Postprint: User Interaction Behavior Characteristics in Virtual Academic Communities: A Conversation Analysis Perspective

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Abstract

[Purpose/Significance] This study investigates the characteristics of user interaction behaviors in virtual academic communities, providing references for the construction of community knowledge services and platform management. [Method/Process] Grounded in conversation analysis theory, this research integrates content analysis, LDA topic modeling, and social network analysis methods to analyze the community' s information interaction types, interaction topic characteristics, and topological features of user interaction networks, revealing user interaction characteristics in virtual academic communities from two dimensions: conversational interaction content and conversational interaction relationships. [Results/Conclusion] The findings indicate an imbalance between demand and supply of user interaction content in virtual academic communities, with a dispersed structure of user interaction topics; factual information, opinions, and suggestions constitute the main types of interactive information; user interaction networks in virtual academic communities exhibit small-world effects, yet the overall network structure remains relatively dispersed and lacks highly influential users; strategies to promote user interaction in virtual academic communities are proposed, including ensuring effective information supply, innovating community academic knowledge services, and improving the design of community interaction functions.

Full Text

A Study on User Interaction Characteristics in Virtual Academic Communities from the Perspective of Conversation Analysis

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Abstract: [**Purpose/Significance**] This study explores the characteristics of user interaction behaviors in virtual academic communities to provide references for community knowledge service construction and platform management. [**Method/Process**] Based on conversation analysis theory, we employed content analysis, LDA topic modeling, and social network analysis to examine information interaction types, interaction theme characteristics, and the topological features of user interaction networks. This approach reveals user interaction characteristics from two dimensions: conversational content and interaction relationships. [**Results/Conclusion**] The findings indicate an imbalance between demand and supply in virtual academic community user interaction content, with decentralized interaction theme structures. Factual information, opinions, and suggestions constitute the primary types of interactive information. The user interaction network exhibits small-world effects but remains relatively decentralized overall, lacking highly influential users. The study proposes strategies to promote user interaction, including ensuring effective information supply, innovating community academic knowledge services, and improving community interaction function design.

Keywords: virtual academic community; user interaction behavior; conversation analysis; content analysis; social network analysis

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As an important component of academic communication, informal academic exchange complements formal academic communication and serves as a crucial pathway for knowledge diffusion and a significant source of knowledge innovation [1]. Traditional informal academic exchange is constrained by space and time, suffering from limitations such as limited influence scope, difficulty in information storage, and inconvenience in processing and utilization. With the rapid development of information technology and the popularization of Web 2.0, virtual academic communities have opened new channels for researchers' informal communication, allowing users to obtain and share information online. These platforms effectively compensate for the deficiencies of formal academic exchange, demonstrating characteristics such as diversified user participation, open communication processes, dynamic information exchange networks, and convenient information storage and processing [2].

Virtual academic communities have transformed how professional researchers access information and conduct scientific work. Current representative platforms include foreign sites such as ResearchGate, Mendeley, Academia.edu, and CiteULike, as well as domestic platforms like ScienceNet, Xiaomuchong, and Jingguanzhijia. Despite years of development, the academic atmosphere in these communities remains less than ideal, with unresolved questions about how to attract users and promote academic interaction. Virtual academic communities are online social media platforms where people search for and share academic

information [3], and their development relies not only on communication and network technology support but also on high levels of user interaction and sustained communication. In practice, increasing user adoption and promoting academic information exchange through various promotional and incentive measures constitutes core business for virtual academic communities. Therefore, analyzing user interaction behavior characteristics can help understand patterns of community utilization, providing practical guidance for management strategies and service promotion, thereby enhancing information exchange effectiveness. However, previous research on virtual academic community user interaction characteristics has primarily involved descriptive summaries and inductions, lacking comprehensive revelation from a sociological perspective based on behavioral data generated during user interactions. To address this gap, this study examines the Xiaomuchong Academic Forum' s Condensed Matter Physics section, employing conversation analysis theory to reveal the social order and patterns behind user interaction behaviors through analyses of both interaction content and interaction networks.

