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## Using wikis in team collaboration: A media capability perspective

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### ARTICLE INFO

#### Article history:

Received 23 September 2015  
Received in revised form 23 May 2016  
Accepted 19 June 2016  
Available online xxx

#### Keywords:

Wikis  
Collaboration  
Media synchronicity theory (MST)  
Capabilities  
Effectiveness

### ABSTRACT

Wikis are widely acknowledged to be capable of promoting team collaboration. However, previous studies have not examined how the characteristics of the wiki media influence team members' perceived collaboration effectiveness in the educational context. Drawing on media synchronicity theory, we examine five wiki capabilities and whether these capabilities are perceived to be effective in facilitating collaboration. Results based on data from 83 undergraduate students in 15 teams show that reprocessability, no other wiki capabilities, plays a dominant role in securing a more favorable evaluation of collaboration effectiveness by students. The findings and their implications on theory and practice are discussed.

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### 1. Introduction

The advancement of modern information and communication technologies (ICTs) has enabled increasingly more people to gain higher effectiveness and efficiency in not only social interaction but also collaborative task accomplishment [12,22]. Business organizations and educational institutions have widely used Web 2.0 technologies, particularly the wiki, to facilitate knowledge creation and collaboration [27,54]. Named after wikiwiki (“fast” in Hawaiian), the wiki is a web application with a set of linked web pages that are commonly used to support open source knowledge creation and sharing [50,17]. Wikipedia is probably the most well-known application of wiki technology in the public domain [27,54].

In recent years, wikis have gradually been adopted in educational practices for collaborative learning at class and group levels [43]. Because of its low requirement of user technological knowledge [17,51], the wiki can be used at almost all educational levels, including primary schools [16]. Previous studies generally report that students prefer to learn by using modern technology such as wikis [5,7].

Despite the widespread adoption of wikis in the education and learning contexts and the commonly held notion that wikis can promote team collaboration, little is understood about whether and how wikis are perceived effective in facilitating collaboration

and yield positive learning outcomes. Most studies on wikis are qualitative or descriptive, with limited statistical analyses, for example, frequencies and percentages [17,37,46]. A few quantitative studies examine Wikipedia as a site for public peer production [3,27] or focus on using wikis for managing knowledge in corporate settings [33]. Favorable team collaboration helps students to learn effectively [43] and enhances their academic achievement, personal development, and learning satisfaction [17]. However, previous research has scarcely examined how the media characteristics of wikis influence the extent to which students think the technology is effective for collaboration. To fill in such a gap, we turn to the theories of communication media.

Communication media, which have a wide range of capabilities, are vital for team collaboration [22]. Without detailed insight into specific capabilities of a technology, we cannot obtain a clear understanding of what wiki functions indeed facilitate collaboration and how information systems (IS) teachers and students can most effectively use the wiki to enhance learning outcomes. Therefore, we use media synchronicity theory (MST; [13]), a recent theoretical framework, to examine the effects of wiki capabilities on team collaboration. MST proposes that the degree to which a medium enables synchronous communication affects information transmission and information processing activities in teamwork, consequently influencing the collaboration performance of the teams. It is argued that both information conveyance (information transmission) and convergence on a shared understanding of the meanings of conveyed information (information processing) are two necessary processes in team collaboration. However, these two terms are supported by different capabilities of a medium. A previous study applies MST to suggest that a more favorable match

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between media capabilities and team interactions yields improved outcomes in virtual teams [34]. However, the empirical evidence on MST and its implications are somewhat limited. Only some preliminary results have supported the basic tenets of MST [14]. The conceptual definitions and operational measures for media capabilities in the theory are still at the developmental stage [6]. This lack in theory development provides opportunities for IS educators and researchers to empirically examine the causal relationships between media capabilities and collaboration outcomes in a specific ICT condition.

Therefore, this study has two main aims. First, we aim to ascertain whether the wiki can facilitate student team collaboration by analyzing its capabilities. Second, on the basis of a set of confirmed associations, we aim to explore how to more effectively use wikis to improve collaboration in the education and learning context. By using both objective and subjective data, we present a case study with an embedded survey of 83 undergraduate students in Hong Kong using wikis to perform a collaborative task. Quantitative analyses reveal that only one capability of the wiki, reprocessability, could enhance collaborative effectiveness, whereas the other capabilities could not.

This study makes three major contributions to the literature and educational practice. First, we extend the wiki research by using the theoretical perspective of MST and explicating that certain feature of the wiki is positively associated with the perceived collaboration effectiveness but others might not be associated. Second, it contributes to MST by proposing and empirically validating the measurement of media capabilities and verifying the relationships between the media capabilities and collaboration outcomes, using the wiki as an example medium. Thus, this study reveals the theoretical importance of separately examining two categories of media capabilities and using wikis for educational purposes contingent on task requirements. Third, validating the causal relationships between specific wiki capabilities and perceived collaboration effectiveness also provides insights to professionals on how emerging ICTs such as wikis can be designed and used most effectively in the education or training field.

## 2. Conceptual background

### 2.1. Effects of wiki use on team collaboration

As a typical Web 2.0 application, wikis have the function of supporting knowledge contribution, storage, exchange, use, and refinement [12]. Educational institutions and organizations widely use wiki applications; however, the IS literature lacks systematic investigation on the effects of wiki use on team collaboration. To comprehensively review on this topic, we searched the literature in the EBSCOhost database by using the keywords “wiki” in either the title or abstract and “collaboration” in the main text. The search generated 770 scholarly articles published during 2004–2015. We further screened out articles on irrelevant topics such as computer software development and artificial intelligence; introductory commentaries (e.g.; available information technology (IT) in library service), and studies focusing on the motivations of contributing on wikis, resulting in a more refined pool of 32 articles, all from education-oriented periodicals. Out of these articles, only six are empirical studies reporting nondescriptive results. We review them in detail below.

