I-GUIDE Climbers: A Model for Multidisciplinary Academic Labs for Early Career Development

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***Abstract*—** *In this paper, we propose a new form of multidisciplinary academic collaboration that goes beyond the traditional modes of knowledge exchange. We argue that most research collaboration today is based on interactions between closely related disciplines, in which researchers share data, methods, and insights within a common framework or problem. However, such collaboration may not foster the development of the communication and management skills essential to a multi-disciplinary research career. Therefore, we suggest establishing a network of researchers from divergent, yet complementary, disciplines who are interested in improving these skills through regular interactions and feedback. The main goal of this network is not to conduct research or address a specific research question, but to create a learning environment where researchers can enhance their interdisciplinary competencies through the diverse perspectives and experiences of their peers. Moreover, a multidisciplinary group of early-career professionals provides a space for collaborations to flourish. In this paper, we also offer practical advice for researchers who wish to join or create a similar network.*

Keywords: research lab, professional development, innovative collaboration, multidisciplinary collaboration, cross-disciplinary, convergence science.

I. Introduction

It is crucial to bridge the social and biophysical sciences to address global and local sustainability challenges and provide tangible outcomes (Brown et al., 2015). Collaboration is a key element of academic research, but traditional modes of knowledge exchange may not always foster important skills for a multi-disciplinary research career. This paper proposes an innovative approach to collaboration that expands on the current framework. Rather than interacting only with closely related disciplines, we suggest creating a network of researchers from divergent yet complementary fields. The primary objective of this network is to establish a learning environment in which researchers regularly interact and provide feedback to each other to enhance their interdisciplinary competencies.

By bringing together researchers from diverse backgrounds and perspectives, we aim to create a space where new ideas can flourish. The multidisciplinary group of early-career professionals can benefit greatly from this approach. While the primary goal is not to conduct research or address specific

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research questions, the network can provide a platform for collaborations to thrive.

This paper provides practical advice for researchers in cross-disciplinary topics. By joining or creating a similar network, researchers can expand their skill sets and benefit from the experiences and perspectives of others. This way of thinking can pave the way for new discoveries and advancements in research.

II. Introducing the Climbers

The Climbers group, named so because of their potential to traverse the intellectual groundwork laid before them, is a group of early career experts that use geospatial data and models to address grand challenges in fields related to sustainability and food security. This group is part of the Institute for Geospatial Understanding through an Integrative Discovery Environment (I-GUIDE), which is supported by the National Science Foundation (NSF) Harnessing Data Revolution (HDR) funds. This includes graduate students, post-doctoral researchers, and early-career faculty from geography, hydrology, economics, climate science, social studies, data science, and computer science. Each member has at least graduate-level training in their field and serves as a valuable source of basic disciplinary knowledge.

A. The main goal

The Climbers group is a platform for knowledge sharing and peer support among researchers from different disciplines with diverse skills, knowledge, and perspectives. It aims to foster convergence science by addressing common challenges and opportunities for collaboration. The collaboration can involve software and code troubleshooting, multidisciplinary perspectives on research questions, brainstorming and assessment of new ideas, and data transfer. The Climbers group is part of a larger project (I-GUIDE) that promotes convergence science as a catalyst for innovation. While the larger project defines the needs and research questions that require multidisciplinary solutions, the Climbers group is less formal and more focused on technical details, exposing researchers to other disciplines' methods, topics and approaches. This includes, but is not limited to, novel ideas and inventions of new tools or lines of collaboration. The Climbers group also helps to shape expectations and understanding of other fields. They support the project as a whole, rather than any one specific team.

B. Why this collection of expertise?

Geospatial science, data science, and computational sciences are fields that hold potential to connect and integrate different disciplinary research, such as economics, climate sciences, public policy, hydrology and food security. These fields share a common interest in understanding the spatiotemporal patterns of natural and human phenomena, and how they interact and influence each other (Brandt et al., 2013). To be specific, geographic information science provides the methods and tools to collect, analyze, and visualize spatial data, such as satellite imagery and geographic information systems (GIS). Data science provides methods such as machine learning, artificial intelligence, and statistics to extract insights from large and complex datasets. Computational sciences provide frameworks such as numerical methods, optimization, and parallel computing to simulate the behavior and dynamics of complex systems.

By bringing together early career professionals from these fields, researchers can improve their understandings of challenging interdisciplinary questions which require spatial thinking, data-driven analysis, and computational modeling. For example, geospatial data science can help economists understand the spatial distribution of economic activities, and how they are affected by environmental factors (Bateman et al., 2002). Data-driven computational hydrology can help climate scientists understand the water cycle and flooding risks. Computational geospatial science can help hydrologists model the impacts of climate extremes on flooding. These are just a few examples of how geospatial science, data science, and computational sciences can bridge different disciplines within multidisciplinary research.

