Motivating Wiki-Based Collaborative Learning by Increasing Awareness of Task Conflict: A Design Science Approach

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Abstract. Wiki system has been deployed in many collaborative learning projects. However, lack of motivation is a serious problem in the collaboration process. The wiki system is originally designed to hide authorship information. Such design may hinder users from being aware of task conflict, resulting in undesired outcomes (e.g. reduced motivation, suppressed knowledge exchange activities). We propose to incorporate two different tools in wiki systems to motivate learners by increasing awareness of task conflict. A field test was executed in two collaborative writing projects. The results from a wide-scale survey and a focus group study confirmed the utility of the new tools and suggested that these tools can help learners develop both extrinsic and intrinsic motivations to contribute. This study has several theoretical and practical implications, it enriched the knowledge of task conflict, proposed a new way to motivate collaborative learning, and provided a low-cost resolution to manage task conflict.

Keywords: wiki, design, collaborative learning, task conflict.

1 Introduction

Wiki, as a kind of collaborative writing system, has been deployed in various collaborative learning contexts to create shared documents. In wiki-based learning project, learners are usually required to jointly write and edit articles through constant negotiation and coordination with their co-learners [1]. Therefore, learners can acquire new knowledge and skills of collaboration. The educational value of wiki has been discussed in past literature [2].

However, deployments of wiki systems to support collaborative learning, as well as public and enterprise wiki collaborations (e.g. Wikipedia) are plagued by lack of motivation [3, 4]. While motivation is considered as a critical factor which determines the success of virtual collaboration [5], how to motivate learners to participate in wiki-based collaborative learning becomes a major issue.

Wiki-based collaborations are often reported by literature regarding the issue of conflict [6–8]. The phenomenon of conflict has been studied for many decades.

And conflict has been categorized into three types: relationship, process, and task conflict [9]. Relationship and process conflict refers to disagreement on interpersonal issues and approaches to the task, respectively, while task conflict only refers to disagreements on ideas and differences of opinions about the task. In wiki pages, a conflict event is more likely to be task-oriented [6], because the most common arguments among wiki users involve opinions about the content [10]. Although conflict (e.g., relationship and process conflict) is often criticized as having a negative effect on group collaboration [11], research evidence shows that task conflict can be beneficial to collaboration. For example, task conflict can increase curiosity, which is an important intrinsic motivation [12]. Therefore, it is possible to enjoy the benefits of task conflict in collaborative learning.

In this paper, we try to motivate learners through designing enhanced tools, and understand how new tools influence learners' motivation. This paper is organized as follows: in Section 2 we summarize some problems encountered in wiki-based collaboration, and provide possible solution. Related studies are reviewed in Section 3. Proposed designs are presented in Section 4. The evaluation process and results are described in Section 5. Finally in Section 6, we draw conclusion and discuss limitations and implications of this study.

2   Problem Statement

Wiki systems have been deployed as a knowledge management tool in many contexts, such as collaborative learning, management of business meta-data, and supporting decision making [13–15]. As a result, much experience about wiki usage has been gained.

The original wiki is designed to hide authorship information. The system presents only the latest version of an article. Such design has its advantages, such as reduced social bias [16]. But it also has significant disadvantages, which may reduce users' motivation to contribute. A summary of problems in wiki-based collaboration is provided in table 1.

The problems mentioned in Table 1 can be attributed to the lack of clues when task conflict occurs. Originally a wiki did not directly show clues like "is there any task conflict issue?", "who has conflicting opinions with me?", "what opinions does he/she hold?" and "when did he/she change my content?" Users who want to know this information should use the "page history" tool to compare every two versions of an article to find the answers. The process can be very time-consuming when the article has a long list of versions.

