Main Paper Introduction

*Harnessing Scientific Discovery for Societal Progress: A Multifaceted Approach to Wicked Problems*

In an era marked by rapidly evolving societal challenges, the role of scientific discovery becomes ever more crucial. A "wicked problem," as described by Rittel and Webber (1973), refers to complex social challenges characterized by their intricacy and resistance to straightforward solutions. These problems, often encountered by professionals in social services, are marked by their interconnectedness, and the repercussions ripple through various social systems. Notably, social processes within these challenges are likened to networks, where each action creates a web of effects, underscoring the importance of considering the broad, interconnected systems (Rittel and Webber 1973). These problems defy simple solutions and necessitate a comprehensive approach that blends scientific inquiry with innovative policymaking.

Examples of global wicked problems are outlined by the United Nations' Sustainable Development Goals (SDGs), which encompass a wide array of long-term challenges in health and well-being (United Nations Department of Economic and Social Affairs 2024). Rittel and Webber (1973) describe wicked problems as unique, with no definitive formulation and no true or false solutions, but rather better or worse solutions. These problems are characterized by an endless cycle of formulation and redefinition, often entangled in ethical, cultural, and ideological debates (Rittel and Webber 1973). The authors illustrate that societal problems, unlike scientific ones, do not afford the luxury of trial and error (Rittel and Webber 1973). A wicked problem like where to build a highway is a one-shot operation with near-irreversible consequences, underscoring the need for a deeply considered approach grounded in scientific rigor (Rittel and Webber 1973).

Boise State University (BSU), recognizing the urgency and complexity of local societal issues, is invested in the ambitious Grand Challenges (GCs) initiative (The Center for Research and Creative Activity 2024). This initiative, a cornerstone of Boise State's strategic plan, is designed to foster a transdisciplinary approach to research and creative activity. The University's Center of Research and Creative Activity plays a pivotal role in this endeavor, leading the charge by investing in interdisciplinary research teams, providing campus-wide faculty training, and funding pilot studies that seek solutions to Idaho's societal challenges.

However, despite these substantial investments, there remains a notable gap in understanding the effectiveness of these interdisciplinary collaborations (Love et al. 2021, citing Falk-Krzesinski et al., 2011; Klein et al., 2009). Recognizing this, the Center has identified the need for comprehensive research evaluating the impact of researcher support. This observation led to the formation of the Social Network Analysis Project (SNAP), asking, “How do the GCs investments change collaborations across campus?” My thesis, set against this backdrop, aims to describe the structural and relational dynamics among BSU faculty (and staff), specifically focusing on understanding the state of the collaborative environment before and when the GCs investments began. This exploration will contribute to understanding how the GCs investments change collaborations across campus by determining what collaboration looked like prior to the investments. This work will act as a springboard for which future studies can capture collaboration changes. Additionally, this work will illuminate areas where treatments should focus, thereby enhancing the efficacy of BSU’s GCs' initiative. (Add a sentence here that connects to understanding wicked problems / SDGs through interdisciplinary research.)

*Advancing Idaho’s Societal Progress: Boise State University's Approach to Grand Challenges*

As far back as 2015, Jana LaRosa, the assistant vice president for the Department of Research and Economic Development (DRED) began to ask what the GCs for BSU are after seeing other institutions, like the University of Texas Austin (UT Austin), promoting GCs (J. LaRosa, personal communication, September 25, 2023).

UT Austin’s Planet Texas 2050 (PT2050) initiative is a testament to the innovative approach adopted by the Office of the Vice President for Research, which encouraged a collaborative, interdisciplinary ethos by supporting researchers in crafting their own thematic roadmaps (Lieberknecht et al. 2023). This strategic approach not only embraced a wide array of disciplines, including engineering, geology, and hydrology, but it also consciously integrated new perspectives by inviting additional experts in public health and computer modeling, thereby enriching the team's diversity and enhancing the potential for groundbreaking interdisciplinary solutions (Lieberknecht et al. 2023).

In 2019, BSU’s Interim Herald Blackman, Provost Tony Roark, and President Marleen Tromp put out a call to campus asking faculty to send in 2–3-page proposals on what could be theme areas for the GCs (J. LaRosa, personal communication, September 25, 2023). They looked at the approximately 150 submissions and then put together five different thematic areas (J. LaRosa, personal communication, September 25, 2023) with two primary challenges: "Resource Nexus for Sustainability" and "Healthy Idaho" (The Center for Research and Creative Activity 2024). At the end of 2019 and the beginning of 2020, Jana LaRosa took on these GCs to drive it forward.

The BSU’s GCs initiative seeks to tackle Idaho’s 'wicked problems' – complex societal challenges that align with the United Nations' SDGs, including sustainable cities and communities, good health and well-being, and responsible consumption and production.

The "Resource Nexus for Sustainability" GC embodies SDG goals like clean water and sanitation, affordable and clean energy, and sustainable cities and communities (United Nations Department of Economic and Social Affairs 2024). This initiative integrates various scholarly disciplines and stakeholders, aiming to build resilient urban and rural systems through a collaborative nexus of scholars and practitioners. The focus on sustainability echoes the necessity of transdisciplinary collaboration in solving complex problems (Dalton, Wolff, and Bekker 2021), where diverse perspectives converge to offer innovative solutions while mitigating repercussions in other social systems.

The development of Resource Nexus for Sustainability mirrors the grassroots approach employed by PT2050, bringing together a committed and diverse group of faculty and staff passionate about the GC and is “tight socially” (J. LaRosa, personal communication, September 25, 2023). In contrast, the formation of the "Healthy Idaho" GC leadership team was picked by the deans (J. LaRosa, personal communication, September 25, 2023).