2 Related Research

2.1 Virtual Community User Interaction Behavior Research

In new media environments, virtual communities in different contexts possess unique characteristics that determine distinct user interaction patterns. Some communities focus on information sharing, while others emphasize consultation to seek social and emotional support, with these behavioral differences significantly affecting members' information sharing and dissemination effectiveness as well as information quality and credibility [4]. S. Nepal et al. [5] argue that identifying user interaction patterns can help community managers better implement personalized recommendation functions and optimize platform models and operational strategies to enhance user stickiness and maintain community vitality. Current research on various virtual communities primarily concentrates on information interaction patterns, interaction network characteristics, and relationships between network position and user interaction behavior.

First, regarding information interaction patterns, scholars have explored patterns across different communities and user groups. W. Jeng et al. [6] found both similarities and differences in information interaction patterns among scholars from social sciences, humanities, and natural sciences on academic Q&A websites. Wang Hai et al. [7] analyzed interaction processes in software development Q&A sites, summarizing seven types of software development problems, eight elements, and ten interaction modes. Second, concerning interaction network characteristics, M. W. Barbosa et al. [8] explored macro and micro topological properties, interaction patterns, and evolution rules in distance education online forums, identifying dynamic evolution characteristics of accounting students' interaction behaviors over time. Hu Zhe et al. [9] discovered small-world effects in online health community user interaction networks during emergency situations. Third, regarding network position and interaction behavior relationships,

Wu Jiang et al. [10] found that core members' behaviors in online medical communities significantly influence other users' interaction behaviors. Chen Yuan et al. [11] examined users' social network positions in different periods on a sharing economy platform using two-mode complex network analysis, constructing a fixed-effects model to observe how individual participation activity affects others' and their own behaviors.

2.2 Virtual Academic Community Information Behavior Research

Research on user information behavior in virtual academic communities helps platform developers and decision-making institutions understand behavioral patterns to optimize academic community platforms. Existing research primarily focuses on user participation behavior, information exchange behavior, and knowledge sharing behavior. First, user participation behavior includes social interactions such as browsing, commenting, replying, and creating, as well as information sharing behaviors like uploading literature and project data [12]. User participation constitutes the internal driving force for virtual academic community development. Foreign scholars have extensively investigated motivations and participation patterns on platforms like ResearchGate, Mendeley, and Google Scholar [13], while domestic research has focused on academic blogs [14] and virtual academic groups [15]. Second, information exchange behavior refers to comprehensive activities of information dissemination and feedback acceptance through various channels [16]. To understand informal academic exchange patterns, scholars have studied multiple academic social networks, including academic organization communities [17], academic WeChat [18], and academic social networking sites [19]. Third, knowledge sharing behavior in virtual academic communities—where users share explicit or tacit knowledge with others [20]—represents a core value of these platforms. Research on knowledge sharing processes, influencing factors, promotion strategies, and implementation mechanisms has drawn attention from scholars employing theoretical perspectives such as social capital theory [21], social exchange theory [22], and social cognitive theory [23].

In summary, while research on user interaction behavior in new media environments is gradually increasing, existing studies on virtual academic communities have concentrated on information exchange patterns, influencing factors, surface characteristics of usage behavior, and knowledge sharing behavior, with relatively few sociological examinations of user interaction characteristics. Building upon these research gaps, this study investigates user participation behavior from conversation analysis perspective, examining both interaction content and relationships to reveal characteristics and provide recommendations for community system construction and service improvement.