For issue (A) in Table 1, if users are able to know the details of changes in the content that they are interested in, they would have more confidence in the quality of the information. For issue (B), knowledge exchange activities would be facilitated if the wiki system could give users information about content changes as well as corresponding editors. For issue (C) and (D), the sense of audience can be enhanced by providing peer feedbacks in the form of content changes. For issue (E), making users' social actions and content authorship visible can motivate users to contribute [16, 22].

Table 1. Some wiki-related problems reported in literature

Problems	Context	Demonstration	Source
(A) Generation of content trust not supported well	General	"does not offer ... how the article content has evolved into its most current form...how much the content can be relied upon"	[17]
(B) Knowledge exchange not supported well	General	"users may not be aware of changes of content when the content they contributed is modified by others"	[18]
(C) Limited sense of audience	Education	"having an audience who can comment on what is written directly supports efforts to write clearly and to write well"	[19, 20]
(D) Limited feedback	Enterprise	"...he believed, communicated to staff that their contributions mattered"	[19]
(E) Limited authorship	General/ Education	"this design is less suitable when users are motivated primarily by self-promotion and career-advancement"	[15, 16, 21]

Since each version of a wiki page is confirmed and submitted by a user, for design purpose, we define task conflict in a wiki page as the content difference between two versions of the page. This definition is broader than classic definition of task conflict, which emphasizes opinion differences. Moreover, our definition is similar to *peer feedback*. However, peer feedback is usually a one-to-one collaboration process where one gives reviews to another (a clear receiver), while task conflict in wiki is a many-to-many communication process that everyone edits each other's work to improve the quality of a wiki article.

Regarding the design of enhanced functions, several possibilities are proposed: First, by highlighting modifications between article versions, users can quickly be aware of a conflict event and identify whether this event is related to them. As a result, they may be motivated to express opinions. Second, by providing a paragraph-based revision history, users can focus on a specific part of the content and reduce the time and effort to locate relevant versions from a huge list of versions. Third, by providing a complete edit history of the content, users can generate a sense of community and know exactly the evolution of opinions and which editors to communicate with. Fourth, by providing word-based content authorship, users can quickly identify whether others have modified the content they contributed or not, and fulfill their needs of content ownership.

3   Literature Review

3.1   Task Conflict and Motivation to Participate

The studies on relationship and process conflict have gained consistent results, indicating that these two types of conflict are harmful to group performance [11]. In contrast, the consequences of task conflict seem to be more complex. Groups

experiencing task conflict can obtain richer collective knowledge, better decision understanding, quality of decision, and decision commitment, since task conflict encourages a diversity of opinions and positively affects members' relational outcomes (e.g., psychological safety) [23–25]. However, task conflict is also found to have a negative effect on group performance due to the influence of unsolved task issues. Besides, a high level of task conflict can trigger relationship conflict and reduce member satisfaction [26].

Existing conflict theories suggest that there exist four kinds of relationships between task conflict and participation. Firstly, participation can generate task conflict due to opinion differences [27], freedom to participate and to express ones' opinions [28], value diversity [12], different opinions on team goals, importance of task characteristics or actions [29], and perceived informational and value dissimilarity [30]. Secondly, participation could reduce task conflict since information exchange behaviors improves mutual understanding [31, 32], group value congruence, trust, and team spirit [33]. Thirdly, participation can be motivated by task conflict because users' knowledge exchange activities and critical evaluation of conflict issues (or resolution) are stimulated [34, 35]. Finally, task conflict may reduce motivation to participate because it increases stress, tension and dissatisfaction [12, 36].

As summarized above, task conflict can have both positive and negative influence on user's motivation to participate. Therefore, how task conflict influence user's motivation needs to be further investigated. In this study, we tried to evaluate the influence of task conflict in collaborative learning context.

