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David Gosselin *Editor*

A Practical Guide for Developing Cross-Disciplinary Collaboration Skills

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Editor

A Practical Guide for Developing Cross-Disciplinary Collaboration Skills

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Editor
David Gosselin
Environmental and Sustainability Studies
and School of Natural Resources
University of Nebraska–Lincoln
Lincoln, NE, USA

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Foreword

The most impactful, fulfilling, and productive part of my fifty-plus-year career as a leader and advisor has been the quest for dynamic crossdisciplinary collaboration. It has brought me more joy and achieved greater results than any other aspect of my professional life. When it works, the results have consistently exceeded my expectations. When it hasn't worked, and all too often this has been the case, the outcomes have always fallen short.

In *A Practical Guide for Developing Cross-Disciplinary Collaboration Skills*, the authors take us on a journey where, candidly, few professionals or leaders have gone. They show us what is possible when we learn new ways to think, to act, and to relate to one another. I believe this group of authors have given us a pathway to outcomes that, while not easy to achieve, are transformative and deeply fulfilling.

Early in my career, my focus was on avoiding failure. Then, as I gained some confidence, my ambition for greater responsibility led me down the path of self-sufficiency and individual performance. I often unknowingly sabotaged opportunities for crossdisciplinary collaboration because I put such a strong emphasis on personal responsibility, self-management, and individual initiative. With many others, something spoke to me every time I heard Frank Sinatra's signature song, "I did it my way."

Over time I came to discover that, as Dave Logan, John King, and Halee Fischer-Wright wrote in their book, *Tribal Leadership: Leveraging Natural Groups to Build a Thriving Organization*, no one can advance to a "We are Great!" mindset without first traveling through, "I am Great!" For most, this is the journey from competition for ego fulfillment to deeper respect that leads to the alchemy of collaboration. Fortunately, I experienced the epiphany they wrote was critical for any professional to move away from self-interest and egocentricity to pursue deep experiences of collaboration. The deeper experiences transcend intellectual and practical exercises and result in something much deeper. One such demonstration of this is relived in the documentary, "Good Night, Oppy," the story of the two Mars Land Rovers designed, created, and managed by JPL Laboratories in Pasadena, CA (available on Amazon Prime).

My journey has taught me the importance of building relationships around shared interests, shared values, shared belief in our potential and shared commitments. I consider these the "glue" that helps us collaborate well over time. The "CTeAM" (Collaborative Team Action Model) model captures these ingredients eloquently. The value of "crossdisciplinary" collaboration is revealed when we recognize and engage the diverse perspectives, different capabilities, and varied networks of relationships that serve as multipliers or accelerators of our efforts. The chapters that explore dialogue, stakeholder analysis, and problem-solving add depth and practical steps to exploring these multipliers. The chapter on the neuroscience of collaboration reminds us that we are not only thinking machines, but we are psychological beings that thrive in environments of mutual respect and connection.

There is so much in this book that I appreciate. It provides a storehouse of wisdom for the pursuit of deeper levels of collaboration. Each of the contributors offers perspectives to challenge our thinking, to direct our actions, and to expand the possibilities for success, impact, and fulfillment. I will go back to this book repeatedly to reflect, experiment, and continue my own quest for crossdisciplinary collaboration. The deeper benefits of collaboration start from a richer definition of collaboration, are built on through practical applications, and are finally fully realized through the master of these practices.

This is not a book to be read superficially, or only for our intellectual stimulation. It is a book that challenges us to practice crossdisciplinary collaboration and to view it as one of the greatest opportunities in our careers and lives. When the insights and practices described in this book are mastered, they will significantly amplify our individual contributions and may just change our world for the better.

January 2023

Ron Price
President, TTI Success Insights Ltd.
Scottsdale, AZ, USA

The original version of the book was revised: The correct volume editor name from "David C. Gosselin" to "David Gosselin". The correction to the book is available at https://doi.org/10.1007/978-3-031-37220-9_12

Preface

Our survival as a species has depended on people working together over the millennia of human existence. Now more than ever, we need to work together to develop effective strategies to address the many types of problems that society, business, and policymakers face currently and, in the future—sustainable development, global climate change, poverty, homelessness, access to clean water, and education to name a few. These problems involve competing values of stakeholders; difficult to predict cause-and-effect relationships; high degrees of uncertainty; no determinable stopping point; and multilevel social interactions. Addressing these problems and their complex interdependencies require teams composed of many people who can effectively collaborate and develop relationships that integrate a wide range of perspectives, values, ideas, mental models, motivations, interests, and expertise.

The Challenge

Unfortunately, many of us who have been trained to work in a specific discipline, content area, subject area, or field of study have not been properly equipped with the knowledge, skills, and abilities to effectively collaborate or work on teams. We have generally not had the training or academic experiences to develop the expertise to effectively use the collaborative processes and practices necessary to address the urgent and complicated nature of societal problems. This lack of expertise reduces the effectiveness of our collaborations, which, in turn, reduces our abilities to address complex problems and create organizations that can continually expand their capacity to create and adapt to change.

In the business world, negative team environments contribute to employees leaving their jobs, which is costly in a variety of ways. Higher education has many of the same problems as it seeks to create team-based, collaborative, multifaceted research, education, and community engagement programs for dealing with societal problems. Organizations spend millions of dollars annually to help their employees develop and maintain working relationships and productively work with others. For many,

the development of the knowledge, abilities, and attitudes (i.e., competencies) to collaborate with others ends up being learned through trial and error, if at all. We need to do better.

Purpose and Structure of the Book

The purpose of this book is for the authors to share insights, experiences, examples, strategies, and approaches to:

- facilitate more effective collaboration among colleagues and stakeholders who have diverse backgrounds; and/or
- provide training experiences to inform and support the development of competencies to collaborate.

This book provides pathways for the exploration of the literature related to interdisciplinary, transdisciplinary, and socio-environmental collaboration along with team science.

The book is divided into two parts. Part I—Collaboration, Connections, and the Collaborative Team Action Model (CTeAM)—consists of three chapters. Chapter 1 provides an introduction to collaboration, its characteristics, and connections to our brain. Chapter 2 provides details on the neuroscience of collaboration and learning. Using a simplified model, referred to as the Collaborative Team Action Model (CTeAM), in Chap. 3 presents five overarching questions to use during the creation and throughout the lifetime of a collaborative team. CTeAM graphically illustrates the interrelationships between people and processes while maintaining the focus on where the team wants to go as identified by their collectively developed shared vision/goals. The premise for the use of questions is that they can fuel innovation and improved performance, build rapport and trust among team members, and mitigate risk by uncovering unforeseen pitfalls and hazards. In each of the subsequent chapters in part two, connections are explicitly made to the neuroscience and the CTeAM framework.

The chapters in Part II—Applications and Approaches—are approaches that have been documented and used by the authors. The first four chapters of Part II are oriented toward the people side of the C-TeAM framework. Chapter 4 focuses on the importance of having basic knowledge about the characteristics that each person brings to the team. This knowledge creates opportunities to take advantage of each team member's strengths and to learn ways to navigate and negotiate their differences. Chapter 5 provides details for using structured dialogue as part of a team's communication practice for exploring the cognitive and disciplinary diversity among members of crossdisciplinary teams. Chapter 6 presents processes to explore influencers and beneficiaries using stakeholder analysis, power maps, and communication in context. The use of the five key questions matrix as a stakeholder analysis tool to help explore social equity challenges in an undergraduate program are presented in Chap. 7.

Chapters 8–10 focus on the use of model-based reasoning as a process to define problems, construct a shared vision, and develop solutions and strategies to move a collaborative project forward. Examples of this approach are provided for training workshops, graduate coursework, and undergraduate student experiences. In the last chapter, strategies and approaches to document project outcomes and output are provided.

We are confident that you will find something useful and applicable in this book.

Lincoln, NE, USA David Gosselin

Acknowledgments

This book evolved out of a series of workshops during 2014 and 2015 at the Socio-Environmental Synthesis Center, University of Maryland. The workshop developed what became known as the EMBeRS project—Employing Model-Based Reasoning in Environmental Science project (NSF Award: DGE-1545404). As the leader of this group, Deana Pennington moved EMBeRS forward with her vision and relentless effort. She assembled a crossdisciplinary team consisting of high-quality individuals, many of whom have contributed to this volume. The editor also benefitted from participation in the InTeGrate Project that was supported by a National Science Foundation under grant DUE 1125331. Collaboration with TTI Success Insights, Inc (TTI-SI) and its staff over the past two decades is greatly appreciated. Specifically, Ron Bonnstetter of TTI-SI is thanked for contributing content for the neuroscience connections for each chapter in Part II as well as his mentorship over the years related to teaching, learning, and brain science. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation or those of any other supporting organization.

Each chapter in this volume was reviewed by two or more external reviewers. Their comments improved each chapter. Their time and efforts are greatly appreciated. A big thank you to all the reviewers—Lalit Agarwal, David Arpin, Jay Bell, David Blockstein, Mark Burbach, Helen Fagan, Trish Ferrett, Kevin Gazzara, David Hassenzahl, Cailin Huyck Orr, Rusty Low, Hillary Mason, Carol Mettenbrink, Chet McLeskey, Kim Morrow, Anna Oetting, Shelley Olds, Ron Oltmanns, Deana Pennington, Ed Robeck, Chelsie Romulo, Patrick Sherman, Kimberly Carroll Steward, Doug Williamson, and Gwen Wittenbaum.

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Contributors

Mark T. Baillie Department of Chemistry, Director, STRIVE Program, STEM Education Center, University of Arkansas Little Rock, Little Rock, AR, USA

Ronald J. Bonnstetter Research and Product Development, TTI Success Insights LTD, Scottsdale, AZ, USA

Edgar Cardenas Toolbox Dialogue Initiative Center, Michigan State University, East Lansing, MI, USA

Amanda Gangwish Nebraska Conservation Voters, Lincoln, NE, USA

David Gosselin Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA

Geoffrey Habron Department of Earth, Environmental and Sustainability Sciences, Furman University, Greenville, SC, USA

Chet McLeskey Toolbox Dialogue Initiative Center, Michigan State University, East Lansing, MI, USA

Richard S. Moog Department of Chemistry, Franklin & Marshall College, The POGIL Project, Lancaster, PA, USA

Michael O'Rourke Toolbox Dialogue Initiative Center, Michigan State University, East Lansing, MI, USA

Roderic A. Parnell School of Earth and Sustainability, Northern Arizona University, Flagstaff, AZ, USA

Deana Pennington Queensland University of Technology, Brisbane, QLD, Australia;
University of Texas at El Paso, El Paso, TX, USA

Marisa A. Rinkus Toolbox Dialogue Initiative Center, Michigan State University, East Lansing, MI, USA

Kate Thompson University of Texas at El Paso, El Paso, TX, USA; Queensland University of Technology, Brisbane, QLD, Australia

Shirley Vincent Vincent Evaluation Consulting LLC, Tulsa, OK, USA

Part I
Collaboration, Connections, and the Collaborative Team Action Model (CTeAM)

Chapter 1
Introduction to Crossdisciplinary Collaboration: Definitions, Systems, and the Brain

David Gosselin

> In the longer run and for wide-reaching issues, more creative solutions tend to come from imaginative interdisciplinary collaboration. Robert J. Shiller

Abstract Collaboration is about the co-creation of a vision/goal to which all members of the collective group have contributed. Collaboration is about building relationships among team members, all of whom bring something of value to the team. Building relationships takes time. They emerge and evolve as team members share responsibilities and contribute to decision-making. Leveraging the power of the brain enhances the effectiveness of collaboration. The use of processes to create an environment in which people feel they belong, are included, and are psychologically safe enhances collaboration. Questions are powerful tools in collaborative teams. They promote learning, the exchange of ideas, and knowledge creation about problems or challenges. Keeping questions at the forefront of a collaborative team during its creation and evolution will create a learning environment in which all group members can learn from each other and create together.

Keywords Crossdisciplinary collaboration · Collaboration · Cognitive and disciplinary characteristics · Surface-level characteristics · Deep-level characteristics

D. Gosselin (✉)
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

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1.1 Introduction

There is no getting around it, collaboration is required for the development of effective solutions to complex societal, business, and policy problems, referred to by some as wicked problems [7, 37]. Collaboration brings together diverse knowledge, skill sets, and work/life experiences that provides the opportunity for innovative problem solving and the development of creative solutions. To effectively collaborate, individuals who have a range of reasons for being involved in a project need an environment that allows them to integrate their perspectives, values, ideas, mental models, and expertise to create a shared vision or common set of goals. This, of course, is easier said than done. Integration requires the development of good relationships and effective communication among team members so they can harness the diversity of their characteristics and increase the chances for successful outcomes. There are many barriers to productively working together and developing the necessary relationships to harness the benefits of team diversity. In some cases, the barriers are successfully navigated and negotiated and in others they are not. It has become clear to me from my experience as a coach, educator, leader, and academic that learning about who people are and using processes that create environments that our brains seek are important elements of success. Of particular importance is establishing environments in which participants feel psychologically safe, experience a sense of belonging, and learn about themselves and others.

1.2 Goals

The goals of this chapter are to:

- Define and describe the characteristics of effective collaboration;
- Provide an overview of basic concepts from the neuro- and learning-sciences that can inform collaborative processes; and
- Introduce a systems framework based on organizational management and team science literature to connect people, processes, and collaboration.

1.3 Collaboration: What It is and What It is not

The word collaboration is used often in professional settings. Yet, people have different interpretations of what it means to collaborate. Collaboration is also used interchangeably with two other c-words related to processes by which people work together—specifically, coordination and cooperation (Fig. 1.1). All three c-words are about processes that are in play when people work collectively together as a team. Coordination, cooperation, and collaboration represent a continuum of human

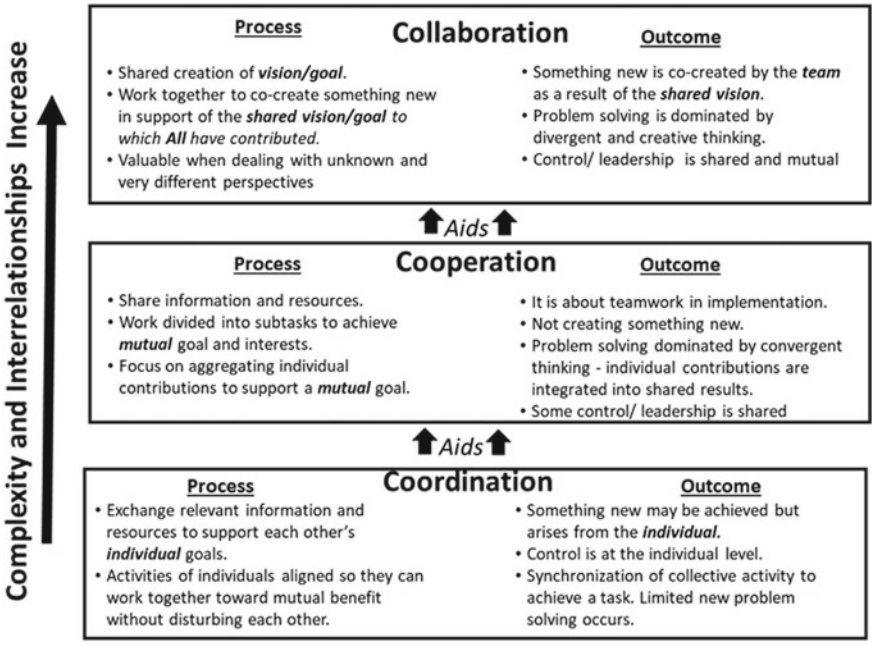

Fig. 1.1 Relationships between processes and outcomes during the collective interaction of people moves from coordinating to cooperating to collaborating

behaviors in which there is an increase in complexity of the processes and outcomes involved when people work together [14, 15].

When coordination is occurring, the process and outcome focus on the exchange of relevant information and resources to getting something done in support of obtaining the goals of the individual or groups involved.

Cooperation involves sharing and aggregating information and resources that support the attainment of mutual goals of the individual or groups involved, predominantly using convergent thinking; However, the development of the goal does not necessarily require input from all participants. A key attribute of collaboration is that all participants contribute their ideas to the development of a shared goal/vision as well as shared control and leadership. A process or processes should be used that promote divergent and convergent thinking during the development of the shared vision. Control and leadership are shared across the individuals and groups involved with creating the shared vision.

The words "teamwork" and "collaboration" are often used interchangeably. However, they have distinct meanings and functions. The Merriam-Webster [29] dictionary defines teamwork as the "work done by several associates with each doing a part but all subordinating personal prominence to the efficiency of the whole." Vince Lombardi, the legendary football coach, describes teamwork as the "individual commitment to a group effort—that is what makes teamwork, a company

work, a society work, a civilization work". Teamwork involves the collective interaction of people; However, there are different levels at which this occurs as illustrated in Fig. 1.1. The measurable outcome for 'collaboration' or 'teamwork' may look the same as both are committed to a single outcome/goal. However, the source of the shared outcome/goal, who controls the extent to which it is achieved, and who is accountable are different. Collaboration is about the co-creation of a vision/goal to which all members of the collective group contributed and the application of divergent and creative thinking to the problem-solving process. Simply put, all collaboration is teamwork, but not all teamwork is collaboration.