Although the literature has provided some valuable knowledge regarding the impact of wikis on individual and team learning in students' collaboration process, mixed findings exist. For example, researchers find that students perceive the Word and e-mail combination as a more useful and easier approach to use in collaboratively creating and editing a report than the wiki

approach [15]. Moreover, there is no perceived difference in the effort of collaboration between these two approaches. This study is among the first to consider the functionality factor of wikis and test its effects on students' perception on collaboration. However, due to the comparative experimental design, it measures the wiki in terms of common functions of word processing, such as to what extent the software supports text creating, editing, sharing, tracking changes, and identifying the author of changes. It thus leaves room for the theory-driven work on students' perceptions of wiki functionalities and their impacts on collaboration outcomes.

Positive evidences come from a study on Hong Kong student journalists learning news writing [31] and a survey on 203 US undergraduate students in their business capstone project [11]. The former study shows that the number of wiki-editing behavior is positively correlated to writing quality, and more interestingly, students keep improving the work on wiki even after it has been graded, which suggests that wiki can facilitate continuous learning and improve learning performance. The latter study focuses on the instructor's ability of designing a course, facilitating discussion, and directing instructions on wikis. The results show that instructors' high level of wiki presence significantly facilitates students' cognitive learning in the dimensions of knowledge exploration, construction, resolution, and confirmation.

Other scholars examine the contingency factors along with the wiki usage process. For instance, medium level of incongruity between a person's previous knowledge and new information provided in the wiki environment can lead to better learning and knowledge-building results than low or high incongruity [28]. Matschke et al. [35] suggest that group membership may affect the extent to which students consider the wiki information such that in-group information on wikis induces better knowledge integration and learning than information from an out-group member). Another study involving 385 part-time postgraduate students in a series of experiments suggests that the type of collaborative task matters: intellectual tasks solved using wiki methodologies yield a higher decision quality in group collaboration than do those solved using face-to-face communication, whereas face-to-face-based teamwork leads to better outcomes for preference tasks (i.e., tasks with uncertain outcomes) [23]. The researchers conclude that wikis are better suited to tasks requiring extensive asynchronous collaboration in an educational setting. Appendix A lists more details of these six studies.

Based on the above literature review, we find that previous studies mostly concern the individual learning mechanism and results, while collaboration-related outcomes are rarely examined (the study by Heidrich et al. [23] is a notable exception). Moreover, there is little research on students' perception or evaluation on using wikis to conduct team collaboration. Especially, we still lack a clear understanding on the specialized capabilities a wiki can offer and how these capabilities may enable or hinder team collaboration. Team collaboration is centered on information transmission, information processing, and interpersonal communication processes. Such a specific focus convincingly directs our attention to MST as a viable theoretical perspective, through which we strive to develop a systematic understanding of the effects of media capabilities on perceptions of collaboration effectiveness. Next, we present a brief overview of the major tenets of this theory.

### 2.2. Media synchronicity theory

The capabilities of media are first documented in media richness theory (MRT), which argues that media differ in richness, that is, the ability to process various quantities and types of information that changes understanding within a period [10]. On the basis of MRT, Dennis et al. [13] propose MST and identify five capabilities of media (transmission velocity, parallelism, symbol

sets, rehearsability, and reprocessability) that may affect information transmission and processing effects.

The transmission velocity is the speed at which a medium can transmit a message to recipients, essentially capturing the synchronicity of the medium. Media with a high transmission velocity enable messages to reach recipients as soon as they are sent, thereby enabling quick responses preferred in team collaboration, for instance, in online chats [34]. Parallelism is the number of concurrent transmissions that can effectively occur over the medium. High-parallelism media enable simultaneous sending and receipt of messages to and from multiple parties (multidirectional communication and multiparty transmissions) and increase the number of concurrent conversations, thereby increasing the likelihood of reaching a consensus. Symbol sets are the number of ways in which a medium can support encoding information for communication; media that are low in symbol sets are considered low in social presence, a crucial determinant of online participation [45]. Low social presence may reduce satisfaction with the communication and interactivity, thus limiting the sharing of knowledge and experience among collaborating parties [44]. By contrast, lean media, such as e-mail and other text-based media, are suitable for teams where communication norms are well established, because in its later developmental stage, a team relies less on within-team communication but mainly gains benefits from coordinated work [26]. Rehearsability is the extent to which senders can rehearse and fine-tune messages before sending them. Media that support rehearsability enable messages to be more clearly crafted and reasoned [34], thus ensuring that the intended meanings are precisely expressed [13]. Reprocessability is the extent to which participants can reexamine or reprocess previously sent content either within the communication event or later. Media that support rehearsability enable recipients to spend more time on decoding messages to attain a clearer understanding and additional consideration as well as to provide a memory that can remind participants about their early discussion content and help new participants understand past activities [13].

Despite being conceptually sound, as a relatively new theory, MST raises normative propositions only and lacks sufficient empirical testing and validation [34,48]. In an initial test of the theory, face-to-face and written communication as two media were used for conducting a comparative study where specific operational measures for each capability were missing [14]. Such a challenge was further exacerbated by the various emerging technologies, such as wikis and social networking sites, and people's need to achieve a detailed understanding of these modern media and their effects. According to our review of relevant literature, no published study offers scale development and validation of media capabilities. Scholars have called for additional work in empirically evaluating and validating MST and clarifying how different media can effectively support information transmission and processing during the communication and collaboration processes [14,34].

