(Sonnenwald, 2007)

Sonnenwald, D. H. (2007). Scientific Collaboration. *Annual Review of Information Science and Technology*, *41*(1), 643–681. [https://doi.org/10.1002/aris.2007.1440410121](https://doi.org/https://doi.org/10.1002/aris.2007.1440410121)

Sonnenwald (2007) highlights the growing frequency and significance of scientific collaboration. It is seen as a vital tool for solving complex scientific problems and furthering various political, economic, and social agendas, including democracy, sustainable development, and cultural integration. Scientific collaboration is defined as a behavior among scientists that involves the sharing of meaning and completion of tasks toward a common, overarching goal, taking place within a social context. The article discusses various types of scientific collaboration, including university-industry, inter-/multi-/trans-/cross-disciplinary, international, intradisciplinary, science-society, remote, interinstitutional, large-scale, and participatory or university-community collaborations. [This idea was then expanded on by Dalton, Wolff, and Bekker (2021) to provide a foundational ontology for multidisciplinary research, emphasizing the importance of collaboration across various disciplines.]  
Intradisciplinary collaboration involves participants from the same field, contributing and generating knowledge within that field. Multidisciplinary and cross-disciplinary collaborations may use knowledge from different fields without integrating it, while transdisciplinary collaboration involves a broader integration of knowledge across natural and social sciences, humanities, and societal stakeholders.

Collaboration can extend the scope of research projects and foster innovation by providing additional expertise. It also increases scientific reliability and success probability by involving multiple perspectives in verifying results. Annotation: This rationale 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. Sonnenwald also addresses concerns about scientific collaboration, such as unethical conduct, intellectual espionage, and skewed funding toward collaborative research at the expense of single investigators. [My interviews revealed concerns about how these aspects affect junior scientists' career advancement, which influences their participation in collaborations.]

Sonnenwald (2007) outlines methods used to study scientific collaboration, including bibliometrics, interviews, observations, experiments, surveys, simulations, self-reflection, social network analysis, and document analysis.

Sonnenwald (2007) discusses the importance of collaboration across organizational boundaries, including academia, business, government, and non-government organizations. University-industry collaboration is a common form where university scientists work alongside professionals in industry. The concept of participatory action research is introduced as a collaborative approach between scientists and community members, including non-government organizations (NGOs) and citizen groups. This approach values the knowledge, experiences, and values of community members, aiming to integrate these into research projects. 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) outlines four stages of scientific collaboration: foundation, formulation, sustainment, and conclusion. These stages represent the progression and complexity of collaboration in the scientific process. They acknowledge that scientific collaboration is dynamic, with potential changes in research questions, collaboration partners, and other factors. At the time of the LOVE team survey, the Grand Challenge teams were in the foundation stage, which focuses on factors crucial for initiating collaborations, including pre-existing knowledge, norms, policies, and relationships.

During the formulation stage, scientists initiate and plan collaborative projects. This stage requires detailed consideration of research vision, goals, tasks, leadership, organizational structure, use of ICT, and legal issues. [SNAP Study participants entered this stage at the time of the survey, and network treatments were implemented to address these issues.] A clear vision and well-articulated goals are crucial for motivating scientists and stakeholders in collaborative projects. However, language and epistemological differences can hinder this process. [DRED’s involvement with teams in defining research vision, goals, and tasks is crucial, especially as differences in disciplinary languages and methodologies can pose challenges.]

Access to resources, including equipment, data, and funding, is a significant motivator for scientific collaboration. Successful collaborations often involve reciprocal resource sharing among scientists from different backgrounds and countries. Collaboration often emerges from social networks, with personal factors like compatibility, mutual respect, and trust playing crucial roles. Gender can also influence social network formation and collaborative dynamics.

Collaborating with various organizations, communities, and countries brings additional 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. [For Idaho, understanding and addressing trust issues, particularly in rural and ideologically diverse communities, is essential for successful collaboration.]

Effective leadership, encompassing scientific, financial, and administrative aspects, is crucial for successful collaboration. Professional managers and consultants may be hired to enhance leadership skills within collaborative teams. [DRED's initiative to train team leaders as part of the Grand Challenges investments aligns with this finding, emphasizing the importance of skilled leadership in collaborative research.]

Collaborations may face challenges due to varying informal traditions and norms among disciplines, especially regarding intellectual property (IP) sharing. For instance, experimental biologists often patent their ideas, while mathematicians are more open. [DRED is addressing these variations in team training by helping teams navigate differences in IP traditions.] Model agreements provided by funding agencies can streamline the process of developing a shared understanding of IP and other legal issues. All participants, including students, should be aware of their rights and responsibilities in collaborations. [DRED's assistance in creating team agreements is a proactive measure to address legal aspects in collaborative research.]

Ongoing evaluation of organizational structure, communication, and tasks is essential in a collaboration. Without evolution and adaptation, collaborations may fail. [DRED's regular office hours for center leaders play a role in addressing and adapting to these challenges.]

Collaborative work may be marginalized or discounted within a department, especially if only one scientist is involved in a specific collaboration (Sonnenwald 2007). Learning, both explicit and tacit, is a critical component of collaborative research, particularly in interdisciplinary settings. However, learning is often a challenging aspect and not typically included in research proposals. [Observations in the SNAP team indicate a need for more engagement in the learning process among researchers from different disciplines.]

Effective communication is vital for coordination, learning, integration of research results, and mitigating perceptions of distrust.

Collaborative projects face challenges in publication and dissemination, including finding appropriate forums for interdisciplinary results, consensus on authorship, and different disciplinary expectations

The final stage of collaboration ideally results in the creation of new scientific knowledge and other outcomes like skill development, administrative system changes, and educational impacts.