In addition, multidisciplinary presentations among early-career professionals are essential for transferring scientific knowledge and understanding complex sustainability challenges (Van den Beemts et al., 2020). Moreover, regular presentations across disciplines can help researchers to understand and discuss their own work in an accessible way. These multidisciplinary presentations can foster innovation, creativity, and synergy in research and education on sustainability. Climbers approach is helpful to addresses disadvantages of interdisciplinary learning due to lack of a standard curriculum or time-consuming to build an efficient curriculum (Field et al., 1994; Jones, 2010). The Climber modes resolve this disadvantage through facilitating knowledge transfer and communication across disciplines.

Conversing across disciplines, either as a speaker or listener, can enhance the quality and impact of research by integrating diverse perspectives, methods, and data sources to address sustainability problems. This can facilitate the development of professional skills such as communication, teamwork, leadership, and project management, as well as foster professional opportunities by expanding networks with potential mentors, peers, partners, and funders. Finally, researchers' learning experiences and outcomes may be enriched by exposing them to different paradigms, approaches, and cultures of inquiry.

C. Differences from common work environments

The Climbers platform is distinctive from more common work environments, such as disciplinary labs and close multidisciplinary collaboration. In disciplinary labs, people have a great understanding of their team's research and methods. The early career professionals typically follow their seniors lead and try to contribute to the lab's techniques and findings. Climbers avoid overinvolvement in advanced techniques and concentrate mostly on general ideas and approaches. They can synergistically work on common needs such as data processing and visualization, as well as computation.

In close multidisciplinary collaboration, there is a clear research goal with a clear expected output. The co-authors are

expected to be deeply involved and learn about each other's work. However, our collaboration model differs substantially in that there is no formal evaluation, whether that be directly in the form of periodic reviews, or indirectly in the form of research output. It is not a mentor-mentee relationship but rather a peer-peer relationship. The Climbers are expected to understand the overall message and application, but not all the aspects of the presented research. Similar to a newspaper with various topics covered each time, this is an opportunity to learn, rather than to be assessed.

III. The meeting format

A. Minimum expectations

Members of Climbers are expected to fulfill certain responsibilities that contribute to the group's collective goals and values. The Climbers do not have any centrally assigned person to organize them, and work on a rotating schedule for leadership, which makes fulfilling these expectations especially important. The minimum expectations include attending and actively participating in meetings, taking turns as the meeting moderator, presenting research findings, and giving and receiving feedback to other members. These expectations are designed to help the Climbers' growth as professionals and as members of our academic community.

B. Recommended guidelines

The Climbers group suggests members to seek counseling from peers and use feedback to improve research. Share publication opportunities and introduce new tools to enhance skills and methods.

IV. Administration

A. Systems and protocols for governance and communication

To help with the coordination of activities, align goals, and better communication, various tools and applications are employed. For example, Slack is used for efficient communications among team members as well as sharing relevant information and updates; Google-Docs are employed for dynamic note-taking and collaborations on documents, spreadsheets, presentations, and more; Emails are used for announcing more general events such as deadlines, milestones, feedback sessions, and newsletters; and Zoom (with shared meeting calendar) was used for online weekly meetings as well as scheduling and managing appointments

B. Voting and democracy in making decisions

The multidisciplinary research group is committed to inclusion and to hearing all voices and opinions. They respect and appreciate the diverse perspectives and expertise of our members. In addition, they strive to create a collaborative and inclusive environment where everyone can contribute and have a vote in the direction of their meetings. For example, they have had a round table to collect ideas for the focus of the next six-month meetings, such as the proportions of research presentations, professional development sharing agenda, and social events. They then make decisions based on dialogue and consensus.

C. Diversity

Climbers are committed to fostering a culture of respect in their multidisciplinary research team. They believe that diversity of backgrounds, perspectives, and skills is essential for advancing scientific knowledge and innovation. Therefore, they have been welcoming and supporting researchers from different disciplines, genders, ethnicities, nationalities, and abilities for a collaborative and supportive environment for everyone.