The "Healthy Idaho" GCs mirror the SDG goal of ensuring healthy lives and promoting well-being for all (United Nations Department of Economic and Social Affairs 2024). This initiative addresses physical and social conditions to foster healthier communities throughout Idaho. Healthy Idaho is rooted in One Health, initially misunderstood by BSU’s Deans as a health-related topic (J. LaRosa, personal communication, September 25, 2023). But One Health has a distinct meaning. It is the intersection between human, animal, and environmental health (J. LaRosa, personal communication, September 25, 2023). It is generally nested under environmental programs, not health programs (J. LaRosa, personal communication, September 25, 2023).

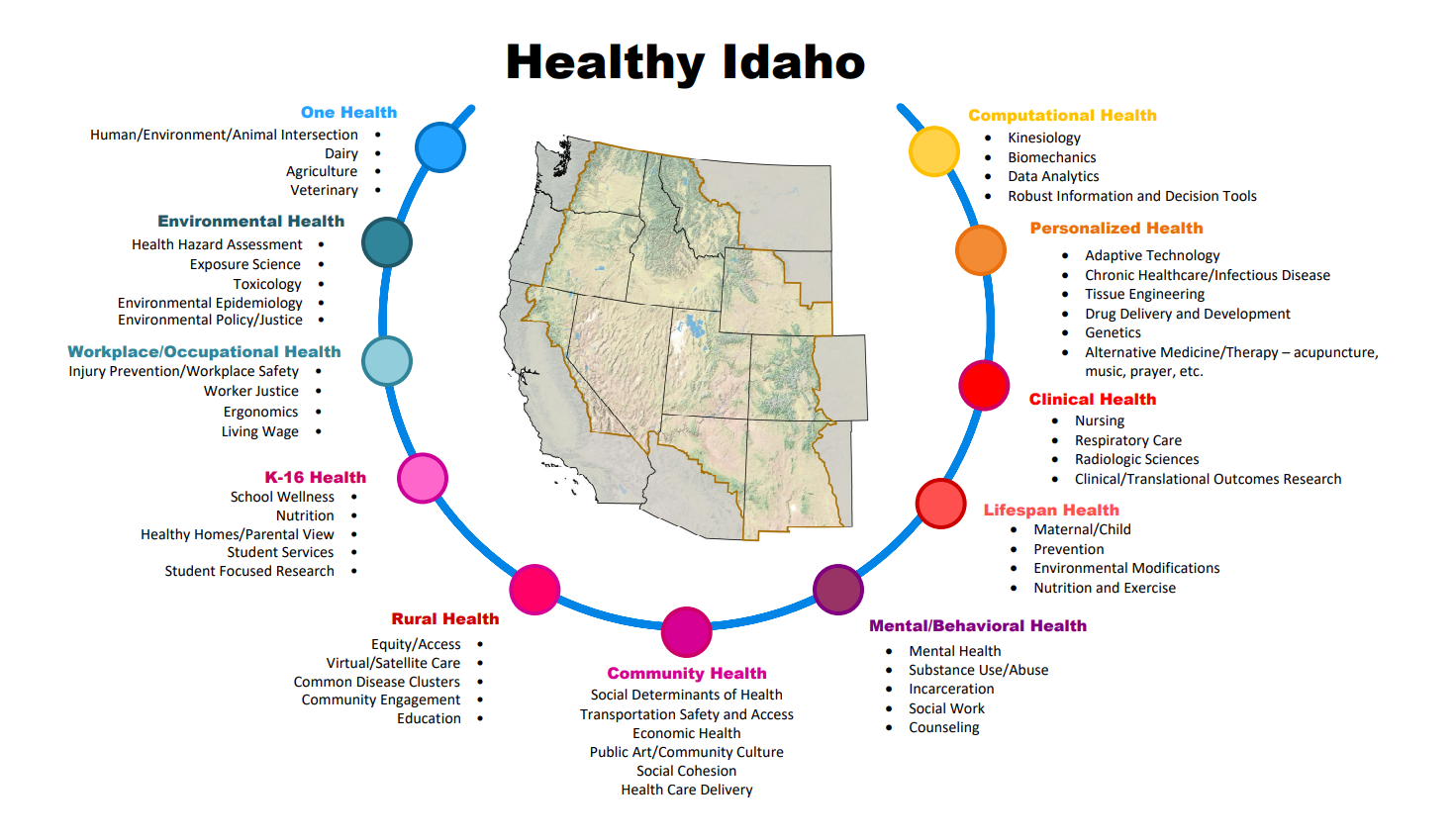
By focusing on these GCs, BSU not only positions itself to make substantial contributions to local and global efforts in addressing critical issues but also enhances its research and educational objectives. The university champions the ethos of "Blue Turf Thinking," which signifies a pioneering spirit (Blue) to break new ground, a pragmatic focus (Turf) on creating effective environments for achievement, and an integrative approach (Thinking) that melds creativity, research, and passions (Boise State University Admissions 2024). At the heart of this philosophy is a dedication to interdisciplinary research, a strategy that has effectively tackled complex, multi-dimensional problems (Lyall and Fletcher 2013). This collaborative approach, especially between social and natural sciences, not only fosters scientific and technological progression but also drives innovation-led economic growth (Lyall and Fletcher 2013). BSU's strategic plan, "Blueprint for Success 2021-2026," encompasses five key goals, each aimed at enhancing various aspects of the university's impact and outreach. Notably, Goal 3 – Advance Research and Creative Activity – specifically highlights the GCs initiative as a pivotal strategy for research advancement (Boise State University 2024). However, the GCs initiative's influence extends beyond this single goal; it actively contributes to all five goals, embodying the diverse strategies outlined in the blueprint. Throughout this thesis, I will point out some of the ways the GCs initiative not only bolsters research but also synergistically supports the broader objectives of BSU, thereby playing a crucial role in realizing the university's vision for success. While this is not the objective of my thesis, it will aid in extending the rationale for supporting the initiative.

