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# Information Quality in Wikipedia: The Effects of Group Composition and Task Conflict

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**ABSTRACT:** The success of Wikipedia demonstrates that self-organizing production communities can produce high-quality information-based products. Research on Wikipedia has proceeded largely atheoretically, focusing on (1) the diversity in members' knowledge bases as a determinant of Wikipedia's content quality, (2) the task-related conflicts that occur during the collaborative authoring process, and (3) the different roles members play in Wikipedia. We develop a theoretical model that explains how these three factors interact to determine the quality of Wikipedia articles. The results from the empirical study of 96 Wikipedia articles suggest that (1) diversity should be encouraged, as the creative abrasion that is generated when cognitively diverse members engage in task-related conflict leads to higher-quality articles, (2) task conflict should be managed, as conflict—notwithstanding its contribution to creative

abrasion—can negatively affect group output, and (3) groups should maintain a balance of both administrative- and content-oriented members, as both contribute to the collaborative process.

**KEY WORDS AND PHRASES:** co-creation, cognitive diversity, collaboration, community-based production, group composition, information quality, task conflict, Wikipedia.

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RECENT YEARS HAVE SEEN THE EMERGENCE OF A community-based model for collaborative work, whereby a self-organizing online community creates knowledge-based goods [10, 29, 52, 86]. Prominent examples of community-based collaboration are open source software (OSS) projects (e.g., [49]) and the online encyclopedia Wikipedia [4, 14]. Community-based groups are often large, and mostly comprised of volunteers who self-manage work processes. Given the lack of clear monetary incentives for participation and the loose governance, the success of such projects seems counterintuitive. What is it, then, that determines the success of community-based collaboration projects?

We center our investigation on Wikipedia [88], an online encyclopedia that is experiencing remarkable growth and has become the most notable example of the community-based model [10].<sup>1</sup> To study the performance of editor groups within Wikipedia, we focus on the quality of its main outcome, the information provided in its articles, as the primary indicator of group output. Wikipedia articles are created using wiki technology, a Web-based collaborative authoring tool that is designed for openness, anonymity, and egalitarianism [56, 87], and therefore suitable for supporting the community-based production of knowledge-based goods [88]. Wikipedia operates many different projects, defined as the authoring and editing of a particular encyclopedic article on a wiki page, where the project group is comprised of a set of volunteers who have contributed to the wiki article. Our definition is in agreement with the inclusive notion of “a group” [57] and with the view of organizations as collections of groups [51].

Prior literature identifies three central aspects in Wikipedia’s collaborative authoring process: (1) the cognitive diversity in members’ knowledge and experiences, (2) task conflict, and (3) the roles members play. Cognitive diversity of an editor group is believed to contribute to the quality of the produced article, in line with “the wisdom of the crowd” argument [7, 44, 80]. Task conflict—disagreements related to the group task—is unavoidable in Wikipedia’s peer-based collaboration [42, 43, 46, 83, 84], and it has a dual effect. On the one hand, conflict may impede collaboration and have negative consequences on group output [39, 43, 46]. On the other hand, when cognitively diverse groups engage in task-related conflicts, the “creative abrasion” that is generated forces members to reexamine their assumptions and promotes knowledge [55, 63], thus having a positive effect on the performance of Wikipedia editor groups [83, 84]. Finally, studies examining members’ roles and group composition in self-organized production communities show that the presence of administrative-oriented

members enables the group to diffuse and restrain task conflict [14, 79], whereas the inclusion of content-oriented members draws on their domain-specific expertise [4] and directly affects article quality.

The objective of this paper is to develop and test a limited-scope theoretical model that explains how the three important factors highlighted above—cognitive diversity, task conflict, and group members' orientation (administrative or content)—interact to determine the quality of articles produced by Wikipedia editor groups. Recent years have produced a large number of studies on Wikipedia, yet this investigation has proceeded largely atheoretically. Our work is informed by these many Wikipedia studies and seeks to ground their observations in theory of group work.

The unique setting of online peer production [52] and the distinctive affordances of the enabling wiki technology [84, 87] raise the need to develop refined theories of wiki-based collaboration [60]. Extant theoretical frameworks developed in the context of traditional organizational work are not well suited for explaining Wikipedia work processes. First, some important constructs are only relevant in the context of online self-organizing production groups (e.g., the construct of administrative/content orientation under investigation here, or “cross-thread connectivity” in Kuk [47]). Second, the relationships between constructs as articulated in extant frameworks may not be appropriate in the Wikipedia context. Third, no single framework ties together the various constructs we are interested in.

Our empirical method relies on Wikipedia's system logs. Harvesting these logs can reveal important insights regarding members' ongoing behavior in its natural setting [39]. While this approach is constrained by the available recorded data, it has advantages over laboratory experiments (investigating the phenomenon in its natural settings) and survey studies (capturing the actual ongoing behavior of all groups' members) that we believe outweigh its limitations.

The paper continues as follows: the next section reviews related work on cognitive diversity, task conflict, members' orientation, and information quality; the following section develops hypotheses regarding the relationships between these constructs; we then describe the research methodology and continue to present the results; the section that follows discusses our findings and highlights implications for theory and practice; and the final section concludes the paper, pointing to future research directions.

## Related Studies

EARLIER, WE IDENTIFIED THREE CENTRAL THEMES in Wikipedia's collaborative authoring process. Two themes refer to the composition of Wikipedia editor groups: the inclusion of specific types of members and the diversity in members' knowledge bases. The third theme refers to group work processes: task-related conflict. Here we review prior studies related to these three themes, as well as works related to the group output (the quality of the produced Wikipedia article), focusing primarily on studies of Wikipedia and on works in related areas: virtual teams, online communities, and OSS projects.

The settings for studies in these related areas differ from Wikipedia in some important aspects. Although content in Wikipedia is created by distributed groups, unlike

corporate virtual teams, participation in Wikipedia is voluntary and governance is egalitarian [10]. Wikipedia is a production environment where groups work toward a well-defined output, and thus it differs from many online communities that primarily serve as a place for deliberation. Wikipedia is also somewhat different from other forms of community-based production, such as OSS projects, in its underlying technological infrastructure, namely, the affordances of wikis. Wikis are designed for peer-based collaboration [56, 87, 88] and remove the workflow constraints associated with traditional knowledge management systems [8].

## Group Composition

Group composition is an important determinant of project success in community-based projects [77], and there is an extensive body of literature that describes the core-periphery structure in online communities (specifically, peer production communities). The core-periphery structure is defined in terms of members' activity in the project, where a small group of highly active core members are responsible for most of the contribution to the project [19, 47, 59, 65].<sup>2</sup> Research on the core-periphery structure is descriptive in nature and does not provide insights into the expected effects when communities deviate from this structure. This line of research has focused on a single dimension of the group's composition—activity—and does not explain how a member's activity, in itself, would determine the quality of the group's output.