3 Analysis of Virtual Academic Community User Interaction Behavior Based on Conversation Analysis Theory

3.1 Virtual Academic Community User Interaction Behavior

Interaction behavior refers to communication between two or more individuals in a given context [24]. This study examines virtual academic community user interaction behavior—also called user information interaction behavior—defined as communication where users exchange information with others around a specific topic in a virtual academic community setting, manifested as conversational interactions through posting and commenting. User interactions can be categorized as communication exchange and collaborative sharing, corresponding to information exchange and knowledge sharing behaviors [25]. Unlike general virtual communities, virtual academic communities primarily serve research users, aiming to provide platforms for knowledge exchange and academic interaction. Their unique positioning endows user interaction behaviors with particular characteristics in both content and relationship dimensions. On one hand, virtual academic communities feature distinct disciplinary themes, where users with similar professional backgrounds often employ domain-specific terminology. Beyond academic topics, users engage in broader informal information exchange, making interaction content distinctive. On the other hand, virtual academic community users are highly educated and typically do not know each other offline, united by common research interests and needs. Their communication aims to solve specific research problems or enhance research capabilities, making interaction relationships unique. Therefore, further exploration of these characteristics is necessary.

3.2 Conversation Analysis Theory

Conversation analysis theory, born in the United States in the 1960s, is a sociological research approach that reveals the internal organizational structure of human discourse communication by observing naturally occurring conversations, summarizing patterns and regularities in human verbal communication, and uncovering the social order behind these patterns [26]. Unlike linguistic analyses focusing on grammar, discourse, turn-taking, and topic structures, conversation analysis primarily explores interaction characteristics between conversational parties and how participants control and regulate discussed topics. While traditional conversation analysis focused on face-to-face communication, research on online interaction has increased with information technology development. Scholars have applied conversation analysis theory to examine public welfare Weibo discourse structures [27] and WeChat group interactions [28], though few studies have interpreted virtual academic community user interaction behaviors from this sociological perspective.

Conversation analysis perspective emphasizes that examining content features through conversational content analysis and network structure features through conversational relationship analysis is key to exploring internal social structures

[28]. Combining content and relationship analysis helps comprehensively reveal social patterns and behavioral regularities. Each conversation sample in virtual academic communities represents not simple text input but real conversations in cyberspace, where real-world norms inevitably permeate and manifest. Conversation analysis theory posits that social order exists behind human discourse communication [29], and revealing this order helps analyze user interaction characteristics. Additionally, conversation analysis emphasizes unmotivated observation of natural data, employing bottom-up induction based on authentic materials rather than top-down deduction from theoretical assumptions [26]. This approach avoids preconceived research assumptions, yielding objective findings.

3.3 User Interaction Characteristics in Virtual Academic Communities from Conversation Analysis Perspective

Features are representative, symbolic, easily identifiable markers that distinguish phenomena. Different virtual communities exhibit distinct user interaction patterns and characteristics, and identifying these features benefits community development [9]. Current research on user interaction characteristics primarily examines interaction content and networks. Content analysis focuses on frequency and proportion of different interaction types, helping qualitatively identify interaction patterns. Social network analysis explores overall network structure and individual positions, enabling quantitative measurement of interaction quality. Combining these methods provides comprehensive characterization [30]. Given the uniqueness of virtual academic community positioning and user groups, their interaction behaviors exhibit particularities in both content and relationship dimensions. Drawing on relevant research, this study defines virtual academic community user interaction characteristics as features distinguishing them from general communities—abstract generalizations reflecting content-level and relationship-level features that capture the essence of these behaviors. These include content features (information distribution and thematic characteristics) and network features (overall and individual characteristics), corresponding to conversation analysis' s two dimensions: conversational content analysis and conversational relationship analysis.