Figure 1. The "Healthy Idaho" Grand Challenge, as depicted in the document provided by The Center for Research and Creative Activity, outlines key areas for collaborative efforts to improve health outcomes across the state. These areas include One Health, emphasizing the human/environment/animal intersection; Environmental and Workplace Health; K-16 Health, focusing on youth wellness and education; Rural Health, addressing equity and access; Community Health, underlining social determinants; and spans to Computational, Personalized, Clinical, Lifespan, and Mental/Behavioral Health. Research teams might explore innovative solutions across these dimensions to foster comprehensive well-being and address the multifaceted health challenges in Idaho's diverse communities.

The Center of Research and Creative Activity, in its efforts to support the GCs initiative, has recognized a gap highlighted by researchers: despite the substantial investment in collaborative and interdisciplinary projects, there's a lack of comprehensive research evaluating the effectiveness of team support measures like training and team performance metrics (Love et al. 2021, citing Falk-Krzesinski et al., 2011; Klein et al., 2009). This recognition led to the formation of the Social Network Analysis Project (SNAP), aimed at examining faculty collaboration at BSU within the GCs framework. SNAP is a research team dedicated to understanding faculty collaboration at BSU in the context of the impact of the GCs initiative. The team includes staff and faculty across campus, including Anthropology, Philosophy, Human-Environment Systems, the School of Public and Population Health, the Library, and DRED. Additionally, the team includes a graduate student, me. As a member of this project, I have access to this innovative learning experience, an example of the GCs initiative performing BSU’s blueprint goal to improve student success (Boise State University 2024).

This thesis aims to understand the structural and relational dynamics of faculty at BSU. These findings will help guide university interventions that allow for the optimization of interdisciplinary and solutions-oriented funding network interventions.

Several research branches were formed to measure the impact of the GCs initiative’s investments. Phase 1 of SNAP moves to characterize research and creative activity at BSU before and at the start of the initiatives' programs.

Vicken And Many Persons Interview Research Enterprise (VAMPIRE) is a research branch of SNAP tasked with conducting and analyzing informal BSU faculty interviews about collaboration. In phase 1, VAMPIRE asks, “How do faculty define collaboration (thinking beyond proposal application and publication)?” and “What other ways do faculty collaborate?” Using focus groups and semi-structured interviews, faculty responses are analyzed ethnographically. The results of this research are reported in chapter one of this thesis.

Collective Understanding of PI Data (CUPID) is a research branch of SNAP that uses social network analysis (SNA) on historical grant application data to answer three research questions. Q1. What are the grant networks' natural fluctuations (growth) between 2016 and 2020? Has the known growth in this timeframe affected the network? Q2. What are the effects of the grand challenges on these natural fluctuations in the grant network? Q3: Can we predict tie formation, PI, and Co-PI, and changes? Chapter two of this thesis contains a report on these grant networks.

The final chapter of my thesis reports on research teams formed out of the GCs initiative. In this project branch, SNAP replicates the mid-point survey by Love et al. (2021) to investigate these characteristics in interdisciplinary scientific teams. Deemed the LOVE branch, SNAP asks how these intensive research collaborations change collaborative relationships over the course of the project. It is anticipated that LOVE will survey the team several times over the course of the GC investment. Chapter 3 reports the initial survey results, relying heavily on SNA methods.

Literature Review

*The Power of Collaboration in Science: Paving the Way for Groundbreaking Discoveries and Solutions*

Collaboration is vital for solving complex scientific problems and furthering various political, economic, and social agendas, including democracy, sustainable development, and cultural integration. Collaboration can extend the scope of research projects and foster innovation by providing additional expertise (Sonnenwald 2007). Disis and Slattery (2010) point out that multidisciplinary research teams possess a robust knowledge base and extended networks and are more prone to dynamic, connective thinking, leading to radical innovations. Collaboration also increases scientific reliability and success probability by involving multiple perspectives in verifying results (Sonnenwald 2007). This perspective aligns with the idea that to effectively tackle society's 'wicked problems' and achieve the United Nations' SDGs, academia must promote and support scientific collaboration (Rittel and Webber 1973). Scientific collaboration is defined as a behavior among scientists that involves sharing meaning and completing tasks toward a common, overarching goal, taking place within a social context (Sonnenwald 2007). This rationale also underpins the promotion of collaboration at the university, as it not only advances research quality but also enhances a scientist’s credibility within the scientific community, in line with BSU’s blueprint goal 4, fostering a thriving community (Boise State University 2024).

Hart (2000) underscores the value of collaboration in enhancing the quality of academic work. In their study on collaborative publications by university librarians, Hart found that collaborative efforts often result in higher quality outputs than single-authored works (2000). This phenomenon is attributed to the diverse expertise, mentoring, and intellectual benefits brought together through collaborative efforts, indicating that multi-authored works tend to undergo more rigorous quality control (Hart 2000).