3.2 Designs for Supporting Wiki-Based Collaboration

Many tools have been designed to support wiki-based collaboration. For example, Arazy, et al., designed an embedded tool to show page-level statistics information and help users build their community influence (e.g., a pie chart shows the proportion of contribution from every editor)[16]. Similarly, the Wiki-Dashboard designed by Pirolli, et al., also shows each editor's influence over the article [37]. These tools can reflect information about authorship as it shows the overall influence of each editor, but cannot tell when, where and how the content is changed. A history flow visualization tool designed by Viegas et al. can only reflect the changes of the whole article [38], but cannot facilitate users' communication (almost no user information provided). Moreover, it is difficult to use the tool when there are too many revisions. The same problem also exists in another study conducted by Wattenberg et al. , which uses chromo grams to reflect different edit actions in time series [39]. Ekstrand and Riedl design a history tree visualization tool to give users information about the content evolution [40]. This tool could partially solve the knowledge exchange issue since it points out the difference between users' opinions. However, the tool does not give any information about the actual content changes among revisions, thus it could not help users easily determine the details of conflict opinions.

4   Design of Two Wiki Tools

The article page of the original wiki (wiki-A) provides no information but content text. We proposed two different designs (Figure 1). The first design (wiki-B) is a dialog box triggered by a "view history" hyper-link, which is located at the end of every paragraph in a wiki article page. This tool has two different sub-functions, namely *paragraph-based edit history* and *word-based content authorship*. *Paragraph-based edit history* highlights the added/deleted content between every former and later revision (the revisions can be sorted by revision sequence in ascending and descending orders), and it also shows information about corresponding editors to facilitate further communication (clicking the name of an editor will trigger the navigation to the editor's talk page), and displays the degree of conflict of this paragraph. *Word-based content authorship* shows the author of a word (or sentence, depending on the length).

The second design (wiki-C) assigns different background-colors to words (or sentences) directly in the text of the article based on the computation of severity of task conflict. For example, when a sentence has been modified many times in a certain period, the background color of this sentence will be set to dark red. If the content is not edited by users for certain period of time, the background color of the content will be changed to lighter colors. Unlike the tool in wiki-B, this tool can reflect a direct and detailed view about the distribution of task conflict issues and related information (e.g., last editor, activeness) as soon as users visit the wiki article page.
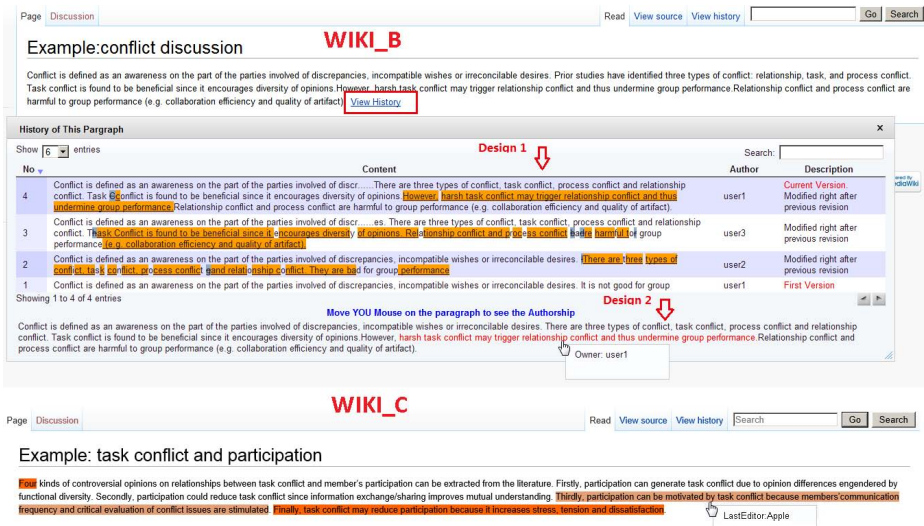

Fig. 1. Two designs of visualization of task conflict in wiki-B and wiki-C

5   Evaluation of Two Wiki Tools

The evaluation of the proposed two designs uses the focus group method, as modified to suit the Design Science Research framework [41]. The basic idea of the modification is the introduction of Exploratory Focus Groups (EFGs) and Confirmatory Focus Groups (CFGs). EFGs are used to iteratively refine the proposed design and the question draft, while CFGs are used to demonstrate the utility of the design in a field setting.