### 2.3. Team collaboration

Collaboration usually requires a great amount of time in mutual activities and thus more frequent communication. It involves a coordinated attempt of team members to develop and solve a problem for achieving a common goal and overall benefit [42]. Previous studies have suggested four levels of task dependence, namely pooled, sequential, reciprocal, and team dependence [47,49]. As compared with pooled tasks, collaboration tasks feature higher levels of dependence and naturally entail varied information processing needs for team communication and collaboration media. As team members work collaboratively, they may recognize

and perceive outcomes in various means, for example, effectiveness, efficiency, and performance score [19]. Learning outcomes are particularly multidimensional in IT-facilitated environment [41]. Team collaboration is more likely to be effective when the members perceive the fit between the team task and communication and collaboration media [34,47].

Because collaboration requires information transmission, knowledge sharing, communication, and coordination within a team, it has been strongly associated with technological advancement in recent decades [1,8,26]. Similar to the effects of Web 2.0 applications in the business domain [12], those of computer-supported collaborative learning tools on team collaboration are not always positive [30]. In particular, media capabilities and the manner in which student teams interact with the media affect knowledge construction [29]. Therefore, closer examination of teams' use of emerging technologies such as the wiki from a media capability perspective is not only valuable but also urgently required.

### 3. Methods

Considering the limited literature on media capabilities and their associations with collaboration, we mainly adopted the exploratory case study method because it is "appropriate to any problem about which little is known" [9]. Moreover, empirical data collected through an embedded survey in the case study can provide more opportunities in obtaining evidence from different sources [20]. One of the authors and a research assistant coded the archival records of wiki collaboration processes in which the team members shared information about their collaborative task, discussed how to proceed with the task, and collectively wrote a report on the task. Naturalistic observations were recorded to identify the behaviors involved in group collaboration processes. Subjective perception data are obtained through a survey questionnaire completed by all students after they submitted the report (i.e., the final deliverable of team collaboration) through wikis. Using both objective and subjective data supports triangulation, which enhances the validity and accuracy of findings [52].

#### 3.1. Case scenario, participants, and team collaboration task

The study was conducted in a 14-week semester of the academic year 2013–2014 at one of the major universities in Hong Kong. In total, 90 sophomore students in a core IS subject were enrolled. Among the 90 students, 83 returned completed questionnaires valid for empirical analysis. The students' age ranged from 18 to 22 years, with an average of 19.8 years. Female students accounted for 68.7% of the entire sample. The students were from 15 self-formed teams, with size ranging from four to seven members. Half of the participants were novice and half were intermediate-level wiki users, except for one student who rated himself as an advanced-level wiki user. Student characteristics are shown in Table 1.

The students were asked to conduct a team project, i.e., a business case analysis on an IS as a part of course assessment. The case analysis included two deliverables: a class presentation and a final written report. The students were instructed to use wikis as a collaborative platform to prepare for and complete the two tasks in teams. The specific wiki platform used in this study was a free version of Wikispaces for educational institutions; it was introduced to the students in the second week of the semester. User training and demonstration were provided in the class to help the students register accounts, create a wiki for each team, and invite the teacher to join the wikis of all teams. In addition, each student was provided a detailed user guide on Wikispaces for reference.

**Table 1**  
Demographical information of the students involved.

	Category	Frequency	Percentage (%)
Age	18	1	1.2
	19	35	42.2
	20	32	38.6
	21	10	12.0
	22	5	6.0
Gender	Male	26	31.3
	Female	57	68.7
Major	Business	79	95.2
	Nonbusiness	4	4.8
Wiki proficiency	Beginner	41	49.4
	Intermediate	41	49.4
	Advanced	1	1.2
	Total	<b>83</b>	<b>100.0</b>

All the students had access to the Internet during the semester. They were reminded regularly that all team collaboration processes, from the initial discussion on the overall design of their project and division of the tasks among team members to information collection and collective writing in an iterative manner, should be performed on the wikis so that the teacher could observe the project progress and provide timely feedback. The students were informed at the beginning that their individual involvement and contribution on their team wikis would be considered when the teacher evaluates their course participation (the participation element carried 10 marks out of the overall course assessment of 100 marks) in the subject. However, using the wiki alone was not an independent component of course assessment, as formally specified in the course outline.

### 3.2. Data collection and analysis technique

Objective data were collected from wiki records in three dimensions: pages and files, discussions and comments, and revision behaviors. By using the predefined coding scheme described in subsequent paragraphs, one of the authors and a research assistant separately coded the objective data. We followed the steps for content coding reported by Oh et al. [39] to ensure intercoder reliability. IBM SPSS Statistics 20 was used for performing statistical analysis of the cleaned objective data and self-reported data collected through the survey questionnaire.

Data regarding pages and files were (1) the number of valid pages created, (2) the total number of edits in the valid pages, (3) the total number of discussion entries in the pages, and (4) the total number and types of files uploaded (e.g., pictures and relevant information in PDF format). "Valid pages" are those that contained meaningful words for forming a team and completing the project instead of "testing" or creating the home page automatically by the system.

We coded the discussion messages of each team according to (1) the total number of messages, (2) the total number of message threads (e.g., the series of messages initiating conversations or replying to the initial message), and (3) the total number of message threads being replied to. Messages sent by the teacher were excluded from the coding. We adapted the code categories used in a previous study on discussion messages in wiki-based collaboration [27] to specify three categories: content (e.g., discussion on whether to include certain information), administrative coordination (e.g., a particular member's duty and timeline for completing tasks), and other discussions (comments unrelated to report development, such as greeting and testing). One of the authors and a research assistant were trained in using the aforementioned coding scheme and performed trial coding of a team's wiki pages to achieve 100% consensus on categorization.

Furthermore, two raters separately coded the remaining discussion posts. Discrepancies were addressed through meetings and discussions between the two coders. Examples of messages for each category are presented in Appendix B.

