Research on Information Exchange Patterns in Interdisciplinary Teams: A Case Study of the University of Wisconsin–Madison (Postprint)

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Abstract

[Purpose/Significance] Taking the interdisciplinary program at the University of Wisconsin-Madison as a case study, this research analyzes the patterns and influencing factors of information exchange among interdisciplinary team members from an informatics perspective, reveals the patterns of institutional and disciplinary collaboration within interdisciplinary teams, and provides reference and insights for studying similar interdisciplinary team issues, promoting interdisciplinary team building, and facilitating interdisciplinary collaboration. [Method/Process] First-hand data on information exchange frequency, members' institutions, and disciplines were obtained from the case study. Statistical methods were employed to analyze the impact of information exchange frequency on team member collaboration, and complex network analysis techniques were utilized to investigate the patterns of institutional and disciplinary collaboration. [Results/Conclusion] Information exchange has a significant impact on team collaboration. Team size is not the sole critical factor affecting communication frequency; it is also influenced by disciplinary span and the complexity of research content. The study proposes improving the information liaison system, establishing effective interdisciplinary research entities, and rationally allocating the disciplinary composition of team members.

Full Text

2.2 Information Exchange and Influencing Factors Analysis

Communication is the transmission and understanding of meaning [6]. Information exchange, also referred to as information communication, is a process based on a specific purpose where information is transmitted between individuals, between individuals and organizations, and between organizations to reach mutual agreement [7]. A. Joshi's research demonstrates that through communication,

team members can better understand each other, become familiar with each other's perspectives, clarify respective responsibilities, and work collectively toward team goals [8]. In interdisciplinary teams, each member is an expert in their own field but knows little about other fields. Only through sufficient and effective information exchange can these seemingly unrelated specialties be connected. By transmitting information related to project objectives, research content, implementation processes, and key outputs to each participant at appropriate times and in appropriate ways, project-related information becomes shared knowledge for the entire team. This study uses "communication frequency" as an indicator to measure the amount of information exchange among team members during team formation. According to statistics, members in funded projects communicated with the service team a total of 742 times via email, face-to-face meetings, and other methods.

Table 1 presents statistics on participants' titles/affiliations, average communication frequency per person, and average number of projects participated in by title/affiliation. The data show that researchers at the associate professor level and above account for 35.95%, and professors and associate professors participated in virtually every project, indicating a high level of research quality. In terms of communication frequency, community members have the highest average number of communications per person, significantly higher than faculty members, demonstrating that professional differences exert a notable influence on project collaboration. Conversely, students have the lowest average communication frequency during the project selection process, which aligns with their role in research teams—typically undertaking foundational research work while idea generation and communication tasks are primarily handled by higher-ranking researchers. This study also conducted a mean analysis and independent samples t-test on communication frequency between funded and unfunded participants (results shown in Table 1). Levene's test indicated acceptance of the homogeneity of variance assumption, revealing that communication frequency has a significant impact on successful project participation. Funded participants communicated an average of 1.27 times more than unfunded participants.

From a project-level perspective, this study also examined the relationship between team size and total communication frequency (see Figure 1 [Figure 1: see original paper]). The results show a positive correlation between communication frequency and team size overall. Case analysis reveals that Project 4 has the largest ratio of communication frequency to team members, with an average of 7 communications per person. This project team consists of 2 members: Associate Professor Kristen Pickett from the Department of Kinesiology and Teaching Assistant Helen Lee from the Arts department. Their research focuses on using glassblowing techniques for restorative training for Parkinson's patients. The project requires integrating knowledge from art, kinesiology, and occupational therapy to apply glassblowing techniques to interventional treatment for Parkinson's patients while also promoting pedagogical research in glassblowing. With participants from two completely different specialties and substantial research span, extensive information exchange is necessary to help participants under-

stand the project content and facilitate collaboration.