The steps of the focus group method used in this study are: (1) the authors proposed two preliminary designs and issues that need to be addressed, a pilot focus group was organized to help anticipate the issues of managing the focus group interview, including length of interview, generation of the initial questions, and evaluation of the moderators' style. The data gained from the pilot focus group were not used for further analysis. (2) A rolling interview guide [42] was utilized for EFGs. The first EFG was organized to test the designs and give suggestions on survey questions. Based on its outcomes, the quality of design was improved, and the interview guide was refined. Then, the second EFG was organized to re-test the designs and, based on its suggestions, the designs and interview guide were refined until their final version was reached. (3) The field test was conducted, and CFGs were organized to collect learners' feedback about the two designs. (4) The data were analyzed and results were reported.

5.1   Design Refinement and Outcomes of EFGs

Both wiki-B and wiki-C were deployed. These two wikis shared the same databases. In other words, the participants discussed the same wiki article; the only difference across the wikis was the difference between the two designs.

The authors organized a pilot focus group consisting of 6 graduate students. These students were all familiar with wiki operation skills. There was no restriction on their wiki usage. Three of them used wiki-B, and the other three students used wiki-C. After two days of trial and a one-hour interview, suggestions of design improvements and questions draft were gained.

The first EFG group contained 4 master students. They all had experience with collaborative learning. Half of them used wiki-B and another half used wiki-C. The authors trained them in basic operation skills, and they were asked to write a literature review, and discuss it using the modified wiki systems in 4 days. Their interview lasted for 1 hour and they gave further suggestions on design and questions draft. The second EFG group contained four undergraduate students who have experience with wiki. Two of them used wiki-B and the other two used wiki-C. They were required to discuss the benefits and pitfalls of gaming in four days. The interview lasted for half an hour. Almost no suggestions were gained on the two designs, and small suggestions regarding term usage were gained for the interview guide. As a result, the test of the two designs and the interview guide used for wide-scale survey and focus group interview were accomplished.

5.2   Field Test: Collaborative Writing Projects

All three wiki systems (wiki-A, B and C) were deployed in field test (two collaborative writing projects). The procedure is described as follows: (1) before the collaboration starts, there was a 10-minute-long face-to-face instruction session to make the participants fully understand how to use the wiki system. The definition of conflict was further introduced in another 10 minutes of instruction to help the participants distinguish among different types of conflict, since this study only focuses on task conflict. (2) All participants were randomly divided into 2 or 3 groups of almost equal size. Each group was assigned an online discussion topic. The goal was to collaboratively write a high quality discussion paper that is expected to include opinions about the topic from every possible perspective. (3) Participation was anonymous, and each participant used an alias to communicate with the others. Therefore the possibility of generating relationship could be reduced. (4) In each group, one half of the participants used the original wiki, while the others used the modified wiki. (5) Only the basic skills of editing wiki articles were required during the discussion. Thus, the probability of generating process conflict was reduced. Note that the use of the Talk/Discussion tab was still available. (6) All the discussions started simultaneously and lasted for two weeks. (7) The definition of task conflict was re-introduced in order to help the participants with recall.

We conducted the wiki-based collaboration two times. Wiki-A and wiki-B were used for the first round of collaboration (Collaboration-A). Undergraduate students, who were enrolled in a campus-level course named *Computer Ethics*, were invited to participate, and 322 out of 346 students agreed to participate. All students were equally divided into three groups, and the discussion topics selected for these groups were *pirated software*, *computer related occupational disease*, and *online gaming*. The second round of collaboration (Collaboration-B) used wiki-A and wiki-C; 116 out of 132 undergraduate students who were enrolled in a campus-level course named *Modern Educational Technology* were willing to participate. All students were equally segmented into two groups, and the discussion topics for these two groups were *game-based learning* and *traditional learning versus e-learning*. These two collaborations involved students from two universities separately due to implementation constraints.