A survey questionnaire was designed to collect the students' feedback on usage experiences and their opinions on using wikis for team collaboration. Based on the conceptualization of Dennis et al. [13], we self-developed the measures of wiki capabilities through the scientific process of conceptual construct validation [38]. The initially developed measures were further pretested through a survey of 109 undergraduate students using Facebook and WhatsApp, other than the samples of this study. These questions were measured using a five-point Likert scale ranging from "1" (*strongly disagree*) to "5" (*strongly agree*). The perceived collaboration effectiveness was measured using an 11-item scale proposed by Borden and Perkins [4]. According to previous studies, the questions in this section were measured using a seven-point Likert scale ranging from "1" (*strongly disagree*) to "7" (*strongly agree*). The actual team collaboration performance was measured by the score of the project's written report rated by the course teacher. The specific items for each variable are listed in Appendix C.

We also asked the students whether they had adopted other means of team collaboration in addition to the wiki platform. The total numbers of communication media used (e.g., face-to-face meetings, e-mails, telephone calls, and instant messages) and hours spent using them were collected. At the end of the questionnaire, two open-ended questions were asked to enable the students to elaborate on the problems or difficulties encountered while using wikis and their suggestions or comments for future improvement in the use of wikis for team collaboration.

## 4. Analysis and findings

### 4.1. Students exhibited positive participation in wiki usage

The sampled teams created 5.1 pages on average, with 4.5 of them being valid. The number of edits (i.e., versions) in the valid pages per group was 36.1. On average, 9.7 files were uploaded by each team, with a maximum of 22 and a minimum of 0 files. These files mainly contain relevant information on project preparation, such as PowerPoint files for presentations and Word files of report sections created by different members.

Of the 15 teams studied, 11 used the message tool on the wiki. In total, 184 messages were sent, with an average of 11.9 messages per team. Altogether, 57.6% of the messages sent were content-related, including shared information related to the team's project topic and discussions or comments on the shared information. Administrative coordination accounted for the second leading category (22.8% of the messages). Furthermore, 19.6% of the messages were not directly associated with the project, for instance, greetings and testing, thus falling into the category of other discussions (Table 2).

Four teams posted their discussions (16 times in total) on the wiki pages rather than the discussion board. The discussion messages on these pages were typically longer and reflected

**Table 2**  
Statistics of discussion messages in categories.

	Category	Number of messages	Percentage
1	Content	106	57.6%
2	Administrative coordination	42	22.8%
3	Other discussions	36	19.6%
	<b>Total</b>	<b>184</b>	<b>100.0%</b>



deeper thinking than those posted on the discussion board. An example screenshot is provided in [Appendix D](#).

4.2. Effects of wiki use and wiki capabilities on collaboration outcomes

Unexpectedly, although more than one-quarter (27.7%) of the students reported in the questionnaire that the wiki facilitated team collaboration, the number of wiki pages, number of edits on the pages, and number of discussions or comments were not significantly correlated with the collaboration performance.

The mean scores of wiki capabilities showed a pattern consistent with MST [13]. On the 1–5 scale of media capabilities, wikis were perceived to be low in supporting synchronicity. The mean scores of transmission velocity and symbol sets were 2.72 and 2.21, respectively, which are lower than the average of 3. Regarding parallelism, rehearsability, and reprocessability, which are expected to reduce synchronicity for benefiting information processing, the participating students rated them slightly higher than the average score of 3. However, they reported a favorable perception of collaboration effectiveness, assigning it a rating of 4.30 on a scale of “1” to “7.”

Table 3 lists the statistics of five wiki capabilities, two major communication media use other than the wiki, and two outcome variables (i.e., perceived collaboration effectiveness and actual performance). The correlations between key variables, that is, five wiki capabilities and two collaboration outcomes, are listed in Table 4.

We conducted linear regression analysis to examine the causal relationships between wiki capabilities and collaboration outcomes. Because the actual performance measured using the quality of the wiki-based project report was team based, the sample size of team-level analysis would be small (i.e., 15 teams in total). Therefore, we examined only the perceived collaboration effectiveness as the dependent variable at the individual level. Using the linear regression test in SPSS, first, we included all control variables, namely gender, age, major, and wiki proficiency of the students. In the second step, we input the two capabilities supporting information transmission (i.e., low in synchronicity), transmission velocity and symbol sets, as the independent variables. In the third step, the remaining three capabilities supporting information processing (i.e., high in synchronicity), parallelism, rehearsability, and reprocessability, were added to the regression analysis.

Table 5 presents the results of the data analysis. In Model 1, all four control variables were nonsignificant. In Model 2, transmission velocity positively predicted the perceived collaboration effectiveness ( $B = 0.51, p < 0.01$ ), whereas symbol sets did not. In Model 3, when all five wiki capabilities were in place, only reprocessability had a significant positive effect on the perceived

collaboration effectiveness ( $B = 0.46, p < 0.05$ ). All variables of interest explained 33.6% of the variance in wiki users' perceived collaboration effectiveness.

4.3. Instant communication was strongly preferred by students during team collaboration

Up to two-fifths (38.5%) of the students agreed or strongly agreed that the wikis helped them concurrently communicate with multiple parties (i.e., the wiki's capability of parallelism), but 83.1% did not agree that the wikis enabled them to receive timely feedback from others. The participating students seemed to be used to using instant communication tools, such as WhatsApp and Facebook Messenger; therefore, they may not have felt comfortable with the asynchronous communication supported by the wikis. Some students provided the following comment:

“The wiki should offer a smartphone application to enable instant communication and notify users about the changes on wikis in real time . . . it would be preferred if I can receive instant notifications of new edits, such as in Facebook Messenger.”

