User Roles and Behaviors in Online Knowledge Collaboration within Study Groups: Postprint

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Abstract

[Purpose/Significance] This study investigates user roles and their behavioral and distributional characteristics in online knowledge collaboration within learning groups. The research will contribute to a deeper understanding of user role characteristics in online knowledge collaboration within learning groups, and help information service providers deliver more valuable services to users of different roles. [Method/Process] Using methods such as social network analysis and cluster analysis, 1,096 collaboration logs from an online learning collaboration platform for a certain course were analyzed. [Results/Conclusion] In online knowledge collaboration within learning groups, leaders play a leading and guiding role; substantive content providers focus on providing content, exist outside internal micro-collaboration, and rarely communicate with other users; managers/maintainers correct editing errors and disorderly behaviors of other roles in the collaboration and maintain relatively close connections with key users in the group; and social connectors do not play a significant role in communication and connection.

Full Text

User Roles and Behaviors in Learning Groups' Online Knowledge Collaboration

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Abstract

[Objective/Significance] This study explores user roles and their behavioral and distribution characteristics in learning groups' online knowledge collaboration. The research will help deepen understanding of user role features in such collaborative settings and assist information service providers in delivering

more valuable services to users with different roles. [**Method/Process**] Using social network analysis and cluster analysis methods, we analyzed 1,096 collaborative logs from an online learning collaboration platform for a course. [**Result/Conclusion**] In learning groups' online knowledge collaboration, leaders play a guiding and leading role; substantial content providers focus on content provision, engage in internal micro-collaboration but rarely communicate with other users; maintainers correct editing vulnerabilities and disorderly behaviors of other roles and maintain relatively close relationships with key users in the group; social connectors' communication and connection role is not particularly prominent.

Keywords: collaborative user role; learning group; online knowledge collaboration; user study; online community
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Introduction

Knowledge collaboration refers to the sharing, transfer, accumulation, transformation, and co-creation of knowledge among collaborative users. The process includes individual provision of knowledge content and the supplementation, reorganization, improvement, and integration of other users' knowledge contributions [1]. Forms of knowledge collaboration include open-source knowledge collaboration (e.g., Wikipedia), online Q&A communities (e.g., Zhihu, Quora), and learning group knowledge collaboration.

Learning group knowledge collaboration can be conducted both online and offline. Existing research shows that the process of online knowledge collaboration in learning groups helps encourage users to think deeply and summarize content before collaboration, thereby deepening their understanding of knowledge [2]. Good online knowledge collaboration can reduce users' anxiety and uncertainty about knowledge and information, enhance their sense of presence in the community, and improve collaboration efficiency [3-4]. Tools and platforms supporting learning group online knowledge collaboration include blogs, forums, and online learning collaboration platforms (also called learning collaboration wikis).

Currently, increasing research attention is being paid to the characteristics and functions of learning collaboration wikis [5]. Building upon general forums, learning collaboration wiki platforms integrate features of open-source knowledge collaboration, with strong user self-organization and high resource openness, which can promote the growth of collaborative users' cognitive levels and collaboration abilities [6]. Functionally, learning collaboration wikis have strong tolerance for collaborative editing, supporting different users to simultaneously browse, create, modify, and publish collaborative content on web pages, with some platforms also providing necessary instant communication tools for collaborative users.

Good knowledge collaboration among different users is crucial for the sustain-

able development of online communities. Knowledge collaboration not only benefits individual users but also enhances the overall value of online communities [7]. While there is existing research on knowledge collaboration both domestically and internationally, studies on user collaborative roles in learning group collaboration remain insufficient. Below, we review existing research on user collaborative behavior from two major perspectives: individual user behavior and social network collaboration.

Literature Review

2.1 Individual User Behavior The determination of online collaborative user roles begins with analyzing and categorizing individual user behavior [8]. A. Kim [9] studied user behaviors across different online communities and summarized the evolution of users from browsers to novices, regulars, leaders, and finally community elders. R. Kozinets [10] examined the relationship between users' interest in topics and their community roles, identifying tourists, socializers, devotees, and insiders—where tourists have only superficial interest in topics and few social connections; socializers have strong social connections but only superficial interest in topics; devotees have deep interest in topics but weak social connections; insiders have both deep interest and strong social connections. H. Welser et al. [11] categorized Wikipedia users into technical editors, vandalism fighters, and social connectors. R. Gazan [12] classified questioners in Q&A communities as information seekers and information slackers, and answerers as expert answerers and ordinary answerers [13]. J. Preece [14] divided user roles in group collaboration into mediators, professionals, lurkers, and other participants.