5.3   Preliminary Survey and Result

Since focus group studies often face the criticism of a small number of participants, we develop two questions in the preliminary survey that was sent to all participants in the field test. These two questions obtain data about how the students notice conflict, and their willingness to solve conflict.

Questionnaires were sent out immediately after each collaboration ended. 301 out of 322 and 108 out of 116 valid responses were received from Collaboration-A and Collaboration-B respectively. Collaboration-A had 21 invalid responses since 13 students withdrew for personal issues, and 8 students who used the original wiki made an incorrect selection indicating that they noticed the conflict from the
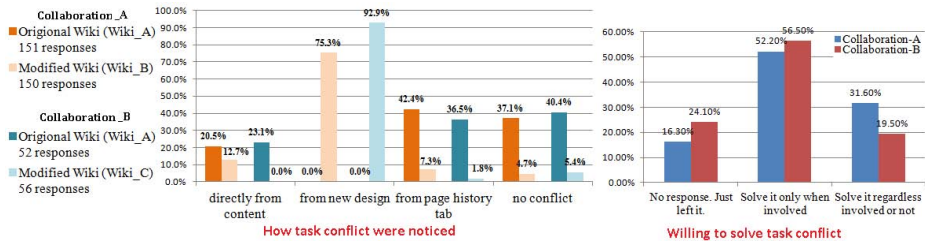
Fig. 2. Summary of wide-scale survey results

new design. Collaboration-B had 8 invalid responses since 3 students withdrew for personal issues, and 5 students who used the original wiki made an incorrect selection indicating that they noticed the conflict from new design.

As is shown in Figure 2, in Collaboration-A, 95 students (62.9%) using wiki-A noticed conflict, while 143 students (95.3%) using wiki-B noticed conflict, including 113 students (75.3%), who noticed conflict from the new design. In Collaboroation-B, compared to the 31 (59.6%) students who used wiki-A and noticed conflict, the percentage of being aware of task conflict among students who used wiki-C is much higher (53 students, 94.6%). And 52 students (92.8%) noticed conflict with the new design.

For the question about how participants reacted to the conflict events, in Collaboration-A, 49 students (16.3%) did not want to solve the conflict, 157 students (52.2%) were willing to solve the conflict issues only when they were involved, and the remaining 95 students (31.6%) were willing to solve the conflict issues whether involved or not. In Collaboration-B, 26 students (24.1%) did not want to solve the conflict, 61 students (56.5%) were willing to solve the conflict only when they were involved, and 21 students (19.4%) were willing to solve the conflict issues whether involved or not.

In summary, the results from wide-scale survey suggest that most of the students were willing to solve conflict, and the new designs seemed to be helpful for students to identify conflict.

5.4   Focus Group Interview Process

Focus group method is useful in both exploratory and confirmatory research settings [41]. In this study, we not only want to confirm the utility of out designs, but also want to understand how these tools influence learners' willingness to contribute. Therefore, the focus group method is chosen as a suitable technique. However, the focus groups are based on open discussions or interviews, thus the size of the group and the recruitment of group members was carefully controlled. By considering our field test settings and suggestions from previous study [41], we decided to setup four focus groups (two from wiki-B, and two from wiki-C) consisting of 6-10 participants for the next step in open discussion.

Since we adopted a policy of anonymity during the collaboration, we could only conduct an open call for focus group participation through email in wiki.