In accordance with the preference for instant communication, all teams reported that face-to-face meetings and instant messengers were the dominant means for within-team communication and collaborative learning. On average, all teams held 3.5 face-to-face meetings (5.9 h in total) and spent roughly similar time (5.7 h) in communicating through instant messengers (see Table 3). Moreover, the total number of hours spent in instant message communication showed a highly positive correlation with the team collaboration performance (correlation coefficient = 0.320,  $p < 0.05$ ). However, we did not find a causal relationship between instant communication and collaboration performance, regarding neither the quantity nor the total length of time.

5. Discussion, implications, and limitations

This study was motivated by two questions: whether wiki capabilities can facilitate student team collaboration and how we can more efficiently use wiki technology to improve collaboration outcomes in IS education and learning. On the basis of our findings, we answer these questions as follows.

5.1. Are wikis an effective tool for facilitating team collaborative learning?

This is a subtle question without a simple yes or no answer. Differing from the common optimistic expectation, our observations and correlation analysis revealed that wiki-use behaviors did not directly contribute to the actual team collaboration performance (i.e., the quality of the wiki-based project report according

Table 3  
 Descriptive statistics of the constructs.

Variables	Minimum	Maximum	Mean	Standard Deviation
Wiki capabilities				
Transmission velocity	1.00	4.00	2.72	0.74
Parallelism	1.00	5.00	3.17	0.77
Symbol sets	1.00	4.25	2.21	0.68
Rehearsability	1.75	4.25	3.05	0.46
Reprocessability	1.00	4.50	3.12	0.78
Face-to-face meeting quantity	1	6	3.46	0.97
Face-to-face meeting time (in hours)	1	15	5.90	3.60
Instant messenger quantity	0	1000	117.46	298.38
Instant messenger time (in hours)	0	30	5.71	5.08
Perceived collaboration effectiveness	1.00	6.20	4.30	0.99
Team collaboration performance (report score)	55	90	75.40	10.40

**Table 4**  
Correlations of key variables.

No.	Variables	1	2	3	4	5	6	7
1	Transmission velocity	–						
2	Parallelism	0.71**	–					
3	Symbol sets	0.44**	0.30**	–				
4	Rehearsability	0.41**	0.49**	0.26*	–			
5	Reprocessability	0.58**	0.66**	0.08	0.58**	–		
6	Perceived collaboration effectiveness	0.35**	0.44**	0.13	0.40**	0.53**	–	
7	Actual performance	–0.31	–0.33	–0.50	–0.30	–0.15	–0.17	–

Note:  $N = 83$ ; \*  $p < 0.05$ , \*\*  $p < 0.01$ .

**Table 5**  
Results of linear regression on perceived collaboration effectiveness.

	Model 1	Model 2	Model 3
Step 1: Control Variables			
Intercept	3.14	2.65	0.58
Gender	–0.44	–0.26	–0.24
Age	0.04	–0.01	0.05
Major	0.59	0.51	0.11
Wikis proficiency	0.30	0.10	0.02
Step 2: Wiki Capabilities			
Transmission velocity		0.51**	0.02
Symbol sets		0.00	0.11
Parallelism			0.14
Rehearsability			0.19
Reprocessability			0.46*
<b>R<sup>2</sup></b>	8.0%	21.0%	33.6%
<b>R<sup>2</sup> Change</b>		13.0%	12.6%

\*  $p < 0.05$ , \*\*  $p < 0.01$ .

to the score rated by the teacher). Objectively, we did not find evidence of advantages of using wikis regarding the quality of wiki-enabled collaborative content, different from some previous studies [27,31]. Unexpectedly, students' perceptions of wiki media capabilities even had a negative correlation with actual performance, although not significantly (see Table 4). The regression analysis results suggested that the wiki as a platform for information transmission does not guarantee desirable collaboration outcomes. This finding seems to be consistent with past research that shows intensity of online participation is negatively related to performance [25]. However, the capabilities supporting information processing, reprocessability in particular, probably facilitate fostering the perceived collaboration effectiveness of the students. This finding infers that using wikis is beneficial in collaboration on content coproduction merely from a psychological aspect. The strongly significant correlation between reprocessability and transmission velocity (see Table 4) might explain why transmission velocity became insignificant when reprocessability was included in the regression (Model 3 in Table 5).

Our findings are in accordance with those of previous studies [22,23] stating that a specific communication medium may not always achieve a higher task performance than other media in all kinds of tasks. Our study offered two potential reasons. First, the extent to which a collaborative technology, such as the wiki, is useful for a team depends on the nature of the task that the teams undertake: does it require more information transmission or more information processing capabilities? Second, the advantages may not be exhibited in the actual performance (if it is easily evaluated), but may be reflected through psychological achievement, such as learner satisfaction, team cohesion, and team commitment [34].

5.2. How can the positive impact of using wikis be maximized?

Our results provide three major implications for educational professionals. First, members of the millennial generation, often

referring to individuals born after 1981, are enthusiastic users of Facebook, WhatsApp, and WeChat. This has been described by previous studies and evidenced by the present study. As compared with the average 11.9 messages sent on the wikis within each team, 117.5 instant messages were sent on average, revealing that the students used instant communication tools more frequently when completing the team project. Our findings are in accordance with those of a previous study [32] stating that using only wikis for communication likely has negative effects on collaboration results because other channels can help throughout the process. We thus confirm the necessity of employing an integrated approach in using Web 2.0 tools in contemporary education [11]. In practice, the only notification channel of wiki updates is e-mail. However, most students do not check their e-mails as frequently as they log in to Facebook; the “always-on” status on WhatsApp or WeChat also ensures frequent activity. Therefore, the asynchronous communication supported by wikis might be insufficient in current educational scenarios, and student performance may be affected because of this inconvenience in communication [53].