There are two important dimensions of group composition that have been investigated: the group's central tendency, that is, “the proportion of group members who possess a characteristic or the mean level of that characteristic within the group” [66, p. 367], and the variability within the group in terms of a specific characteristic. We investigate these two dimensions of group composition, focusing on the proportion of members with an administrative (rather than content) orientation and on the group's cognitive diversity.

## Group Members' Orientation

We center our attention on the focus of group members on a continuum between content and administrative orientation. This concept is specific to the context of online communities. Studies of online communities [9, 15, 45] and Wikipedia [4, 11, 14, 44, 71] make the distinction between two types of prototypical users, as described in Table 1.

Members of online communities—specifically, Wikipedia—can volunteer to become administrators. As contributors take on organizational responsibilities, they often develop identification with the community and its core values and see themselves as caretakers of this community. They are generally more active than other members, and their activity is often spread across many tasks. The presence of such a core set of administrative-oriented members has become the signature of successful online communities [9, 45, 94]. A survey of administrators (or “owners”) of 284 Internet groups, including both work-related and nonwork groups [15], sheds light on the

Table 1. The Characteristics of Content- and Administrative-Oriented Members

Member's orientation	Commitment and identification with the community	Engagement and participation in community	Pattern of contribution	Roles and responsibilities
Content	Low	Low	Centered on few items	Basic
Administrative	High	High	Distributed across many items	Volunteer for additional responsibilities

roles of these community officials. Administrative-oriented members share responsibilities for both the technology infrastructure and social management tasks, such as controlling for improper use of the forum and encouraging appropriate use. In Wikipedia, administrators are essential for streamlining the production process; they hold decision-making privileges that are associated with their added responsibilities and they play an important role in conflict management, quality control, and in defining and enforcing Wikipedia's norms and procedures [14, 79]. The roles of individual Wikipedia contributors have been investigated extensively [11, 14, 44, 79, 84], but little is known about how administrative-oriented members in article editor groups affect the quality of the produced article.

Another important role in online communities is that of content-oriented contributors who are attracted to the specific topic at the center of discussion but have less interest in the broader community. Their overall activity is low and sporadic, and they usually do not sign on for additional responsibilities. Content-oriented members are an essential component of online communities [9]. Studies of OSS suggest that such occasional members are critical to project success: the contributors provide the variety of ideas that is required to fuel innovation while the administrators select and retain the features that would make up the product [47, 52], and similar patterns have been observed in Wikipedia [14, 46, 79]. In Wikipedia, content-oriented editors are drawn to a particular article because it is closely aligned with their interests and expertise. The contributions made by these topic-focused members (identified by not registering to Wikipedia) are, on average, of higher quality than those made by registered members [4].

### Cognitive Diversity

Diversity refers to differences among people on "any attribute that another person may use to detect individual differences" [93, p. 81]. Diversity in a group's composition is often divided into surface-level diversity (differences in demographic characteristics) and deep-level diversity (member differences in educational or functional background, expertise, and knowledge) (for a review, see [61, 93]). We focus on deep-level diversity,

which has the potential to enhance group performance. Group members' shared mental models and common task knowledge (i.e., low cognitive diversity) have been shown to positively affect team success [33, 96]. Nonetheless, deep-level diversity can enhance groups' performance, especially when the task is cognitively complex and requires multiple perspectives or entails creativity [3, 32], since cognitive diversity increases the variety of perspectives brought to a problem, creates opportunities for knowledge sharing, and leads to greater creativity [62].

Even though cognitive diversity in online groups could potentially be high, many communities suffer from "cultural tribalism" [41], in which people sample a large number of communities and migrate to the ones in which they hear what they want to hear, resulting in low cognitive diversity. Thus, cognitive diversity in online communities is only temporary and usually diminishes over time, resulting in dysfunctional communities [41]. To the best of our knowledge, no prior studies of online communities have investigated the effects of cognitive diversity on online work processes and community performance.

## Task Conflict

*Task conflict* refers to differences in viewpoints and opinions pertaining to a group task. There is mixed evidence regarding the effect of task conflict on group performance [18]. For collocated teams, some studies demonstrate the negative effect of task conflict on productivity and satisfaction [75, 89], while others show positive effects [95], especially in tasks that require significant cognitive effort. These positive effects are explained by the benefits derived from differences of opinion about the work being done [22, 35], such that the resulting synthesis is superior to the individual perspectives [76]. In virtual collaborations, conflict resolution is of paramount importance because virtual teams are more susceptible to task conflict [34] than collocated teams [31], and thus task conflict may impede the success of virtual collaborations [67]. Empirical evidence from online communities [94] and OSS projects [74, 91] suggests that conflict is common. Nonetheless, conflict has been underinvestigated in the context of community-based projects.

Conflicts of opinions are inherent to the Wikipedia collaborative authoring process [39, 43, 46, 83]. Decisions about whether a piece of text, link, or image should be included, reordered, or rephrased are all grounds for heated discussion, and resolving these disputes through consensus is the most fundamental discursive work that Wikipedians perform [46]. Even within the bounds of Wikipedia policies, there are often contentions, conflicts, and power plays where an editor or a group tries to influence the content and claim legitimate control over the article [46]. Conflicts may be observed in the evolution of an article by studying the comments editors append to it [83]. In addition, a "talk page" ("discussion page") is associated with each article and provides a place for editors to argue their positions, negotiate disagreements in opinions, and try to reach a consensus [14, 46, 83]. An analysis of some 4,200 comments in 625 distinct discussion pages revealed that changes appeared and disappeared repeatedly as the community wrestled for control of content; the most common issues

in the discussion pages were task-related conflicts: what content should be added or removed and how information should be structured [39].

## Information Quality

Our interest is in the effects of group composition and task conflict on groups' performance, or more specifically, on the quality of the produced Wikipedia article. The construct of *information quality* is difficult to pin down. Some definitions highlight the objective view (i.e., information meets the requirements of the particular activity the user is engaged in; e.g., [81]), whereas others emphasize a subjective view (i.e., information meets the user's expectations; e.g., [30]). For the purposes of the current investigation, we adopt the more general definition of quality—"fitness for use" [90]—which encompasses both of these objective and subjective aspects [26].

Information quality is a multidimensional construct [81]. There is a large body of research on the concept of information quality and its underlying dimensions [5, 30, 53, 90], and this literature describes a large number of primitive-level attributes of information quality that could be grouped into higher-level categories. In our investigation of Wikipedia article quality, we focus our attention on a restricted set of information quality dimensions, rather than trying to cover the gamut of information quality attributes. For the purpose of the current study, we focus on Lee et al.'s [53] information quality categories, employing factors that were frequently used in the studies examined in their survey of the literature: accuracy and objectivity ("intrinsic information quality"), completeness ("contextual information quality"), and representation ("representational information quality").