We sent out invitation letters (including a description of our interview purpose, style of discussion, time schedule, etc.) to the most active (30%) participants in wiki-B and wiki-C in both Collaboration-A and -B; 62 invitation letters were sent and 57 responses were received. We carefully selected responders based on their profile and telephone conversions. Finally, we selected 20 students who used wiki-B, and 16 students who used wiki-C. These subjects were suitable for our focus group study because they were familiar with the wiki environment and were not too diverse in relationship to the topic of our interests; thus, they had sufficient knowledge to provide data of sufficient depth [41]. We segmented these 36 subjects into four focus groups. Every participant received 20 RMB (3 dollars) plus food and transportation expenses.

We assigned an instructor to lead the conversation in each group. All subjects in each group were seated in a U-shape arrangement to encourage collaboration [41]. Each session of the discussion lasted 60 to 90 minutes. And the discussion were all related to the influence of proposed two designs. For example, the instructors asked the participants to recall their experience with two designs and imagine the situation without design. All conversations were video recorded after gaining permission from the subjects. Notes of key ideas and themes were taken during the discussions by an observer (either a Ph.D student or mater student). A qualitative analysis was carried out to extract the statements.

5.5   Focus Group Interview Results and Discussion

Two categories were extracted from students' feedback: perception of task conflict and motivations triggered by two tools. We further divided motivation factors into two sub-categories: extrinsic and intrinsic motivation. For each motivation factor, we counted the number of students who mentioned the factor.

Perception of Task Conflict. Students said they could notice task conflict by direct view from the content since they had strong impressions about what they wrote. However, if they closed the tools (e.g. the dialog box in wiki-B), they were usually unaware of changes in content contributed by others. Students said they liked the tools that reflected the changes made to the text and that once they got used to these tools, they would not visit the page history any more. Moreover, students generally reported that they were not willing to use Talk/Discussion pages when there were different opinions. They preferred to edit the article content directly, and no one wanted to act as a icebreaker to initiate discussion. One possible reason to explain this phenomenon is that our collaborative writing project did not employ Wikipedia-like mechanisms for students to vote for conflict resolution.

Students reported that the most frequent style of modifications was corrections of typos and punctuation. A content author would accept other's modifications, if the changes were reasonable. Moreover, the phenomenon of self-conflict (someone modified his/her previous contributions) was very pervasive. Students cared more about content written by themselves, after they had no changes to

their own content, they began to check and edit others' content. Harsh task conflict (e.g., back-and-forth editing) was rare since students thought the discussion topics were open questions and had no exact answers. Overall, students reported a moderate level of task conflict during collaborative writing.

Extrinsic Motivation Triggered by New Designs. As it can be seen from Table 2, six extrinsic motivation factors were extracted from students' feedback. Five students mentioned that the tools gave them a feeling of being visible to others; sometimes they were motivated to contribute in order to avoid blame for too little contributions from other learners. Eighteen students said that the tools helped them form a sense of group norm of participation (subjective norm). They were motivated because they felt that other learners contributed actively. Since collaborative writing is a group task, and the quality of a group artifact is related to everyone's contribution, a learner at the low-contribution level may be afraid of others' blame, especially when they perceive a strong subjective norm about contribution from system interface (e.g., highlighted modifications occur frequently). In past studies, subjective norm has been proven as a significant predictor of knowledge sharing behavior [28]. But few studies can be found to support our observation about avoiding blame.

Desire for peer recognition was mentioned by 14 students. Since the tools made students' editing activities visible to others, the students could promote themselves in the learning group through frequent contribution. The positive impact of peer recognition on learners' motivation have been found in previous studies [43].

Fifteen students reported that the tools helped them to identify co-learners who held the same opinions, and further helped them to make friends. The desire to increase social capital has been found to maintain users' intention to use a system in previous studies [44].

Nine students felt safe to express opinions when they saw the tools highlighted/listed many modifications and perceived an open style of discussion. As indicated by the Work-Engagement Theory [45], psychological safety is an important factor that predicts job engagement. In our collaborative learning project, different opinions are brought into the open and discussed, which makes students feel safe to express themselves, and encourages learning from each other [24].

