<tr>
<th>Design Science Research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
</tr>
<tr>
<td>Pre-Wiki Experience</td>
</tr>
<tr>
<td>Phase 2</td>
</tr>
<tr>
<td>Wiki Course Development</td>
</tr>
<tr>
<td>Phase 3</td>
</tr>
<tr>
<td>Post Wiki Experience</td>
</tr>
<tr>
<td>Phase 4</td>
</tr>
<tr>
<td>Infrastructure &amp; Management Support</td>
</tr>
</tbody>
</table>

Figure 2. Elements of a wiki pedagogy

**Conclusions: Shifting the mindset for education stakeholders**

This study found that wiki is an effective tool to support collaborative learning and knowledge sharing in schools. All three collaborative learning approaches were successful, confirming showing that wiki facilitates group learning where students can learn and share knowledge more effectively than learning individually. Moreover, this study confirmed that student-centred learning approaches are well suited for wiki environments in schools. Other factors play a significant role in order for wiki to be a successful medium of teaching and learning in classroom. The wiki pedagogy outlined in this paper provides a pathway for understanding use of wiki in classroom teaching. Lastly, this study also confirms the value of using design-based research methodology in conducting research on technology in school.
References


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