## Theory Development

GIVEN THE ABSENCE OF A THEORETICAL MODEL that explains how group composition variables and task conflict interact to determine content quality, there is a need to develop a Wikipedia-centric theoretical model. Recent years have seen numerous studies on Wikipedia, yet much of this investigation has not been grounded in theory. Theories from the related areas of virtual teams and online communities provide some important insights, yet are not directly applicable to our setting. The literature on group processes in virtual teams highlights the essential role of task conflict, but does not consider the composition that characterizes community-based collaboration. Literature on the community-based model, however, acknowledges the importance of group composition [19] and documents this phenomenon [59], but provides little insight into how this distinctive group composition affects work processes (specifically, task-related conflict) and group output. Moreover, the distinctive affordances of wiki technology promote work processes that differ fundamentally from knowledge creation processes in online communities and virtual teams [60], highlighting the need to develop Wikipedia-centric theory.

In developing our hypotheses, we build on two primary literatures. The first is the extensive organizational theory (in both collocated and virtual teams) on the relationships

between diversity, conflict, and group performance. The second is the group composition literature in online communities and OSS projects. We explain what effects we expect to persist in Wikipedia and extend these frameworks where necessary.

## Cognitive Diversity and Task Conflict Affect Information Quality

Diversity has been shown to have mixed effects on outcome variables [61]. Cognitive diversity has the potential to enhance group performance [62], especially when the task is cognitively complex and requires multiple perspectives or entails creativity [3, 32], as is the case with Wikipedia's collaborative authoring. Conflict has been viewed as a central variable that explains the relationships between diversity and group performance [32, 73].

The theory of groups describes the dual effects of task-related conflict on group performance [18]; while conflict can impede collaboration [75, 89], it can contribute to group performance [37, 95], especially in complex tasks that require significant cognitive effort [22, 35]. The explanation for these positive effects is that task conflict (1) makes members more receptive to new information, (2) fosters a deeper understanding of task issues, (3) increases the range of alternatives considered, (4) motivates members to question fundamental assumptions and engage in cognitive restructuring, (5) allows assumptions and recommendations to be evaluated systematically, and (6) eventually leads to novel insights and enhanced problem solving [2, 73, 97]. For example, Pelled et al. [73] found that task conflict had a positive association with cognitive task performance in work groups, and Amason [2] reported that task (or cognitive) conflict is positively related to the quality of group decisions.

When groups are diverse in terms of expertise and viewpoints regarding the task being done, task conflict is most effective [22, 35], and the synthesis that emerges from the negotiation of viewpoints is generally superior to the individual perspectives [76]. Recently, a number of studies on organizational learning and innovation have stressed the positive role of creative friction—or abrasion—in facilitating innovation and learning [55, 63]. Thus, given a cognitively diverse group of people, task conflict can contribute to the quality of the information-based group output by encouraging members to reassess existing knowledge, challenge others' viewpoints, and come up with creative solutions. In online communities, despite the fact that interaction is computer mediated, members' postings reveal their knowledge and views; the fact that members have complementary knowledge bases still contributes to the cumulative knowledge [20, 40, 64]. Thus, cognitive diversity still plays an important role. Evidence suggests that creative abrasion occurs in online communities, and conflicts were found to help in clarifying issues, eventually resolving disagreements, and reaching a (and often a better) commonly accepted solution [25, 94]. We expect Wikipedia groups to experience such creative abrasion because (1) these editor groups are often diverse in terms of occupation, geography, age, and breadth and depth of previous experience [39]; (2) the collaborative editing task is complex and requires much cognitive effort; and (3) Wikipedia norms and procedures help streamline the collaboration process. Therefore, we propose:<sup>3</sup>



*Hypothesis 1: Task conflict will moderate the relationship between cognitive diversity and information quality, such that when task conflict is high, cognitive diversity would have a positive effect on information quality, whereas when task conflict is low, cognitive diversity would have a negative effect on information quality.*

Task conflict, beyond its contribution to creative abrasion, may impede collaboration and have negative consequences [75, 89]. Conflict in technology-mediated collaboration is often viewed as having negative consequences. Virtual teams may suffer from task conflict, as the coordination of conflict resolution is more difficult virtually, and as a result, task conflict impedes project success [67]. In Wikipedia, groups become preoccupied with minor semantic issues and have difficulty resolving them [39], disagreements often escalate to heated debates [43], and conflict is generally perceived as detrimental [46]. Thus, we expect that—like the reported relations in collocated and virtual teams—the direct effect of task conflict on Wikipedia article quality (beyond its interaction effect with cognitive diversity) will be negative, and we propose:

*Hypothesis 2: Task conflict will be negatively related to information quality.*

## Group Members' Orientation, Task Conflict, and Information Quality

We conceptualize the orientation of a group's members as a single construct on a continuum between administrative and content orientation. The more there are members who act as administrators, the more the group leans toward administrative orientation; the more there are members who are occasional contributors attracted to the article's topic, the more the group gravitates toward content orientation.

The inclusion of administrative-oriented members who have gone through the Wikipedia socialization process can enable groups to better manage task conflict, and thus indirectly affect the article's quality. Norms play a critical role in providing a shared terminology and regulating behavior in online communities [9, 71, 94], and specifically in Wikipedia [79, 83]. By relying on policies, editors can more easily interpret complex situations and legitimate their actions [46], as well as work through and resolve content disputes [11, 84]. The rules and norms that guide Wikipedia collaboration consist of over 100 style, presentation, and formation rules, as well as an extensive set of rules for managing the work process (e.g., conflict resolution) [83, 84]. Administrators have gone through the Wikipedia socialization processes [11, 14, 79, 83] and in addition play an important role in developing, promoting, and enforcing policies [14, 71, 79]. Thus, administrative-oriented members share Wikipedia culture and norms more than other members do [14, 46], and groups that include a high concentration of administrative-oriented editors are more likely to agree on the collaborative authoring process.