Finally, 23 students reported that they generated a sense of belonging with the help of the tools. Students mentioned that they couldn't perceive a community by just looking at the wiki article page. It was the tools that helped students perceive the activeness of the learner group. The value of sense of belonging in collaborative learning has been discussed in previous studies [46].

Intrinsic Motivation Triggered by New Designs. Four intrinsic motivation factors were extracted from students' feedback (Table 3). Thirty-three students reported that they were curious about others' modifications on their own contributions. And the tools increased their frequency of visiting and reading wiki articles. Twenty-nine students felt that the new designs made them feel excited

Table 2. Extrinsic motivation extracted from feedback

Name	Participant quotation	Counts
Avoid blame	"I am afraid that other people think I contribute too little, and they might criticize me"	2(wiki-B); 3(wiki-C)
Subjective norm	I think everyone in my team is very active, and it is unwise not to express my own point of view	8(wiki-B); 10(wiki-C)
Desire for peer recognition	"Once I knew my name was shown in the dialog boxI want to get recognized by other students and become a leader of this team"	9(wiki-B); 5(wiki-C)
Make friends	"The dialog box helped meI think I found someone who has similar opinions with me... We could be friends"	7(wiki-B); 8(wiki-C)
Psychological safety	"When I saw so many red spots in the articleThis kind of open discussion made me express my view freely"	4(wiki-B); 5(wiki-C)
Sense of belonging	"I couldn't feel there is a community working on this page...But the design did show a group of people I feel I am a member of this team, others have not isolated me"	12(wiki-B); 11(wiki-C)

because of the unexpected presence of modification. Moreover, 22 students generated a sense of audience under the influence of new designs. They could feel that their writing has readers. As a result, their satisfaction of participation increased.

Although curiosity to check the modifications did not directly lead to contribution behaviors, it increased the chance of participation in knowledge exchange activities, and the satisfaction of contribution. In the same way, sense of audience and excitement also increases learners' satisfaction. Content modifications and highlights are dynamic; therefore, the sense of curiosity, excitement and sense of audience these actions gave to participants is self-reinforcing. The value of flow experience (curiosity, excitement) has been discussed in previous educational studies [47]. And the positive impact of sense of audience on student's willingness to contribute is discussed in [48].

A few cases of participation caused by unhappiness/annoyance were reported by 6 students. These cases only happened when others' modifications were unreasonable. The reactions (e.g. revert) caused by negative emotions are usually considered as defensive behavior, because people have the need to protect their perceived integrity and worth of self, as suggested by the Self-Affirmation Theory [49].

In summary, the effectiveness of our new tools on motivating learners is strongly connected to the experimental settings. First, we provided an autonomous, supportive style of administration during collaboration that only required basic operation skills, and did not limit students' freedom to use the wiki. Second, the new designs provided up-to-date peer feedback information about content. The positive effects of peer feedback have been discussed extensively in educational studies [50]. Third, since the two designs can directly reflect the interactions of community members, they provide students with a sense of audience and belonging to group. Our findings are in line with the Self-Determination

Table 3. Intrinsic motivation extracted from feedback

Name	Participant quotation	Counts
Curiosity	"I was so curious that I almost go to check if somebody modified my content every once in a while "	18(wiki-B); 15(wiki-C)
Sense of audience	"When I saw the background color of my content change to red, I felt very satisfied, because somebody read my content"	12(wiki-B); 10(wiki-C)
Excitement / Interest	"I think this kind of discussion is interesting, others can modify my content, and this system can unexpectedly show this kind of modification "	15(wiki-B); 14(wiki-C)
Unhappiness/ annoyance	"For myself, when I saw my content was modified, I didn't care if such modification is a kind of extension, but if somebody distorted what I mean, I will feel angry that they changed the content, and revert the content"	2(wiki-B); 4(wiki-C)

Theory, which suggests that providing people with senses of autonomy, competence, and relatedness will facilitate internalization of external motivation [51]. Moreover, our collaborative learning project was not bothered by process conflict and relationship conflict since the project did not require students to spend their effort on dealing with process issues, and the generation of relationship conflict was carefully suppressed due to the sample characteristics and the policy of anonymity.