Project 6 also shows a relatively large ratio of communication frequency to team members, with an average of 5.66 communications per person. This team comprises 3 members from the Psychology department, community organizations, and the Wisconsin Center for Education Research, researching language tutoring for immigrant families in Wisconsin using hybrid methods that unite university faculty, administrators, and community workers. As team members belong to different disciplines and institutions, more information exchange is needed to bridge knowledge structure differences. Conversely, Project 10 has the smallest ratio, with an average of only 0.6 communications per person. This 5-member team includes 3 members from the Wisconsin Center for Education Research and 2 from the School of Education, all with educational research backgrounds and closely related disciplines. The project aims to help non-English-speaking students from elementary to high school develop academic leadership, which closely matches participants' research expertise, resulting in fewer information exchanges overall. These findings demonstrate that team size is not the only key factor affecting communication frequency; discipline differences and research content complexity also play important roles. Section 2.4 will further discuss disciplinary characteristics and influencing patterns.

2.3 Institutional Characteristics and Cooperation Network Analysis

This study standardized participants' institutional affiliations by consolidating departments within the same school, as disciplinary differences within a single school are relatively small. For example, participants from the School of Education's "Department of Curriculum and Instruction," "Department of Educational Policy Studies," "Department of Educational Leadership and Policy Analysis," and "Department of Rehabilitation Psychology and Special Education" were all categorized under the School of Education. Similarly, departments from the School of Human Ecology were grouped together. If only one department from a school participated, the department name was retained as the institutional unit. As shown in Table 2 , team members came from 26 institutions, with the School of Education representing the largest proportion, consistent with its role as the project sponsor. The Arts department (primarily Dance and Theater) ranked second. Additionally, 18 institutions had fewer than 4 participants, accounting for 18.2% of the total, indicating dispersed institutional distribution. Community members also represented a significant proportion, primarily from social organizations such as the Wisconsin Children's Museum, Cooperative Children's Book Center, and Wisconsin Children's Theater Center. Although specific disciplinary and educational backgrounds of these participants could not be determined, their involvement substantially enhanced research applicability, aligning with the project's value orientation of "making scholarship work in the real world."

To analyze cross-institutional collaboration, this study constructed a complex

network map of institutional cooperation, with nodes representing institutions and links representing collaboration frequencies between different institutions within projects. Complex network analysis was used to examine institutional cooperation patterns reflected in these interdisciplinary projects. Complex networks represent a method and perspective for studying complex systems, focusing on the topological structure of interconnections among individuals within a system, characterized by self-organization, self-similarity, attractors, small-world properties, and scale-free features [9]. Using nodes and lines to represent networks is a formal definition of complex networks and a common language in current research. This analysis employs two centrality measures: degree and betweenness centrality. Degree is a crucial indicator describing nodes in complex networks; a higher degree indicates more connections with other nodes. In institutional cooperation networks, higher degree values signify more extensive institutional connections [10]. Betweenness centrality measures the extent to which actors control resources, indicating how much a node lies "between" other nodes. In institutional cooperation networks, higher betweenness centrality indicates greater similarity with other institutions and stronger "hub" functionality [11].

Figure 2 [Figure 2: see original paper] presents the institutional cooperation network map, where node colors and sizes and edge colors and thickness reflect node importance and connection strength. The network comprises 26 nodes and 272 edges, with a density of 0.16, classifying it as a sparse network. The average degree is 4.15, network diameter is 4, and average path length is 2.13, indicating that connections between any two institutions can be established through an average of two intermediaries. Degree and betweenness centrality analysis (see Table 2) reveals that the School of Education, Psychology department, and School of Social Work possess high degree and betweenness centrality, positioning them at the network center and serving as bridges connecting other institutions. Additionally, the Wisconsin Center for Education Research and Community Relations department exhibit high centrality in the network. The former primarily conducts research in mathematics, cognitive psychology, and education in Wisconsin, including developing education policies at various levels, while the latter focuses on developing community management policies and establishing university-community connections. Both institutions occupy important positions in the cooperation network as key bridges linking other organizations.

2.4 Disciplinary Characteristics and Cooperation Network Analysis

This study determined each member's disciplinary background using information provided by applicants through institutional websites and social media platforms such as Facebook and LinkedIn. Considering differences in disciplinary nomenclature and structure between China and the U.S., classifications primarily followed the "Undergraduate Major Catalogue" issued by China's Ministry

of Education in 2012, while merging clearly related specialties such as Foreign Languages and Literature, Social Work and Sociology, and Dance and Arts. Seven members from community organizations and administrative departments could not be classified, leaving 146 members for disciplinary analysis. According to Table 3 , participants came from 17 disciplinary fields covering 8 broad categories: Education, Arts, Science, Engineering, Medicine, Law, Literature, and Agriculture, demonstrating clear interdisciplinary characteristics. Consistent with institutional patterns, Education has the most participants, while 19 individuals belong to 12 other disciplines with relatively loose interconnections.