Some researchers believe that certain lurkers gradually develop strong attachment to online collaborative groups, which transforms them into participants [14-15]. Other studies categorize users based on different collaborative behaviors into topic initiators, topic discussants, question answerers, respondents, discussants, fans, troublemakers, trolls, and lurkers [8, 16-19].

Some research uses frequency of participation and magnitude of contribution as important bases for determining user roles. J. Fuller et al. [20] found through posting frequency that lurkers basically do not post but only passively observe others' speech, posters post regularly, and frequent posters post almost daily. S. Koch et al. [21], B. Nonnecke et al. [22], and O. Arazy et al. [23] all confirmed that in online collaborations such as open-source programming communities and wiki collaboration, a small portion of active users contributes most of the content. Y. Ye and K. Kishida [24] identified eight different user roles in open-source programming community collaboration: project leaders, core members, active developers, peripheral developers, bug fixers, bug reporters, browsers, and passive users. F. Viegas and M. Smith [25] found five user role types in online news communication communities: communication connectors, arguers, burst contributors, questioners, and novices. J. Chan et al. [26] discovered through research on posting and replying frequency and quality in online forums

that elites, supporters, silent ones, noise makers, initiators, active participants, conversationalists, and ignored ones exist.

A. Kittur et al. [27] found that elite editors' editing frequency in Wikipedia decreases over time. B. Alder et al. [28] argued that editors' reputation cannot be defined solely by editing frequency; the duration their edited content remains should also be considered. Z. Wang and P. Zhang [29] studied the Chinese online knowledge community Zhihu and found that technical editors and questioners ask more questions, answerers contribute more content and receive more likes, followers generally do not participate in discussions, and there is also role overlap in collaboration.

2.2 Social Network Collaboration Social networks can reveal direct and indirect connections among collaborative users, thereby revealing the social capital differences among different collaborative users in the network and positioning individual users' roles in the collaboration network [30]. Social Network Analysis (SNA) is often applied as an important analytical perspective and method in defining online collaborative user roles. Software tools supporting social network analysis include Ucinet, Pajek, Gephi, and NodeXL.

J. Hautz et al. [31] explored the social networks of users in an online innovation community and their collaborative relationships with other users, using the sources of comments accepted by users as in-links (in-degree), the paths of users commenting on other users as out-links (out-degree), and the number of posts by users as the degree of content contribution, defining eight user types in the collaboration network: motivators, attention-grabbing motivators, idea-generating motivators, attention-grabbers, idea-generating attention-grabbers, motivating and idea-generating attention-grabbers, idea generators, and passive users. These user types have some overlapping behaviors but play different roles in the social network.

J. Fuller et al. [32] used user log data from an online collaborative community, combining quantitative and qualitative methods such as social network analysis, cluster analysis, and content analysis to construct a network of collaborative user roles and contributions, identifying six types of collaborative users: socializers, idea generators, masters, efficient contributors, passive idea generators, and passive commenters, and summarized the different performances of different types of users in community contributions and collaborative interactions. S. Toral et al. [33] discovered the role of brokers in open-source programming communities through research on user collaboration networks—brokers connect expert-level developers and peripheral developers in collaboration, helping user collaboration in open-source programming communities proceed smoothly by sharing knowledge and transmitting information. R. Cross et al. [34] found central connectors, brokers, and peripheral users in virtual communities through research on social collaboration networks. R. Nolker and L. Zhou [35] constructed a user social collaboration network in an online knowledge-sharing community, used social network analysis to calculate user centrality in the collaboration

network, and introduced the TF-IDF (Term Frequency-Inverse Document Frequency) algorithm from information retrieval to calculate users' social capital, concluding that leaders, motivators, and chatters are the three core users in online knowledge-sharing communities. Additionally, D. Fisher et al. and T. Turner et al. both constructed user roles in the online news community Usenet from a social network perspective [16, 36].

2.3 User Roles and Behavioral Characteristics Summarizing the above research on defining user roles in online collaboration from the perspectives of individual user behavior and collaborative social network structure, we categorize collaborative users into five types: communication connector users, substantial content provider users, elite users, maintenance users, and peripheral users (Table 1).