6   Conclusions

6.1   Summary of Findings

The original wiki system has usability problems (it does not well support content trust and knowledge exchange); meanwhile, users in wiki-based collaborations often experience lack of motivation due to a limited sense of audience, limited feedback and limited authorship. These issues can be attributed to the lack of clues of task conflict. In this paper, two wiki tools were introduced to increase user's awareness of task conflict and motivate users to contribute in collaborative learning context. The main evaluation process followed the focus group framework proposed by [41], a method adjusted for Design Science Research.

The effectiveness of the designs was confirmed in two ways. First, the results from the large-scale survey shown in Figure 2 suggest a higher awareness of task conflict with the modified wiki. Second, responses from the CFGs show that our designs, which display clues of task conflict, improve wiki usability and facilitate the generation of a series of extrinsic and intrinsic motivations. The result is in line with our expectations.

6.2   Limitations

Our study has limitations, which may influence the applicability of our findings. First, our field test and focus group interview only used undergraduate students

as subjects. Undergraduate students represent the majority of users in collaborative learning. However, disregarding other kinds of users (e.g. middle school students) can cause variance in the final result.

Second, our field test adopted a relative loose policy on user participation, and our focus group interviews only included active participants. Therefore, we cannot address free-riding problems well and we cannot explain free-rider motivations, as well as how our designs might impact their motivations. In future studies, we will focus on evaluating the effects of our designs on the transition from non-active users to active users.

Third, although we did not observe significant negative impact of our design on learner's motivation, the proposed designs can still inhibit contributions behaviors by antagonizing learners. This negative effect is in accordance with the complex consequences of task conflict. We argue that whether task conflict is beneficial to collaborative learning depends on the management style of collaboration (e.g., active and agreeable conflict management style).

Fourth, since our field test was conducted in collaborative learning context, the results from CFGs might not be able to explain the situations in other contexts (e.g., enterprise). Different wiki applications may have very different profiles. For example, the policy of anonymity is usually not allowed in enterprise wikis. Therefore, it may be much harder to mitigate relationship conflict and the generation of motivations factors might be different in other wiki implementations. Since the two designs provide useful tools to let users know about changes of content and provide other task conflict clues, we expect that these designs may be effective in different contexts.

6.3   Implications

This study yielded implications for literature. First, previous studies on task conflict largely focus on exploring the consequences of task conflict, since task conflict can be both beneficial and detrimental to collaboration. This study made an early attempt to use the good side of task conflict. By providing clues of task conflict, problems of lack of motivation caused by wiki usability issues can be addressed. Second, previous studies have not fully explained how task conflict benefits the collaboration process, while this study provided evidence that increasing learner's awareness of task conflict could trigger many motivations which are important for learner's participation–especially for their continual participation (e.g., curiosity, excitement, sense of belonging).

This study also results in practical implications. First, the lack of motivation is partly due to the fact that the collaborative learning platforms cannot generate effective incentive mechanisms [52]. In contrast to the way of using trust and reciprocity to motivate learners, the two tools offer a new approach to achieve the same goal. Second, people in online collaborative work tend to care about their own contributions most. Such behaviors are not compatible with the original objective of collaborative work [15]. The new designs can motivate users to contribute to others' work and generate valuable communication. Third, since the effectiveness of conflict management is based on how well such conflicts can be

understood by group members, increasing the awareness of task conflict can help group members to be aware of task conflict at an early stage, track evolution of opinions, and negotiate with each other (active conflict management). Instead of designing complex conflict monitoring and resolution mechanisms, this method could allow conflict to be resolved by people in a self-organized way.

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