4 Research Design

4.1 Data Collection and Preprocessing

Xiaomuchong Academic Research Interactive Community is currently one of China' s largest academic research websites, where users participate in knowledge exchange and academic interaction through searching, browsing, posting, and replying, primarily comprising researchers and graduate students. This study selected interaction conversations from the discipline-specific "Condensed Matter Physics" section as the data source. Forum topics are called posts, categorized as root posts (initiating new topics) and reply posts (responding to root posts). A Python-based web crawler collected all data from the "Condensed Matter Physics" section from August 20, 2009, to May 25, 2019. The

original dataset contained 14,581 posts, including 2,252 root posts and 12,329 reply posts. Key information included root post titles, content, posting times, usernames, reply content, reply times, and reply usernames. During preprocessing, posts with blocked content, duplicates, meaningless information, or missing data were removed, yielding 2,091 root posts and 10,425 reply posts.

4.2 Research Methods

Research indicates that employing mixed methods and multiple analytical approaches from both content and relationship dimensions facilitates deeper understanding of community member interactions [4, 31-33]. Therefore, this study combined content analysis, topic analysis, and social network analysis. Before data analysis, preprocessing involved using the Chinese word segmentation component jieba to extract keywords and annotate parts of speech based on domain dictionaries. From the content dimension, we analyzed user-generated content using interaction process coding frameworks from existing literature and conducted topic analysis using the LDA topic model in gensim. From the relationship dimension, we performed social network analysis and visualization of forum member relationships, using Gephi to calculate network density, average path length, clustering coefficients, and centrality measures. The research process is shown in Figure 1 [Figure 1: see original paper].

Content analysis first required sample extraction following these principles: (1) sample size comparable to existing literature for manual coding feasibility; (2) inclusion of both large conversations with many posts and small ones with few posts; (3) random sample selection. Ultimately, 113 root posts and 471 reply posts were selected as the content analysis sample, with individual posts as the analysis unit. Preliminary analysis revealed that user interaction purposes primarily included solving specific academic or learning problems, seeking academic resources (literature, books, course materials), networking resources, and expressing personal emotions like stress or gratitude. Using inductive methods, we developed coding indicators for task information interactions, dividing them into 12 categories: providing or requesting suggestions, opinions, factual information, personal experiences, recommendations, and networking resources. Using deductive methods, we developed coding for emotional interactions based on psychologist A.R. Plutchik' s emotion wheel theory [34], which categorizes emotions into eight basic types: joy/sadness, anger/fear, trust/disgust, surprise/anticipation. Since virtual academic community users rarely express intense emotions like surprise or hatred, we selected two opposing emotional categories based on textual orientation: friendly/unity and unfriendly/hostility. Drawing on R.F. Bales' interaction process coding framework [35] and Wang Xuefen et al.' s forum interaction analysis framework [4], we developed a virtual academic community user interaction process coding scheme comprising two major categories—task information and social-emotional—subdivided into 14 subcategories, as shown in Table 1 .

To ensure coding validity, two coders received training on coding rules and

standards, working independently. Inter-coder reliability was assessed using Cohen' s kappa coefficient, yielding a value of 0.872 (>0.75), indicating good reliability. Disagreements were resolved through discussion with a third coder until consensus was reached.

A meaning unit is an independent unit expressing complete ideas [36]. For this study, when multiple similar meaning units appeared in the same post, they were counted only once. Based on coding results, we identified 664 meaning units across the sample, with statistical results shown in Figure 2 [Figure 2: see original paper].

5 Results and Discussion

5.1 Analysis of Virtual Academic Community User Interaction Content Characteristics

5.1.1 Interaction Process Analysis Results show that users primarily initiate conversations to request factual information (31.25%), request opinions (16.88%), request recommendations (15.00%), and request suggestions (11.25%). While requesting task information, conversation initiators also share information, mainly providing factual information (5.63%), personal experiences (10.63%), and networking resources (1.88%). In reply posts, the most frequent meaning units are expressing opinions (17.15%), providing factual information (15.69%), and providing suggestions (7.74%), followed by providing relevant resources (6.28%), personal experiences (5.44%), and contact information for follow-up (3.77%). Reply posts also request relevant information to deepen exchanges, primarily requesting factual information (8.37%), recommendations (7.32%), and opinions (5.23%), followed by personal experiences (3.97%), suggestions (2.72%), and networking resources (1.67%). Users rarely initiate conversations specifically for emotional support, instead expressing friendly emotional appeals (18.4%) while seeking information or discussion. The most frequent emotional expression in replies is positive emotion (13.39%), mainly gratitude toward resource providers and problem solvers, along with encouragement and blessings for other users' research lives; a small number express negative emotions (1.26%), such as anxiety and tension when posts receive no responses.