Research Methods

This study uses social network analysis, log analysis, and cluster analysis to investigate user collaborative editing data recorded on the teaching platform. Specifically, based on log analysis, this study uses social network analysis methods to construct user collaboration networks and cluster analysis methods to construct a user collaborative role indicator system, thereby defining user roles in learning group collaboration.

3.1 Data Collection The data for this study comes from user collaborative editing logs recorded on the Peking University Teaching Network online wiki learning collaboration platform (http://courses.pku.edu.cn/). Researchers collected data from each group's online wiki collaboration, including wiki version records, editor IDs, editing times, and editing content. The platform records editing content in six forms. Table 2 shows the number of collaborative revision versions and the number of collaborative users for different topics. As shown in the table, this study collected 36 wiki collaboration outcomes and 1,096 wiki version comparisons, with an average of 31 wiki collaboration versions generated per group per topic. A total of 61 users participated in the collaboration, with groups G1, G5, and G6 each having 9 collaborative users, G2 having 12, and G3 and G4 each having 11. Users were represented by codes in the form of letters plus numbers (e.g., A1), and the combination of user code, group code, and topic code (e.g., B1:G2:S1) specifically refers to a user in a particular group's collaboration on a particular topic (in this example, user B1 in group G2 for topic S1). The combination of group code and topic code (e.g., G1:S1) specifically refers to a collaborative group in a particular topic (in this example, group G1 for topic S1).

The course had a total enrollment of 61 students, who were divided into six groups (G1, G2, G3, G4, G5, G6) based on personal preference and enrollment status, with 9-12 participants per group. Each unit of the course consisted of three parts: professor lectures, group discussions, and group online wiki collabo-

rative editing. After two weeks of instruction, the professor assigned a wiki entry on a specific topic for each learning group to collaborate on. The collaboration method involved each participant submitting discussion outlines related to the topic and conducting 0.5-1.5 hours of offline group discussion, followed by two weeks of online wiki collaboration and publishing the collaborative results on the Peking University Teaching Network. During one semester, each learning group conducted group collaboration on six topics, represented chronologically from S1 to S6: S1 was "Information," S2 was "Information Retrieval Evaluation," S3 was "Metadata," S4 was "Organizing Network Information Resources Using Taxonomy," S5 was "Application of Natural Language Processing in Information Organization," and S6 was "Network Information Resource Organization."

3.2 Data Analysis

3.2.1 Construction of Collaboration Networks Collaborative users' social network behaviors are based on social network analysis. To analyze user collaborative behaviors in learning group collaboration, this study introduces social network analysis methods, which explore node attribute characteristics and network structure characteristics through analysis of relationships among nodes in collaboration networks [37].

In this study, a collaboration network is constructed for each learning group's collaboration on a topic, with nodes representing each user participating in that topic's collaboration. The wiki for the same collaborative topic is divided into several sections, and users who co-edited content under the same section generate a directed edge between their nodes, with the direction from the actively editing user node to the edited user node. The number of times two users co-edit is the weight of the edge between these two user nodes.

This study uses five social network indicators: out-degree, in-degree, betweenness centrality, eigenvector centrality, and clustering coefficient. Out-degree refers to the number of times a user co-edits other users' content; in-degree refers to the number of times other users co-edit a user's content. Out-degree and in-degree together reflect the number of neighbor nodes of a node. Betweenness centrality refers to the number of shortest paths passing through a node, reflecting its importance. Eigenvector centrality refers to the importance of a node's neighbor nodes, reflecting the quality of a node's neighbors and indirectly reflecting the quality of the node itself. Clustering coefficient refers to a node's ability to gather other nodes around it; users with higher clustering coefficients may have more users gathered around them.

This study uses the social network analysis tool NodeXL to construct the above user collaboration networks and calculate these social network analysis indicators.

3.2.2 Collaborative Role Indicator System This study defines user collaborative roles from two dimensions: individual behavior and social network

behavior. As shown in Table 3 , individual behavior dimension indicators include: editing count, which refers to a user's total number of edits in a topic's wiki collaboration; and initial editing percentage, which refers to the number of times a user makes the first edit in various sub-sections of a topic divided by the total number of edits in that group for that topic. Editing count and initial editing percentage reflect the degree of individual content contribution and innovation ability.