D. Challenges

Despite the numerous merits of interdisciplinary works, they have also experienced challenges as they connect researchers from various disciplines and facilitate collaborative environments. One of the most challenging aspects is the trade-off between in-depth knowledge sharing and attention/participation of the Climbers. For example, audiences often lose track of presentations if they are too much of a "deep-dive". On the other hand, there would be less take-away if knowledge sharing is too superficial. To tackle this issue and foster inclusive collaborative environments, they have recommended presenters focus on the general ideas and messages that can be applied across disciplines. In particular, the tendency to go into technical details can harm the group's longevity. Similarly, structuring an effective meeting that balances knowledge sharing, feedback, participation, discussion, and professional development can be difficult in a short meeting time (Golden et al., 2021). This challenge is compounded by the weekly meeting intervals. It is recommended to gauge interest by having round-table discussions which provide an open space for participants to give feedback to improve meeting efficiency.

V. Lessons learned

A. Research advancements

Pin-Ching Li, a Ph.D. student in the civil engineering department at Purdue University with a focus on Machine Learning, Hydrological Modeling, and Soil Mechanics, listed how being part of I-GUIDE Climber helped him learn new techniques, practical cases, and data ethics. Within the I-GUIDE, he developed his expertise in Machine Learning models, which helped him develop new datasets and develop various tools. To be specific, the I-GUIDE Climbers helped him to learn more about new Machine Learning (ML) techniques. Furthermore, he gained a deeper understanding of data ethics and data management for publishing research results and datasets. Climbers from different research teams emphasize various codes of data ethics. By joining discussions during Climbers' meetings, he comprehensively understood data ethics.

Jimeng Shi, a Ph.D. student in computer science at Florida International University, indicated that participation in the Climbers group broadened his vision. He has been working on deep learning (DL) methods for flood prediction and management. By getting feedback on his presentations during the weekly meeting, he learned how to improve his work from multidisciplinary perspectives. In addition, by listening to the presentations, he learned new DL models (Graph Transformer)

from the Hypercube group and adapted them to his project. Furthermore, communication with other researchers broadened his vision and provided him with some ideas of how to use DL for other domains.

Zhaonan Wang, a postdoc specializing in geospatial information science and GeoAI at University of Illinois Urbana-Champaign (UIUC), shared that his participation in the Climbers group helped him think about his research from the big picture. Besides the Climbers group, he has been working on research and development for I-GUIDE, specifically on the geospatial knowledge hypercube at the GeoAI team. The hypercube is a novel knowledge extraction system for massive spatial-related text data. He also shared his Ph.D. work on spatiotemporal traffic/mobility forecasting, published on various domain-leading AI venues, with the Climbers. In addition, he has learnt a lot from NLP aspects, spanning the pre-trained language models to recently popular generative models like ChatGPT. These new perspectives motivate him to think about the foundation of geospatial AI and the future of this emerging interdisciplinary field.

Jinwoo Park, a postdoctoral research associate at the CyberGIS Center for Advanced Digital Spatial Studies at UIUC (who will start a new position at University of North Dakota as an assistant professor), mentioned that participating in the weekly meeting has been extremely helpful in bringing multidisciplinary perspectives to his research. His research focused on revealing the socioeconomic characteristics of at-risk populations affected by aging dam infrastructure in the USA. From the Climbers group, he acquired helpful feedback, such as how to address computational intensity entailed by large datasets, and insights, such as how to link environmental risk and social vulnerability, thanks to the interdisciplinary aspects of the group. He pointed out that he has learned the following two aspects both from the Climbers group and a larger I-GUIDE team. First, he learned that how civil engineers simulate flooding, particularly induced by dam failures, which he was not aware of, given that he had solely focused on the geography domain. Second, presentations from computer science acquainted him with the fundamentals of artificial intelligence/machine learning, which is an emerging topic regardless of any discipline.

Ayman Nassar, a postdoctoral fellow III in civil and environmental engineering at Utah State University. He also echoed with benefits of bringing multidisciplinary perspectives to his research, which primarily focuses on advancing cyberinfrastructure and geospatial information to support large-scale collaborative, reproducible hydrologic modeling. The I-GUIDE Climbers' group was an exceptional opportunity to delve into the realm of multidisciplinary geospatial research topics and promote collaboration among diverse groups with different backgrounds. Immersing ourselves in this research environment not only allowed us to broaden our horizons but also enabled us to improve research work in hydrologic modeling using National Water Model (NWM) along with existing community cyberinfrastructure.