The expected outcomes in Fig. 1.1 indicate that collaboration is not always necessary to solve a problem. There are times to use collaboration and there are times when collaboration is not useful. As outlined by [42],

Collaboration is useful when you are:

1. Dealing with complex problems that require multiple 'expert' opinions (i.e., wicked problems).
2. Getting buy-in. People are more invested in an idea when they are involved in defining the problem and developing workable solutions.
3. Dealing with strategic issues. The more fundamental the issue is to the organization's purpose the more essential collaboration becomes.

Collaboration isn't useful when:

1. You need to really think about things. This benefits from solitude and purposeful exploration.
2. You need to be really radical. Truly disruptive thinking happens in small groups.
3. You don't have time. When you have a situation that requires an immediate decision, you're better off being autocratic.

Because wicked problems are inherently complex, teams composed of many people, who have a range of motivations, perspectives, relationships, values, ideas, assumptions, and expertise are required. Developing solutions for these problems requires interdisciplinary and transdisciplinary research [30]. Inter- and transdisciplinary research requires sharing of knowledge from different disciplines in teams, and convergence of expertise (e.g., [21, 23, 3, 32, 34, 35]). The generic term that is used in the book title, crossdisciplinary, captures the spectrum of integration that occurs across levels: disciplinary, interdisciplinary, and transdisciplinary integration and refers to any type of knowledge integration among disciplines, fields, domains, professions, and other stakeholders that are involved in the problem space of interest [23, 32]. Table 1.1 provides a summary of definitions.

As indicated above, collaboration is most useful when input from many stakeholders who may be impacted by, benefit from, or influence the outcomes related to addressing complex problems or organizational situations is required. People are motivated to become involved in collaborative efforts for many reasons. Successful collaborations rely on the ability of the group to balance and align the individual ideas, agendas, goals, etc. of the participating individuals or groups in the co-creation of a shared vision/goals (Fig. 1.2). Balancing and alignment requires communication,

Table 1.1 Definitions of interdisciplinary, transdisciplinary, and crossdisciplinary. Considering that solutions to wicked societal problems as defined here require engagement with stakeholders beyond the academia, meaning 2 for transdisciplinary is the preferred definition

Interdisciplinary: Integration that combines separate perspectives through the development of connections between them (from [35]).
Transdisciplinary (*meaning* 1): Integration that further develops connections between perspectives and generates a new, independent area of knowledge (from [35]).
Transdisciplinary (*meaning* 2): Integration that extends beyond academic disciplinary perspectives to incorporate knowledge from outside of academia (modified from [35]).
Crossdisciplinary: Generic term that recognizes that teams encompass three levels of integration: disciplinary, interdisciplinary, and transdisciplinary integration and refers to any type of knowledge integration among disciplines, fields, domains, professions, and other stakeholders that are involved in the problem space of interest [23, 32]

compromise, and the development of consensus, all of which involve the investment of time and energy. It takes time to develop mutual trust, respect, and understanding of what each individual brings to the team. The development of collaboration becomes an emergent property of the group of people who have been brought together. When a group of people become a team that collaborates, individuals work together, learn together, and think together to create a shared vision for the team through consensus.

Effective collaboration depends on individuals treating each other with parity. Parity, in this context, refers to each individual having an equal voice in the development of the shared vision and goals. The underlying premise is everyone brings something of value to the team. Each participant recognizes that each individual has their own goals and reasons for participating in the collaboration. The specialized expertise of individuals is an important component of a team's value proposition. Acknowledging the diversity among team members' individual goals along with their differences in skill sets, expertise, background, etc. creates opportunities that will enhance creativity and team effectiveness. Diversity in perspectives, approaches, and questions leads to a shared vision that is more creative and holistic than what can be developed individually.

The development of a shared vision by valuing contributions from all team members results in an increased sense of responsibility and accountability for the

Fig. 1.2 The key characteristics of effective collaboration. Characteristics adapted from [16]

outcome of the project. Utilizing the specialized expertise of individuals by giving them the responsibility for progress in the domain of their expertise also results in an increased sense of responsibility and accountability for the outcome of the project. Members of a team will contribute in different ways depending on their expertise and become accountable for different aspects of the project depending on their expertise. Different people will have different roles. For example, consider a team that has a shared goal of developing innovative environmental science curricula. The team consists of environmental scientists, educators, curriculum writers, editors, and project coordinators/managers. During project development, questions arise about how to assess the extent to which educational activities impact student learning. The environmental scientists and project managers would certainly have ideas on how to accomplish this. However, the project would benefit more from the expertise of individuals who have been trained in the arena of education to have more responsibility and accountability in this area. Building off this example, to what extent should scientists on the team have responsibility for editing manuscripts when a trained editor is part of the team? To what extent should the editor be responsible for the science? It benefits a team at a variety of levels to respect, recognize and utilize the expertise of each person on the team. All of whom have worked long and hard in their area of expertise.

Participation in collaboration is voluntary. You cannot force people to collaborate by throwing them into a room and telling them to make it so. Collaboration is about building relationships. Various organizational parameters and policy structures influence the creation and operation of teams. There are a lot of possibilities. In the workplace, people may get assigned to a team. This assignment may not be voluntary; However, collaboration is about building relationships and an environment in which all members can effectively contribute to the vision and positive outcomes for the team. The extent to which people collaborate is a function of their willingness to develop relationships and build trust among others on the team. This is voluntary.

At the most basic level collaboration is about acting in a way you would like others to act towards you. The use of proclamation, administrative mandate, peer pressure, or coercive approaches are counterproductive. Work within the team itself should strive to create an environment in which all members contribute to a positive group dynamic and are accountable to each other for outcomes. Each person does what needs to be done to get the work completed. Collaborating groups move forward even when key members are away. The group is to the extent possible self-managed. There may be no ‘leader’ per say. Temporary leaders will surface in the context of when and what is needed for specific tasks to achieve the shared goal.

1.4 People and Processes

Research over the past 25 years about the characteristics and best practices of effective teams has resulted in various team process models that use frameworks that include inputs, team processes, and outputs along with the setting in which the team is working (e.g., [4, 10, 27, 28].

Figure 1.3 is a simplified team process model. In this model, P1 and P2 represent the individual team members who are fundamental input ingredients for every team.

Each team member has different characteristics that influence the interactions and function of the team when they are brought together to engage in team processes [20]. Three general categories can be used to describe these characteristics (Fig. 1.4). They include:

- Cognitive and Disciplinary Characteristics (CDC) = disciplinary knowledge, expertise, experiences, and perspectives. Includes cognitive abilities include thinking, knowing, remembering, judging, and problem-solving.
- Surface-Level Characteristics (SLC) = demographic, social category, bio-demographic, and observable individual differences; refers to readily detectable

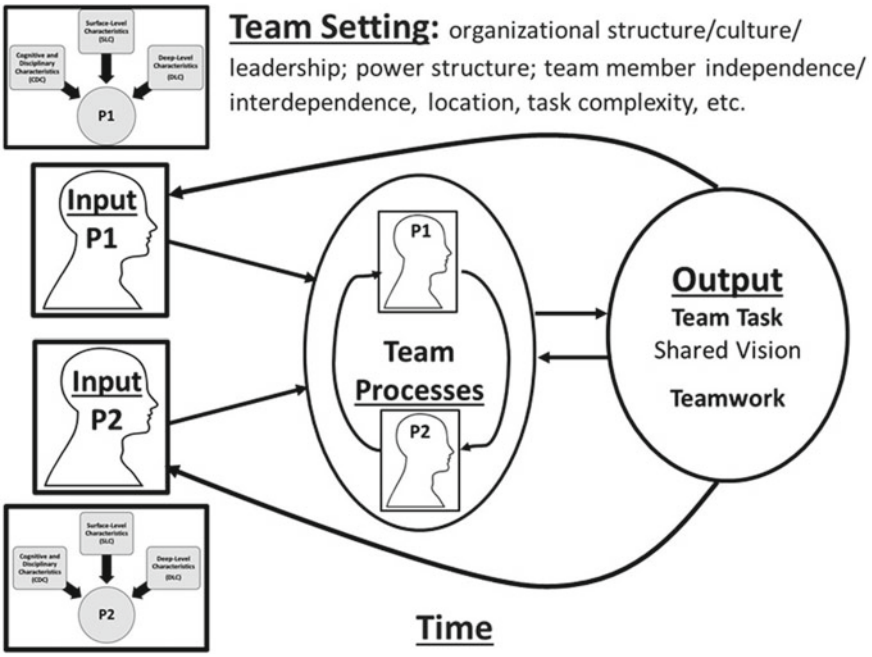

Fig. 1.3 A simplified team process model that illustrates the relationship among inputs, team processes, and outputs along with the setting in which the team is working. These are influenced by time

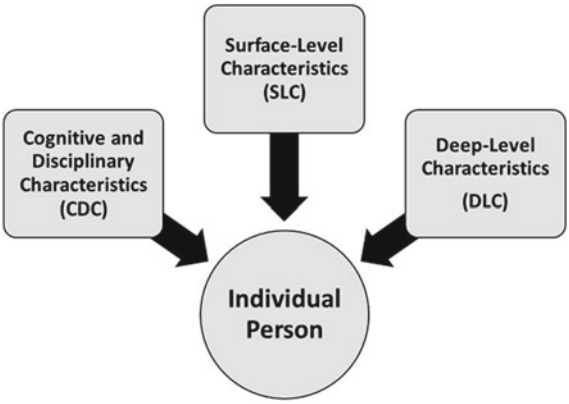

Fig. 1.4 Each person on a team brings a different set of characteristics to the team that influences their ability to function in a team and engage in team processes

attributes such as gender, age, sexual orientation, ethnicity, ability/disability, and cultural traditions.

- Deep-Level Characteristics (DLC) = task-related, psychological, informational/functional, and underlying attributes; includes less observable deeper-leveled attributes such as values, mindset, attitudes, beliefs, functional expertise, and mental models.

Theoretically, the best-case scenario would be that the characteristics of each team member are explicitly known and understood to most effectively blend them together. Practically speaking, however, this would be a huge undertaking and require a significant investment of resources, specifically time, that most teams do not have. A pragmatic approach is to recognize that the diversity of the characteristics among team members can create barriers to effective interactions among team members. Where possible, invest time to explore the various characteristics of team members. Strategies for accomplishing this exploration are provided in other chapters of this volume.

Commonly, team members are selected based on their cognitive and disciplinary characteristics. They have been invited to the team because of their expertise and have a specific role on the team. They may also be selected because they are the nearest available person who has some time available and some capacity to contribute to the project. O'Rourke et al. [8] provide a guiding process to explore the cognitive and disciplinary diversity of interdisciplinary teams. Differences in the surface- and deep-level characteristics will contribute challenges to blending team members together. Gosselin and Bonnstetter (This Volume) provide strategies and considerations concerning the blending of surface- and deep-level characteristics.

Various team processes and strategies need to be used to create a shared vision, develop methods to achieve the vision/goal, and assess the extent to which the project has achieved the vision/goal. These team processes need to include opportunities for team members to learn about the diversity in their individual and collective compositional characteristics. The application of relevant team processes should integrate

individual team members into a distributed cognitive system through which data, information, ideas, tools, artifacts, etc. flow freely [34]. Team processes can be divided into action and interpersonal processes [27]. In the context of this book, action processes include practices related to coordination, cooperation, and collaboration. Interpersonal processes include, but are not limited to, communication, conflict resolution and mediation, managing your own and other's emotions, and negotiation. Unfortunately, team members often have not learned systematically or explicitly about collaborative approaches and processes so that they can maximize the contributions of diverse individuals to the team.

1.5 Neuroscience and Collaboration Processes

Collaboration is not easy; However, it can be made easier and more efficient by using processes that are consistent with how the brain works. Harris [26] of NeuroPower Group said it well, "Teams naturally reach high performance in three to five years…you can fast track it to as little as six months. Understanding how the brain works literally accelerates everything." PROCESS is important. The use of brain-friendly processes will create brain-friendly collaborators. This begins by honoring the basic biology of our brains and its development over time [1, 2]. Andreatta in her books, *Wired to Connect (2018)* and *Wired to Grow (2019)* and [24] in her book, *Culturally Responsive Teaching and the Brain* masterfully describe many key findings from the literature related to the biology of our brains and its abilities to connect people and learn. Except where indicated the following summary was synthesized from these sources.

Our brain is a social organ. It works best when it connects and interacts with others [25, 46]. The existence of mirror neurons and neural synchrony are evidence that brains work and connect with each other. When processes are set up so that team members see themselves as part of a group and working together, a *sense of we* develops during which mirror neurons from individuals become attuned with others in the group. This leads to better performance. As team members work together and their brain waves come into increased alignment, the neural signatures associated with various tasks become similar during periods of high performance. Stevens and colleagues [40, 41] refer to this as the *rhythm of a team.*

There are three core human needs that need to be met to achieve the *sense of we* and *team rhythm* in order for collaborative teams to be more effective. Andreatta [1] refers to these three needs as safety, belonging, and becoming. Our brains have evolved structures and processes to minimize threats to our safety, seek well-being, and keep us alive. Regardless of the activity with which we are involved, our brains continuously scan our surroundings for changes in the environment and/or relevant events that might indicate a threat, or for that matter a reward, that might impact our physical or social safety. Whenever a person feels unsafe, their body's resources including a variety of hormones are mobilized into action to help them survive. This diversion of resources to keep themselves safe reduces a person's mental capacity

by shrinking working memory and the extent to which their rational brain is in control of their thoughts, reasoning, and actions. In addition, a lack of safety reduces the likelihood that the person will want to build rapport with others, challenge the status quo, explore new challenges, take innovative risks, ask questions, or speak up in meetings, among many other actions. All of these reduce the effectiveness of a collaborative team because they impact relationship building and creativity.

Now consider an environment in which you enter a room of people with whom you do not know, but with whom you are going to work on a project. Upon entering this environment, if you are simply not acknowledged or are actually ignored, the brain interprets the environment as not socially, emotionally, or intellectually safe. Danger is present (or seems to be). This initiates anxiety, leads to the interpretation of the environment as unwelcoming, unsafe, and you may feel marginalized. Under these circumstances, a variety of physical and emotional responses impact your abilities to collaborate. Your ability to read social cues is altered. You may interpret neutral facial expression as aggressive or angry when they are not. Your prefrontal cortex that is responsible for higher level thinking shuts down to varying degrees as brain resources are allocated to manage your "fight or flight" response. This impacts your creativity, problem-solving ability, and memory. Cortisol also floods into your system which among other things decreases your ability to learn. This sequence explains why if a person does not feel safe their ability to think and communicate with others is reduced, which in turn, hampers their effectiveness as a collaborator.

On the other hand, the power of the brain can be leveraged to enhance the effectiveness of collaboration by creating an environment in which people feel they belong and are included. People want to feel they belong, are included, and can form positive relationships [1]. To meet these needs, Edmondson and colleagues [11–13] have identified the importance of creating an environment in which people feel psychologically safe. Edmonson defines "psychological safety" as:

> *a sense of confidence that the team will not embarrass, reject, or punish someone for speaking up with ideas, questions, concerns, or mistakes. It is shared belief that the team is safe for interpersonal risk taking. It describes a team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves.*

As a result of a psychologically safe environment, oxytocin levels in our brains rise. Oxytocin suppresses and calms the amygdala and limits the fight or flight response. Brain resources are therefore available for creativity, problem-solving, and memory. Oxytocin encourages bonding with others and elicits trust and trust-making behavior. Building trust between individuals builds the level of psychological safety and contributes to a positive collaborative environment. Creating a sense of belonging and the development of social alliances produces oxytocin. Zak [45] identified eight behaviors that increase oxytocin levels among team members and enhance the feeling of being psychologically safe. The behaviors result in an increased level of engagement, productivity, and greater willingness to work with others. To enhance the effectiveness of a collaborative team, these behaviors can be individually and collectively encouraged: (1) Develop relationships, (2) Give recognition; (3) Develop challenging, but achievable goals; (4) Empower team members to

individually and collectively plan, structure, and execute their work; (5) Define and update roles; (6) Share information; (7) Create opportunities for personal growth; and (8) Show vulnerability.

There are different levels in which individuals experience psychological safety. Clark [9] recognizes four levels or ages of psychological safety:

- *Inclusion Safety*—members are comfortable being present, feel included, and feel wanted and appreciated.
- *Learner Safety*—members are comfortable to the point they want to learn through asking questions. They can experiment, make (and admit) small mistakes, and ask for help.
- *Contributor Safety*—members contribute their own ideas, without fear of being embarrassed or ridiculed. This is a challenging stage in that volunteering your own ideas increases vulnerability of the team member.
- *Challenger Safety*—members question and challenge others' ideas as well as suggest substantial changes to ideas, plans, or ways of implementing and working.