On the basis of this result, we suggest that teachers consider encouraging student teams to establish an instant communication platform, for instance, on WhatsApp, WeChat, or Facebook Messenger. Either one student member or the system can send an instant message to all team members whenever he or she seeks immediate peer attention on new ideas or changes recently made on wikis; such a mechanism would likely ensure consistent progress in team collaboration without considerable time lag. The students who feel disrupted by instant notifications can simply turn off the notification function; thus, they can still select either synchronous or asynchronous communication. The additional platforms could lessen the concern that students may prefer a different tool [15] and are likely to enhance learning performance [11].

Second, a previous study reveals that teams with higher collaborative performance tend to have fewer but longer discussion threads, where opinions of each member are carefully considered [40]. However, the rate of reply to the initial messages in the present study was slightly low. We postulate that the inability of wikis to provide instant notifications caused the unfavorable user attitude toward wiki-based discussion. If a student did not enable the e-mail notification function, the only way for him or her to learn about others' messages was to log in to the wikis. When the messages were unbeknown or the time lags between the messages and replies were too long, peer members were unlikely (or less motivated) to reply. In addition, we observed that the discussions on wiki pages were typically longer and more thorough than those initiated on discussion forums. A possible reason is that when discussing academic reports, the students had to show all relevant information and clearly explain their ideas. However, separate discussion forums are normally perceived as an outlet for a short and quick exchange of ideas [21]. In addition, typing a lengthy thread in a discussion forum seems to be

inefficient when the users still must input relevant content in the corresponding wiki page later. Therefore, having discussions on wiki pages rather than on separate discussion forums might be efficient. The viability of this option certainly depends on other factors, such as teacher preference, team size (possibly manageable when a team has few members), and team norms.

Third, as proposed in previous studies, it may be helpful if students receive more stepwise instructions on how to use wikis during class. Wikis are not difficult to use; however, their features might not be suited to the intended purpose, particularly when the versions adopted by the educational institutions are not customized for improved user experiences. Furthermore, the capabilities of rehearsability and reprocessability are unique in facilitating content-building tasks, but they raise more demands in format-related operations. Therefore, educators may need to carefully review the functions and design concerns before deciding to adopt wikis in their practice. Once adopted, in addition to a simple training or demonstration session, classroom practice exercises can be conducted so that the students can become familiar with wiki use in a relaxing manner. Furthermore, close monitoring of student progress on wikis and proactively providing guidance would facilitate the overall wiki-use process.

### 5.3. Theoretical and practical implications

This study contributes to the literature in three crucial ways. First, we add to previous studies on adopting wikis in IS education and learning by indicating the importance of examining its capabilities in a decomposed manner. This view supersedes the commonly held approach regarding wiki functionalities as a whole, which might hinder our detailed understanding of the effects of wikis on educational or learning outcomes.

Second, by separately examining the individual capabilities, we establish a clear association between the reprocessability, not the other capabilities, of the wiki and team collaboration effectiveness in the context of university undergraduates coproducing their group project report. Thus, our study enriches the implications of task–technology fit theory and addresses the calls for more empirical investigation on how to more effectively adapt existing technology [19].

Third, the study directly contributes to MST by proposing and empirically measuring a specific type of medium, the wiki, and testing the associations between media capabilities and collaboration outcomes. Thus, this study addresses the call for further evaluation of MST and for disaggregating tasks into specific dimensions of information transmission and information processing [14,34].

From an IS educator's perspective, our findings are crucial because they provide insights into approaches to improving the effectiveness of student collaboration when wiki use is designed in learning processes. Echoing previous studies, our results reveal the practical importance of separately examining two categories of media capabilities – velocity and symbol sets versus parallelism, rehearsability, and reprocessability – and using wikis wisely, for instance, considering the task nature and requirements [23]. Although it seems that wikis have been more often adopted in IT education context than in non-IT courses, information conveyance and convergence are invariably two necessary dimensions in team collaboration [13,34]. It is possible that students enrolled in an IT course are more likely to be open to use new technologies for team collaboration. However, previous studies have evidenced that students engaging finance and accounting case studies [23], management capstone projects [11], clinical studies [28], and news writing [31] are generally able to reap the benefits of using wikis in their learning and collaboration activities. Therefore, we

believe that our findings can shed a light on the educational practice across different disciplines.

### 5.4. Limitations and future research

In the present study, although the students were suggested to write their reports on the wikis, the final submission still required both a soft copy through e-submission in the Blackboard system and one hard copy; thus, the students were eventually required to transform the wiki-based report into a Word file. Finally, they were probably less motivated to write on the wikis because the teacher did not formally allocate a specific weight to wiki participation in the written course assessment document. Furthermore, an oral statement that wiki-based activities would be considered in assessing individual participation sounded vague and probably insignificant to the students. All these factors might have led to inactive engagement in the wikis by the students. A stronger top-down approach and aligning wiki use with the classroom environment [12] deserve more attention in the future from researchers and educators.

Second, because of the explorative design of this study, we did not propose a theoretical model associated with some hypotheses. Although the embedded survey enabled some statistical analyses and clarified the potential causal relationships, quantitative analyses at the team level were constrained because of the small sample size of 15 teams. Future studies are expected to theoretically formulate a more comprehensive framework and empirically verify the potential cause–effect associations in wiki use.

Third, the present study was conducted only at a university in Hong Kong. Therefore, the generalizability of its findings to other educational scenarios is subject to cultural effects. Specifically, Eastern people are considered more cautious in commenting on others' work, and they would rather correct the obvious errors rather than make major changes even though their major revisions might enhance the quality of the cocreated knowledge. However, previous studies on Western people revealed the same conclusion that “people tend not to edit others' work to avoid publicly criticizing others' work” [2,21]. Therefore, the cultural influence may not be a major concern.