Intradisciplinary collaboration, or unidisciplinary (Okraku et al. 2017) or simply disciplinary, is a form of scientific cooperation where participants from the same field contribute and generate knowledge within their specific domain, as noted by Sonnenwald (2007). Moody (2004) describes research specialties within these collaborations as central clusters of scientists instrumental in generating innovative concepts and ideas. Dalton, Wolff, and Bekker (2021) further define a scientific discipline as a distinct field characterized by unique discourses and practices, akin to a specific language code. This 'language', encompassing methodologies, terminologies, and theoretical frameworks, remains largely exclusive to the discipline, providing its practitioners with a framework for focused scientific progress (Dalton, Wolff, and Bekker 2021).

Interdisciplinary collaborations play a crucial role in addressing global challenges by merging diverse expertise and perspectives, thus enabling a more comprehensive understanding of complex issues. Jana LaRosa, the Assistant Vice President for the DRED at BSU, emphasizes the importance of integrating disciplines (J. LaRosa, personal communication, September 25, 2023). She notes that while disciplinary work is valuable for its incremental contributions to specific fields, interdisciplinary work is essential for tackling broader, society-driven questions that single disciplines cannot address alone. This perspective aligns with the growing trend among federal agencies to prioritize interdisciplinary research in funding decisions (cite this). LaRosa highlights that researchers at BSU must excel in team-based approaches to capitalize on funding opportunities that demand interdisciplinary efforts. She points out the need for authentic collaboration between STEM and social sciences, moving away from superficial integrations towards genuinely co-created and co-developed research questions that synergize both domains. This shift marks a departure from traditional practices where social science elements were often added as afterthoughts to STEM projects; instead, it calls for an equal and integrated partnership from the outset of research initiatives.

Measuring Interdisciplinary Collaboration

Scientific disciplines will have to work together to solve complex and large-scale societal challenges like resource sustainability and One Health. Collaborative research is often categorized into three distinct yet interconnected types: multi-, inter-, and transdisciplinary (e.g., Dalton, Wolff, and Bekker 2022; Sonnenwald 2007; Lieberknecht et al. 2023). Multidisciplinary research involves various disciplines working in parallel, each contributing their perspective without integrating their efforts (Dalton, Wolff, and Bekker 2021). In contrast, interdisciplinary research signifies a deeper level of collaboration where multiple disciplines actively merge their methodologies and viewpoints to tackle a common problem (Dalton, Wolff, and Bekker 2021). Transdisciplinary research transcends traditional academic boundaries, incorporating inputs from external entities such as industry, government, and community stakeholders, thus offering a holistic approach to complex societal issues (Dalton, Wolff, and Bekker 2021).

Bolger (2021) zeros in on the degree of interdisciplinary research by categorizing discipline distances. Through a study of three established research centers, the study surveys faculty members on their motivations for joining the centers, their perceptions of interdisciplinary research, and the nature of their collaborative activities. Bolger introduces a novel classification based on the 'distance' between collaborating disciplines: 'within-discipline' collaborations (e.g., between biologists with different specializations), 'short distance' within the same super-discipline (e.g., an engineer collaborating with a biologist), and 'long distance' across distinct super-disciplines (e.g., an ecologist working with a social scientist) (Bolger 2021). This final categorization distinguishes collaborations spanning 'hard' sciences (natural and applied sciences) and 'soft' sciences (social sciences and humanities), offering a more granular understanding of interdisciplinary research dynamics.

Expanding our viewpoint of the various degrees in academic collaboration, including academia, business, government, and non-government organizations, is important to solving society’s wicked problems. The concept of participatory action, a collaborative approach between scientists and community members, values community members' knowledge, experiences, and values, aiming to integrate these into research projects (Sonnenwald 2007). Its goal is to generate knowledge that leads to effective social action and solves real-life problems, with the effectiveness of the action determined by participants (Sonnenwald 2007). Illustrating the transformative power of participatory action, initiatives like SPECTRUM and PT2050 stand as exemplary models, bridging the gap between academic research and real-world application in addressing societal challenges.

Enns et al. (2023) present a compelling case for a collaborative approach to tackling these societal challenges. Through the SPECTRUM project, they demonstrate the efficacy of a tripartite partnership model where community organizations, government, and academia work in concert (Enns et al. 2023). This model moves away from a hierarchical approach to a more egalitarian, knowledge-sharing framework (Enns et al. 2023). It embodies the essence of tackling wicked problems by leveraging diverse perspectives, experiences, and expertise (Enns et al. 2023). This collaborative approach not only aids in developing more holistic solutions but also ensures that these solutions are attuned to the real-world complexities of the problems they aim to address (Enns et al. 2023).

Lieberknecht et al. (2023) present a comprehensive view of the transdisciplinary climate research PT2050, a model that equally values scientific and humanistic disciplines. PT2050's success in integrating diverse epistemologies and methodologies is credited to its focus on disciplinary equity and its inclusion of community partners in co-designing research, thereby avoiding technological solutionism (Lieberknecht et al. 2023). By fostering an environment where different disciplines and community stakeholders can collaborate as equals, PT2050 serves as an example of how GCs can transcend traditional academic silos to address 'wicked' problems.

Transitioning from focusing on successful transdisciplinary projects like SPECTRUM and PT2050, it's important to address the inherent challenges of such collaborations. Merging various academic disciplines and community insights, transdisciplinary work often faces hurdles due to conflicts with entrenched discipline-based conventions, structures, and norms. Because of this, it is generally more difficult to co-create than aggregate research. This reality calls for understanding the intricate dynamics and challenges research teams encounter in interdisciplinary settings.