In addition, administrators use policies to actively help diffuse conflicts once they emerge [43, 46].<sup>4</sup> As has been observed in collocated teams [36] and OSS projects [54], administrative-oriented Wikipedians play an active role in facilitating conflict

resolution [71]. These administrators serve on arbitration and mediation committees, which help diffuse extended conflicts that the community has been unable to resolve [14]. In sum, groups that have a high concentration of administrative-oriented members are likely to experience less conflict, as these members share a common understanding of Wikipedia work processes and can more easily diffuse conflicts and prevent them from escalating. Therefore,

*Hypothesis 3: The more group members gravitate toward administrative orientation, the lower task conflict the group experiences.*

Content-oriented members also play an important role in Wikipedia, and the inclusion of such members can have a direct positive effect on the quality of the article the group produces. A central tenet in the user innovation literature [85] is that occasional contributors are essential in innovation processes because they sometimes possess expertise that surpass the skills of those in official roles. In addition, these occasional contributors are not entrenched in any one opinion, and are likely to challenge old conceptions. Findings from OSS projects [47, 52] document a similar phenomenon. In the context of online knowledge-sharing communities, it has been shown that content-oriented members who restrict their contributions to specific domains provide higher-quality answers than members who contribute across the board. In Wikipedia, content-oriented contributors are drawn to the article's specific topic because of their interest and expertise in the area. They have little interest in Wikipedia beyond the specific article and often choose not to register. A recent study explains the finding that anonymous contributions are of higher quality in comparison to the contributions of registered members by arguing that these anonymous individuals are often domain experts, while members in official roles are committed to Wikipedia at large, but often lack domain expertise [4]. Thus, we expect a group that includes content-oriented members to produce relatively high quality articles, and we hypothesize:

*Hypothesis 4: The more group members gravitate toward content orientation, the higher the quality of the article the group produces.*

## Controls

In order to control for the effects of exogenous factors, we included a number of control variables. We control for group size, as the number of contributing editors may affect quality in two ways. First, because large groups represent a broader set of opinions and knowledge bases, a larger group size may be associated with cognitive diversity and may affect information quality [80]. Second, the editors also act as quality assurers; the more editors working on the article, the more rapidly errors and incomplete information will be discovered and corrected (reflecting the principle of “given enough eyeballs, all bugs are shallow” [74, p. 8]). Evidence for the relationship between group size and article quality is provided in a recent study that found high correlations between Wikipedia article length and the nomination of articles as high-quality (i.e., “featured”) articles [13]. We also control for factors related to the Wikipedia article.

Wikipedia articles mature slowly, often in small increments. It is through an ongoing refinement process that content develops and quality improves. The age of the article might thus reflect the article's maturity and may be associated with quality. Similarly, the amount of editorial activity applied to an article could affect the article's quality. In addition, the article length may reflect the completeness of the article and be linked to article quality. We therefore control for these three factors: article age, activity, and length (see [29] for similar controls applied in the study of OSS projects). Finally, we included in our model control paths from group members' orientation to cognitive diversity and from cognitive diversity to information quality.

## Research Method

WE CONDUCTED AN EMPIRICAL STUDY OF THE English version of Wikipedia. The unit of analysis is an article, the authoring of each article represents a distinct group project, and the group is defined by the set of authors who contributed to the article. Since group output in Wikipedia is an encyclopedic entry about a specific topic, group performance was defined by the quality of the article. According to Kane and Fichman [39], a key limitation of prior research in the area is the narrow focus on easily accessible quantitative data, and in order to remedy this, information systems research into Wikipedia should employ both quantitative "shallow" data and a deeper analysis of collaboration patterns. We adopt this recommendation and utilize both quantitative data from Wikipedia logs and a detailed content analysis of Wikipedia discussions.

We randomly sampled articles from Wikipedia, with the requirement that the article's length be between 200 and 3,500 words. An article's topic may impact conflict levels because some topics are more controversial than others [42]. In order to represent the various Wikipedia topics, we used a stratified sampling approach, congruent with Wikipedia's top-level classification [42],<sup>5</sup> which we organized into a smaller set of six mutually exclusive and collectively exhaustive classes: (1) culture, art, and religion; (2) math, science, and technology; (3) geography and places; (4) people and self; (5) society;<sup>6</sup> and (6) history and events. The length limit excludes undeveloped ("stub") articles, and captures approximately 98 percent of the nonstub articles.<sup>7</sup> We randomly sampled articles from this population—17 articles from each category (102 in total) using Wikipedia's "Random Article" feature. After some preliminary analysis, we found that we had to exclude six articles: articles that had not passed the early inception phase (age less than one month), as well as those with one or two editors (the concepts of group composition carry little meaning in dyads), were discarded; in addition, we removed articles that were discontinued by Wikipedia during the study's duration. We arrived at a sample of 15–17 articles per category and 96 in total.

In order to measure the quality of Wikipedia articles in our sample, we used the following procedure. In December 2006, we created a copy of each article in our sample, and this version of the articles was analyzed by three senior librarians at a major North American university. The librarians used a variety of sources for judging the quality of Wikipedia articles, including reports that were prepared by undergraduate students as part of a class assignment.<sup>8</sup> After an initial training session, each of the three librarians

independently analyzed the articles in a random order both by performing her own analysis of the topic and by using the students' reports. The librarians were asked to pay attention to the particular set of relevant information quality dimensions described above in the section reviewing studies of information quality: accuracy, completeness, objectivity, and representation. After the librarians independently marked down their perceptions of the articles' quality along these dimensions, we sought to reach a consensus on the overall quality of the articles, and a researcher facilitated a discussion of the evaluations, where conflicting views were negotiated and a consensus reached (in line with the Delphi methodology [58]). The consensus quality value for each article (on a seven-point Likert scale) was used as the *information quality* measure.

Group composition variables—group members' orientation and cognitive diversity—were measured by “harvesting” Wikipedia, relying heavily on the articles' history logs maintained by Wikipedia and the contributors' personal pages. The data were cleaned by excluding all nonhuman authors (i.e., software bots). Because the contents of Wikipedia change continually, the estimates for all the constructs were based on the article version on which quality assessments were made.

We operationalized *group members' orientation* as a reflective latent construct,<sup>9</sup> where high values indicate administrative orientation and low values denote content orientation. We measured this construct using four items, in line with the characteristics described in Table 1. First, we calculated the proportion of group members who hold an official “administrator” status within Wikipedia.<sup>10</sup> Second, we calculated the average number of edits the article authors have made across Wikipedia at large, where a high value is associated with administrative orientation. Third, since content-oriented members concentrate on a specific article, but their overall contribution to Wikipedia is low, we calculated the ratio of members' overall Wikipedia edit activity to their article activity; a high ratio indicates an administrative orientation and a low value denotes content orientation. Fourth, since administrative-oriented members spread their activity across many articles and content-oriented contributors are characterized by a concentration of few topics [1], we analyzed—for each member—the dispersion in his or her Wikipedia activity pattern. We used the entropy measure [3, 20]  $Entropy = -\sum_{i=1}^N P_i \ln P_i$ , where  $N$  is the number of states (i.e., different articles the member has contributed to), and  $P_i$  is the probability of being in state  $i$  (i.e., the percentage of edits in that specific article). Entropy is high when a member contributed evenly across various articles, and is low when the member concentrated his or her activity on a few articles. Entropy is well suited for estimating the extent to which categories are equally represented, as it measures dispersion irrespective of the location of the mean, unlike variance, which measures concentration only around the mean [21]. In the organizational literature, entropy has been employed to measure dispersion of power structure [68], categorical variables (background, gender, and race) [73], and functional assignments [20]. We then calculated the average of group members' entropy, in which a high value denotes administrative orientation and low entropy signifies content orientation.