In addition, closeness and openness among team members are suggested to be predictors of wiki-use behaviors [18]. Previous work experience of the team members might be another contingency factor that should be considered. When team members are acquainted with and trust each other, they may exhibit different patterns of wiki-use behaviors. However, the present study did not collect data on these factors and thus missed the opportunity to rule out alternative explanations. It would be of theoretical and practical interest to comprehensively understand team dynamics in using the wiki for collaboration to generate thoughtful conclusions.

Finally, most of the undergraduate students typically conducted face-to-face meetings on the campus, in which they might have completed most of the collaboration required [23]. Potential factors such as team dispersion that may affect the team collaboration processes and behaviors were not taken into consideration in this study. Future research involving diversified student teams with varied geographical dispersion degrees may provide a more comprehensive view of the collaboration on the wiki platform.

## 6. Conclusion

The present study examines how effective wikis are perceived in facilitating team collaboration in the IS education and learning context. Building upon the existing literature on

wiki use from the educational research perspective, the current study reveals a relatively clear picture of how student teams use wikis to perform a collaborative task and why or why not the wikis help in terms of perceived collaboration effectiveness through the theoretical lens of MST. We empirically examine MST by focusing on wiki as the focus of interest and found preliminary support for differentiated effects of media capabilities on team communication and collaboration. The findings enable us to develop a more detailed understanding of the causal relationship between wiki reprocessability and perceived collaboration effectiveness. Thus, we can also contribute to the context-specific fit research. In addition, our findings call attention to problems that

educators must resolve. When we are moving toward an era of online collaboration and blended learning, wiki technology has great potential in promoting team collaboration; however, challenges and paradoxes coexist with opportunities.

**Acknowledgments**

The authors thank the guest editor and two anonymous reviewers for their valuable comments that have helped us to improve the quality of this paper significantly. The work described in this paper was fully supported by The Hong Kong Polytechnic University Grant Project No. G-UA3P.

**Appendix A.**

*Empirical studies on collaboration through wikis in the educational context*

Studies	Context	Methodology	Key Constructs	Findings
[11]	203 US students in an undergraduate business capstone course	Survey; Structural modeling techniques	- Teaching presence; - Social presence; - cognitive presence	Teaching presence in the wiki environments has a direct and an indirect (through open communication and knowledge sharing) influence on learning (knowledge exploration, construction, resolution, and confirmation), which highlights the pivotal role of teaching presence of the instructor in technology-enhanced environments.
[15]	472 US business major students in an introductory IS course	Field experiment; One group uses MS Word document + e-mail, the other group uses TWiki	- Perceived usefulness; - Perceived ease of use; - Perceived effort of collaboration; - Task-technology fit (knowledge, work, plan, and technology)	Students found the Word and e-mail combination more useful and easier to use than the wiki environment in completing the project. There was no perceived difference in the effort of collaboration between the two methods. This study raises questions about the widely held belief that web-based collaboration platforms are superior to e-mailing documents among collaborators.
[23]	385 part-time master students in Hungary	Experiment; Structural equation modeling	- Technology/task fit; - Productivity; - Decision quality; - Satisfaction; - Key competences	Wiki technologies do not suit all kinds of tasks, and do not always increase productivity or the decision quality of team collaboration. Wikis are better suited to tasks requiring extensive asynchronous collaboration in an educational setting.
[28]	72 university students in using a wiki about clinical psychology	Experiment; Analyses with log file and survey data	- Modifications in the wiki (logs); - Assimilative knowledge building; - Accommodative knowledge building; - Factual knowledge (about the cause of schizophrenia)	Accommodative knowledge building and a development of conceptual knowledge takes place particularly when there is incongruity at a medium level between people's knowledge and the information contained in a digital artifact. Assimilative knowledge building and the development of factual knowledge depends largely on people's previous knowledge.
[31]	138 Hong Kong undergraduate students in a journalism program	A two-phase field study; Survey data and content analysis of wikis	- Open-ended questions on the processes of news writing using wikis, for example, What makes you use wiki to write articles? - Writing self-efficacy	Total number of wiki edits was a significant factor that predicted the score of the news reporting. Three writing modes (individual authorship, group authorship, and large-scale collaboration) should complement each other and help learners fully benefit from using wikis.
[35]	70 German-speaking university students	Experiment; Groups of up to 10 people; T-test and regression analyses	- Knowledge integration; - Factual knowledge (16 statements about causes of fibromyalgia)	Wiki information from the in-group led to more integration of information into previous knowledge as well as more increase of factual knowledge than information from the out-group. The results demonstrate that individuals apply social selection strategies when considering information from wikis, which may foster, but also hinder, learning and collaboration.



**Appendix B.**

*Examples of student messages and their categorizations*

Example messages	Category
<a href="http://www.aabri.com/manuscripts/10478.pdf">http://www.aabri.com/manuscripts/10478.pdf</a>	Content
This article talks about some updated systems (JetBlue's activities system).	
I think there is no need to analyze the market as our focus of the project is the system of the company.	Content
Tasks division:	Administrative coordination
(Member 1 <sup>1</sup> ) 1. Writing purpose and basic background involving business model and IT application;	
(Member 2) 2. CRM	
(Member 3) 3. TPS	
(Member 4) 4. ESS	
(Member 5) 5. Current challenge, market/industry future forecasting	
(Member 6) 6. Recommendation and conclusion	
Deadline: Sunday 6:00 pm	
Please send to summer <a href="mailto:xiaXXXXXX@gmail.com">xiaXXXXXX@gmail.com</a>	
Dear all, I have combined all of your versions together and made some polish.	Administrative coordination
Hi ^^	Other discussions
This is Angelina testing~	Other discussions

<sup>1</sup> The real names of students appearing in the original discussion thread were replaced by Member 1, 2, 3, 4, 5, and 6 to conceal their identity.