*Teaming Concerns: Academic Culture and Interpersonal Dynamics*

Interdisciplinary research often demands significant time, is prone to disagreements, necessitates blending different knowledge systems and methods, and calls for adaptability, thorough planning, and mutual trust within the team (Piqueiras, Stanley, and Laskey 2023). Piqueiras, Stanley, and Laskey conducted a detailed ethnographic study within a larger, federally funded, interdisciplinary scientific team, employing participant observation, semi-structured interviews, and a focus group over six months. They aimed to uncover and mitigate challenges in team science across institutional, cultural, and interpersonal levels. Their findings emphasize the significance of understanding and addressing three primary barriers: academic culture, institutional structures, and interpersonal dynamics (Piqueiras, Stanley, and Laskey 2023).

Crossing Disciplinary Boundaries

Dalton, Wolff, and Bekker (2022) argue that interdisciplinary research systems, characterized by a central organizing principle (CrOP), are essential in addressing 'metaproblems' that individual disciplines cannot solve alone. This approach highlights the necessity of integrating diverse disciplinary perspectives to effectively address complex societal challenges, emphasizing the importance of both top-down and bottom-up approaches in forming successful interdisciplinary collaborations (Dalton, Wolff, and Bekker 2022). GCs are CrOPs. The challenge is getting researchers to imagine their work and the work of other researchers in differing disciplines as appropriate to the CrOP.

Early in promoting the GC initiative “Healthy Idaho,” LaRosa noted that researchers struggle to think creatively about how their research might contribute to the larger societal problem (J. LaRosa, personal communication, September 25, 2023). The solution was the design of Figure 1 to show researchers paths to access the “Healthy Idaho.” Similar issues were reported by Piqueiras, Stanley, and Laskey's study, which found that team members often reverted to thinking through their disciplinary lens, leading to conflicting ideologies and tensions in knowledge integration (Piqueiras, Stanley, and Laskey,2023). Differences emerged between trusting team members' expertise and trusting them as individuals, highlighting the necessity of actively creating a culture of trust (Piqueiras, Stanley, and Laskey 2023). Collaborating with various organizations, communities, and countries brings additional trust challenges, such as differing research goals, ethical practices, and resource availability. Including stakeholders in the planning stages and ensuring mutual benefits can help manage these issues. Understanding and addressing trust issues, particularly in rural and ideologically diverse communities, is essential for successful collaboration.

Collaboration failures have been blamed on epistemic and ontological incompatibilities, such as interpersonal or political problems and barriers related to language and terminology between disciplines (Dalton, Wolff, and Bekker 2021). In their study, Duysburgh et al. (2012) examined the collaboration dynamics within six Belgian multidisciplinary research groups focusing on information and communication technologies. Using ethnographic methods, including surveys, workshops, observations, and interviews, they explored the integration of diverse academic and community members. The study identified several teaming challenges.

Duysburgh et al. found that the teams struggled to understand how other members would contribute to that larger, common goal, explaining various reasons why. STEM scientists struggle to understand how social scientists can contribute to a project or see their added value (Duysburgh et al. 2012). Additionally, rapid growth in team size led to increased specialization and differentiation among members, which posed a challenge to maintaining coordination and cohesion (Duysburgh et al. 2012). Competition both within and between groups fostered further specialization, creating clusters within the teams and distancing the research groups from their university affiliations (Duysburgh et al. 2012). Teams were structured hierarchically with junior, senior, and head levels, alongside supportive roles like secretaries. However, this structure sometimes led to a sense of exclusion among junior researchers, who had limited involvement and access to information (Duysburgh et al. 2012). These factors lead to researchers not understanding the greater research agenda, which means that the result is an aggregation and not a co-creation of creative work.

In addressing interdisciplinary understanding, the perspective of critical realism, as advocated by Dalton, Wolff, and Bekker (2022), offers valuable insights. Critical realism, combining ontological absolutism (external structures) with epistemic relativism (the subjectivity of human understanding), provides a robust framework for understanding the structures and mechanisms in the real world and, by extension, within interdisciplinary teams. This philosophical approach assists in unraveling the complexities of interdisciplinary interactions and identifying potential sources of conflict or misunderstanding among diverse team members.

Effective communication is vital for coordination, learning, research integration, and mitigating distrust perceptions. Trust, including cognitive (trust in the expertise of others) and affective trust (emotional bond among team members), is fundamental in collaborations (Sonnenwald 2007). Critical realism may help in building both cognitive trust and affective trust by acknowledging and valuing the contributions of different disciplines. By recognizing and accommodating different epistemological standpoints, critical realism fosters a constructive working environment where differences are not seen as barriers but as enriching elements of a shared objective reality. Critical realism can be instrumental in addressing STEM scientists' skepticism toward social scientists' contributions, as Duysburgh et al. reported. Learning, both explicit and tacit, is a critical component of collaborative research, particularly in interdisciplinary settings (Sonnenwald 2007). However, learning is often challenging and not typically included in research proposals (Sonnenwald 2007). Duysburgh et al. (2012) suggest that plenary project meetings, while bridging gaps between specialties, often missed opportunities for effective collaboration. A more frequent and focused meeting approach based on common research interests was recommended (Duysburgh et al. 2012).

Furthermore, critical realism’s emphasis on reflexive thinking encourages team members to be aware of and question their biases and assumptions, leading to more empathetic interactions and stronger affective trust. Critical realism encourages researchers, such as engineers, to appreciate social sciences' qualitative, context-rich insights, complementing the quantitative, empirically focused approaches typical of STEM fields.