*Cognitive diversity* was estimated based on the uniqueness of group members' experiences within Wikipedia. The uniqueness in group members' knowledge (i.e., the extent to which there is no overlap in the interests and expertise that members bring

to the group) is a key descriptor of the group's cognitive diversity [96]. Our measure for the cognitive diversity of a Wikipedia article editor group was based on the editors' activity in Wikipedia articles other than the specific article at hand, assuming that an editor's contribution to an article reflects his or her interests and expertise. For each editor group, we created a two-dimensional matrix, on one dimension listing all the group members and on the other dimension listing all the Wikipedia articles that were edited by at least one of the members, where each cell indicated whether the editor was active on that specific article (0 or 1). When there is much overlap in members' Wikipedia activity, the matrix would be dense, and when members have a unique set of Wikipedia experiences, the matrix is sparse. Thus, our measure of cognitive diversity was based on the sparsity of the matrix (i.e., the percentage of cells with zeros [78]).<sup>11</sup>

*Task conflict* was measured by an analysis of articles' discussion pages. Wikipedia associates a discussion page with an article's main page. Editors commonly use the discussion page to discuss, argue, and negotiate their views regarding the information that should be included in an article's main page. Thus, the discussion pages serve as the primary mechanisms for managing conflicts in Wikipedia [43, 83, 84]. Since the discussion page captures the conflicts, challenges, and decisions in the group involved in creating the article, it is recommended as a source for studying the group's dynamics [39]. Three independent assessors analyzed the discussion page of each article in the sample and rated the level of task conflict working with the Jehn and Mannix scale [37] adapted to the Wikipedia context (see the Appendix for details). The assessors ranked their perceptions of the levels of task conflict evident in the discussion page text (using a seven-point Likert scale).<sup>12</sup> For each item, we employed the average of the three assessors, and interrater agreement was calculated using the intraclass correlation agreement (ICC). Agreement was high for all three conflict perception items (ICC above 0.8 [50]). For testing the moderating effect of *task conflict* on the relation between *cognitive diversity* and *information quality* (H1), we created an interaction variable, *cognitive diversity* × *task conflict*, by mean-centering indicator items before multiplication.

Control variables were operationalized as follows. *Group size* was measured based on the number of editors who had contributed to the article. *Article age* was measured by the number of days since the inception of the article. *Article activity* was extracted from the article's "History" tab and calculated as the number of revisions (i.e., edits) the article went through. *Article length* was measured by the number of words included on the article's wiki page.

## Results

### Descriptive Statistics

DESCRIPTIVE STATISTICS ARE OUTLINED IN TABLE 2. The average group included 49 active content contributors, where 15 percent of the contributors were administrators, 52 percent were regular members, and 33 percent contributed anonymously. Members made, on average, over 6,200 edits to Wikipedia articles. Cognitive diversity was,

Table 2. Descriptive Statistics

Construct/measure	Mean	Standard deviation
Group members' orientation		
Percent of administrators	0.15	0.113
Average of members' Wikipedia edits	6,217.1	5,204.2
Ratio of members' Wikipedia edits by article edits	3,552.9	3,084.8
Average of members' entropy in Wikipedia article edits	4.89	1.32
Cognitive diversity		
The sparsity of the editors to external articles matrix	0.92	0.077
Task conflict		
"Participants often have conflicting opinions about what should be included in the article"	2.1	1.24
"Participants frequently have disagreements about what information the article should include"	2.1	1.23
"There exists substantial conflict of ideas among participants"	2.0	1.12
Group size		
Number of unique editors who have contributed to the article	49.2	70.4
Article length		
Number of words in the article	901.6	825.2
Article age		
Days since the inception of the article	812.2	462.3
Article activity		
Number of edits made to the article since its inception	90.9	125.0
Information quality		
Raters' consensus on the quality of the article	4.4	1.16

on average, 0.92, reflecting the little overlap in members' activity outside the group. The average article was more than two years old, went through roughly 90 edits, and included close to 1,000 words. The discussion pages' average level of conflict was relatively low, and its variance was quite high. Finally, the quality of articles was moderately high: 4.4 out of 7.

## Path Model

Data analysis was conducted using the partial least squares (PLS) algorithm [38], which estimates multistage path models using composite variables from a number of indicator items. In this respect, variance-based PLS path modeling is similar to covariance-based structural equation modeling (SEM) because both algorithms estimate complex relations between several latent variables simultaneously. Compared to covariance-based SEM, PLS can be used with smaller samples, thus it is well suited for the current study. Furthermore, PLS requires fewer assumptions about data distributions and is robust in case these assumptions are violated [16], making it suitable for dealing with variables of nonnormal distribution (some of our variables exhibit power-law distribution).

The ordinal indicator items (*task conflict* and *information quality* perception items) were treated as interval scale variables, assuming that the underlying scale is continuous, but because of the lack of a sophisticated instrument, they could not be measured on an interval scale. The psychometric properties of the instrument were analyzed before examining the data for hypothesis testing. The estimate for composite reliability of the multi-item *task conflict* and *group members' orientation* constructs was 0.99 and 0.94, respectively, well above the recommended threshold of 0.8 [70], thus demonstrating good internal consistency. Convergent validity for all constructs was good. The average variance extracted (AVE) for *task conflict* and *group members' orientation* was 0.98 and 0.79, respectively, substantially greater than the suggested minimum of 0.5 [23], and item loadings were 0.80–0.99, greater than the suggested level of 0.7.

Discriminant validity was examined by comparing the square root of the AVE (RAVE) of a particular construct (presented in Table 3 on the diagonal) and the correlation between that construct and other latent constructs [24] (presented in the off-diagonal positions of Table 3), as well as based on item loadings. We found discriminant validity to be good. The constructs' RAVEs are 0.89 or higher, and the RAVE for every construct is higher than the correlation between that construct and all other constructs. The correlations between latent constructs did not exceed the recommended threshold of 0.5, with two exceptions related to the control variables. The correlation between two of the control variables—*group size* and *article activity*—was extremely high (0.98). Because of multilinearity concerns, we were not able to include both controls in the same model, and tested the model twice, alternating between *group size* and *article activity*. We also observed a relatively high correlation between *task conflict* and these two control variables (0.63 and 0.67); however, we do not perceive this as a risk to discriminant validity since the metrics for *group size* and *article activity* directly measure these constructs and *task conflict* was estimated from an alternative source. Item loadings on their corresponding constructs were all above 0.7, and those loadings were substantially higher than any cross-loadings on any other construct, thus further supporting discriminant and convergent validity.

Next, we tested the research model by specifying paths in the PLS structural model corresponding to the model's hypotheses. The significance of structural path estimates was computed using the bootstrapping resampling method (with 200 resamples; see Tenenhaus et al. [82]), and the structural model was evaluated based on both the  $R^2$  for each composite variable and the statistical significance of structural paths. All the independent variables were standardized. Figure 1 shows the results of the PLS analysis.