These stages reflect increasing levels of candor that make for productive disagreements and free exchange of ideas. Moreover, these stages recognize that the level of psychological safety can evolve throughout a team's journey. It takes time for a team to progress through these stages. This progression is an emergent property of the team. It is not linear. Individuals who comprise the team, and the team, as a whole, may experience these stages in different ways and at different times. In addition, each time a new member joins the team there is the likelihood that the stage of psychological safety will change. While some teams may work through these stages as a result of their common efforts to achieve the goal, it is possible to use a process or series of processes to cultivate and enhance the extent to which individuals and group experience psychological safety. Such processes can make use of the eight behaviors outlined above. Throughout the process and the increasing level of psychological safety, an environment is created in which team members use supportive behaviors that makes everyone feel included, their contributions are valued, questions can be asked, mistakes can be admitted and learned from, and can become more open-minded, resilient, motivated, and persistent. In this type of environment, divergent thinking, a thought process, or method used to generate creative ideas, can be effectively employed for the generation of new ideas and solutions.

Psychological safety enables team members to volunteer unique information and present dissenting perspectives that enables teams to create new knowledge and produce innovation [38]. When members of a team feel comfortable speaking up, asking questions, and sharing unique insights, they can build a shared mental model that improves understanding of the complexity of the issue they are trying to address. Developing an environment that feels challenging but not threatening results in teams that can sustain a "broaden-and-build" mode and evolve as a learning organization.

Creating a psychologically, socially, and emotionally safe environment helps team members build positive relationships that reduce real and perceived threats. Threat reduction increases the opportunity to have a team-learning environment that maximizes the use of individual team member's intellective capacity to effectively process

cognitively complex information. To leverage the diverse knowledge on a collaborative team, which may include academic researchers as well as stakeholders from outside the academic community, implementing learning processes can enhance the effective exchange and integration of knowledge and expertise.

Coincident with the challenge of building positive relationships, crossdisciplinary teams struggle to combine their knowledge and expertise to create a shared vision [6, 31, 36, 43, 44]. Each team member has different background knowledge, disciplinary jargon, and different epistemologies that results in different mental conceptualizations/mental models of the situation [17, 22, 36]. Differences in mental models, referred to as conceptual distance [35], can be significant between team members. This results in challenges to creating a shared vision. To reduce conceptual distances to develop common vision, learning processes such as model-based reasoning, experiential learning, reflection, reflective discourse, disorienting dilemmas, design thinking, among others, can help team members learn from each other [33]. This learning stimulates growth of neurons [5] and connects individual expertise, knowledge, and mental models. Wicked problems are in and of themselves disorienting dilemmas in that when new information is experienced it causes the person to re-evaluate their values, beliefs, or assumptions, which invokes learning.

Questions are powerful learning tools in collaborative teams. They can be used to promote learning and the exchange of ideas. In a team environment, questions can drive knowledge creation about the problem or challenge. In addition, questions can be used to learn about the values, behaviors, and knowledge of team members relevant to the problem and approaches being used to address it. These are characteristics that influence a team member's abilities to communicate. A simplified model that can keep questions at the forefront of a collaborative team during its creation and evolution is the Collaborative Team Action Model (CTeAM; Fig. 1.5).

Details for CTeAM are provided in [19]; However, the basic premise is that questions fuel innovation and performance improvement; build rapport and trust among team members; and mitigate risk by uncovering unforeseen pitfalls and hazards. Questioning is a skill that can be honed. For example, if the five questions in CTeAM are asked continuously throughout a project, then a learning environment can be developed among diverse individuals who may have disparate personal characteristics, fields of expertise, and mental models about the problem. In such a learning environment group members value contributions from each team member and learn from each other. As each additional chapter in this book unfolds one or more of the CTeAM questions will be addressed in detail.

Using knowledge of how the brain works and employing the question based CTeAM framework will help teams harness the diversity of strengths among team members and maximize their contributions as individuals to the team. This volume provides explicit approaches, processes, and examples that will help team members navigate and negotiate the diversity of team members so they can more effectively and efficiently create new knowledge and solutions for wicked problems through collective action. Furthermore, the collaborative team becomes a learning organization, a term coined by [39] in which members can expand their capacity to create

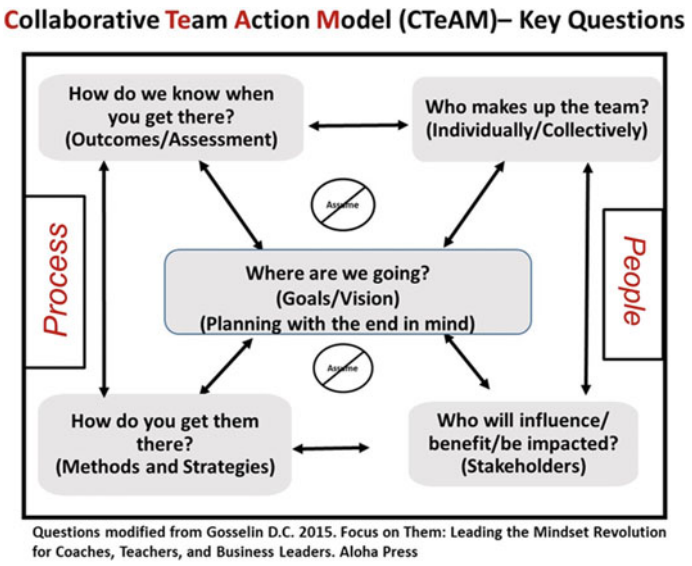

Fig. 1.5 Collaborative team action model. The basic premise of CTeAM is that action needs to be continually taken related to these five fundamental questions throughout a collaborative project. See text for details

new results, nurture new patterns of thinking, collectively create, and where people are continually learning to see the whole together.

1.6 Final Words

Collaboration is about the co-creation of a vision/goal to which all members of the collective group have contributed. It involves the application of divergent and creative thinking during the problem-solving process. Collaboration is about building relationships among team members, all of whom bring something of value to the team. Building relationships takes time. As a result, collaboration results in an environment that emerges and evolves where team members share responsibilities for group management and resources, contribute to decision-making and are accountable to each other for outcomes.

The power of the brain can be leveraged to enhance the effectiveness of our collaboration by using processes that create an environment in which people feel they belong, are included, and are psychologically safe. When people feel they belong, are included, and are safe, the probability for the formation of positive relationships increases and an environment in which ideas are freely shared and creativity flourishes exists.

Questions are powerful tools in collaborative teams. They promote learning, the exchange of ideas, and knowledge creation about problems or challenges. The Collaborative Team Action Model (CTeAM; Fig. 1.5) is a simplified model that keep questions at the forefront of a collaborative team during its creation and evolution. If the five questions in CTeAM are asked continuously during a project, then a learning environment is developed in which all group members can learn from each other and create together.

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Chapter 2
What's the Brain Got to Do with It? Unlocking and Activating the Brain for Better Collaboration

Ronald J. Bonnstetter and David Gosselin

Abstract Our brains create behaviors that become someone else's experience. The exchange of experiences are the heart of team dynamics. Understanding the neurological underpinnings of team dynamics is important to unlocking and activating the brain to enhance the collaborative experience at both an individual and collective level. The goal of this chapter is to introduce some key elements of the brain and strategies that can promote more effective teaming and learning. Highlights of such elements include inter-brain synchrony, mirror neuron activation, the role of emotions, explicit and implicit biases, a sense of safety, belonging, inclusion and trust, and related hormone changes. All these influence team success.

Keywords Collaboration · Neurology · Decision-making · Neural synchrony · Mirror neurons

2.1 Introduction

We spend most of our lives with other people. The tribal nature of humanity has been a key to our success as a species. Our human ancestors needed others to survive because belonging to a group increased protection (i.e., safety), access to food and other resources, and sharing of workloads, among other things. The willingness and need to connect with other individuals from an evolutionary perspective has allowed humans to form larger, more cooperative groups and accomplish tasks that no individual could ever achieve.

R. J. Bonnstetter (✉)
Research and Product Development, TTI Success Insights LTD, Scottsdale, AZ, USA
e-mail: ron.bonnstetter@ttiltd.com

D. Gosselin
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

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As a result of these connections, we have developed what is referred to as social thinking. Social thinking is the ability to consider your own and others' thoughts, emotions, beliefs, intentions, knowledge, etc., to help interpret and respond to the information entering the mind through daily social interactions [15, 16]. At the core of social thinking is the realization that our behaviors are experienced by others. In this context, our behaviors become someone else's experience. Recognizing the importance of social thinking helps us interpret and respond to others' thoughts, emotions, and behaviors. Developing the skills to interpret and respond to others requires us to think about other people's perceptions, feelings, and intentions as we contemplate how we might experience and respond to them.

Our brain works best when it connects and interacts with others [19, 34]. To improve connections and interactions, basic knowledge of how the brain works is useful so that we can better activate the parts we need to enhance connections among people and increase the opportunities for social learning. Although humans may be genetically prone to work together, improving our knowledge of how our brain functions can enhance effective collaboration and team learning [1, 2]. The topic of brain function and activation networks that promote effective teaming related to collaboration is a complex issue [1, 2, 7, 20, 32].

2.2 Goal

The goal of this chapter is to introduce some key elements of the brain and strategies that can promote more effective teaming and learning.

We begin by focusing on new research on brain microstates in the context of decision-making and judgements. Next, we acknowledge the basic biological development of our brain over time and the importance of creating a psychologically safe environment. Each member of the team needs to feel secure within the team. The biochemical responses of our brain activity including the release of oxytocin, cortisol, and dopamine will be explored in the context of our ability to learn and the extent to which we feel psychologically safe. Next, we examine how our brains are wired to work and connect with others as evidenced by the existence of mirror neurons and neural synchrony. The bottom line is that we need to employ brain-friendly processes to create brain-friendly team members.

2.3 Brain Microstates: Where Decision-Making and Judgement Start

Imagine being able to see the activity in your brain and that of every team member while an idea is being discussed in a meeting or when new information is presented, or a new member joins the group. During all these experiences, we are processing

the situation, making decisions and judgements, and experiencing emotions. Behind every decision/judgement is a unique and identifiable state of brain activity—a brain activation state. Collura et al. [9] opened the door to expose the real-time response of the brain to an individual's acceptance or rejection of what they experience. A key finding from this body of work is that every decision or judgement a person makes has an initial amygdala-based emotion of which we may or may not be aware. Figure 2.1 shows examples of different responses in that part of the brain that experiences emotions—the frontal and temporal lobes. These images document the response of the brain in the context of the level of agreement that a person has with a given statement or piece of information provided. These emotional responses are in essence judgements being made in the brain about a given situation, information, circumstance, etc. The different responses represent a range of emotional states that one might find within an individual or across a group of people when ideas and information are being exchanged and discussed. For example, enthusiastic agreement during a discussion, results in an intense response in the left frontal lobe of the brain as indicated by the amount of red in the image (Fig. 2.1). In contrast, strong rejection of an idea leads to an asymmetric response in the brain in which the right frontal lobe lights up red. Researchers have found that we rethink our judgments at a rate of once every 125th of a second. These one-eighth of a second processes are referred to as brain microstates [5, 6, 9, 10]. These microstates strongly influence our interactions with others because it is at this level that decisions are being made including consideration of new ideas or reacting to other people in the group.

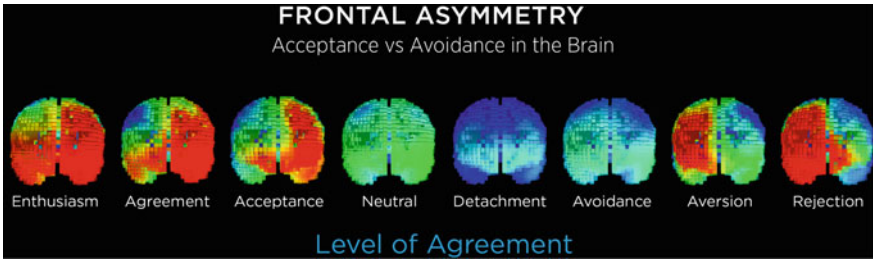

Fig. 2.1 Figure 2.1 provides an overview of the range of brain agreement as shown by EEG gamma wave activation in the frontal cortex and is a direct indication of the associated emotional load of the decision

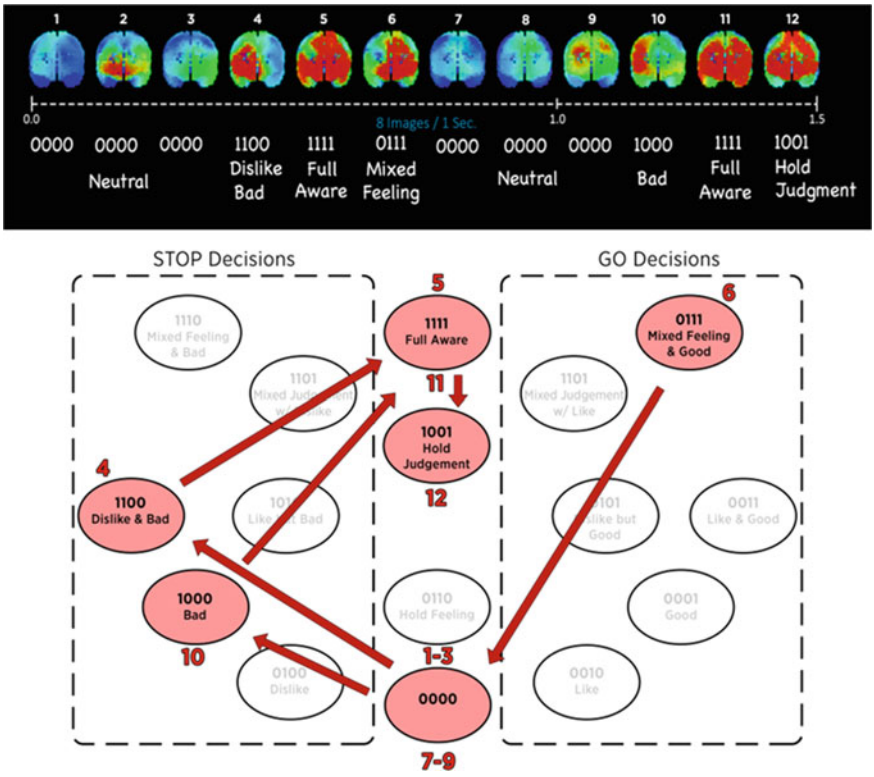

Fig. 2.2 The top diagram provides frontal lobe images of twelve 1/8th second images. The bottom of the diagram provides 16 different microstates provided in ovals. The following decision-making microstates emerge. Images 1–3 show a neutral reaction to the topic (0000); Image 4 shows increased right frontal lobe gamma activity representing a dislike of the idea; Image 5 moves to full awareness as the scope of the idea is mentally considered; Image 6 indicates mixed feelings, as the potential benefits are processed; Images 7–9 indicated that the brain wanders and momentarily leaves the issue at hand; Image 10 the brain reengages with a negative (right lobe) avoidance response; Image 11 the brain is processing the numerous ramifications and considering both pros and cons. Image 12 the brain lands on holding judgement and ready to listen to other perspectives

Figure 2.2 shows a sequence of 1/8th of a second images that illustrate the complexity of the decision-making process. The EEG images at the top of the figure illustrate the brain's primary and secondary emotional responses along a decision-making path. In this example, a person's decision went from dislike to a state where they are going to hold judgement on the situation. The reader can apply their own scenario to this brief illustration of brain processing. The brain's response to pleasant and unpleasant stimuli are internalized as primary and secondary emotional responses that ultimately influence our final decisions, reactions and responses—in essence our behaviors [10].

Emotions play an important role in maintaining successful communication and personal interactions with others [11]. Acknowledging the role and complexity of emotions that are involved in decision-making at an individual level is critical to working with others because it recognizes that our decisions are not necessarily the result of deductive and abstract way of reasoning—rationalistic approach. Understanding the existence of microstates also adds logic to the occurrence of hasty emotional judgments, implicit bias, and mental rationalizations that influence our interactions with others.

Haidt [18] presented a decision-making model that accounts for brain pathways and the emotional components, referred to as intuitions, of decisions of which we may or may not be aware (Fig. 2.3). His model refers to these intuitions as "primary emotions/sensations" and the the judgment as "secondary emotions/perceptions". Although he does not use the term, recent psychology research refers to these primary emotions/sensations as implicit memories [23]. Implicit memory research recognizes that most human cognition, those mental actions, or processes of acquiring knowledge and understanding through thought, experience, and the senses, occurs outside conscious awareness or conscious control.