The information distribution characteristics of root and reply posts are shown in Table 2 . Overall, virtual academic community interactions focus on academic task information, emphasizing information needs expression, demonstrating that user interaction behaviors prioritize academic features with social characteristics. Factual information, opinions, and suggestions are the three main interaction types, consistent with findings from other virtual communities [4, 37]. Users primarily achieve academic information exchange through these three information types. Additionally, users emphasize recommending and sharing academic resources like literature, books, and course materials, as well as exchanging personal experiences from research and learning processes. Root and reply posts

differ in content emphasis while sharing some commonalities. For requesting task information, both prioritize factual information, recommendations, and opinions. For providing task information, root posts emphasize personal experiences and supplementary factual information, while reply posts focus on opinions, factual information, and suggestions—possibly because initiators provide more factual details to better express their needs, and self-disclosure of personal experiences can attract more participants. In emotional categories, both initiators and participants tend to display positive emotions and demonstrate good social etiquette.

Virtual academic communities are established based on common academic themes, where users interact according to conventional academic customs and ethical norms, forming community-specific interaction protocols.

5.1.2 Interaction Theme Analysis The LDA (Latent Dirichlet Allocation) topic model is a three-level Bayesian model comprising words, topics, and documents that can extract discrete topics from text [38]. To further analyze thematic characteristics, we applied the LdaModel function in the Gensim toolkit based on segmentation results, identifying topics as probability distributions of feature words. Due to space limitations, Figure 3 [Figure 3: see original paper] shows the top 10 feature words for 16 latent topics.

Figure 3 indicates that the 16 topics identified by LDA consist of high-probability feature words from the condensed matter physics domain, with each topic representing conversational hotspots. Though some feature words overlap across topics, boundaries remain relatively clear. Consulting domain experts, we inferred labels for these 16 topics: physics textbooks, superconductivity physics, laser optics, condensed matter theory classics, magnetron sputtering, experimental problems, help-seeking consultation, request gratitude, magnetism, topological insulators, graphene, X-ray diffraction, batteries, graduate education, quantum Hall effect, and solid-state physics. Topics 2, 3, 5, 9, 10, 11, 12, 14, and 15 represent various research directions and important concepts in condensed matter physics, indicating that the "Condensed Matter Physics" section requires effective topic guidance systems. Feature words like "urgent," "help," and "thanks" in topics 7 and 8 reveal scholars' strong and urgent desire for assistance. The "work" feature word in topic 13 shows that user interaction themes extend beyond academic research to include life-related topics like graduate education and job seeking. Feature words like "textbook," "basic," and "university" in topic 1 demonstrate users' emphasis on academic resource interaction, validating how informal academic exchange supplements and promotes formal literature.

Unlike real-world social order, virtual academic community user interaction behaviors exhibit sociality, with behavioral purposes, objects, and processing methods influenced by real social environments [39]. Due to the openness of informal academic exchange and disciplinary complexity, user interaction themes show decentralized characteristics, covering both academic topics (superconductivity,

solid-state physics, optics, magnetism) and non-academic topics (job seeking, graduate education, personal emotions). Additionally, influenced by academic community norms and disciplinary "contracts," interaction theme structures remain relatively stable over time.