As shown in Figure 1, a substantial amount of variance in *information quality* was explained by our model ( $R^2 = 32$  percent). The effects of all paths but one were statistically significant. The results of the PLS analysis demonstrate that the interaction between *cognitive diversity* and *task conflict* was statistically significant (H1)<sup>13</sup>; *task conflict* had a direct negative effect on *information quality* (H2); and the presence of *group members' orientation* had direct negative effects on both *task conflict* (H3) and *information quality* (H4). The only control variable to have a significant (positive) effect on the outcome variable was *article length*. The only control path to have a significant

Table 3. Square Root of the AVE (on the Diagonal) and Correlation Between the Latent Constructs

Constructs	<i>CD</i>	<i>GMO</i>	<i>TC</i>	<i>TC</i> × <i>CD</i>	<i>GS</i>	<i>AL</i>	<i>AAg</i>	<i>AAc</i>	<i>IQ</i>
<i>Cognitive diversity (CD)</i>	1								
<i>Group members' orientation (GMO)</i>	-0.41	0.89							
<i>Task conflict (TC)</i>	0.49	-0.34	0.99						
<i>Task conflict</i> × <i>Cognitive diversity</i>	-0.48	0.14	0.38	0.99					
<i>Group size (GS)</i>	0.49	-0.31	0.63	0.32	1				
<i>Article length (AL)</i>	0.20	-0.15	0.44	0.27	0.48	1			
<i>Article age (AAg)</i>	0.37	0.15	0.30	0.08	0.47	0.18	1		
<i>Article activity (AAc)</i>	0.49	-0.33	0.67	0.35	0.98	0.50	0.44	1	
<i>Information quality (IQ)</i>	0.14	-0.30	0.24	0.26	0.45	0.36	0.15	0.46	1



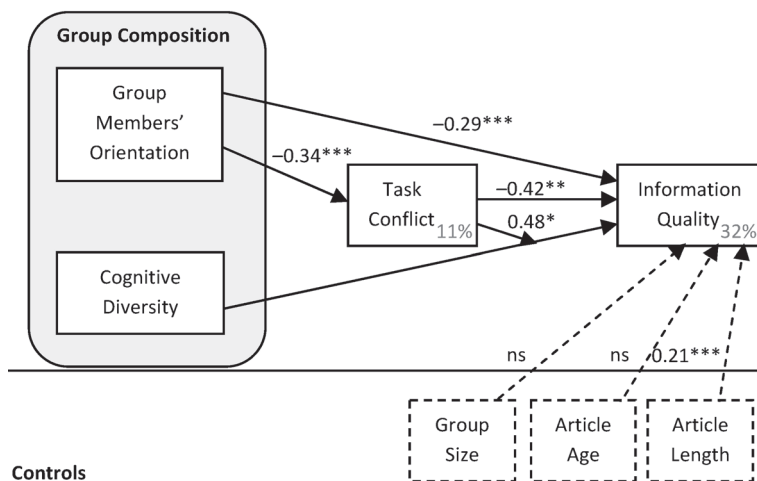


Figure 1. Results of PLS Analysis

Notes: Values on arrows represent path significance: \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; ns = nonsignificant.  $R^2$  percentages are in gray.

effect was from *group members' orientation to cognitive diversity*. The results when using *article activity* as a control instead of *group size* were indistinguishable.<sup>14</sup>

## Discussion

THE SUCCESS OF COMMUNITY-BASED PROJECTS has attracted significant attention in the research community [86], and Wikipedia has been investigated extensively in recent years [39, 88]. Yet many of the studies on Wikipedia success, and specifically its article quality, have been rather anecdotal [27, 79], and our understanding of the factors driving Wikipedia content quality is still limited. In the current study, we explored the relationships between groups' cognitive diversity, the conflict that arises during the collaborative authoring process, group members' orientation, and the quality of Wikipedia articles created by these groups.

The composition of Wikipedia has been described in previous studies, demonstrating that articles' editor groups are characterized by a composition of a few highly active members and many occasional editors that make a few contributions [39], similar to the core-periphery structure that characterizes online communities and OSS projects [19, 47, 59, 65]. However, it is not clear how the core-periphery composition affects collaborative work processes and group performance. We argue that the main limitation of research on group composition in community-based projects is the underspecification of the dimensions on which composition is analyzed. To address this gap, we investigate two dimensions of Wikipedia groups' composition: group members' orientation and diversity in members' knowledge.<sup>15</sup> We contribute to the literature of members' roles by formulating the constructs of group members' (administrative/content) orientation

and by proposing measures for this construct. Our model demonstrates three ways in which these group composition constructs, through their interaction with task conflict, impact the quality of the article produced by the group. First, the presence of administrative-oriented members enables the group to diffuse and restrain task conflict [11, 14, 79, 84]. Second, the inclusion of content-oriented members draws on their domain-specific expertise [4] and directly affects article quality. Third, the interaction between cognitive diversity and task conflict generates a creative abrasion [55] that positively affects information quality.

An important contribution of the current study is in documenting the effect of *cognitive diversity*—in interaction with *task conflict*—on *information quality*. Prior studies show that diversity of expertise and knowledge has the potential to enhance group performance [62], especially when the task is cognitively complex and requires multiple perspectives or entails creativity [3, 32], as is the case with Wikipedia's collaborative authoring. Moreover, in cases where groups are cognitively diverse, conflicts related to the task at hand can produce a creative abrasion that results in more innovative solutions [55, 63]. The results of our study show that task conflict moderates the effect of diversity (effect size = 0.48;  $p < 0.05$ ) such that when task conflict is low, cognitive diversity is detrimental, but when conflict is high, cognitive diversity has a positive effect on information quality. Our findings support earlier results of online groups [25, 94] and illustrate the value of creative abrasion in Wikipedia's collaborative authoring. This moderation effect is illustrated in Figure 2.

Task conflict, beyond its positive moderating effect, had a direct negative effect on information quality (effect size = 0.42;  $p < 0.01$ ). This main effect, in the presence of an interaction term, is interpreted as the effect of a given exogenous predictor when the moderator it interacts with is at its mean value [12]. Our findings can inform the organizational literature on group conflict and offer a possible explanation for the reported mixed effects of task conflict [18]. Note that while conflict has been discussed extensively in previous Wikipedia studies [14, 36, 43, 54, 71], to the best of our knowledge, this is the first study to demonstrate the relationships between cognitive diversity, task conflict, and article quality.

We also contribute to the growing body of literature on Wikipedia—and more broadly to the online communities' literature—by demonstrating how the presence of administrative-oriented members contributes to the quality of the information good the group produces. There is extensive literature describing the roles of administrators in Wikipedia [43, 46, 71] and other communities [15], and their contribution in terms of quality assurance, conflict resolution, and the development of procedures, but there is little evidence to show how these efforts impact product quality. Our study contributes to the field by demonstrating how the inclusion of administrative-oriented members helps to restrain task conflict (effect size = 0.34;  $p < 0.001$ ). It is interesting to note that this effect acts as a double-edged sword: on one hand, it limits the negative direct effect of task conflict on information quality, and on the other hand, it limits the potential for creative abrasion, thus restricting the potential value of cognitive diversity. This contrasts with the all-positive view of administrators in extant online communities literature [14, 15, 43, 46, 54, 71, 79].