B. Collaboration & Communications

Iman Haqiqi, a senior research economist at Purdue University, highlighted that his participation was helpful in building multidisciplinary collaboration, which brought him big rewards. His work focuses on geospatial economic analysis of sustainability and global changes through a comprehensive gridded economic model. From the Climbers group, he learned how to improve presenting complex economic problems to a multidisciplinary audience and how to improve the validation of our models, which helped in a published paper. He learned that the validation concept can be different across disciplines. This establishes the foundational terminology for future communications among hydrologists and economists. He also learned that research about flooding is a hot topic in hydrology and bringing a socioeconomic perspective to the research can be a potential future development of economic modeling.

Wei Hu, a Ph.D. student in geography and geographic information science at UIUC, shared that learning from senior members was one of the most helpful aspects of the Climbers group. As a part of the I-GUIDE GeoAI team, she studies natural language processing combined with geospatially related text data. While working on hypercube system construction and spatial topological relation extraction, she acquired valuable feedback and insights on how to present to the audience with different domains. She has learned about other disciplines and various research topics from the Climbers meeting, such as water level prediction and socioeconomic characteristics of aging dams. Besides, she acquired research insights from senior postdocs in the group, such as how to publish papers targeted at domain-leading ML conferences.

Nick Manning, a Master's student at Michigan State University in the Center for Systems Integration & Sustainability, said the Climbers group helped him to set up realistic research goals by asking questions to the group members. His work processes geospatial and temporal datasets on drought and land cover change related to the telecoupling framework, disasters, and their distant impacts. Nick has learned to efficiently summarize his work and to present to interdisciplinary audiences with various levels of expertise. Through I-GUIDE, he has also learned about the applications of machine learning and language models to many environmental and societal problems. Especially, he said that Climber's multidisciplinary group helped him set realistic goals in his research work. Collaboration with experts has helped him approach questions with a fresh perspective, how and when to ask appropriate and clear questions, to prioritize his time, and to reach out for help when needed.

Adam Tonks, a Ph.D. Candidate in Statistics atUIUC, shared that Climbers group could be a new method for communicating research findings. He recently completed an interdisciplinary paper involving data processing and modeling in the context of hydrology and climate change. During his recent webinar on cartograms, he found the audience to be highly interested in the potential application of the data visualization technique within their own work. He mentioned that there is a lot that he has learned from other work that may not be of his direct academic interest, but nonetheless provokes thoughts and questions related to his own research. More specifically, he likes seeing how other members have visualized

their data, or chosen to develop their models, since these are things that he can directly apply to his own work.

Alex Michels, a Ph.D. student in Informatics at UIUC, said the Climbers group was helpful in identifying the demand for his computational skill sets. He works with the I-GUIDE developer team and is responsible for the tasks on CyberGIS-Compute and supporting the I-GUIDE Platform. He has gained a lot of perspective about the computational and technical bottlenecks facing researchers in various domains, which has helped him to guide the development of CyberGIS-Compute.

Ramya Kumaran, a Ph.D. student in Educational Psychology and UIUC, shared that the Climbers group was integral in thinking about the connections and collaborations across teams and individuals across the I-GUIDE project. She has found it to be a unique opportunity to gain a deeper understanding of the I-GUIDE ecosystem. As a part of the I-GUIDE team working on program evaluation for the project, her involvement in the Climbers group has allowed for a holistic perspective on the research, collaboration, and collaborative learning across teams to be captured and integrated into the development of I-GUIDE's internal evaluation plan.

VI. Conclusions

Weekly lab meetings are one way to foster collaboration, communication, and feedback among research lab members, however, they can also be challenging to organize and run effectively, especially for a multidisciplinary team. There are many different approaches to constructing and running these multidisciplinary meetings. This paper introduced the "Climbers" model of weekly multidisciplinary research meetings. Climbers are early-career professionals who are part of a broader multidisciplinary team (I-GUIDE) that conducts cutting-edge research on convergence problems in human-natural systems enabled by the geospatial data revolution. The Climbers group encourages active participation, constructive feedback, and peer support among all members, while also allowing for flexibility and diversity in the presentation formats and contents.

The future prospects of Climbers-type lab meetings are promising. As sustainability research becomes increasingly interdisciplinary, the need for effective communication and collaboration among researchers is greater than ever. Weekly lab meetings among early-career professionals from various disciplines provide a valuable opportunity for researchers to share their work, get feedback, and learn from other perspectives. In addition, Climbers-type meetings can help to foster a sense of community among researchers working on different angles of sustainability problems. This can be especially important in large multidisciplinary labs, where researchers may not have the opportunity to interact with other disciplines on a regular basis. Weekly meetings of multidisciplinary researchers, such as those in the Climbers group, can provide a venue for researchers to share their ideas, learn from other fields of science, and build relationships outside of their specialty in a broader network of researchers.

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