So why is what is happening in an individual brain important to a team? Fig. 2.3 illustrates the complexity of interactions that occur between individuals (A and B) when they are exposed to a situation to which they do or say something that makes other people respond or react (i.e., triggering event). In this model, persons A and B are two members of a team who are discussing an issue. The triggering event

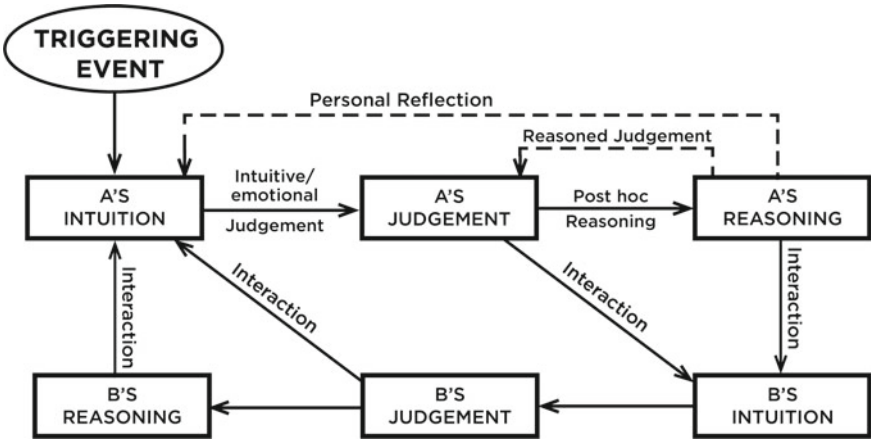

Fig. 2.3 Haidt's intuitive model of decision-making model. This example schematically shows two people communicating (A and B). The solid lines are opportunities when emotional response occurs during the interaction that can lead to modifications of judgment and internal reasoning. The dashed lines suggest taking time and making the effort to apply logic (reasoning), reconsidering judgment, and revisiting the initial emotional responses. This can reduce behavior that may negatively affect the building of relationships. The major takeaway is conscious thought needs to be employed to check implicit emotions and underlying biases. Permission granted from publisher. Modified from [18]

(the issue) triggers an intuition/emotion that leads to a judgment by A, followed by reasoning. Notice that judgment occurs before reasoning and that interactions with others can occur without the use of reasoning at each stage. This model highlights the microsecond interactions between people as a result of brain activities of which we may or may not be aware. In essence, our brain's behaviors become someone else's experience. This sequence of cognitive activity is a process of rationalization and justification rather than a logical review of evidence. As a result, individuals can be victims of rationalizing and justifying their thoughts based on unchecked implicit emotions and underlying biases. Because these processes take place over microseconds, developing personal strategies to delay reaction and responses to the triggering event will help avoid hasty emotional responses that can lead to communication challenges with others. Delaying the reaction also provides the brain time to use reasoned judgement moving beyond post-hoc reasoning that that leads to false conclusions where we believe that because one event follows another, the first must have been a cause of the second. In some cases this is true, but other factors may be responsible. Time also provides an opportunity for personal reflections that may lead to new reasoning, intuitions and emotions that could reduce opportunities of conflict during interactions of team members.

Strategy. Employ Wait Time. Based on what has been presented about the brain, the origin for impulsively saying something that a person may regret later should be apparent. In the context here, wait time is directly related to thinking before speaking. Basically, giving your brain time to use reason. Words have power both positive and negative. Speaking before you think can lead to negative outcomes and stressful situations by saying the wrong thing at the wrong time. It can negatively affect the development of relationships that are key to collaboration. Employing wait time provides the opportunity to:

1. **Take three breaths**: Practice the habit of pausing before you speak. Take a few breaths before you start to talk. While you are breathing, you are naturally pausing the conversation and giving yourself time to weigh your response. Taking a breath can be paired with asking for more time to gather your thoughts. For example, if a colleague makes a statement during a meeting that you do not agree with, then take three breaths while you consider your response.
2. **Take time to THINK**: A simple and effective mnemonic device is the THINK technique. It encourages choosing your words with care. "THINK" stands for "true, helpful, inspiring, necessary, and kind." Before speaking, ask yourself if what you're about to say aligns with each of those qualities. If your answer is "yes" to all five questions, then your thought is worth sharing.
3. **Practice awareness**: Practice active listening skills. Use positive body language so you are fully present during a conversation. Notice the other person's posture, tone of voice, and mood. Listen to what they are asking or saying. Be patient.
4. **Be curious**: Ask questions to get clarity from the person and learn more about their perspective. Question and address your assumptions.

2.4 The Brain Seeks Safety

Feeling safe is a fundamental human need. Structures and processes within the brain have evolved to meet this fundamental need, that is, to minimize threats to our safety, allowing us to seek well-being and to stay alive. Regardless of the activity with which we are involved, our brains continuously scan our surroundings for changes in the social and physical environment. It looks for relevant events that might indicate a threat, or for that matter a reward, that might impact our physical or social safety. Meeting the core human need of feeling safe is required before the next level of human need can be addressed, that is, the feeling of belonging [1].

Edmondson and colleagues [12–14] identified the importance of creating an environment in which people feel psychologically safe to form effective teams and organizations. Edmonson defines "psychological safety" as:

> a sense of confidence that the team will not embarrass, reject, or punish someone for speaking up with ideas, questions, concerns, or mistakes. It is shared belief that the team is safe for interpersonal risk taking. It describes a team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves.

Psychological safety enables team members to volunteer unique information and present dissenting perspectives that enables teams to create new knowledge and produce innovation [27]. Clark [8] recognizes four stages of psychological safety.

- Inclusion Safety—members are comfortable being present, feel included, and feel wanted and appreciated.
- Learner Safety—members are comfortable learning by asking questions. They can experiment, make (and admit) small mistakes, and ask for help.
- Contributor Safety—members contribute their own ideas, without fear of being embarrassed or ridiculed. This is a challenging stage in that volunteering your own ideas increases vulnerability of the team member.
- Challenger Safety—members question and challenge others' ideas as well as suggest substantial changes to ideas, plans, or ways of implementing and working.

It takes time for a team to progress through these stages. Progressing a team through these stages should not be left to chance. A process or series of processes needs to be used to help create an environment that cultivates and nurtures each team member and their interactions with each other. In addition, each time a new member joins the team the stage of psychological safety will change. Regardless of when members join the team, they need to feel they belong, are included, and can form positive relationships that lead to the creation of trust within the group. Increased levels of trust are associated with the progression through the four stages of psychological safety.

2.5 Role of Oxytocin, Dopamine, and Cortisol

It turns out that the extent to which we feel safe and trust and, for that matter, the extent to which our brain can learn is directly related to brain biochemistry and hormonal activity. When a person enters a new environment or situation a variety of physical and biological things occur within the brain. If the brain interprets the situation as "safe", the oxytocin levels in the brain rise. This rise suppresses and calms the amygdala which is the seat of emotions along with a range of processes including the fight or flight response. Keeping the brain calm leaves more of its resources available for creativity, problem-solving, learning, and memory. Dr. Paul Zak, sometimes referred to as "Dr Love", refers to oxytocin as the hug drug. The simple acts of making eye contact with other people or hugging them are powerful ways to promote a sense of trust, but why? It turns out that these simple acts of connecting cause the pituitary gland to release oxytocin as a reward. It makes a person feel good and leads to a greater sense of well-being. This, in turn, drives a person to make even more connections as oxytocin is joined by the other feel-good hormone dopamine, leading to small talk and a feeling of joy. The sense of belonging and the development of social alliances leads to further production of oxytocin, and dopamine along with it. This response occurs regardless of whether we are with the actual person or interacting electronically because, at some level, our brain views both as real connections. Zak [31] correlated levels of oxytocin and trust. His research showed that the release of oxytocin in the brain increases a person's empathy, which is a crucial component of teaming and group dynamics. An increase in dopamine will also positively affect other aspects of a person's behavioral and physical functions, a key one being learning.

Now let's consider the situation in which a person enters an environment that they perceive as physically or emotionally unsafe. This situation may be as simple as a person entering a room that includes a group of people they do not know, and they are not acknowledged. Anxiety results. Some people's brains may interpret the environment as unsafe socially, emotionally, and/or intellectually unwelcoming. The person may feel marginalized. Danger is present. The perception of an 'unsafe' situation results in a feeling of stress, and the body's resources respond quite differently than they do when a 'safe' environment is perceived.

Among other responses, the 'flight or fight' response associated with the unsafe feeling diverts resources from the part of the brain, the hippocampus, that influences a person's mental capacity including memory, learning, and emotional control. The release of the hormone, cortisol, also occurs when the stress of an unsafe environment is experienced. Cortisol, in and of itself, is necessary for many natural processes of the body. However, elevated levels can influence the transfer of brain signals influencing sociability, avoiding interactions with others, and influencing memory and learning. As a result, a person's ability to build rapport with others, challenge the status quo, explore new challenges, take innovative risks, ask questions, or speak up in meetings, among many other actions, may be impacted. You may misread social

cues and interpret facial expressions as aggressive or angry when they are not. All of these impacts can reduce the effectiveness of collaboration.

Strategy. To leverage the power of the brain to increase trust, enhance the sense of belonging, and improve the effectiveness of collaboration, use strategies that increase the opportunities for the brain to produce oxytocin. A simple strategy to get people to feel they belong and are included is to simply smile at others in the room or as they enter the room. Higher levels of trust are correlated to oxytocin production within team members [31]. Zak [31] identified eight strategies to increase oxytocin levels among team members that will contribute to increased levels of engagement, productivity, profitability, and greater willingness to collaborate and work with each other. The use of these eight strategies from [31] should be individually and collectively encouraged among team members:

1. ***Recognize excellence***

   Acknowledge the team's accomplishments and document their contributions to overall productivity.
2. ***Induce "challenge stress"***

   Each team creates challenging but achievable tasks that create positive focus without undue workplace stress.
3. ***Give people discretion in how they do their work***

   This management style requires that team members recognize that they have the "right" to prioritize tasks in the manner they feel most comfortable.
4. ***Enable job crafting***

   Allow freedom concerning "how" employees work to identify and prioritize projects based on the team goals and shared vision. Provide opportunities for people to use their voice and have a choice.
5. ***Share information broadly***

   Being able to decide how to work and what to make a priority works best when everyone knows what others are accomplishing and everyone's projects fit into the organization's goals, strategies, and vision.
6. ***Intentional relationship building***

   Intentionally take the time to build community. This is best done in the conext of the project. It results in heightened levels of safety, trust, and a shared purpose. Oxytocin is released when individuals feel deeply connected to the tribe, in this case, the workplace family.
7. ***Facilitate whole-person growth***

   Professional and personal growth are valued by promoting a growth mindset for each team member. Being all we can be professionally and personally is celebrated by All members of the team celebrate professional and personal growth.

(For additional insights: Why Recommitting To Employee Learning Is Crucial For Growing Businesses: https://www.forbes.com/sites/sap/2022/04/05/why-recommitting-to-employee-learning-is-crucial-for-growing-businesses/?sh=248d228237a9

8. ***Show vulnerability***

   Team members can ask for help from others and are not micromanaged by other team members.

2.6 Role of Mirror Neurons

We are social beings. Our survival depends on our understanding the actions, intentions, and emotions of others. Mirror neurons allow us to understand other people's mind, not only through conceptual reasoning but through imitation. Feeling, not thinking.-[24].

Our brains are wired to work and connect with others as evidenced from the existence of mirror neurons. Mirror neurons were first identified by Dr. Giacomo Rizzolatti and colleagues in the 1980s in macaque monkeys and their ability to imitate and learn; hence their nickname, "monkey-see, monkey-do" cells. These nerve cells in the premotor cortex fire up when we perform an action or when we observe an action being performed, thus creating an "inner experience" as we watch. For example, when a colleague scowls after learning about new demands for a shortened deadline in a meeting, we feel their pain. Or, when another colleague grins after being recognized for doing their job well, we feel their pleasure. We subconsciously place ourselves in their shoes and recall their same emotions. We may even find ourselves mirroring our team members' facial expressions and body positions. This signals to them that we know what they're experiencing. Even more interesting is that in response to an observed behavior in another person, that behavior may be magnified in a person who has had similar prior experiences. For example, even if you never played American football, when a person is about to be tackled, you tend to sense the movement and actually move with the play action. If you have actually played the sport, your reaction is even more intense, and you have a more personal connection to the event. This level of variable responses by mirror neurons helps us better understand why different people do not react to the feelings of others in the same way. It is thought that these varied responses to the feelings of others can be traced back to personal experiences that have created implicit memories that either intensify or weaken our response to others.

Mirror neurons play a fundamental role in our ability to be empathetic. Empathy is a skill that detects other people's feelings and emotions, understands their perspective, and imagines what it would be like to be in that person's situation (i.e., "to put yourself in another person's shoes"). **Mirror neurons, also called empathy neurons, let us feel what others physically experience ("I feel your pain") and "live" their emotions.** They influence the feelings that motivate us and the **impressions, good or bad, that we have about others**. Our brains are quite literally wired to feel

empathy. Making the effort to be more empathetic will yield deeper, more meaningful relationships, a greater sense of belonging, and the development of social alliances, which, in turn, will result in more effective collaboration.

Strategy. Improve your Emotional Intelligence To boost the use of mirror neurons to better connect and empathize with others requires improvement in our overall emotional intelligence. The concept of emotional intelligence, first introduced by Salovey and Meyer [26] and popularized by Goleman [17] is the ability to recognize and manage one's own and others' emotions. Improving your abilities to express and control your emotions as well as your abilities to understand, interpret, and respond to the emotions of others is critical. Improving this intelligence goes beyond having emotions, seeing emotions, and sharing emotions; it's about learning to master how emotions can be used and managed within ourselves and others.

Empathy is one of the five foundational elements for the development of emotional intelligence. Emotional intelligence takes empathy to the next level by combining it with the other four foundational elements—self-awareness, self-regulation, self-motivation, and social skills (Table 2.1). These five elements fit nicely with the question of "who is on your team—individually and collectively?" within the Collaborative Team Action Model (CTeAM) framework introduced in chap. 1 (Gosselin, This Volume). In a high-level sense, emotional intelligence is about knowing self and others. It is about active listening—actively listening to yourself through self-reflection and actively listening to others. This requires an understanding that our behavior results in someone else's experience.

Strategy. **Improve active listening skills**. One of the five questions of the CTeAM framework focuses on knowing and learning about who is on your team (Gosselin, This Volume). To know and learn about others, as well as develop connections and empathy, listening to the other person (people) is critical. Empathy is not about you. It is about the other person. The use of active listening will lead to more empathy and better collaboration. Here are some skills to practice.

a. Face the speaker and make eye contact. Lean in towards the person.
b. Be aware of non-verbal clues. Be aware of your posture and to whom you are speaking. Avoid crossed arms and legs. Keep in mind your and the speaker's facial expressions, tone of voice, and gestures. These non-verbal cues are windows to emotions.
c. Avoid interruption. Respect the speaker and give them time to express themselves.
d. Listen without judging, assuming, or jumping to conclusions. Let them finish. Use wait time.
e. Acknowledge you are listening. Nod your head, smile, and use "yes" and "uh huh", to show that you're listening. Encourage the speaker to continue.
f. Authentically listen. Focus on hearing their thoughts and feelings instead of what you are going to say next.
g. Provide a supportive ear. Rather than providing advice about what they should be doing. Listen and let them work towards their own solutions. If you really need to share your solution, ask first if they want to hear it—say something like "Would you like to hear my suggestions?"