5.2 Analysis of Virtual Academic Community User Interaction Network Structure Characteristics

Social network analysis abstracts individuals and relationships into nodes and connections, analyzing network topology structures and properties. To investigate user interaction behaviors from a network perspective, we constructed a virtual academic community user conversation network based on forum member interactions, using all participating users as nodes, interaction relationships as edges, and reply frequency as relationship strength. The resulting network comprised 4,846 nodes and 5,956 edges, visualized using Gephi as shown in Figure 4 [Figure 4: see original paper].

5.2.1 Overall Network Morphology Analysis Network density reflects the closeness of connections among community members and group structural patterns. The calculated network density was 0.001, indicating a sparse network with weak ties and polycentric characteristics, consistent with findings from Wu Jiang et al.' s study of online medical communities [10] and Wang Xuefen et al.' s study of virtual job-seeking communities [4]. The sparse network may result from three factors: (1) data from the "Condensed Matter Physics" section over 10 years (2009-2019) faced disciplinary domain restrictions, yielding relatively small user and interaction volumes compared to general discussion sections; (2) unlike academic blogs and WeChat groups, virtual academic communities employ anonymous communication rules with "stranger social space" features, where members lack familiarity and trust; (3) virtual academic community users typically only engage with posts matching their academic information needs, forming relationships with few users and resulting in weak overall connections.

As Figure 2 shows, some nodes have dense connections (e.g., "孙 730,""tianzi4373,""夕阳西下," "ocean416"), forming concentrated local mesh structures, while most nodes have few connections at the network periphery, creating an overall loose structure consistent with the decentralized interaction theme structure. Distinctive academic themes attract members with common research interests, extending into diverse and complex topics where users engage in small-scale interactive sessions around topics of interest, producing network structures that mirror thematic decentralization.

In related social media academic communication research, academic WeChat group conversation network density is 0.055 [28], while academic blog recommendation and comment network densities are 13.173 and 8.283 respectively [40]. Conversation analysis posits that interactive dialogues generate their own internal order, with interaction behaviors influenced by participants' understanding of communicative order [26]. Different academic new media platforms have

distinct attributes and interaction rules, resulting in different social orders and network densities. Academic WeChat group members have natural hierarchical divisions where status influences expression willingness affected by group pressure and familiarity [28], producing sparse networks. Academic blog users create academic identities and manage images through personal information, updates, comments, and recommendations [40], forming good community order with higher network density. Virtual academic community users engage in anonymous conversations in relatively equal, open environments without fixed rules, creating free and casual internal order with weaker relationships than academic WeChat groups or blogs.

Small-world effects feature average path lengths close to random networks and clustering coefficients larger than random networks. To verify information flow efficiency, we constructed three random networks with the same node count (4,846) and average edge count (2.458) for comparison. Table 3 shows relevant parameters, where S represents the small-world measure calculated as S = (C_{actual}/C_{random}) ÷ (L_{actual}/L_{random}). S > 1 indicates small-world effects.

Table 3 shows S > 1, confirming small-world effects and good network stability. Disciplinary research demonstrates both inheritance/consensus-forming and innovation/transformation characteristics. Over time, user interaction themes remain relatively stable, contributing to network stability. The average path length of 2.946 indicates that any two users can connect through at most three intermediaries, conforming to "six degrees of separation" theory and demonstrating efficient information dissemination. Virtual academic communities maintain platform order through dedicated administrators who enforce external regulations, while distinctive disciplinary themes attract like-minded participants, forming internal community culture that influences user interaction behaviors. This combination of internal culture and external norms creates favorable communication atmospheres and community order.

5.2.2 Network Centrality Analysis Network centralization indicates the degree of network concentration around central nodes, including degree centralization and betweenness centralization. Node centrality indicates actors' positions and influence distribution. The network' s out-degree centralization was 0.193%, indicating low and dispersed user participation with "decentralized" structure. Betweenness centralization was 0.02%, suggesting minimal possibility of individual nodes controlling community resources. Average out-degree and in-degree were 1.229, with 92% and 89% of nodes having degree < 3, indicating low activity among most users and a lack of highly influential users. Only 4.765% of users had high betweenness centrality (relative betweenness = 1), serving as bridges, while 94% had betweenness centrality of 0, showing low conversation participation and insufficient core participants, consistent with the 80/20 rule.