Scarcity of Time

Piqueiras, Stanley, and Laskey (2023) study found that a constant perception of being behind and urgency affected project management and task division. Additionally, a consistent issue was the regret and guilt expressed by team members regarding their inability to dedicate sufficient time to the project. This scarcity of time also affected the follow-through on tasks, depending on each member's availability and capacity (Piqueiras, Stanley, and Laskey 2023). Unrealistic timelines and conflicting responsibilities strained investigators and trainees (Piqueiras, Stanley, and Laskey 2023). The research team faced challenges with project management due to a lack of dedicated coordinators and unrealistic funding expectations (Piqueiras, Stanley, and Laskey 2023). This was exacerbated by funding institutions' requirements for principal investigators to propose ambitious project timelines, often beyond realistic scopes (e.g., a 10-year project within a 5-year timeframe) (Piqueiras, Stanley, and Laskey 2023).

Duysburgh et al. (2012) also recommend strong project management to solve the difficulties inherent in interdisciplinary work (Duysburgh et al. 2012). The lack of a unified software solution led to confusion, and project websites were viewed negatively (Duysburgh et al. 2012). Multiple funding sources, while providing stability, imposed greater administrative burdens, particularly on senior researchers and administrators (Duysburgh et al. 2012).

Institutional Structures

Various institutional structures, including funding agencies, universities, IRBs, and bureaucratic partners, highlight how these structures shape collaborative research (Piqueiras, Stanley, and Laskey 2023).

Institutional Structures affect the attraction to research collaboration. As Okraku et al. (2017) emphasize, the predominance of unidisciplinary collaborations in scientific research is often a result of established organizational structures, training processes, and institutional reward systems. Such collaborations enable rapid consensus-building and efficient results production due to shared training and language (Okraku et al. 2017). Nonetheless, this emphasis on unidisciplinary work often leads to its prioritization in tenure and promotion processes, potentially fostering knowledge silos (Okraku et al. 2017). Lyall and Fletcher (2013) suggest that the preference for disciplinary over interdisciplinary research is often shaped by the funding frameworks of research institutions, which establish the guidelines and priorities governing the allocation of resources. Collaborative work can be marginalized or discounted within departments, especially if only one scientist is involved in a specific collaboration (Sonnenwald 2007), leading to the creation of knowledge silos and impeding the diffusion of knowledge across disciplines (Okraku et al. 2017). The GC initiative aims to allow individuals to work in an interdisciplinary way that serves their own disciplinary work (J. LaRosa, personal communication, September 25, 2023). This thesis will not evaluate institutional incentives and disincentives to collaborating at BSU. It is beyond the scope of this project.

Politics Prevent Innovation Freedom

A limitation to achieving the goals of the GCs is political intervention in creative work. Political barriers related to 'wicked problems' impact the formulation of research questions, and the GC initiative navigate these political landscapes cautiously, potentially limiting innovation. For example, when the GC thematic areas were being designed, there were three thematic areas. LaRosa explained, “There was another really great question, but we were in 2020, and Marlene Tromp was getting hammered by the legislator over DEI (Diversity, Equity, and Inclusion) questions. The third thematic area was an equity and justice question. We decided we couldn’t “poke the bear” (J. LaRosa, personal communication, September 25, 2023). Because of Idaho politics, the GCs were reduced to two thematic areas. An additional political barrier occurred when a Health Idaho award team posited research plans that entered into contentious domains, demonstrating the intricate balance between academic inquiry and political sensibilities. While the specifics of their original plans remained confidential, the repercussions were evident in the suspension of their research and funding, leading to a significant delay in my ability to conduct surveys of the team for this research. This incident exemplifies the challenges researchers face in navigating political landscapes. Researching and determining solutions to societal problems inevitably enter grounds of political tension. Restrictions limit the potential impact of the GC initiative.

Interpersonal Relationships

Pre-existing collaboration histories among senior team members set implicit expectations for new members, complicating the team dynamics and contributing to feeling overwhelmed (Piqueiras, Stanley, and Laskey(Piqueiras, Stanley, and Laskey 2023). Sonnenwald (2007) also addresses concerns about unethical conduct, intellectual espionage, and skewed funding toward collaborative research at the expense of single investigators (Sonnenwald 2007). Duysburgh et al. (2012) noted that internal competition reserved team member collaboration efforts, resulting in some researchers and companies only using the initiative as a funding source.

Leadership

Networks of scientific collaboration facilitate the spread of knowledge and innovation throughout various disciplines and institutions (Okraku et al., 2017). Disis and Slattery (2010) describe the connective thinking process through which an individual’s innovative idea moves through the team. After being fully evaluated, the idea becomes a sum of the team’s input (Disis and Slattery 2010). Moody (2004) cites theorists who argue that an individual’s ideas are a function of their position in a social setting, which is deeply structured by interaction patterns. The shape of the idea can be linked to the structure of a network, and in small groups, ideas and their movement depend on the authority structure (Moody 2004). Leadership, therefore, plays a pivotal role in the success of these teams, with transformational leaders being essential for motivating, moderating, and mentoring diverse groups (Disis and Slattery 2010).

Glied et al. (2007) describe sustainable leadership characteristics of center directors as charismatic, capable of negotiating with administrators, department chairs, and center members. A transformational leader is dedicated to mentoring and sacrifices self-interests to ensure all projects and resources match the interests and priorities of the team (Disis and Slattery 2010). Bland et al. (2005) describe research leaders as being regarded highly as a scholar and a sponsor, mentors, and peer models. When selecting interdisciplinary leaders, DRED considered faculty researchers seasoned in their careers, capable of “floating other boats” (J. LaRosa, personal communication, September 25, 2023). Additionally, DRED is invested in leadership training. Interdisciplinary team leads attend “Office Hours,” held by The Center for Research and Creative Activity, where they workshop teaming challenges and receive planned leadership training (J. LaRosa, personal communication, September 25, 2023). During the connective thinking process, team members may assume leadership roles as projects evolve (Disis and Slattery 2010). This aligns with DRED’s approach, where all members are potential leaders and active participants in leadership training, contributing to the project's adaptability and success. LaRosa said in our interview, “It isn't necessarily the lead only [who attends Office Hours]. Whoever is on the team wants to do that kind of work is invited. We build a more distributed leadership structure this way” (J. LaRosa, personal communication, September 25, 2023). All members are potential leaders and active participants in leadership training, contributing to the project's adaptability and success. This may, in turn, prevent problems arising when leaders need to reduce responsibility or leave their positions (Glied et al. 2007).