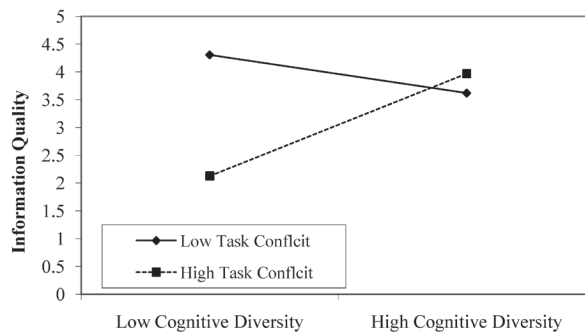


Figure 2. Task Conflict Moderates the Effect of Cognitive Diversity on Information Quality

A third contribution of the current study is in demonstrating the direct positive effect of a group's content orientation on the quality of Wikipedia articles (effect size = 0.29;  $p < 0.05$ ). Although this construct has not been investigated to date in the context of Wikipedia, results from the related areas of user innovation [85], OSS projects [47, 52], and online communities [1] show that occasional contributors are essential in the design process because they sometimes possess expertise that surpasses the skills of those in official roles. In Wikipedia, Anthony et al. [4] demonstrated that the anonymous contributions (likely by those who are drawn to the article's specific topic) are of higher quality in comparison to the contributions of registered members. To the best of our knowledge, ours is the first study to demonstrate this effect at the group level. Our findings regarding the direct effects of group members' orientation are of special importance, given that most extant research on online communities, in particular production communities, assumes that greater engagement leads to more successful projects, and thus focuses on the motivational factors driving participation and engagement [69, 72, 86]. Our findings reveal that this line of research provides only a partial explanation of the factors driving the success of online communities, and that the inclusion of occasional, content-oriented contributors (who are often less engaged and active) is essential to producing quality outputs. Another distinctive aspect of the current study is that it investigates performance at the group level; research on the motivations for participation in online communities focuses on individual performance, and the factors contributing to group outputs have been underinvestigated. The current study thus helps to fill this gap and explain how members' orientation affects group output.

## Conclusion

THIS STUDY CONTRIBUTES TO THE GROWING RESEARCH ON Wikipedia by developing and testing a framework for the determinants of the quality of group output. The study's primary contribution is in demonstrating the multiple effects of group composition. The presence of occasional editors contributes to the group, as these content-oriented contributors often possess domain-specific expertise. Administratively oriented

members, however, can help the group restrain and diffuse task conflict. Last, groups that contain members with diverse knowledge bases and experiences may benefit from the variety of opinions, especially in the presence of task conflict that promotes creative abrasion. Our contribution extends beyond the specific Wikipedia context: our formulation of the *group members' orientation* construct and the findings regarding its effects can inform research on online communities, and the formulation of the relationship between cognitive diversity and task conflict contributes to the research on group work.

In addition, our findings have two important implications for practice. First, our findings illustrate that it is difficult to compose groups for effective performance, since opposing ends along the group members' orientation continuum—administrative and content orientation—both play an important role, and it would be challenging to optimize the effects of these opposing forces. Organizers of online production communities should strive to reduce entry barriers in order to entice the participation of occasional content-oriented contributors (who may possess relevant expertise) and increase group diversity; at the same time, they should strive to include some administrative-oriented members, which would streamline the production process and help diffuse conflicts. A second important practical implication is for managing task conflict and providing conflict resolution tools. Communities should encourage task-related conflicts while providing the tools for preventing conflicts from escalating and the mechanisms to resolve conflicts. Some (e.g., [7]) have suggested that the success of Wikipedia can be attributed to the diversity of opinions and knowledge bases it attracts (i.e., “the wisdom of the crowd” argument); our findings suggest that Wikipedia's extensive conflict resolution mechanisms are responsible for unleashing the potential of this cognitive diversity. Another important aspect of Wikipedia's conflict management is in preventing task-related conflicts from escalating into destructive personal conflicts; the Wikipedia community has developed an extensive set of behavior norms for preventing such conflict intensifications. Finally, our data-driven proxies of group composition variables offer a practical way for practitioners to analyze the effects of group composition and determine optimal arrangements for their specific settings.

Our study provides preliminary results, and further research is warranted. The study concerns a large number of projects in one setting (i.e., Wikipedia). As such, it provides a useful context for the preliminary validation of our research model, as the setting controls for exogenous factors that might have interfered in an interorganizational study (e.g., differences in organizational culture and norms). We expect that our findings will generalize to other forms of community-based knowledge production projects beyond Wikipedia. However, it is possible that specific features of Wikipedia (both in terms of the social mechanisms and the underlying technological infrastructure) play a role in allowing the effects of group composition and task conflict (e.g., low entry barriers in Wikipedia may affect group composition). Hence, further research is warranted in order to test whether our findings hold in other types of online communities. Another way in which our study could be extended is in the operationalization and measurement of the outcome variable. We used university librarians as assessors; however, future studies may help validate our proposed model by using alternative

methods for estimating quality. In addition, we conceptualized information quality as a single construct; we suggest that future research explore specific information quality dimensions.

Finally, our data-driven research method constrained the types of constructs that could be investigated. The availability of comprehensive records of wiki-based collaboration allows us to analyze group members' actual ongoing behavior in its natural settings [39]. Still, the main limitations of this approach are that the measurement of constructs is restricted to available proxies and that other relevant factors that have not been recorded might be omitted. Alternatively, we could create groups in a laboratory experiment and test cause and effect relationships between relevant variables; however, it would be difficult to generalize these results to institutions such as Wikipedia. Thus, the proposed data-driven approach has advantages that—we believe—outweigh its limitations, and this approach has been valuable in the study of online communities [47]. That being said, we hope that future research would conduct more comprehensive investigation of the factors explaining the success of community-based projects, include additional relevant variables (e.g., members' personal characteristics, such as expertise and motivations), and use more direct measures of these constructs.

In conclusion, we believe that Wikipedia can serve as a test bed for studying decentralized information technology-enabled production of knowledge-based goods. Research on Wikipedia is in the early phases, and the success of Wikipedia-like projects remains to a large extent unexplained. This study extends our current understanding of online production communities by enhancing our knowledge of the role of relatively unexplored, yet important, factors—cognitive diversity, task conflict, and group members' orientation. We hope that this study will open the door to future research in the area.