Table 2.1 Five foundational elements of emotional intelligence linked to Collaborative Team Action Model (CTeAM) framework including their characteristics and strategies of improvement

Element (C-TeAM Question)	Characteristics	Strategies for improvement
Self-awareness (Who are you?)	Know your feelings: Know your emotions. Know your strengths and weaknesses. Know your cultural frame of reference. The more self-aware a person is the better they can understand and accept their strengths and limitations. Once we know these things, we can manage them	• **Identify words or situations**—What words bring up negative emotions and memories? Write them down. Now you are aware of them • **Keep a journal**—Reflecting by writing improves your self-awareness. Spend a few minutes each day writing down your thoughts • **Slow down**—When you experience negative emotions. Pause, Slow your thinking, and ask yourself why. This gives you time to choose how you react
Self-regulation (Who are you?)	Control your verbal response. Control your decisions—avoid making rushed or emotional decisions. Control your assumptions, stereotypes, and bias. Self-regulation is all about staying in control	• **Use Ten-Second Rule**—When a challenging/emotional situation arises—give yourself at least 10 s during which you take deep breaths to calm yourself • **Use 24-four Rule—**In a situation that involves strong emotions and challenges, invoke the 24-h rule to let cooler heads prevail • **Write it down! Throw it away!**—write down the negative things you want to say. Then rip it up and throw it away. Express these emotions on paper. Do not show them to anyone. Keep them to yourself. This helps you challenge your reactions and reflect on your emotions. This is useful when invoking the 24-h rule • **Be accountable**—Commit to admitting your mistakes and to facing the consequences, whatever they are. Avoid the blame game. You will earn the respect of those around you

(continued)

Table 2.1 (continued)

Element (C-TeAM Question)	Characteristics	Strategies for improvement
Self-motivation (Who are you?)	Identify what drives you to invest energy, time, and resources. What is important to you? What do you want to achieve?	• **Write down your whys?**–Reflect on why do you get up in the morning? Why did you get into your job or join an organization? Answering these questions will help develop your goals for where you want to go • **Develop a find something good mindset –** When faced with a challenge, be hopeful, find something good, explore and consider the possibilities and positive outcomes, adopt a mindset to innovate, take action, navigate and negotiate the challenge and turn it into an opportunity
Empathy (Who are you?) (Who is on the team?)	Feel emotions *with* someone, from their perspective, based upon how you would feel in their situation	• **See strategies for Active Listening** • **See strategies to help the brain to produce oxytocin** • **Act with Kindness—Show them you care—**Act with genuine kindness, show others you care about them as members of a family, team, community, or the human race. Be a good Samaritan, actively force yourself to engage with others, causing connection. Helping others helps you in that your body releases hormones that result in you feeling better, allowing you to think more creatively, and to be empathetic

(continued)

Table 2.1 (continued)

Element (C-TeAM Question)	Characteristics	Strategies for improvement
Social Skills (Who are you?) (Who is on the team?)	Skills used to communicate and interact with each other, both verbally and non-verbally, through gestures, body language, and our personal appearance. Be aware of social and cultural norms in the environment within which you are working	• **Become a Better Listener.** See strategies for Active Listening • **Create an environment for communication** - Be respectful, be courteous, and treat all in a professional manner. ***Everyone*** brings something to the team - Establish expectations for positive communication and interactions - Promote the asking of questions and curiosity. Respond in a respectful manner - Reduce command and control language such as "need to", "have to", or "should." Consider more reflective language like "consider" or 'think about." - Acknowledge success, positive behaviours, contributions, and outcomes – publicly - Focus on solutions and innovation - Diversity of all kinds is beneficial to the team. Diverse groups are more innovative and handle conflict better

h. Ask Questions. Be Curious. Use questions to understand the other person's point of view. This shows that you are listening and care about what they are saying in that you want clarifications. Try to use open-ended questions. This requires avoiding questions that can be answered with yes or no or short responses. When appropriate, employ probing questions that acknowledge the speaker's contribution and offer an opportunity for clarification or more in-depth responses [3, 4].
i. Stay focused on the speaker - repeat their words in your head. This will help you concentrate and reinforces what they are saying in your mind.
j. Reflect, Repeat, and Paraphrase—Think and rephrase what you think you heard them say in your own words to show that you understand. It shows you've been paying attention and allows the speaker to correct you if you haven't understood correctly. A starting sentence such as "Sounds like you are saying…"

Active listening takes a variety of skills and as such, they all need to be practiced. For one week, try one or two skills and see if you can improve. Practice makes perfect of course.

2.7 Role of Interpersonal Neural Synchrony

Interpersonal neural synchrony is the correlation of brain activity across two or more people over time. This is another example of how our brains are wired to work and connect with others. Neural synchrony refers to the degree of similarity between the neural or brain activity fluctuations of multiple people in space and over time. This phenomenon represents the convergence and coupling of different people's neurocognitive networks (i.e., nerve cell (neurons) groups that perform cognitive functions). Interpersonal neural synchrony is thought to be the foundation for many forms of interpersonal dynamics and shared experiences. Using functional near-infrared spectroscopy (fNIRS), and electroencephalography (EEG - in alpha, delta, or theta frequency bands), among other technologies, synchronous brain activities across people are well documented. When two people are behaving in a synchronized way, their brain activities are at the same time coupled, demonstrating inter-neural synchronization [21]. As team members see themselves as part of a group and working together, a "sense of we" develops during which neurons become attuned with others in the group, leading to better performance. As team members work together and their brain waves come into increased alignment, the neural signatures become similar and the "rhythm of a team" is developed [28–30].

It is important to note that these group rhythms vary depending on the team task [22]. Convergent and divergent thinking activities create very different levels of brain synchronization. In the early stages of group/project development, unconstrained divergent thinking is necessary to allow for creative thinking and the generation of novel solutions [25]. A group tends to generate more unique and original ideas when a trusting and safe environment is created that encourages divergent thinking.

Once divergent thinking has been allowed to take place, the group can then begin the process of convergent thought development that will ultimately lead to enhanced neural synchronization within the group and the development of shared goals [33].

2.8 Final Words

Our individual and collective brains are at the core of team dynamics. Unlocking and activating the brain to enhance the collaborative experience at both an individual and collective level will promote more effective team interactions and learning environments. Developing the abilities to experience and respond to your own and others' thoughts, emotions, beliefs, intentions, knowledge, etc., will enhance the collaborative experience at both an individual and collective level. Understanding the neurological underpinnings of team dynamics including key elements such as brain microstates, inter-brain synchrony, mirror neuron activation, the role of emotions, explicit and implicit biases, a sense of safety, belonging, inclusion and trust, and related hormone will contribute to more effective crossdisciplinary collaboration.

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Chapter 3
Five Key Questions to Facilitate Crossdisciplinary Collaboration

David Gosselin

Abstract This chapter presents the use of five key questions as a framework to facilitate an on-going process of learning and interpersonal interactions to develop successful crossdisciplinary collaboration.

Keywords Crossdisciplinary collaboration · Collaborative team action model · C-TeAM · Logic model

> Asking questions is a uniquely powerful tool for unlocking the value in organizations: It spurs learning and the exchange of ideas, it fuels innovation and performance improvement, it builds rapport and trust among team members. [1]

3.1 Introduction

Questions are powerful tools for unlocking learning and promoting the exchange of ideas in a team. In a team environment where questions drive learning and knowledge creation about the problem or challenge—a learning organization evolves that will yield creativity and innovation [2]. Questions are important to helping team members learn about the values, behaviors, and expertise of their teammates and developing a sense of trust, responsibility, and accountability for the creation of a psychologically safe environment. Throughout a project, individuals, groups, and organizations (i.e., stakeholders) who will benefit from or be influenced by the project should be asked questions to obtain their input to maximize impact. A simplified model to keep questions at the forefront of a collaborative team during its creation and throughout its lifetime is the Collaborative Team Action Model (C-TeAM, Fig. 3.1).

The basic premise of CTeAM is that the use of five key questions promotes curiosity, fuels action and innovation, improves performance, helps build rapport,

D. Gosselin (✉)
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

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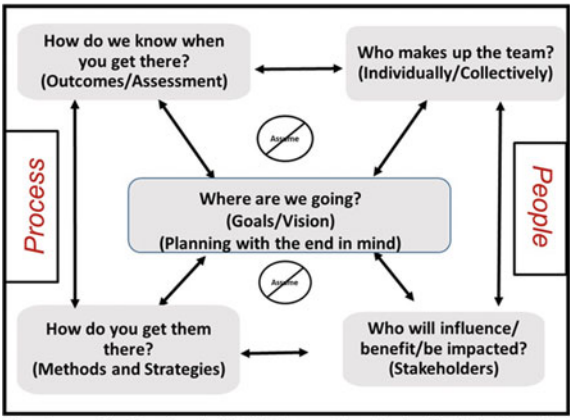

Fig. 3.1 Collaborative team action model. The basic premise of CTeAM is that action is continually taken to address the five fundamental questions throughout a project

trust, and a sense of parity amongst team members, and mitigates risk by uncovering unforeseen pitfalls and hazards. Questioning is a skill that takes time and practice to develop. An inquiry-based framework driven by questions provides opportunities to explore the strengths of and connections between team members whether they are from academic disciplines or from the non-academic real world.

If these five questions are asked continuously throughout a project, a learning environment will be created among diverse groups of individuals who bring many seemingly disparate personal characteristics, fields of expertise and mental models about the problem to the team. Everyone can learn from everyone else because everyone brings something unique to the team. Each chapter in this book addresses one or more questions. The implementation of this framework should result in a more creative, collaborative, and inclusive problem-solving environment in which the team members work and contribute to the evolution of the team as a learning organization.

3.2 Goal

The goals for this chapter is to:

- Provide background knowledge about the five key questions in the CTeAM model:

  Where are we going?
  Who makes up the team?
  Who will influence, benefit, and/or be impacted?
  How do we know when we get there?
  How do you get there?

- Introduce basic approaches to explore the answers.

3.3 Team Formation and Collaboration

Teams form in a variety of ways. Members may volunteer in response to a call for participants. An individual or small group may seek out participants based on their disciplinary knowledge in the case of academic teams, areas of expertise in non-academic settings, and/or availability and accessibility. Individuals may be selected by their bosses and are told to participate. Regardless of the approach, several processes are in play when people work collectively together as a team. Coordination, cooperation, and collaboration are a continuum of human behaviors in which there are different levels of complexity in terms of processes and outcomes when people work together (See Gosselin [3]).

The characteristics that distinguish collaboration from the other two c-words are:

- All participants have the opportunity to contribute to the development of the shared goal/vision for the project; and
- Leadership/control is shared.

Collaboration can be simply defined as two or more people (a team) working together (process) to develop and achieve a shared goal/vision/purpose. The shared outcome/goal and the leadership/control of the group should have their origins internal to the group. The collaborative group may be influenced by external factors, exist within a hierarchical structure, and seek outside input; However, the members of the group collectively share responsibility and accountability for the creation, implementation, and success of the project and achieving the shared vision.

3.4 Approach: Where Are We Going? (Planning with the End in Mind)

> To begin with the end in mind means to start with a clear understanding of your destination. It means to know where you're going so that you better understand where you are now so that the steps you take are always in the right direction.
>
> Steven Covey, The 7 Habits of Highly Effective People

This quote initiates our thoughts about a number of questions related to societal problems—What do we want the future to look like? What needs to change to improve the situation? What do we want to know and learn about the issue? What are the important research questions related to the issue? What does this project look like if it is successful? The centrality of the question of "where are we going?" in the C-TeAM model emphasizes the importance of creating a shared vision/goal to collaborative efforts. Centrality also makes the question a target for revisiting; Hence the vision and goals evolve and are refined over the course of a project.

These types of questions related to "where we are going?" is a form of backward design [4]. Gosselin [5] used a family trip metaphor to characterize the importance of planning with the end in mind. Knowing the destination for the family trip is

important. Is it a lake cabin or Disneyland? The end-in-mind for the trip focuses the planning energy on what is needed for the trip to be successful and creates expectations for the trip's outcomes—catching a bunch of fish or enjoying your day in an amusement part. If the development of the end-in-mind for the trip is being done collaboratively, then a process needs to be used to ensure that all voices are heard and considered during the development of the shared vision and goals.

In the context of this book, the terms 'vision' and 'goals' are used interchangeably based on the. guidelines from Kantabutra and Avery [6] for developing an organizational vision. A vision contains a prime goal to be achieved that encompasses organizational interests and its achievement is viewed as desirable by participants. The goal(s) provides the overall context for what the project will achieve. It offers a long-term perspective for the group and is the target of their activities. Hence, the key question, "where are we going?" is at the center of the matrix serving as both a target and motivation for the group's efforts.

Process: The development of the shared vision/goal for the project requires that the issue/problem/challenge is defined by gathering relevant information about the current situation, potential destinations, and potential paths to get to the final destination. Gathering this information benefits from background research including input from individuals and groups who are both directly and indirectly involved in the project and/or engaged in the issue of interest. Integrating these "lenses" requires the recognition of differences in disciplinary cultures and levels of expertise. Valuing these differences and respecting the spectrum of expertise and interests/values/approaches within the group is important.

To gather and integrate relevant information and "lenses", a facilitation process (es) for crossdisciplinary and boundary spanning needs to be used. This process should allow participants to learn what is known about the situation/issue, explore options, ensure that all voices are heard, struggle with differing viewpoints, and develop relationships among the team and external constituencies (i.e., stakeholders). The EMBeRS approach [7] is a prime example of processes that can be used for this type of exploration during the development of the shared vision and goals.

As the shared vision/goal is developed, specific objectives and activities can be identified. The objectives will lead to the development of expected outcomes and outputs from the project. Some advice—it is recommended that a person be included on your team who can facilitate the processes necessary to take advantage of the brain-trust, that is your team.

3.5 Approach: Who Makes Up the Team? (Individually and Collectively)

Individual team members are the fundamental building blocks for every team. "Who makes up the team" is a key C-TeAM question because it focuses on the people, individually and collectively, who are the individual building blocks from which the

team is built. Answering this question provides basic information to the team that will support communication and development of relationships between team members. An effective team relies on quality relationships. Often times, the development of effective relationships is left to chance. A facilitated process or a series of processes conducted in the context of project activities will help develop and maintain the relationships necessary for success. The extent to which this type of process is needed will be a function of the history that team members have working together.

Basic knowledge of the characteristics that each person brings to the team is important to increasing the likelihood that team members can take advantage of their strengths as well as navigate and negotiate their differences. There are three general categories of characteristics that need to be considered [3].

- *Cognitive and Disciplinary Characteristics (CDC)*: disciplinary knowledge, expertise, experiences, and perspectives. Includes cognitive processes include thinking, knowing, remembering, judging, and problem-solving.
- *Surface-Level Characteristics (SLC)*: demographic, bio-demographic, and observable individual differences; refers to readily detectable attributes such as gender, age, sexual orientation, ethnicity, ability/disability, and cultural traditions.
- *Deep-Level Characteristics (DLC)*: task-related, psychological, informational/functional, and underlying attributes; includes less observable deeper-leveled attributes such as values, mindset, attitudes, beliefs, functional expertise, and mental models.

In the context of knowing who is on your team, knowing yourself, your characteristics, and related tendencies are critical [5, 8]. Knowing who you are is the foundation upon which all relationships are built. An accurate perception of oneself and the way in which you act and react towards others (i.e., your behavioral characteristics) is a surface characteristic that is foundational to effective communication. Most people are aware of and sensitive to the ways with which they prefer to be communicated. Your deep level characteristics are, in many cases, your motivational drivers that drive your actions and reactions. They are the why behind the how.

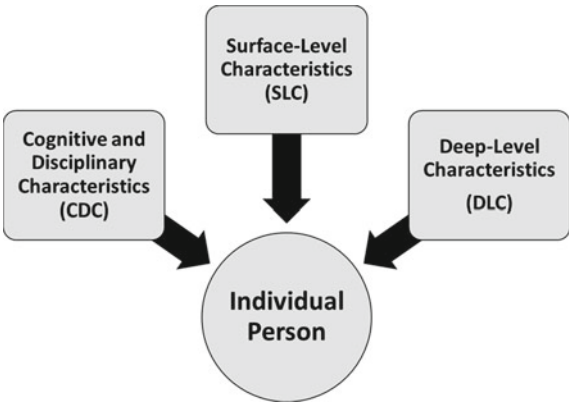

Fig. 3.2 The characteristics of individuals who comprise the team are important to learning how to navigate and negotiate differences among team members. From Gosselin [3]

Commonly, team members are selected based on their cognitive and disciplinary characteristics and/or areas of expertise. However, assumed differences and/or similarities in the surface- and deep-level characteristics among team members can contribute significantly to the challenges of blending team members together into a cohesive collective. Surface-level characteristics are easily observable—age, gender, socio-cultural background, skill level, and behaviors to some extent. Deep-level characteristics are not quite as apparent, including what a person's motivational drivers are, what are their mindsets, what are their values and beliefs, what do they know, among many other questions. In addition to the impact that the real differences in these characteristics have on blending the team, there are also assumptions made about the characteristics that individuals possess or, for that matter, may not possess. These assumptions will influence the effectiveness of team blending. When assumptions are made—tensions can arise.

Process: Gosselin et al. [9], Gosselin [3, 10] provide approaches you can you use to explore the surface- and deep-level characteristics. O'Rourke et al. [11], Gosselin and Bonnstetter (This Volume) provide guidance for exploring the cognitive and disciplinary diversity among members of crossdisciplinary teams. Exploration of the surface- and deep-level characteristics will contribute to enhanced interpersonal communication. This knowledge about your team can help understand sources of conflict and help you navigate and negotiate differences before they have a negative impact on the relationships among team members. Relationships are at the heart of a team because that is where trust is built—without trust you will have a dysfunctional team [12].

The extent to which you have time to explore or learn about these characteristics is dependent on the situation, the time available, and the people involved. In some cases, teams are formed as a result of a history of working together. In other situations, the members of the team may have minimal experience with one another. In the former situation, the team members already know something about one another which may reduce the necessity for and/or amount of exploration time. The latter situation may require the investment of more time for exploring what everyone brings to the team. In either case, the time you invest in knowing who is on your team in the context of your challenge, the better you can build on their strengths, and the more effectively your group can navigate and negotiate differences among team members.

3.6 Approach: Who Will Influence, Benefit, and/or Be Impacted? (Stakeholders)

When dealing with any type of project involving societal issues, there is commonly the intent that it will influence, benefit and/or impact others at some level. These others are stakeholders. As is often the case with making assumptions about the characteristics of individuals who comprise a team, assumptions are made about

what stakeholders want and need in order to address their challenges and issues. Consider the following:

> You are stuck in a car during a snowstorm. No one other than you can know exactly how you felt in that situation. Others may have read about similar situations or even had a similar experience. However, you are the expert on your situation because you experienced it. The same concept applies to any problem or challenge that impact multiple people. People who directly experience the actual problem have different perspectives about it than let's say a person who has only read about the problem in the newspaper or once wrote a college essay about it.