Leaders are more successful with project management experience (Sonnenwald 2007) and high levels of organization (Disis and Slattery 2010). Project managers can be added to teams to alleviate burdensome leadership responsibilities (Sonnenwald 2007). Interdisciplinary teams share a project manager who helps in training during office hours (J. LaRosa, personal communication, September 25, 2023). Project management and leadership training include proactive documentation to prevent misunderstandings (J. LaRosa, personal communication, September 25, 2023). Collaborative projects face challenges in publication and dissemination, including finding appropriate forums for interdisciplinary results, consensus on authorship, and different disciplinary expectations (Sonnenwald 2007). LaRosa gives an example from her personal experience assisting research collaboration.

“In computer science, they rarely write papers. They do lots of conferences. That is all they need to get a promotion and tenor. The social science policy person needs to publish to get a promotion and tenor. This leaves one person stuck writing” (J. LaRosa, personal communication, September 25, 2023).

Addressing these issues at the onset of collaboration is critical for the success and recognition of research outcomes. Collaborations may face challenges due to varying informal traditions and norms among disciplines, especially regarding intellectual property sharing. For instance, experimental biologists often patent their ideas, while mathematicians are more open (Sonnenwald 2007). Model agreements provided by funding agencies can streamline the process of developing a shared understanding of IP and other legal issues (Sonnenwald 2007). Further research may consider investigating the personality characteristics of interdisciplinary team leaders to customize leadership training and extend the specific resources to fill the leader’s gaps.

New and Expanded Opportunities Across Campus

With the selection of seasoned faculty as leaders, there is a concern that the GCs investment may not benefit campus researchers as a whole. LaRosa articulated this by saying, “Any time an initiative holds money or [someone] has a title, faculty will think that it is intended to empower the powerful and not help the faculty as a whole.” Additionally, the blueprint for BSU’s success calls for the promotion of a fair, equitable, and accessible environment for all members of campus to make a difference (Boise State University 2024). Therefore, SNAP must ensure that the GCs’ initiative fairly enhances career growth.

Disis and Slattery (2010) point out that loud and powerful researchers tend to receive resources. This could undermine the goals of the GCs investment as those with the most power perhaps could have found external resources where those without prestige continue to struggle to collaborate. Sonnenwald (2007) points out that collaborations “become powerful lobbying groups, influencing research policy and funding decisions in their favor.” The cumulative advantage in science posits that scientist already recognized for their contributions are more likely to gain further recognition and resources (Mali et al. 2012, 235). This concept, drawing parallels to the biblical passage in Matthew's Gospel and referred to as "The Matthew Effect," implies a disparity in the distribution of resources and opportunities within the scientific community, where established researchers gain disproportionately more funding and power, while emerging scientists face challenges in achieving recognition and success (Mali et al. 2012, 235–36). This inequality underscores the importance of ensuring systemic biases in allocating resources and opportunities do not undermine BSU’s GCs initiative. I aim to examine whether individuals selected to participate in the GCs teams are positioned so that they can effectively promote new and expanded opportunities across campus.

*Methods Used to Evaluate Scientific Collaboration*

In modern science, cumulative advantage is a key driver for the development of scientific stars (Mali et al. 2012, 235), a term that refers to a specific network structure. SNA provides a framework for understanding these structures, focusing on the relationships among actors within a network (Borgatti et al. 2022, 2). These actors, or nodes, can be characterized by various categorical attributes, such as department affiliation or continuous, like years of employment. The relationship in this context, termed as ties, connects researchers to each other and can be quantified in multiple ways, including the frequency of interactions over a given period (Borgatti et al. 2022, p 2).

These ties interlink through common nodes, forming paths and, ultimately, a network. Within this network, actors who frequently interact may form a distinct subgroup. The analysis of such subgroups and the overall network structure allows for the examination of shared attributes, offering insights into the collaborative dynamics in scientific communities (Borgatti et al. 2022, 2–3, p 214). By leveraging SNA, researchers can analyze the intricate web of scientific collaboration, indicating how relationships and network structures contribute to developing high-impact scientific work.

For example, Moody (2004) comprehensively analyzes collaboration structures in the social sciences. The paper outlines three key types of network structures: "Small-world," "Cohesive Core," and "Star." In a "Small world" network, local clustering is high, but the average number of steps between actors is minimal (Moody 2004). This is in contrast to a "Star" structure, where there is a significant inequality in collaborative offers, as a limited number of scientists or scholars receive disproportionate offers to collaborate (Moody 2004). Finally, Moody describes a "Cohesive Core," where a growing number of authors show a tendency toward collaboration across different specialties (Moody 2004).

Sonnenwald (2007) outlines methods used to study scientific collaboration, including bibliometrics, interviews, observations, experiments, surveys, simulations, self-reflection, social network analysis, and document analysis. In this thesis, I employ several of these methods, such as faculty semi-structured interviews and focus groups analyzed ethnographic, historical grant proposal data analyzed using SNA and survey results, and research team surveys analyzed using network ethnography, demonstrating a comprehensive approach to studying scientific collaboration.