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## NOTES

1. For a comprehensive list of Wikipedia-related academic papers, see Wikipedia's page on the topic, [http://en.wikipedia.org/wiki/Academic\\_studies\\_about\\_Wikipedia/](http://en.wikipedia.org/wiki/Academic_studies_about_Wikipedia/).

2. Findings from OSS studies show that, for example, in the Apache project, a small core of committed insiders (4 percent of the members of the project group) was responsible for 88 percent of the contributions [65] and provided the majority of answers to questions posted on the Apache Usenet help site [48]. Similarly, in Wikipedia, core members are responsible for most of the edits [39].

3. While extant organizational theory conceptualizes task conflict as a mediator of the relationship between cognitive diversity and group performances [32, 73], this conceptualization may not be suitable for our study of Wikipedia. Theories related to diversity and conflict were developed and tested in settings with a clear temporal sequence in the measurement of constructs: group members' knowledge is measured prior to beginning the specific task, conflict is analyzed during the work on the task, and group performance is assessed at completion. In addition, the group boundary is kept constant for the duration of the task. In the context of Wikipedia, however, such a temporal sequence could not easily be established. Wikipedia editor

groups work on articles over prolonged time periods, gradually developing articles' contents through an ongoing exchange of opinions, and members' knowledge is likely to evolve over this time. Moreover, over time, the group changes, new members join and others leave, and thus the group's cognitive diversity changes even if the knowledge base of each member was to remain constant. Hence, in our study of Wikipedia, we model the relation between cognitive diversity and task conflict as a moderation effect: the interaction between group members' diversity in knowledge base and the task-related conflict experienced when working on the article affects the quality of the article.

4. For more detail on Wikipedia's conflict resolution mechanisms, see [http://en.wikipedia.org/wiki/Wikipedia:Dispute\\_resolution/](http://en.wikipedia.org/wiki/Wikipedia:Dispute_resolution/).

5. For a list of Wikipedia top-level categories, see [http://en.wikipedia.org/wiki/List\\_of\\_overviews/](http://en.wikipedia.org/wiki/List_of_overviews/).

6. Our "culture, arts, and religion" class corresponds to the following Wikipedia categories: "Culture and the arts," "Religion and belief systems," and "Philosophy and thinking." Our "math, science, and technology" class corresponds to the following Wikipedia categories: "Mathematics and logic," "Natural and physical sciences," and "Technology and applied sciences." Our "society" class corresponds to the following Wikipedia categories: "Society and social sciences" and "Health and fitness."

7. The lower limit of 200 words excludes stubs, which represent roughly 30 percent of all Wikipedia articles. Very long articles are rare because Wikipedia's guidelines suggest that articles be concise, such that Wikipedia articles contain, on average, 460 words. Thus, the upper limit of 3,500 words on article length excludes only extremely lengthy outliers. For details on Wikipedia article length guidelines, see [http://en.wikipedia.org/wiki/Article\\_Length/](http://en.wikipedia.org/wiki/Article_Length/). For statistics on article length, see [13] and <http://stats.wikimedia.org/EN/TablesWikipediaEN.htm> and [http://en.wikipedia.org/wiki/Wikipedia:Size\\_comparisons/](http://en.wikipedia.org/wiki/Wikipedia:Size_comparisons/).

8. Each student was randomly assigned to analyze three articles. When analyzing an article, the students had to identify five alternative information sources that are relevant to the article's topic, and they were given clear guidelines on considering the authority of these alternative sources, distinguishing between academic sources, government and nonprofit organizations, media institutions, and corporate and personal publications (e.g., a personal Web page). The students compared the contents of the Wikipedia article to the alternative sources, and based on this analysis they prepared an extensive report that included ten pieces of evidence (either validating or invalidating the Wikipedia information), open-ended comments, and ratings of their perceptions of the article's quality. The students were instructed to consider factual accuracy, completeness of information, objectivity and biases, and representation (readability, clarity). To encourage diligent work, the students were marked on the sources they employed (credit was linked to the authority of sources) and the gravity of the evidence (detecting a factual error received more credit than detecting a typographical error). Initially, six students were assigned to each article. We only used reports from the students who consented to release their work for this study and utilized only articles with a minimum of three student reports. We later tested to make sure that the number of reports employed did not affect the article's quality score.

9. Modeling members' orientation as a formative construct was not appropriate in this case because of concerns related to content coverage, as well as multicollinearity and network effects [17].

10. Note that data on editors is based on how they chose to identify themselves, and data might be imprecise when an administrator chooses to edit articles while not registered or when a user contributes under multiple accounts.

11. Sparsity is often used in the analysis of online social networks to measure how connected the network is (see [92]). The network sparsity metric is analogous to our measure when we consider a pair of group members that have edited the same Wikipedia page as being connected.

12. In order to corroborate the perception measures, we investigated an alternative metric of task conflict. The assessors were instructed to analyze the discussion pages and highlight the words related to task conflict. We then counted the number of conflict-related words and calculated their percentage from the overall number of words in the discussion page. After verifying interrater agreement, we calculated assessors' average word-count percentage. We

found that the word-count metric highly correlates (0.73–0.78) with the perception measures. Furthermore, the pattern of effects remains unchanged when the word-count metric replaces the conflict perception measures, thus further validating our analysis.

13. In order to address the concern raised by Goodhue et al. [28] regarding the statistical power of interaction effects in PLS (as compared to using multiple regressions), we ran a regression analysis and found that the interaction effect (as well as all other hypothesized relations) was still significant in the regression model.

14. It is worth noting that when running the model without the control variables, all the hypotheses were supported and all the paths were statistically significant.

15. Note that the activity-based core-periphery structure is fundamentally different from the composition dimensions that we are interested in. Our group composition constructs are defined at the level of the institution (i.e., Wikipedia): group members' orientation and cognitive diversity were both based on editors' activity patterns across Wikipedia. The core-periphery structure, on the other hand, is defined at the project group level (see [6] for a discussion of the difference between project-level and organization-level core-periphery composition in Wikipedia).

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## Appendix: Procedure for Analyzing Task Conflict in Wikipedia Discussion Pages

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EACH ARTICLE'S DISCUSSION PAGE WAS ANALYZED, independently, by three research assistants, under the supervision of the authors. Assessors processed the documents in a random order.

Since the task at hand is the authoring of an encyclopedic entry, task-related conflicts are disagreements among contributors regarding the contents of the article being authored. The product of the authoring process should be an encyclopedic entry that is accurate, comprehensive, unbiased, and clear, and thus conflicts often relate to the accuracy, coverage, objectivity, and clarity of the article. Some examples of statements that contain evidence for task conflict are:

Jim was born in 1954 in Argentina, not in Belgium.

This information should be removed, as it is not directly related to the topic of the article.

Once an assessor completed reading the article's discussion page, the assessor rated his or her perception of conflict with respect to the following statements:

Participants often have conflicting opinions about what should be included in the article.

Participants frequently have disagreements about what information the article should include.

There exists substantial conflict of ideas among participants.

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