This story highlights the fact that different people bring different knowledge, experiences, and perspectives to addressing a problem or issue. All of which have value. In the context of addressing societal issues, engaging stakeholders—community members, community leaders, non-profits, businesses, etc. will provide a clearer picture of the opportunities, challenges, support, assets, and potential pitfalls that may be encountered during the project. Stakeholders also provide ideas and perspectives about what products, outputs, or outcomes that they would like to see from the project. When stakeholders have a voice in the process and can contribute to project development, they develop a sense of ownership and become supporters of the process instead of being obstacles. They will take ownership to do their best to make it work. These conversations strengthen your position and develop social capital by increasing your web of acquaintances, relationships, friendships, buy-in and support from the community. Stakeholder engagement reduces the opportunities for you to be blindsided by perspectives that you did not know about. Creation of a more diverse set of contacts and connections leads to new relationships that can spark new initiatives that would not have come into existence without this process.

The identification and inclusion of stakeholders is part of an emergent process critical to the development of shared goals/vision for any crossdisciplinary program. The investment of time and effort to include stakeholders will result in a better, more inclusive, and effective projects. The earlier you engage stakeholders in the process, the better. Investing time in stakeholder conversations, especially during the early stages of the process, will save you time and energy in the long run [13].

To illustrate the importance of stakeholders, consider a common situation in an academic environment in which an academic program is developing curriculum. Two primary stakeholder groups that directly impact, affect and/or benefit from curriculum are instructors and students. The curriculum is being designed by instructors to take students from where they are to some place new via the curriculum and its educational activities, yet students are commonly not included in the development process. Addressing the question, "For whom are we developing the curriculum?" along with knowledge of the background and experiences students bring into the classroom are important considerations. Students at an Ivy League school are likely to have a different set of characteristics and experiences than students attending an institution historically serving a predominantly latino population . The answer to this

question is not trivial and requires investing time to learn about the characteristics of your students [14].

Process: To get started, a simplified process for stakeholder analysis is presented in Table 3.1.

Table 3.1 Simplified stakeholder analysis process

Logistics: Break your team into groups of 3–5. Each person should have access to sticky notes. Use a marker to write on sticky notes so they can be seen by others. Access to white board or poster paper ***Step 1. Individual Brainstorming***: Record each stakeholder or stakeholder group on an individual sticky note—write down whatever comes to your mind—post to white board/poster paper. All responses need to be respected. Everything is in play. Think about with whom your program has/will/should interact and who values what you do ***Step 2. Organize Stakeholders***: *Organize into* categories—primary, secondary, and key (See Below) 3.1). Start by doing this silently. Each person moves one sticky note into a category. Sequentially do this until all sticky notes have been organized. Once everyone has been given the opportunity to participate in the silent categorization, ask each person to silently move sticky notes to other locations if they so desire. Go to an interactive group activity to discuss and negotiate the organization
(a) Descriptions of stakeholder categories
Primary stakeholders: People or groups that are directly affected, either positively or negatively, by efforts or the actions of your program. They stand to gain something—services, skills, money, goods, social connection, etc.—as a direct result of your program. Have a direct stake in the program's success
Secondary stakeholders: People or groups that are indirectly affected, either positively or negatively, by the efforts or the actions of your program. **Those whose jobs or lives might be affected by the process or results of the effort.** Examples—other departments or programs in your institution, employers. Secondary stakeholders are more interested in the program's impact on the community rather than having a direct stake in the program's success
Key stakeholders: People in positions of influence. Examples—deans and vice chancellors. Individuals or groups of people who can devise, pass, and enforce policy and procedures that may either support your effort or directly cancel them out. Examples—department head, associate dean for curriculum, curriculum, and other university committees. Individuals and groups who may not be affected by or be involved in your program, but nonetheless care enough to try and influence the program. Examples—funders, elected or appointed government officials, heads of businesses, community activists, and other community figures who wield a significant amount of influence
Step 3. Gather Information from Stakeholders: At this stage, step back and ask some questions of your stakeholders. You should not have to guess what stakeholder interests are in your program. Ask them what's important to them. Explore their concerns. Stakeholders will tell you how they feel about a potential or ongoing effort, what their concerns are, and what needs to be done or to change to address those concerns. The extent to which you can explore their concerns depends on the situation and the time available ***Step 4. Identify Importance to the program***: Circle the people/groups that you feel are most important to your program and the extent to which you feel your program is and supported. Don't worry if it gets a little messy. As you move forward, addressing the concerns of your stakeholders will increase the likelihood that your project will be successful

3.7 Approach: How Do You Get There? (Methods and Strategies)

Different methods and strategies need to be used to address the people- and process-related questions of CTeAM. The following questions should be considered as the process, methods, and strategies are developed to achieve your team's vision and goals:

- What is the theory of change?
- What frameworks or models exist?
- What are the SMART objectives?
- What activities are required to achieve the objectives?
- What resources (funds, people, equipment, etc.) are needed to complete tasks?
- What strategies will be used for data collection, training, media and communication work, coalition development, etc.
- Who is responsible for assessment and by whom and when?
- What assessment data needs to be collected?
- Who will facilitate?
- Who else needs to be involved, reached, targeted, and/or participate to achieve the objectives? Consider such things as relevant diversity and inclusivity of audience (s) being addressed.

Theory of Change: The methods and strategies you choose will depend on the question and some underlying theory of change (TOC) that your team is employing. Depending on the circumstances, your planning process could start with something as a simple If–Then statement. For example, If I use this cover crop on my field, then I will increase the carbon storage in my soil. If I increase the carbon in my soil, then I will decrease runoff from my soil and increase water infiltration. These If–Then statements are based on existing knowledge or experience that in essence is your TOC.

The TOC typically arises from one or more of the following:

• Local knowledge, wisdom, and common sense	• General social science theories of change. Examples include:
• Research and evidence base. Examples:	– Stages of change or "trans-theoretical" model – Diffusion of innovation – Ecological systems – Empowerment – Social marketing
– Model-based reasoning – Experiential learning – Design thinking	
• Best practices	
• Evaluation studies	
• Other lessons from the field	

The TOC is the theoretical framework that provides the rationale for selecting the relevant processes, methods, and strategies that will take you from the current

situational context for the problem or issue (i.e., where you are now) to your end-in-mind (i.e., your goals and vision). The theoretical framework addresses why you are doing what you are doing and how you are going to achieve it. The TOC helps define the specific steps (i.e., objectives) that will be used to obtain the goals and vision. This plan of attack needs to be clearly articulated to the people involved so they know why they are doing what they are doing. The why behind the how needs to be communicated as it will result in greater buy-in from all involved.

Frameworks and models: Ideally, the framework that you use will identify pathways in the context of your backward design process and the achievement of your shared goals and vision. When working in the arena of social change, there are many existing frameworks for models that can provide guidance related to the measurement and acquisition of relevant quantitative and qualitative data. Ebrahimn [15] is an excellent resource for practical approaches to measuring social change and provides a downloadable list of resources (https://fletcher.tufts.edu/people/alnnor-ebarhim). Other common frameworks include the Impact Management Project (https://impactmanagementproject.com) United Nation's Sustainability Development Goals (https://sdgs.un.org/#goal_section); Principles for Responsible Investment (https://www.unpri.org/pri/about-the-pri); Social Return on Investment (https://neweconomics.org/uploads/files/aff3779953c5b88d53_cpm6v3v71.pdf); and B Impact Assessment (https://bimpactassessment.net/about-b-impact). Vincent et al. [16] provide an example of a detailed assessment framework for a series of educational workshops.

SMART Objectives: Objectives define strategies or implementation tasks to achieve the identified goals. Goals are the direction and overall destiny for the team that need to be accomplished in order to achieve the vision. They are typically broad and long-term. Your objectives outline your plan of attack. They provide specific, measurable actions that the team must take to achieve the goal. The SMART methodology is used by organizations of all sizes to provide a structured approach to describing how the goals will be achieved. SMART objectives provide the "who, what, when, where, and how" of reaching the goals.

The answers to these questions provide the framework for the development of SMART objectives that are:

- **S**pecific: Concrete, detailed, and well defined so that you know where you are going and what to expect when you arrive.
- **M**easurable: Numbers and quantities provide means of measurement and comparison.
- **A**chievable: feasible and easy to put into action.
- **R**ealistic: Considers constraints such as resources, personnel, cost, and time frame.
- **T**ime-Bound: A time frame helps to set boundaries around the objective.

Table 3.2 provides details for writing each component of the SMART objectives as well as some models for sentence structures.

Activities: Activities are a means to an end, not an end in themselves. Activities answer a very important question, "What actions are needed to meet objective?"

Table 3.2 Key questions and concepts for writing SMART objectives and model sentence structures

Specific: What is the specific task?
Considerations: **: What exactly will you do? What is the action?**
Who is responsible for carrying out the action? What are you intending to impact or who is your target population?
Measurable: What are the data, standards or parameters that will show success/impact over time?
Considerations: Use numbers, percentages, or some standard unit to express the amount and direction change that will occur OR provide level of performance needed to represent success
Achievable: Is the task feasible?
Considerations: Objectives should be within reach for your team or program, considering available expertise, resources, knowledge, and time
Realistic: Are sufficient resources available considering day-to-day workload, personal commitments, and proposed time-frame?
Time-bound: What are the start and end dates? jhn
Considerations: Objectives should be achieved within a specific time frame
Model sentence structure: Here are some sentence structures for objectives:
[**Who**] will do [**what**] resulting in [**measure**] by [**when**]
By [**when**], [**who**] will do [**what**] resulting in [**measure**]
By [**when**], [**measure—includes who and what**]
[**Measure—includes who and what**] by [**when**]
To develop SMART Objectives that will help you reach your goal fill in the blanks below:
By_____ _/ _____/_____
(When?) (Who?) What? Include a number you can measure.)
Will have _____ ___ _____
(How? Why? Remember to specify results

They are the specific tasks to achieve the objective. Activities are the steps taken to accomplish an objective that ultimately contributes to achieving the project goal. Table 3.3 provides a template to connect your goals, objectives, and activities.

Table 3.3 Template for linking goals, SMART objectives and activities

Goal:
SMART objective 1:
Activities/Steps taken to accomplish objective
SMART objective 2:
Activities/Steps taken to accomplish objective

Facilitation and Assessment/Evaluation: Developing effective collaboration will benefit from having a person or persons who have expertise in facilitation. A facilitator brings expertise and strategies necessary to guide the team where they need to go.

A good facilitator provides the following:

- Advanced preparation.
- Clear communication through active listening and asking questions.
- Effective use of time.
- Creates a psychologically safe environment for sharing.
- Creates focus amongst the group.
- Manages the group decision process.

A facilitator serves as a compass for the collaborative journey. They provide direction to lead the team to their destination. A team can navigate without a compass, but the journey will be easier and more effective if they have someone to guide them, especially when they do not have a vested interest in the outcome.

3.8 Approach: How Do We Know When We Get There? (Assessment and Evaluation)

In the arena of messy societal problems in which crossdisciplinary collaboration is required to create change, assessing performance and the extent to which you achieved what you set out to achieve is, and of itself, a messy problem. People often cringe when they hear the word assessment because they have had bad experiences that stems from its interchangeable and/or synonymous use with the word evaluation. Evaluation is very much outcome focused. It involves judgement about performance or the measurement and comparison of performance to some existing standard, which, at times, are not well articulated. In contrast, assessment is about process. It involves the collection, review, and use of data, for the purpose of improving performance, outcomes, and outputs. In the words of business management guru, Peter Drucker—"If you can't measure it, you can't improve it." Assessment and evaluation (A & E) is the foundation for improving what we do and documenting success.

From a pragmatic perspective, a useful A & E framework collects data to document the effectiveness of a program/project that is crucial to program improvement and securing and maintaining funding [17]. These quantitative and qualitive data documents the effectiveness of various strategies to achieve the intended objective and goals, establishes a track record of success that can be used to track positive change, and demonstrates impact from the individual to community to societal level. Assessment and evaluation information provides support for the spread of good ideas and their infiltration into a broader community. This helps improve practice, process, and outcomes. Equally important, A & E identifies opportunities for change and

improvement so that the resources committed to achieve the environmental, social, or other positive impacts/outcomes/outputs are used as intended. A & E also helps identify areas in which the target has been missed and creates an opportunity to learn by reflecting on what happened, listening to stakeholders, and asking new questions. A person having expertise in A & E should be an integral member of the collaborative team. Vincent et al. [16] provide an example for your consideration.

Process: A natural question that arises is, what metrics and data need to be collected? The answer is it depends. There is not a "one-size-fits-all" approach. Most often, evidence for unambiguous cause and effect does not exist. Results are not easily comparable across disciplines and social sectors. Questions about what to measure, what measurement systems to use, and how to align the A & E system with the demands from stakeholders need to be thoughtfully addressed during project planning and iteratively revisited throughout the project [15].

Measuring the effectiveness of the methods and strategies and their impact focuses on the output and outcomes from the project as defined by the objectives.

- ***Outputs*** are the activities completed and/or direct and tangible results from activities. Examples include: a program created to infuse sustainability into the curriculum; conference to disseminate research results; number of partnerships created; number of people trained; number of publications produced.
- ***Outcomes*** are the desired results of the program or the impact it has had—what was achieved, what changed for individuals, families, groups, or communities. Expected outcomes/impacts need to be clearly articulated. Examples include change in knowledge, change in behaviors, and/or changes in societal conditions.

Outputs and outcomes are commonly presented in the context of time and can be characterized as short-, intermediate-, or long-term. This time component depends on the objectives, the length of the program, and expectations for the program or intervention.

Institutional Metrics: Every institution has metrics and data used to assess their programs. The following questions provide a framework for data collection relevant for different stakeholder groups.

- What do you need to report to your administration, funding organization, etc.?
- What data/information would be useful to demonstrate the effectiveness of the program—to stakeholders, to your administration, to the broader community, to the larger civic community, to potential employers?
- What evidence do you need to collect to determine the extent to which your program is meeting the expected outcomes?
- Where are the places in the program where these data are, or could be, collected?

Educational Metrics: From an educational perspective, a program matrix approach can be used to specifically address the last two bullets above, that is, what and where to collect the evidence. A program matrix visually illustrates the relationship between program learning outcomes, course outcomes, course activities, and assessment opportunities [18]. The matrix approach helps align all course specific

student learning outcomes to overall programmatic goals. The matrix provides a framework for program assessment that integrates and identifies opportunities for gathering formative (https://serc.carleton.edu/departments/degree_programs/assess_plan.html#refs) and summative data (https://serc.carleton.edu/departments/degree_programs/assess_plan.html#summative).

Research Metrics: Traditional research assessment metrics are the amount of grant funding received, the quantitative measure of the number, dissemination, and content of research publications, and external recognition [19]. However, this level of documentation significantly undervalues the impact of research. Rand [19] provides 100 metrics to assess and communicate the value of research. This list of metrics is organized into nine target areas:

- Research impacts;
- Teaching and career development impacts;
- Research and institutional processes;
- Networks and dissemination;
- Policy impacts;
- Health impacts;
- Economic impacts and commercialization; and
- Broader metrics (i.e., approaches that capture information across a range of these categories).

These target areas and associated list of metrics in the Rand publication are admittedly not comprehensive but they provide a framework to stimulate and broaden thinking about project value and its broader impact.

Impact Assessment Designs: Reed et al. [20] indicate that impact assessment needs to be tailored to the aims of the research, impact being evaluated, and the expectations and perspectives of stakeholders regarding impact/outcomes/output [21]. For example, policy makers are less concerned with the *output* of a program: number of participants in an educational program and more concerned about the *outcome:* number of participants who changed their behavior or who worked to change a local policy because of the program. The frameworks and models provided earlier provide assessment frameworks upon which to build. See Fig 2 in Reed et al. [20] for a methodological framework for evaluating research impact. Five general assessment designs are identified: (i) experimental and statistical methods; (ii) textual, oral and arts-based methods; (iii) systems analysis methods; (iv) indicator-based approaches; and (v) evidence synthesis approaches.

Here are some words of advice:

- *Start simple*. Stay focused on what is most important to the project first. Progressively add complexity to your approach based on emerging questions, needs of stakeholders, and the expertise that you have available. Metrics should be straight forward and minimize frequent and burdensome reporting; are easily understood, accepted, and promote quality; and maintain relevance overtime to be able to document progress [21].

- *Start with available frameworks and models.* Existing frameworks and models provide a foundation and/or targets for the identification and development of relevant quantitative and qualitative metrics and information. Build off others' work.
- *Consult, collaborate with, and/or hire assessment expertise.* Avoid the do-it-yourself approach. Bring people into your team who have relevant A & E experience to develop an effective, efficient, and robust A & E framework in the arena in which you are working—social change, educational change, climate change, etc.
- *Allocate time and resources.* A & E data are only useful if you reflect on and use it to improve what you are doing. Allocate time at an individual level to reflect on and learn from these data sets. Then apply what you learn to improve to maximize the benefit of A & E. Allocate time as a team to learn from others and collectively reflect on the A&E data. This contributed to building a collegial and collaborative environment in which participants develop a sense of shared responsibility and accountability for the project outcomes.