This may relate to the utilitarian purposes and urgent help-seeking psychology of virtual academic community users. Conversation analysis views conversation as

purposeful social practice where users primarily seek to satisfy knowledge needs at the cost of contributing their own knowledge or experience [41], typically terminating interaction after achieving their goals. Users expect material and spiritual social support, focusing on sharing and seeking academic information and resources while providing psychological support as secondary.

5.3 Research Findings

Under conversation analysis theory guidance, analyzing interaction content, themes, and networks yields three conclusions: (1) In conversational content, user interaction shows demand-supply imbalance, with factual information, opinions, and suggestions as primary types. Users' utilitarian purposes and urgent help-seeking psychology significantly affect participation patterns. (2) In conversational relationships, despite small-world effects, interaction relationships remain loose with low participant activity and insufficient core participants. Core members possess rich social experience and professional knowledge, capable of introducing new topics and solving problems, while peripheral members remain in browsing mode, rarely expressing opinions. (3) Interaction themes show diversity due to research complexity and open informal exchange, covering academic and non-academic topics. Theme structure diversity aligns with sparse, decentralized network structures; user group and interaction characteristics contribute to thematic stability, which corresponds with network stability.

5.4 Strategies to Promote Virtual Academic Community User Interaction

Based on these characteristics, we propose targeted strategies: (1) **Ensure effective information supply.** To address weak overall cohesion and interactivity, community operators should explore methods to encourage online interaction, such as organizing offline activities to stimulate online engagement, attracting more users, recruiting domain experts and scholars to provide abundant quality academic resources, and leveraging core members' guiding capabilities. (2) **Innovate community academic knowledge services.** Considering the decentralized interaction themes and focus on sharing and seeking academic information, knowledge services should address user group particularities and domain specificity to meet academic information needs. This includes providing knowledge navigation services supporting thematic expansion and deepening to promote sustained, progressive knowledge exploration, and establishing link systems among knowledge elements in academic resources to address knowledge fragmentation. (3) **Improve community interaction function design.** During interactions, users may wish to direct information to specific users, a need currently unmet. Virtual academic communities should adopt broader interaction methods to meet diverse needs, such as implementing @-functions for one-to-one communication like general social media. Additionally, unlike typical UGC, academic conversations have long lifecycles with lasting value. Operators

should strengthen content guidance through featured topic rotation schemes to ensure user participation in earlier conversations.

6 Conclusion

Network communities extend real society, with virtual academic community user interaction behaviors demonstrating strong internal social order and sociolinguistic patterns during informal academic exchange. This study combined content analysis, LDA topic modeling, and social network analysis to examine information interaction types, thematic features, and network topology.

Innovations and significance include: (1) Previous research lacked in-depth analysis of virtual academic community user interaction characteristics. This study explores content and network features from conversation analysis perspective, sociologically interpreting social order behind user interactions and providing new findings on content, relationship, and thematic characteristics, enriching theoretical research on network user behavior and providing references for information behavior theory construction. (2) Combining content and network analyses from both dimensions overcomes previous single-dimension limitations, offering methodological references for virtual community user behavior research. (3) The proposed community development strategies are targeted and credible, helping operators optimize knowledge services and promote user interaction, enhancing practical value.

Limitations include: (1) Only Chinese virtual academic community Xiaomuchong Forum was examined; future research should verify conclusions in English virtual academic communities. (2) Only "Condensed Matter Physics" natural science data was used; humanities and social sciences virtual academic community characteristics require further investigation. (3) Analysis was limited to static structural features; future studies should reveal dynamic evolution characteristics over time.

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Note: Figure translations are in progress. See original paper for figures.