**Appendix C.**

*Survey Items*

Construct	Measuring item	Source
Media Capabilities	This wiki technology . . .	(Self-developed)
- Transmission velocity	TV1. allows my messages to reach the recipients as soon as they are sent TV2. allows my messages to be responded immediately TV3. allows interactive conversation in real time TV4. allows instantaneous feedback	
(Cronbach's <i>alpha</i> = 0.827)	P1. allows me to communicate with multiple parties concurrently P2. allows simultaneous sending of messages to multiple recipients P3. allows simultaneous receipt of messages from multiple senders P4. allows concurrent conversations to occur	
- Parallelism	SS1. allows simultaneous transmissions of multiple cues (textual, verbal and visual cues) SS2. allows me to use multiple cues in a message (e.g., both written symbols and verbal cues, both written symbols and visual cues, or both verbal and visual cues) SS3. approaches interactions to face to face communication	
(Cronbach's <i>alpha</i> = 0.882)	RH1. allows me to carefully edit my message before sending it RH2. allows my message to be better crafted and reasoned RH3. allows me to ensure the intended meaning of my message is expressed precisely	
- Symbol sets	RP1. allows me to reexamine and reprocess previously sent content during the interaction RP2. allows me to reexamine and reprocess previously sent content after the interaction RP3. allows me to reexamine and consider previously sent content for developing understanding and additional consideration RP4. provides a memory that can remind me on early discussion contents	
(Cronbach's <i>alpha</i> = 0.741)		
- Rehearsability		
(Cronbach's <i>alpha</i> = 0.757)		
- Reprocessability		
(Cronbach's <i>alpha</i> = 0.846)		
Perceived Collaboration Effectiveness	PCE1. There was an established process for communication between meetings. PCE2. Need assessment has been conducted and we have obtained information to establish our goals. PCE3. We keep collecting data to measure our goal achievement. PCE4. The environment surrounding decision making in this collaboration is positive. PCE5. We have access to needed resources for the project. PCE6. Wiki allows our project collaboration to function effectively. PCE7. Our group worked cooperatively to solve problems. PCE8. Members of this team are connected by formal and informal networks at all levels. PCE9. Leadership exists to facilitate and support team building. PCE10. There is a communication system and formal information channel in our team that permits the exploration of issues, goals and objectives. PCE11. The collaboration has allowed understanding between team members.	[4]
(Cronbach's <i>alpha</i> = 0.922)		

## Appendix D.

Screen snapshots of one team's students discussing on one of their wiki page

Below is the screen snapshot of comparison between version 3 and version 4. Texts highlighted in green means the newly added contents by one wiki user.

The screenshot shows a Wiki page titled "Let's do something for real!". At the top, there is a navigation bar with "nobody uses this name > Home", a search box, and user information "JoyHe | My Wikis | Help | Sign Out". Below the title, there are buttons for "Edit", "0" comments, and "6" views. A comparison bar shows two versions: "12131391d Mar 26, 2014 12:18 pm" and "Ryan\_Runyuan\_LI Mar 26, 2014 2:15 pm". There are links for "View WikiText" and "Review Changes".

The main content area contains the following text:

<OK! Welcome everyone, this is the discussion forum for us to talk about our inspirations after reading the case. I have to say this is a confusing case. So we must put more weight on it!

With difficulty, I would say it is also an interesting one. I'm even considering make some actions or drama relating to this topic.

Problems identified:

1. Hard to attract customers. Why? You will never go to hospital, do surgery and buy expensive medicine until you are badly ill. Same with this case. This company is like a hospital for company. So how to promote his company?  
We may also need to present the original promotion methods that have ethical concerns, so that we can illustrate the dilemma. the solution we are going to propose should also eliminate the such concerns.
2. Not attractive to talents. You will never be willing to work in India, are you? If you got one offer in Hong Kong, one in a small village in Guangdong, which one will you choose. So how to attract talents? Michael>

solution to problem 1:

As a general promotion method, we may use the previous successful defense example of the company to promote, I mean, examples that by using our security solution, the penetrations are successfully defended; [highlighted]  
As for those big entities who have no awareness of cyber security, we may send a promotion team to them to present them the possible results of being hacked, and show them some possible ways to intrude only with their permission. [highlighted]  
We may also cooperate directly with the system provider of those entities instead of persuading the entities to accept us. For example, A uses the e-infrastructure provided and maintained by B, then we can try to incorporate with B to make our security solution a customized part of the system provided by B instead of trying to sale a separate security solution to A. [highlighted]

solution to problem 2:

As talents will flue to big company anyway, why not use this as company's chips to attractive? By showing how many ppl can find nice jobs after employment in our company, what kind of career development we currently have, etc. Just personal idea. Gorden>  
[Gorden...I think in this way we are no longer a company providing security solutions, but a training company....] [highlighted]

Except identifying and solving problems (as the outline provided by Micheal), we may also talk some background and explain some terminology in both presentation and report. So besides thinking about enriching the content above, I think the following part also need our contribution. [highlighted]

3. Background (including data, charts, famous real world case about cyber security) [highlighted]
4. Terminology [highlighted]  
Custom perspective [highlighted]  
(the case says "Big datasets demanded a custom perspective and a novel approach, and hence provide open opportunities for both the attackers [highlighted]

The right sidebar contains a table of contents:

  - Wiki Home
  - Recent Changes
  - Pages and Files +
  - Members
  - All Pages
  - Actually wiki is user friendly
  - Case
  - introduction and background
  - Let's do something for real!
  - promotion
  - promotion revised
  - test 1
  - Work Allocation 3.29

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