3.9 Final Words

The development of crossdisciplinary collaboration requires the use of a variety of methods, strategies, and approaches to blend team members and their ideas. These are featured in other chapters in this book. Whatever the process or processes employed, the goal should be to create an environment that:

- Cultivates and nurtures each team member;
- Values the contributions of each team member;
- Uses supportive behaviors to create a learning environment;
- Allows challenging questions to be asked; and
- Lets participants admit and learn from their mistakes.

This type of environment is psychologically safe (e.g., [22, 23]) whereby team members are comfortable being themselves. Discussing psychological safety to some people may sound "touchy-feely", However, in reality, a psychologically safe environment is critical to getting the most out of the team. Team members need to have a safe place for interpersonal risk taking and ideas, asking questions, expressing concerns, and/or sharing mistakes without fear of embarrassment, rejection, or punishment. This type of team climate is characterized by interpersonal trust and mutual respect in which relationships are strengthened, and trust-making behavior develops.

The five key questions foundational to the C-TeAM model provide opportunities to use the power of questions to unlock the true power of a collaborative team. As a wise colleague once told me, "the answers are easy, it is identifying the questions that are hard". The model is intended to promote the continuous use of questions throughout the life of a collaborative team in order to integrate process and people. The centrality

of the shared vision/goal in Fig. 3.1 is intended to keep the collaborative team focused on its importance. Figure 3.3 provides a key question matrix that can be used as a starting point for continuous learning about the people and processes involved in a collaborative team. Logic models come in many forms [24]. However, in contrast to other logic models, C-TeAM emphasizes the importance of the people component to the collaborative team effort. Processes are important to bringing people together to work effectively and efficiently in a psychologically safe environment. Asking questions about how processes and interactions between people can be improved, leads to more effective teams.

C-TeAM is a model for enhancing program performance. It is not an end in itself. Time needs to be invested in the process and people to build trust, understanding, consensus, and clarity in thinking about the program—all of which are critical to the program's success. Keep the dynamics of the model in mind and change what you do as you learn about the people and processes as you create and innovate.

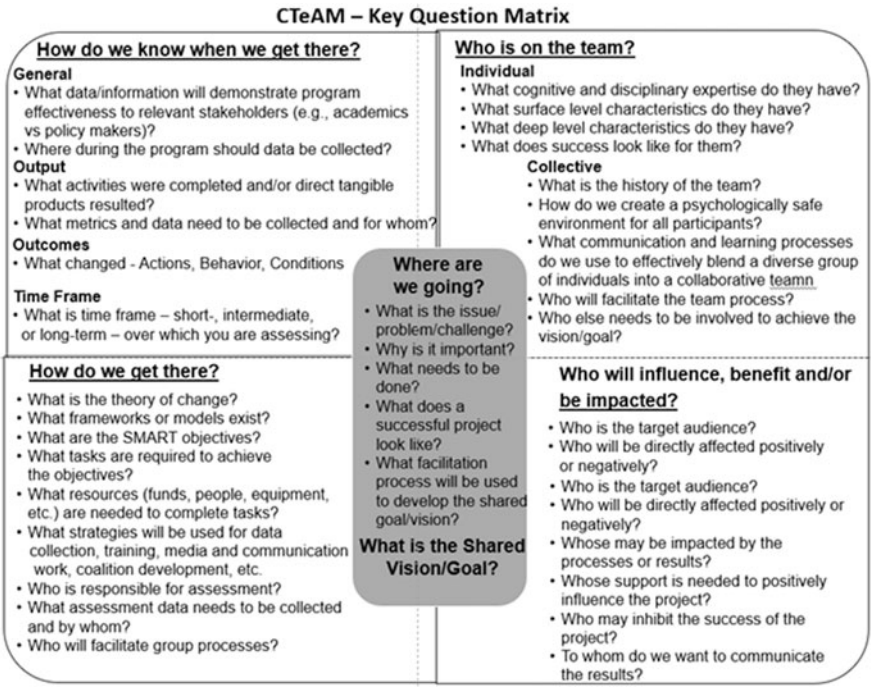

Fig. 3.3 Key question matrix to guide continuous learning and integration of people and processes involved in crossdisciplinary collaboration

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Part II
Applications and Approaches

Chapter 4
Who is on the Team? Exploring the Diverse Characteristics of Collaborative Teams

David Gosselin and Ronald J. Bonnstetter

Abstract The development of relationships between individual team members is critical to effective collaboration. Whether you are a person who considers themselves a team member or a team facilitator, the development of quality relationships influences the extent to which the shared goals of the project are achieved by the team. It is important to intentionally facilitate the emergence and growth of relationships using a variety of processes whereby team members can learn more about each other's characteristics—behavioral styles, approaches to research, motivational drivers, world views, values, talents, and interests. The extent to which these characteristics are explored will be dependent on the context/complexity of the project and the extent to which team members have worked with each other in the past (i.e., team history). This chapter focuses on the importance of accounting for the compositional characteristics of team members—e.g., behavior patterns, motivational drivers, personality, dispositions, demographics, cultural heritage, etc.—as an inherent part of the collaborative process. Learning to respect, manage, and navigate the differences in these characteristics in your specific context is important to team development and its long-term effectiveness.

Keywords Collaboration · Dispositions · Surface-level characteristics · Deep-level characteristics · Cognitive and disciplinary characteristics · Personal characteristics

D. Gosselin (✉)
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

R. J. Bonnstetter
Research and Development, TTI Success Insights LTD, Scottsdale, AZ, USA
e-mail: ron.bonnstetter@ttiltd.com

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CTeAM Connections
- Who makes up the team?
  (Individually/Collectively).
  - How do you get them there?
  (Methods/Strategies)

4.1 Introduction

Solutions to complex societal issues requires collaboration, which, in turn, requires building trusting relationships among people from very diverse academic and non-academic backgrounds, areas and levels of expertise, cultural perspectives, personal characteristics, among others. Effective collaboration leads to the development of an environment in which thinking together, sharing of knowledge, convergence of expertise, capacity to create and innovate, and psychological safety exists (e.g., [1–5]). This environment leads to the development of a "learning organization" [5]. A learning organization within which crossdisciplinary collaboration thrives requires individual members to effectively manage their relationships with others who have different disciplinary knowledge, expertise, and ways of knowing (epistemological frameworks).

Factors and team processes that lead to effective collaboration and teamwork have been summarized in many models and conceptual frameworks [6–11]. Managing relationships among compositionally diverse individuals—e.g., age, dispositions, world views, competencies, cultural heritage, etc.—requires effective process-oriented mechanisms to blend team members together [8, 9].

4.2 Goals

The goals of this chapter are to:

- provide background about compositional features of team members; and
- introduce approaches and strategies for learning about team members.

4.3 Background

This chapter seeks to provide approaches and strategies to address the core question: "who are the people that make up the team?" of the Collaborative Team Action Model (CTEaM). Knowing more about the details of "who" is on team is important to all team members because it will lead to better team function and output. Many attributes contribute to who a person is (Figs. 4.1, 4.2). A person's culture (Fig. 4.1) along with their personal characteristics (Fig. 4.2) influences how they interact, communicate, and develop relationships with other people. Three general compositional categories—surface-level, deep-level, cognitive and disciplinary—provide a general framework for characterizing the range of personal attributes that people bring to a team [12–15]. Volumes have been written about these attributes. This chapter's intention is to increase awareness of their potential influence on your team.

Surface-level features are observable and of which we are conscious or aware. A person's behavioral patterns and tendencies (i.e., characteristics) consist of their actions and reactions (responses). They can be observed, recorded, and measured. These characteristics are their manner of doing things some of which are natural and inherent to them while others come from their upbringing, social, and cultural experiences. Easily observable characteristics such as a person's race, gender, age, or ethnicity can lead to implicit bias that influences judgments, decisions, and behaviors towards others. A person's responses show up in how they act and how they interact with others. Body language, tone of voice, rate of speaking, how they listen, introversion or extroversion, directness or indirectness of verbal communication, punctuality, among others, are examples of observable behavioral characteristics. Recognition of behavioral tendencies and implicit bias leads to opportunities to control them. A

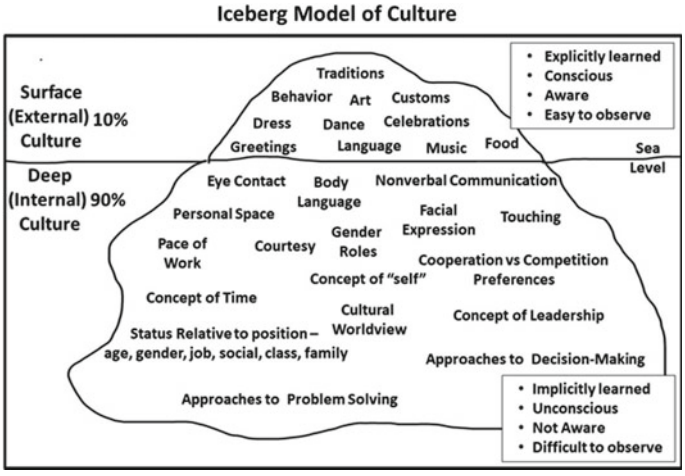

Fig. 4.1 Iceberg of cultural characteristics. See text for details

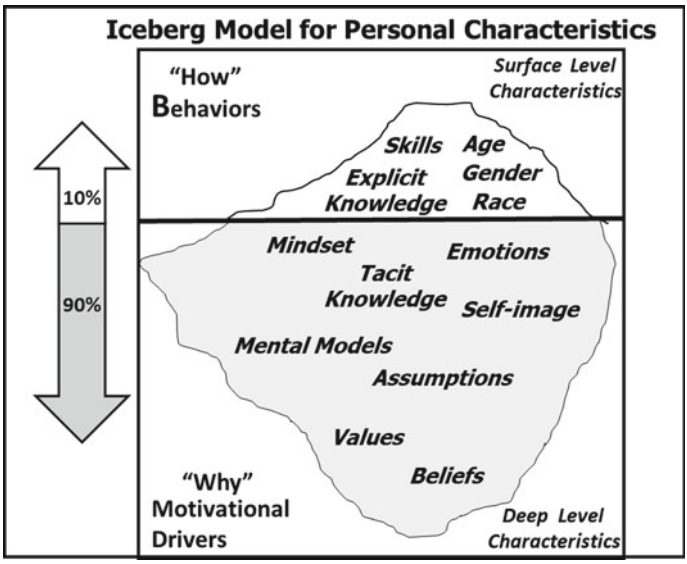

Fig. 4.2 Iceberg model for personal characteristics. See text of details. Modified from [16]

heightened awareness that behavioral tendencies are different from one person to another creates opportunities to modify behavior so differences can be navigated and negotiated.

Deep-level attributes include individual psychological constructs such as values, attitudes, preferences, beliefs, worldviews, and assumptions [14]. These not so readily observable characteristics are forms of tacit knowledge which are resident within the mind and perceptions of individuals [17, 18]. Gosselin et al. [16] refers to these characteristics collectively as motivational drivers in that they are the "why behind the how and what we do". Motivational drivers are those things about which a person is passionate, perceive as important, and/or are the values that provide purpose and direction in their life. These drivers strongly influence the way individuals look at life, their mindsets, their decisions, and their behavioral characteristics. Diversity in motivational drivers can lead to knowledge and social gaps between individuals that can reduce team effectiveness [19].

Each person brings different expertise, disciplinary and cognitive backgrounds, levels of knowledge, ways of knowing, project language, and mental models about the issue to the team. These differences yield distinct perspectives regarding assumptions, strategies, and beliefs related to such things as the use of quantitative and qualitative data, the methods for collecting data, importance of stakeholder engagement, and motivations for research (e.g., community benefit or intellectual curiosity). Although bringing different perspectives together is the point of collaboration, failure to understand them can strongly influence the development of effective communication and the trust necessary for building the relationships necessary for successful collaboration [20–23].

4.4 Approach

Team Exploration Factors: Learning about the surface-level, deep-level, cognitive and disciplinary characteristics of other team members is commonly assumed to develop organically as people interact over time. Although this is true to a certain degree, the importance of these characteristics to the evolution of relationships necessary for collaboration supports the basic premise that some level of intentionality be placed on learning about and exploring the characteristics of team members. It is too easy to just skip over and neglect these characteristics. The extent to which a team wants or needs to explore is dependent on a number of factors, that include, but are not limited to:

1. Team Formation—Teams form in a variety of ways. Members may volunteer in response to a call for participants. A facilitation group may seek out participants based on their disciplinary knowledge in the case of academic teams, areas of expertise in non-academic settings, and/or availability and accessibility. Both these approaches are certainly reasonable places to start, but the resulting group will be highly heterogenous.
2. Team Function—The extent to which a team is going to operate in a collaborative way whereby parity among participants and development of a shared vision are important will influence the level of relationship building necessary.
3. Team History—In the case where team members have a history of working together, they will be in a place where these characteristics have been explored to varying degrees. They understand one another's tendencies. However, when new people are added to the group or a new group is formed, an investment of time to explore these characteristics in the context of the project will be beneficial.
4. Team Duration—how long will the team work together on the project?

Self-Knowledge: Regardless of the team status in terms of formation, function, history, and duration, the person on your team that you should be most concerned about knowing is yourself. To maximize your impact on the team, you must know who you are [24]. Research suggests that we make sounder decisions, are more creative, more confident, build stronger relationships, and communicate more effectively when we see ourselves clearly [25]. The Gallup organization has documented the importance of self-knowledge and having an acute knowledge of your strengths as important to being an effective leader [26]. Self-knowledge requires the recognition of our patterns and tendencies that manifest themselves in our surface level characteristics related to how we interact, communicate, and develop relationships with other people.

Know Your Team: A significant challenge above and beyond learning and improving knowledge of self is integrating this information with that from the people with whom you are collaborating to create a psychologically safe environment. An important first step to addressing these challenges is to recognize that each team member including yourself has a set of surface- and deep-level characteristics, none of which are necessarily good or bad. They are just different.

Once these differences are acknowledged, the next step is to be intentional about learning about other team members and questioning our assumptions. Communication is key. O'Rourke provides an excellent overview of the practice of communication [23]. Assuming how others think and feel, why they act the way they do reduces the listening a person does and, therefore, effectively reduces communication and increases opportunities for misunderstanding. Assumptions can be the beginning of the end of the relationships necessary to build quality collaborations.

During interactions with students, employees, colleagues, community volunteers, assumptions inadvertently arise when a person focuses on phrases such as—when I was their age, when I was in school, when I got my first job… when I was part of this research team… We did this. Or we did that. Or this or that worked for me. Or we would have never done that. These statements are based on the "It worked for me so it should work for them" assumption. All these statements reflect an inward-looking focus. They illustrate the power of personal experience in shaping our views and assumptions and the importance of questioning the extent to which personal experience is representative.

The "First an Expert" assumption often occurs in the world of higher education. It manifests itself in the following way. If you have a Ph.D. and have research-based expertise in a given discipline, then you will be an effective teacher, an effective academic leader, and/or an effective communicator about your expertise in the community. An interesting corollary in the coaching world is that if you played the game at a high level, then you will be a good coach. These assumptions can result in people getting put into positions for which they have not been trained or do not have the required expertise.

Another source of assumptions is related to cultural differences. Culture is the "shared patterns of behaviors and interactions, cognitive constructs, and affective understanding that are learned through a process of socialization. These shared patterns identify the members of a culture group while also distinguishing those of another group" [27]. Culture includes the knowledge, language, religion, cuisine, social habits, music, and arts of a particular group of people [28]. We are all part of a culture. Whenever we interact with a new person or group of people, we are interacting with one or more new cultures. The cultural lens through which we view other people focuses on the surface/external level cultural attributes that we can see, the 10% (Fig. 4.1), because the brain processes these visual attributes in the context of keeping us physically and emotionally safe. This may lead to unconscious assumptions (i.e., implicit bias) about another person or group of people based on easily visible attributes. These early time assumptions do not consider the significant influence that the more difficult to observe deep-level cultural components have on the person's surface-level characteristics.

4.5 Strategies

The ability of a person to understand their characteristics at a level where they know what they want to do and why they want to do it, is a challenging task that each individual faces during their journey to becoming an effective collaborator, teammate, and leader [24]. Continually asking questions to focus and learn more about ourselves and the people with whom we work are at the forefront of the strategies provided. Asking questions moves us past assumptions that can create problems for teams at a variety of levels. Recognition that each team member including yourself has a set of surface- and deep-level characteristics that need to be explored is a good first step towards effectively blending team members. In the remainder of this chapter, various strategies are provided to explore some of the key characteristics—individually as well as collectively.

4.6 Self-Knowledge

> Knowing yourself is the beginning of all wisdom.—Aristotle.