Social network indicators include out-degree and in-degree, which reflect the number of neighbor nodes of a user. Out-degree reflects how frequently a user modifies other users' edits—the larger the out-degree, the more frequently the user modifies others' edits. In-degree reflects how frequently other users modify a user's edits—the larger the in-degree, the more frequently the user's edits are modified by others. Betweenness centrality reflects user importance—the larger the betweenness centrality, the more shortest path resources to other user nodes the user controls, and the more important the user is in the network. Eigenvector centrality reflects whether a user is connected to many important users—the larger the eigenvector centrality, the more important users the user is connected to, and the higher the node quality. Clustering coefficient reflects user leadership ability—the larger the clustering coefficient, the more users gathered around a user node, the closer the relationships with other users, or the more popular the collaborative organization, and the stronger the leadership ability.

3.2.3 Collaborative Role Clustering Method This study uses the K-Means clustering method with SPSS data analysis tools to cluster users based on collaborative role indicators. For clustering units, this study uses a learning group's collaborative behavior across six topics as the unit, so each node's collaborative role indicators reflect a learning group user's collaborative behavior on one topic. The determination of collaborative role types is primarily based on literature review, which finds that all online community collaborations can basically be encompassed by these five types.

Additionally, when conducting cluster analysis, besides K=5, this study also tried K values from 3 to 8, proving that when K=5, the role clustering effect is the best.

The reason for choosing K-Means clustering is that this study's sample size is greater than 30, all indicators can be expressed through numerical data, and through literature review, user roles can be preliminarily divided into five categories (i.e., K=5), which meets the data requirements and methodological requirements of K-Means clustering. Therefore, using the K-Means clustering method is the most effective and appropriate.

Considering objective differences between groups, this study first conducts cluster analysis on each group's user role indicators separately, then summarizes the characteristics of each group's indicators, and finally presents the overall distribution of user role types.

Research Results

4.1 Collaborative Role Clustering Results After clustering user collaborative role indicators across six topics for each learning group, we obtained the role cluster numbers for each user in each group across the six topics. The K-Means clustering results show that G1, G2, G3, G5, and G6 had good clustering effects for five role types. In G4 and G6, the fourth role type only had 1 person, which is not suitable as a role type. Therefore, after observing the indicators of these users, they were assigned to more appropriate role types. Consequently, only four collaborative role types appeared in G4 and G6, while G1, G2, G3, and G5 contained all five collaborative role types.

A user can only have one role classification in one topic, but may hold different collaborative role types across different topics. Table 4 shows the number of role types each user held across the six topics, grouped by group. It can be found that among all 61 users, 1 user (1.6%) held all five collaborative roles across the six topics, 6 users (9.8%) held four collaborative roles, 14 users (23.0%) held three different roles, 20 users (32.8%) held two different collaborative roles—meaning over 67% of users held more than one role; and 20 users (32.8%) held the same collaborative role across all six topics.

The significance test results of K-Means clustering are shown in Table 5 .

4.2 Characteristics of Collaborative Roles Based on clustering results and the distribution characteristics of collaborative role indicators, there are five collaborative roles in learning group collaboration: leaders, social connectors, substantial content providers, maintainers, and peripheral users. Peripheral users are further divided into primary, medium, and extreme peripheral users based on their degree of marginality.

Overall, peripheral users account for the highest proportion in all learning groups (average 71%). Among them, peripheral users in G1 and G6 account for over 60% of total collaborative person-times, those in G2, G3, and G5 account for over 70%, and those in G4 account for over 80%. Among peripheral users in each group, extreme peripheral users account for the highest proportion.

Table 6 shows the distribution and proportion of user collaborative roles. Social connectors account for 10.9% of total collaborative person-times. Substantial content providers account for 7.5% of total collaborative person-times. Leaders account for 6.5% of total collaborative person-times. Maintainers have the lowest proportion (4.1%) in total collaborative person-times. In G1, substantial content providers (16.7%) and social connectors (14.8%) have relatively high proportions; in G2 and G3, social connectors (9.7% and 13.6%) have relatively high proportions; in G4, leaders and social connectors each account for 7.6% of the group's total collaborative person-times; in G5, maintainers have a prominent proportion (13.0%); in G6, leaders (11.1%) and social connectors (16.7%) have relatively high proportions.