To analyze cross-disciplinary collaboration, this study constructed a complex network map of disciplinary cooperation, with nodes representing disciplines and links representing co-occurrence frequencies between different disciplines within projects. Similar to the institutional analysis, degree and betweenness centrality were used to examine network structure. Higher degree values indicate more extensive disciplinary connections, while higher betweenness centrality suggests greater similarity with other disciplines and stronger "hub" functionality. Figure 3 [Figure 3: see original paper] illustrates the disciplinary cooperation network, where visual elements represent node importance and connection strength. The network comprises 17 nodes and 309 edges, with a density of 0.206 (sparse network), average degree of 3.294, diameter of 4, and average path length of 1.97, indicating that connections between any two disciplines can be established through an average of two intermediaries. Centrality analysis (see Table 3) shows that Education, Psychology, and Arts possess high degree and betweenness centrality, positioning them at the network center and serving as bridges connecting other disciplines.

This study also analyzed team disciplinary diversity to measure the communication environment from a diversity perspective. The diversity concept, widely applied in biological sciences to measure species richness in ecosystems, has been adapted in scientometrics. Diversity encompasses three dimensions: (1) categories of elements within a system, (2) distribution balance among categories, and (3) similarity among different categories. Higher values across these dimensions indicate greater diversity [12-13]. Based on this framework and Stirling and Liu Xiaojuan's diversity calculation framework [14], this study calculated team diversity from a disciplinary perspective using Formula (1):

$$SR_X = \sum_{i,j=1}^{N} P_{xi} P_{xj} D_{ij}$$

where SR_X represents the diversity value of Project X, D_{ij} indicates disciplinary differences among team members, and P_{xj} represents the proportion of members from discipline i in the project. Since related specialties within the same discipline were merged during statistical processing, resulting in clear and distinct classifications, this study assumes disciplinary differences equal 1. Calculations yielded disciplinary diversity distribution values for 32 project teams (see Table

4). If all members were evenly distributed across 17 disciplines, the resulting diversity would be 0.889. Table 4 shows that 18 teams have diversity values above 0.6, indicating prominent disciplinary diversity overall. However, disciplinary diversity alone cannot measure disciplinary differences; it must be combined with team members' research interests. For example, Team 32 includes 7 members with backgrounds in Law, Sociology, Architecture, Anthropology, and Education. Further investigation revealed that Joel Rogers is a professor of administrative law who also conducts sociology research and participates in public affairs; Samuel Dennis Jr. is an associate professor in landscape architecture focusing on community development and public health; Lori DiPrete-Brown researches community public health improvement; and Julie Underwood and three others focus on community education. These researchers from different specialties share common interests in social affairs and community development, enabling successful collaboration on the "Building Wisconsin Community Schools" project. This demonstrates that faculty and researchers' attention to multidisciplinary fields and research interests positively impacts interdisciplinary team formation.

3 Conclusions and Implications

Based on the case study of interdisciplinary team formation at the University of Wisconsin-Madison, this paper analyzed information exchange patterns, institutional cooperation, and disciplinary collaboration rules, proposing three recommendations for institution-led interdisciplinary team building.

First, establish an information contact system. Traditional research teams typically have team leaders or principal investigators responsible for team formation and management, usually selected from scholars with high academic standing, reputation, and authority [15]. However, this model cannot be directly replicated in interdisciplinary teams because members are experts from different disciplines, each with their own disciplinary language and thinking patterns. Breaking disciplinary barriers and using accessible, non-technical language for project communication becomes crucial for team formation. The UW-Madison case demonstrates that assigning dedicated information contacts to each project—prohibiting contacts from participating in more than two projects to ensure adequate capacity for communication and service—significantly impacts team cooperation. Data analysis confirms that information exchange frequency significantly influences team formation, suggesting that dedicated communication personnel enhance collaborative efficiency.