Okraku et al. (2017) champion a mixed-methods approach, combining ethnography and SNA to track and foster collaboration in emerging scientific fields. This integrative method transcends traditional unidisciplinary collaboration barriers, facilitating interdisciplinary partnerships. My study adopts a similar approach, using codes derived from literature (Piqueiras et al., 2023) to analyze data from diverse sources, thereby ensuring comprehensive validation. Berthod et al. (2017) underscore the necessity of synthesizing qualitative and quantitative methods, advocating for a research design that encompasses field access, parallel data collection, independent analyses, and the integration of findings from both SNA and ethnography.

Social Network Analysis (SNA)

A common type of relationship used to study scientific collaboration is co-authorship. Mali et al. (2012), for example, explore the complexities of scientific collaboration using co-authorship networks, but they also highlight that co-authorship is just one of several forms of collaboration. They stress the prevalence of various other collaborative activities, such as shared editorship, joint supervision of research projects, collaborative research proposal writing, participation in formal research programs, and the organization of scientific conferences (Mali et al. 2012, p 213). Mali et al. highlight the foundational elements of modern social network analysis (SNA) as identified by Freeman (2004): a focus on structural analysis of actors within social relations, the use of systematic empirical data, extensive use of graphical imagery, and a foundation in formal, mathematical, and computational models (Mali et al. 2012, p 216). The modular structure of researcher networks operates across disciplinary, sectoral, and geographical boundaries (Mali et al. 2012, p 219). Mali et al. (2012) also acknowledges the complexities and challenges in fostering and measuring interdisciplinary research due to its demands for extensive networks, time, and mobility among researchers (Mali et al. 2012, p 222). Research specialties can be described as a central cluster of collaborating scientists, responsible for producing a significant number of innovative concepts and ideas (Moody 2004). Mali et al. (2012, p 215) posit that collaboration within specific scientific disciplines often leads to the emergence of distinct clusters within knowledge-production networks, indicative of a *small-world* network structure marked by high local clustering and minimal steps between clusters. Conversely, networks formed through *preferential attachment* suggest a scale-free structure characterized by a power-law degree distribution where burgeoning scientists tend to collaborate with established 'scientific stars', reflecting the principle of cumulative advantage in science (Mali et al. 2012, p 215).

In the seminal paper by (Newman 2001), the author undertakes a comprehensive study of social networks with a specific focus on scientific collaborations. Newman leverages co-authorship of scientific papers as an unbiased and scalable measure for mapping social connections within the scientific community. The study is based on data gathered from multiple scientific databases, such as MEDLINE and the Los Alamos e-Print Archive, within a five-year window (1995-1999). Newman (2001) found that researchers tend to collaborate with peers who have gained influence through numerous prior joint projects, following a pattern of preferential attachment.

The presence of clustering and fragmentation within our network could signify disciplinary grouping (Mali et al. 2012, p 221–22). The small-world network structure suggests that our network may comprise numerous tightly-knit clusters connected by a few inter-cluster links (Mali et al. 2012, p 234). In contrast, a scale-free structure could indicate a hierarchical network dominated by a few highly connected individuals or "hubs" (Mali et al. 2012, 237). The concept of "gatekeepers" and "invisible colleges": Gatekeepers, with their control over resources and opportunities, play a crucial role in shaping the network's topology, while invisible colleges may drive the intellectual and creative output of the scientific community (Mali et al. 2012, p 236).

The degree distribution could reveal a cumulative advantage, or mentorship activity (Norton et al. 2017). Norton et al. (2017) offer a comprehensive examination of the field of dissemination and implementation (D&I) science in health research, integrating network mapping (SNA) and bibliometric methods, similar to our approach, to analyze the evolution and dynamics of D&I as a scientific discipline. Using an online survey, they gather data about participant demographics, engagement with D&I resources, and network dynamics (Norton et al. 2017). Participants rate the frequency of engagement with D&I resources, providing insights into preferred communication channels in the D&I field (Norton et al. 2017). They used a roster-nomination method, collecting data on advice and collaboration networks, allowing participants to report their D&I-related advice-seeking behaviors and collaborations (Norton et al. 2017). The study uses actor-specific measures (e.g., in-degree, betweenness centrality) and broader network metrics (e.g., size, density, clustering coefficients) (Norton et al. 2017). Regression analysis is applied to individual and network-level data to identify predictors of scientific performance (Norton et al. 2017). The advice network in D&I is dominated by a few influential individuals, which is evident from the high centrality scores (Norton et al. 2017). These networks show small-world characteristics, indicating a close-knit but sparsely connected community (Norton et al. 2017). The collaboration network shows trends like the advice network with a few central actors (Norton et al. 2017). Despite its sparse structure, it retains small-world characteristics. Advanced or intermediate expertise in D&I correlates with a higher likelihood of funded grants (Norton et al. 2017). The status in the advice network also plays a significant role in securing grants (Norton et al. 2017). The results highlight the significance of central individuals in the D&I community, essential for connectivity and information flow (Norton et al. 2017). Norton et al.’s approach to network analysis, particularly in understanding the role of central actors and the dynamics of advice and collaboration networks, guides the investigation into the characteristics and dynamics of interdisciplinary collaborations at BSU.

Work Here: \*conclusion of this section. Methods: See [SNAP\_Thesis\_Research\_Proposal.doc](https://1drv.ms/w/s!AhwwF6wwohQ9h55LUjMngLh7lZcl0g?e=hesxjf)

[I plan to work through the three chapters first. Then, I will upload them into NVIVO and sort them. I will use the results from NVIVO to help me write the update on the above methods section and the overall thesis discussion and conclusion.]