Table 7 summarizes the behavioral characteristics and indicator features of each collaborative role. Based on collaborative role indicators, this study plotted radar charts of user collaborative role indicator distribution for each group in each topic. The following sections provide specific analysis of the five collaborative roles combined with cases.

4.2.1 Leaders As shown in Figure 1 [Figure 1: see original paper], users in the leader role have relatively high values across all major user role indicators including editing count, initial editing percentage, in-degree, out-degree, betweenness centrality, eigenvector centrality, and clustering coefficient. Figure 1 lists two typical leader roles: A1:G1:S2 and D3:G4:S2.

Leaders generally control core knowledge information resources and human resources in the group, with relatively high collaboration frequency and innovation willingness, and maintain frequent contact with high-quality users. They actively gather many users of various role types around them and perform actively in group collaboration. Leaders do not exist in every collaboration cycle—approximately 60% of the 36 collaboration cycles across 6 groups and 6 topics had leaders present.

4.2.2 Social Connectors As shown in Figure 2 [Figure 2: see original paper], users in the social connector role have very high betweenness centrality and in-degree, while other indicators show uneven fluctuations. Figure 2 lists two typical social connector roles: C4:G3:S6 and D1:G4:S6.

Social connectors have connections with various types of users and play a bridging and linking role in communication among different users in group collaboration. Most social connectors' collaborative behaviors are concentrated in the negotiation and integration stage. In the 36 collaboration cycles across 6 groups and 6 topics, social connectors appeared in approximately 65% of cycles.

4.2.3 Substantial Content Providers As shown in Figure 3 [Figure 3: see original paper], substantial content provider roles have high values for editing count and initial editing percentage, but generally low betweenness centrality. Figure 3 lists two typical substantial content provider roles: C2:G3:S5 and E7:G5:S1.

Substantial content providers make outstanding content contributions to learning group collaboration, with high editing frequency and innovation willingness. They actively participate in the collaborative process of searching, sorting, screening, integrating, and arranging information and viewpoints, and assist leaders in making final decisions through consensus formation. However, substantial content providers rarely communicate and cooperate with other users, having limited influence on other role types compared to leaders. Substantial content providers do not exist in all collaborations—approximately 50% of the 36 collaboration cycles had substantial content providers present.

4.2.4 Maintainers As shown in Figure 4 [Figure 4: see original paper], users in the maintainer role have high editing counts and out-degree, relatively high eigenvector centrality, and average performance on other indicators. Figure 4 lists two typical maintainer roles: A2:G1:S2 and C1:G3:S3.

Maintainers primarily correct content vulnerabilities in collaboration and mediate disorderly behaviors. Due to their functional characteristics, maintainers generally maintain relatively close relationships with key users in the group and have some influence on other users. In the 36 collaboration cycles across 6 groups and 6 topics, maintainers appeared in only 22% of cycles.

4.2.5 Peripheral Users As shown in Figure 5 [Figure 5: see original paper], peripheral user roles rarely participate in the collaborative process, rarely generate connections with other users, and have generally low user indicators. Peripheral users are further divided into primary peripheral users, medium peripheral users, and extreme peripheral users. The left radar chart in Figure 5 shows primary peripheral user E3:G5:S2, whose indicator values are moderately low; the middle radar chart shows medium peripheral user A6:G1:S4, whose most indicator values are very low; the right radar chart shows extreme peripheral user F7:G6:S3, whose all indicator values are very low. Peripheral users' collaborative behaviors mostly remain superficial and are cursory.

Conclusion, Discussion, and Outlook

5.1 Research Conclusions Five types of users exist in learning groups' online knowledge collaboration: leaders, social connectors, substantial content editors, maintainers, and peripheral users. Each user's role is not fixed—over 67% of users held different collaborative roles across different collaborative topics.

Ranked by role distribution quantity, peripheral users account for 71% of total collaborative users, appearing in 100% of collaborative cycles; social connectors account for 10.9% of total collaborative users, appearing in approximately 65% of collaborative cycles; substantial content providers account for 7.5% of total collaborative users, appearing in approximately 50% of collaborative cycles; leaders account for 6.5% of total collaborative users, appearing in approximately 60% of collaborative cycles; maintainers account for 4.1% of total collaborative users, appearing in approximately 22% of collaborative cycles.