Second, establish effective interdisciplinary research entities to cultivate researchers' interdisciplinary awareness. The investigation revealed that the university has established independent interdisciplinary research platforms such as the Wisconsin Institutes for Discovery, International Academic Programs, and Center for Academic Excellence. These entities identify and cultivate interdisciplinary research projects, providing open-access laboratories, discussion venues, and necessary funding support. The Wisconsin Institutes for Discovery, for instance, occupies a four-story building centrally located near the Medical School,

Engineering School, and College of Letters and Science, facilitating encounters among scholars from different disciplines. Its mission is to support forward-looking experiments exploring fundamental questions across multiple disciplines and to encourage new generations of scientific thinkers. The institute provides generous research funding and scholarships for student participation in interdisciplinary projects in biology, medicine, and mathematics, primarily supported by internal research allocations and alumni donations. These interdisciplinary entities play important roles in fostering academic exchange across disciplines and cultivating cooperative research awareness among faculty and researchers. Case studies also show that researchers' interests in multidisciplinary fields facilitate successful interdisciplinary collaboration, as evidenced by the participation of these entities in the project network as key connecting nodes (see Figure 2).

Third, rationally allocate disciplinary proportions to maintain disciplinary diversity. According to Habermas's theory of the "ideal speech communication situation," an effective communication group should exhibit diversity and decentralization [16]. Although the interdisciplinary project was initiated and hosted by the School of Education, with 37% of participants from this school and 49% from the Education discipline—resulting in 17 projects including two or more Education researchers—the participant distribution shows a concentration trend with unbalanced disciplinary representation and clear "central" and "peripheral" disciplines. Network analyses reveal that Education, Psychology, and other dominant disciplines hold absolute discourse power, with most institutional and disciplinary connections established through them. When conducting interdisciplinary research through institutional frameworks (including universities and funding agencies), attention must be paid to disciplinary proportionality to balance research forces, promote equal participation, and ensure full contribution of disciplinary knowledge. While institution-led interdisciplinary teams face these challenges, institutional entities provide funding support, institutional guarantees, and trust mechanisms that non-institutional platforms (such as social media) cannot offer, making them the primary model for advancing interdisciplinary collaboration.

The findings and insights from this study offer guidance for current new engineering initiatives, which require interdisciplinary cooperation and communication, particularly between science and engineering and across fields such as environmental science, medicine, materials, energy, communication, and artificial intelligence. As leading institutions in interdisciplinary research, universities must establish robust information communication channels, such as assigning vice president-level leaders as project contacts to ensure equal academic information exchange among participating disciplines. Concurrently, existing interdisciplinary research resources, such as established industry-academia-research centers, should be fully integrated into new engineering construction to serve as bridges connecting different disciplines.

This empirical study has limitations, including a relatively small sample size and over-representation of Education school and discipline members, which

prevented deeper exploration of disciplinary integration characteristics—an acknowledged shortcoming. However, the first-hand data on communication frequency, institutional affiliations, and disciplinary backgrounds provide valuable support for similar interdisciplinary cooperation studies. As a representative case of institution-led interdisciplinary projects, the experiences and deficiencies identified offer reference points for future initiatives.

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Author Contributions:

ZHANG Zhang: Provided research ideas and collected data; LI Jing: Conceived the paper, developed the framework, and wrote the manuscript; ZHANG Shuai: Processed data.

Abstract: [Purpose/significance] Taking the interdisciplinary project of the University of Wisconsin-Madison as a case, this paper analyzes the laws and influencing factors of information exchange among interdisciplinary team members from an informatics perspective, and reveals interdisciplinary teams' institutional cooperation and discipline cooperation rules. [Method/process] The paper obtained first-hand data on team members' information exchanges, institutions, and disciplines from the case, analyzed the impact of information exchange frequency on team cooperation using statistical methods, and examined institutional cooperation and disciplinary cooperation through complex network analysis techniques. [Result/conclusion] Information exchange has a significant impact on team cooperation. The number of team members is not the only key factor affecting the number of team communications; it is also influenced by the diversity of disciplines and the complexity of research content. We suggest building an information contact system and an effective interdisciplinary research entity, and rationally allocating team members' discipline proportions.

Keywords: interdisciplinary team; information exchange; academic exchange; institutional cooperation; interdisciplinary cooperation

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