Leaders control core knowledge information resources and human resources in the group, perform actively in group collaboration, and play roles in leading topic direction, controlling collaboration rhythm, promoting consensus formation, and producing decisions, with relatively high collaboration frequency, persistence, and innovation willingness. Substantial content providers have high editing frequency and innovation willingness, rarely communicate with users of other roles, actively participate in searching, sorting, screening, integrating, and arranging information and viewpoints, and assist leaders in making final decisions through consensus formation on content. Maintainers correct content vul-

nerabilities in collaboration, mediate disorderly behaviors, generally maintain relatively close relationships with key users in the group, have some influence on other users, and assume partial leadership responsibilities in collaboration cycles without leaders, maintaining collaboration order and guiding topic direction.

Social connectors have limited influence in collaboration, and their collaborative behaviors lack persistence compared to leaders, substantial content providers, and maintainers, with collaborative behaviors often concentrated in time. Peripheral user roles have strong randomness in the timing of their collaborative behaviors, are cursory, and play no observable role in collaboration.

5.2 Discussion and Implications From the perspective of the leader role, leaders in learning groups' online knowledge collaboration replace the elite users in previous online community collaboration research [26]. Unlike elite users who rarely maintain extensive outward social connections [27], leaders tend to actively maintain outward connections and actively promote group collaboration negotiation and decision-making processes.

From the maintainer role perspective, the characteristics presented by this role in this study are basically consistent with existing research. What needs to be added is that in collaboration processes where leaders are absent, maintainers often step forward to assume part of the responsibility for guiding topic direction and promoting negotiation processes, rather than merely being "technical editors" [11, 29].

From the substantial content provider role perspective, previous research shows that substantial content providers are mainly responsible for providing information and knowledge related to content, with very few social behaviors unrelated to content contribution [11]. However, this study finds that micro-collaboration often occurs among users who are all substantial content providers, indicating that substantial content providers in learning group collaboration are not "silent" as previously described. Substantial content providers in learning groups often have micro-collaboration among themselves. From the perspective of ensuring collaboration quality, content editing in learning group collaboration requires strong structural and professional foundations, requiring several substantial content providers to coordinate division of labor among themselves. From the users' perspective, substantial content providers in learning groups have similar knowledge backgrounds, providing the prerequisite for communication.

From the social connector role perspective, communication connector users in previous research were active and influential in online community collaboration [32], but social connectors in learning group collaboration have lower behavioral persistence, only completing social or communication tasks without paying attention to communication outcomes. It can be found that in learning groups' online knowledge collaboration, the function of social connectors is weakened, while the roles of substantial content providers and maintainers are significantly enhanced. Most online knowledge collaboration still occurs stably among collab-

orative users without social relationships [1], possibly because learning groups have strong knowledge collaboration attributes, with completing topic collaboration tasks as the final goal, making the structure stronger, and users' need for social functions relatively secondary.

From the peripheral user role perspective, this study distinguishes three types of peripheral users with different degrees of marginality (primary, medium, and extreme) and finds that extreme peripheral users account for the highest proportion among all peripheral users [16-17]. Therefore, maintaining knowledge vulnerabilities and order disorders caused by numerous peripheral users has become an important work content for the maintainer role in learning group collaboration.

Finally, user roles in learning groups are not fixed but frequently change. Unlike previous research [18-19], over 67% of users in this study changed their collaborative roles during different topic collaborations in learning groups. Possible explanations are: first, each user is good at different topics and adjusts their positioning according to their proficiency; second, users in learning group collaboration tend to learn different skills or understand different knowledge by purposefully trying to assume different collaborative responsibilities; third, in collaboration cycles with leaders, leaders tend to use their decision-making power to directly assign different collaborative tasks to users.

5.3 Limitations and Outlook In this study's research design, the data mainly comes from log data of the online wiki learning collaboration platform, which cannot encompass all collaborative behaviors of learning groups, potentially leading to incomplete analysis of learning group collaborative behaviors. Future research should combine online and offline collaborative behaviors of learning groups to enhance data richness and interpretability, further explore the causes of user collaborative roles and differences in collaboration effectiveness under different collaboration modes, and attempt to find possible complex relationships between collaboration stage characteristics of different collaboration modes and collaborative roles.

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Author Contributions

Wang Zhe: Responsible for data collection, data analysis, and initial draft writing;
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Note: Figure translations are in progress. See original paper for figures.