4.6.1 Surface- and Deep-Level Characteristics: Self-Reflection Methods

Volumes have been written about reflection. It is defined as "the conscious examination of past experiences, thoughts, and ways of doing things. Its goal is to learn about oneself and the situation, and to bring meaning to it in order to inform the present and the future. It challenges the status quo of practice, thoughts, and assumptions and may therefore inform our decisions, actions, attitudes, beliefs, and understanding about ourselves" [29].

Self-reflection methods seek to maintain a positive self-view so that a person can receive critical feedback from themselves. Self-knowledge sometimes requires confronting things that are uncomfortable, or things that don't feel so good. We need to be willing to ask ourselves, "What can I do better?", "What are some of the worst things about myself?". We need to be willing to listen to the answers and grow from them. People need to accept that they may not be as great as they think they are. Continuously challenge what you think you know and why you do what you do.

Reflection is a process that allows a person to link experiences so that they become more aware of their own knowledge and actions and evaluate them relevant to their values. The purpose of the process is to improve self-knowledge—in terms of what you do (practice) and why you do it. Development of knowledge, skills, and abilities to reflect will improve performance.

Table 4.1 Examples of self-reflection activities

Type	Brief description
Reflect on experience	**What? So what? Now what?** Driscoll [30]
	'What?' helps you describe the situation you want to learn from. You should identify the facts and feelings of the situation
	'So What?' allows you to extract the meaning of 'What?'. Moreover, you should question what knowledge you and others had in the situation, and what knowledge or theories could help you make sense of the situation
	'Now what?' allows you to create an action plan based on the previous questions
Reflect for self-awareness	**Self-Questioning**
	What is one of my strengths/weaknesses?
	How do I know?
	What does evidence do I have for this practice? (For example, if a strength is being conscientious, maybe you are always on time, or meet deadlines.)
	What other strengths/weaknesses may contribute to the abilities? (For example, the strength 'meet deadline' may come from being organized and committed)
Reflect on personal values	**Live Your Core Values: 10-min Exercise to Increase Your Success** [31]
Reflect on personal values	Discuss with colleagues: Share with a colleague and gain others' perspectives regarding what you value and the source of your values? How do you prefer to be communicated with? One of the most common mechanisms for making sense of your own as well as others deep-level characteristics are person-to-person interactions using stories, analogies, metaphors, and discussion [17]
General resource on reflection	Reflection toolkit: https://www.ed.ac.uk/reflection

Tables 4.1 and 4.2 provide examples that may assist you in reflecting on yourself. The reader is referred to the website under general resource on reflection for an extensive review of the literature.

4.6.2 Surface- and Deep-Level Characteristics: Assessment Instrument Methods

The process of self-reflection can be aided by the use of assessment instruments. These instruments can assist an individual in the articulation of tacit knowledge (Fig. 4.2, i.e., knowledge, skills, and abilities that are difficult to put into words) into more explicit knowledge. That is, knowledge that can be more straightforwardly expressed, reflected upon, and shared between people. Assessments are not 100%

Table 4.2 What are your motivational drivers? How do they drive your actions?

Instructions: Listed below are values			
1. Read through the list. When you find a value that describes you, circle it			
2. Select your top 10. Assess the values you circled and choose your top ten			
3. Connect actions to values. Describe how these 10 values influence your actions, especially as they relate to your work with the group			
4. Share with a colleague and gain others' perspectives regarding what you value and the source of your values?			
ACCEPTANCE	DUTY	INNER PEACE	RESPONSIBILITY
To be accepted as I am	To carry out my duties and responsibilities	To experience personal peace	To make and carry out important decisions
ACCURACY	ECOLOGY	INTIMACY	RISK
To be correct in my opinions and actions	To live in harmony with and protect the environment	To share my innermost experience with others	To take risks and chances
ACHIEVEMENT	FAME	JUSTCE	ROMANCE
To accomplish and achieve	To be known and recognized	To promote equal and fair treatment for all	To have intense, exciting love in my life
ADVENTURE	FAMILY	KNOWLEDGE	SAFETY
To have new and exciting experiences	To have a happy, loving family	To learn and possess valuable knowledge	To be safe and secure
ATTRACTIVENESS	FLEXIBILITY	LEISURE	SELF-ACCEPTANCE
To be physically attractive	To adjust to new or unusual situations easily	To make time to relax and enjoy	To like myself as I am
AUTHORITY	FORGIVENESS	LOGIC	SELF-CONTROL
To be in charge of others	To be forgiving of others	To live rationally and sensibly	To be self-disciplined and govern my own activities
AUTONOMY	FRIENDS	LOVED	SELF-ESTEEM
To be self-determining and independent	To have close, supportive friends	To be loved by those close to me	To feel positive about myself
BEAUTY	FUN	LOVING	SELF-KNOWLEDGE
To appreciate beauty around us	To play and have fun	To give love to others	To have a deep, honest understanding of myself
CARING	GENEROSITY	MASTERY	SERVICE
To take care of others	To give what I have to others	To be competent in my everyday activities	To be of service to others
COMFORT	GENUINENESS	MODERATION	SEXUALITY

(continued)

Table 4.2 (continued)

To have a pleasant, enjoyable life	To behave in a manner that is true to who I am	To avoid excess and find a middle ground	To have an active and satisfying sex life
COMMITMENT	GOD'S WILL	MONOGAMY	SIMPLICITY
To make a long-lasting and deep commitment to another person	To seek and obey the will of God	To have one close, loving relationship	To live life simply, with minimal needs
COMPASSION	GROWTH	ORDERLINESS	SPIRITUALITY
To feel and show concern for others	To keep changing and growing	To have a life that is well-ordered and organized	To grow spiritually
COMPLEXITY	HEALTH	PLEASURE	STABILITY
To have a life full of variety and change	To be physically well and healthy	To have experiences that feel good	To have a life that stays fairly consistent
CONTRIBUTION	HELPFULNESS	POPULARITY	STRENGTH
To make a contribution that will last after I am gone	To be helpful to others	To be well-liked by many people	To be physically strong
COURTESY	HONESTY	POWER	TOLERANCE
To be polite and considerate to others	To be truthful and genuine	To have control over others	To accept and respect those different from me
CREATIVITY	HUMILITY	PURPOSE	VIRTURE
To have new and original ideas	To be modest and unassuming	To have meaning and direction in life	To live a morally pure and excellent life
DEPENDABILITY	HUMOR	REALISM	WEALTH
To be reliable and trustworthy	To see the humorous side of myself and the world	To see and act realistically and practically	To have plenty of money
	INDEPENDENCE		
	To be free from depending on others		
	INDUSTRY		
	To work hard and well at my life tasks		

Modified from Miller and C'de Baca [32] Values Card Sort. Unpublished manuscript: University of New Mexico. www.winona.edu/resilience updated 11/16/16 who adapted it from: Hayes [33]. Strength spotting card sort. http://thrivingadolescent.com/2016/01/19/strength-spotting-card-sort-free-download/

accurate. Their value lies in that they are tools that provide a common language. They are a starting point for self-reflection regarding the ways individuals think, act, react, respond, learn, and communicate with others. A basic premise behind the use of any of these tools is that through knowledge of individual characteristics and those of collaborators, relationships, communication, and trust will grow (e.g., [24, 34, 35]).

Surface-Level—Behavior Characteristics: Since the ancient Greeks, scientists, researchers, business leaders, human resource managers, among many others, have sought ways to characterize people's styles, tendencies, and patterns of behavior. As a result, there have been many assessments that have been created to characterize styles and tendencies. Behavior is influenced by both personal and environmental factors, but people also influence themselves and their environment, through their behavior. People control their behavior.

The following are examples of tools that can be used:

Example 1. The TriMetrix® HD assessment tool [36] provides a framework to explore individual as well as collective dispositional characteristics. A person's dispositional characteristics includes their behaviors and motivational drivers [37]. The DISC model is one part of the three-part TriMetrix® HD assessment. DISC assesses behavioral characteristics. Please contact the authors about accessing the assessment. The DISC results provide behavioral characteristics in terms of "how" a person carries out decisions, interprets "how" individuals relate and interact with each other, and "how" they communicate. It describes a person's behavioral style on a continuum of four primary behavioral dimensions D, I, S, and C (for details see [34]):

- D = the way an individual manages problems/challenges and exercise power;
- I = how a person interacts and uses their influence with people;
- S = a person's steadiness, which reflects how the person responds to change, variation, and pace of their environment;
- C = how an individual deals with procedures and complies with rules and other constraints that are set by others and responds to authority.

Each person operates in all four domains. The dominant style (highest score) and the least dominant styles are the primary influences on your behavior preferences. An application to a team is given below in Explore Surface-level Characteristics of Team using TTI Success Behavioral Insights Wheel®. To learn more about the TTISI DISC instruments see https://www.ttisi.com/.

Example 2. Martha Borst, a leader in effective, peak performance strategies, has developed a personality and behavioral styles inventory based on in-depth research. This assessment identifies four basic styles each having its own behavioral attributes, examples include:

- Driver = Directive—Action-oriented, produces results, unemotional, efficient, problem solver, takes charge, is direct with communication.

- Promoter = Visionary—Idea generator, optimistic, creative, spontaneous, exciting, motivator, inspirational, fun
- Supporter = Personal/relating—Listens well, helpful, caring, excellent follower, collaborator, great team player, sensitive to others, loyal
- Analyzer = Evaluating—Thorough and accurate, methodical, detailed, intelligent, persistent, inquisitive, systematic, logical, practical

As with DISC, each person operates in all four domains but has one dominant style (highest score) that indicates behavior preferences. This style most strongly influences "choices, lifestyles, communication techniques, basic human needs, how we learn, what we fear, what we like/dislike, how we think and solve problems, what we avoid, how we react to other people and circumstances and how we use our skills and abilities." The style having the second highest score also influences behaviors. More information and access to the basic personal inventory can be found at https://www.marthaborst.com/resources/assessment-tools.asp.

Deep—Level Characteristics—Motivational Drivers: Another component of the TriMetrix® HD assessment provides information about six motivational drivers based on the descriptions of [38]:

- Theoretical—a passion for learning and wanting to learn as much as they can.
- Individualistic—a drive to control their destiny and that of others as well. They have a desire for control, and recognition.
- Social—seek to give back to the community, charities, solve global social problems etc. They are generous with their time, talents, and resources.
- Utilitarian—pursue a positive return on investment of time, energy, or money. They will focus on practical results and what is useful.
- Aesthetic—seek harmonious outcomes in which life is a procession of events, each of which needs to be enjoyed for its own sake.
- Traditional—live by a certain set of standards, beliefs, or principles commonly based on family and culture.

The top two motivators are usually the two most important for an individual. In the section Explore Deep-level Characteristics of Team and Fig. 4.6, the Motivational Team Wheel illustrates the primary and secondary drivers for a set of workshop participants are plotted in the outside and inside rings, respectively, to illustrate the variability in motivational drivers.

Deep-Level Characteristics—Mindset: Dweck [39] identified two mindsets—a "growth mindset" and a "fixed mindset." Focusing on persistent effort is important for success in the boardroom, on the field, in the classroom, and beyond. The development of this type of effort comes from within. A "growth mindset" recognizes that hard work, learning, training, and perseverance lead to success. For people who have a growth mindset, individual and collective performance can always be improved, and mistakes are important opportunities from which to learn. Mistakes come from doing and so does success. People who focus on the questions of "How can I get better and what do I have to do?" are important to have on any team.

It is also useful to know who on your team has a fixed mindset. These people believe individuals are born with innate talent and ability and that these traits are fixed. These individuals typically have a fear of making mistakes because they feel it makes a negative statement about their abilities and themselves at a very personal level. They are typically risk averse in contrast to individuals who have growth mindset who are more risk tolerant. Knowing the extent to which you have a collective growth mindset set among the members of your collaborative team provides opportunities to reflect on the extent to which the team focuses on doing and improving things as well as the extent to which risks are willing to be taken. Reflective practice on mindsets can help the team maintain focus on things over which it has control, can take responsibility for its own success, assess the extent to which the group is willing to take risks, and use setbacks as motivation to improve.

IDRlabs provides the Growth Mindset Test based on Dweck's work (https://www.idrlabs.com/growth-mindset-fixed-mindset/test.php). The American Bar Association has a self-administered 16-item questionnaire and score sheet for assessing mindsets as well (https://www.americanbar.org/content/dam/aba/administrative/women/mindset-quiz.pdf).

4.6.3 Cognitive- and Disciplinary Characteristics: Toolbox Dialogue Initiative

Team members in many cases are often selected based on their disciplinary knowledge in the case of academic teams and/or areas of expertise in non-academic settings. Regardless of the selection process, it is important to communicate individual perspectives regarding assumptions, strategies, and beliefs related to such things as the use of quantitative and qualitative data, the methods for collecting data, importance of stakeholder engagement, among others. O'Rourke et al. [23] provides an important discussion about the practice of communication related to the facets of a person's cognitive and disciplinary frame of reference. This should be explored because they influence many aspects of relationship development. The Toolbox Dialogue initiative (http://tdi.msu.edu/; [20, 23] provides a framework for exploring similarities and differences in perspectives among team members. Of course, this exploration starts with the individual. Gosselin et al. [16] used an abbreviated version of the Toolbox Likert-type scale instrument (Table 4.3) in a workshop for Ph.D students learning about collaboration. This instrument assesses an individual's perceptions about the nature of reality and scientific inquiry, the tension between qualitative and quantitative approaches, the importance and type of communication, and other deeply engrained ways of thinking that can differ between disciplinary cultures and different areas of expertise. These differences can lead to communication challenges at a variety of levels.

The instrument consists of a set of elements, each comprised of a core question and probing statements that concern philosophical aspects of research (Table 4.3). Below we will discuss how this information can be used to get to know your team.

4.7 Know Your Team

4.7.1 Navigating and Negotiating Dispositional Characteristics:

A person's individual dispositional characteristics includes their motivational drivers and behaviors [37]. The concept of dispositional distance describes the differences in the dispositional characteristics among a group of team members ([16], Fig. 4.3). Learning to navigate the dispositional distances between and among team members is critical to building better relationships, developing effective communication, and producing better team outcomes. The following strategies are examples that can serve as a guide.

4.7.2 Just Like Me: A Change of Focus

Foundational to the integration of individuals into a team is a simple acknowledgement that each team member brings their own set of values, beliefs, perspectives, etc. to the group. To get started down a path of learning about others, a simple activity called "Just Like Me" used by Paul Santagata, Head of Industry at Google, can be used [40]. The following approach modified from Santagata's activity asks participants to consider the following items as they begin their work with a new group of people.

- This person has beliefs, perspectives, and opinions, just like me.
- This person has hopes, anxieties, and vulnerabilities, just like me.
- This person has friends, family, and perhaps children who love them, just like me.
- This person wants to feel respected, appreciated, and competent, just like me.
- This person wishes for peace, joy, and happiness, just like me.

This activity acknowledges that each person has needs that they want to fulfill so they can walk away with a sense of accomplishment. These statements focus on deep-level characteristics that relate to why people do what they do. After reflecting on these statements, questions that are at the forefront of learning about team members are natural outcomes and changes the focus to others on the team. These statements and related questions provide a framework for small or large group conversations and the questioning of assumptions. Sinek [41] emphasizes the importance of questioning in that it helps move people beyond their assumptions and what they think they know

Table 4.3 Core questions and probing statements from an abbreviated version of the ToolBox survey for the exploration of individual perspectives related to discipline and expertise

Responses to probing statements, use the following Likert scale:						
Disagree					Agree	
1	2	3	4	5	I don't know	N/A
Motivation**						
Core question: What motivates me to participate in environmental research?						
1. Knowledge generated by scientific research is valuable even if it has no application						
2. Good science products are more important to me than major funded projects						
3. Incorporating one's personal perspective in framing a research question is never valid						
4. Collaborative research should be motivated primarily by grant opportunities						
Methodology**						
Core question: What methods do you employ in your disciplinary research (e.g., experimental, case study, observational, modeling)?						
1. Basic and applied research are equally important for environmental science research						
2. Scientific research (applied or basic) must be hypothesis driven						
3. Qualitative science is as credible as quantitative science						
4. The methods I use in my disciplinary research are easily integrated with methods used by researchers in other disciplines						
5. Experimental work conducted in the laboratory is too dependent on context to yield general principles						
6. Modeling, fieldwork, and laboratory research are of equal importance for environmental science research						
Values**						
Core question: Do values negatively influence scientific research?						
1. Incorporating one's personal perspective in framing a research question is never legitimate						
2. Value-neutral scientific research is possible						
3. Scientists should never engage in advocacy						
4. Public outreach detracts from good science						
5. Responsible scientific research requires meeting the productivity goals of your						
6. Scientists have a moral obligation to improve society through research						
Reality**						
Core question: Do the products of scientific research more closely reflect the nature of the world or the researchers' perspective?						
1. Scientific research aims to identify facts about a world independent of the investigators						
2. Scientific claims need not represent objective reality to be useful						
3. Models invariably produce a distorted view of objective reality						
4. The subject of my research is a human construction						

Modified from [16]

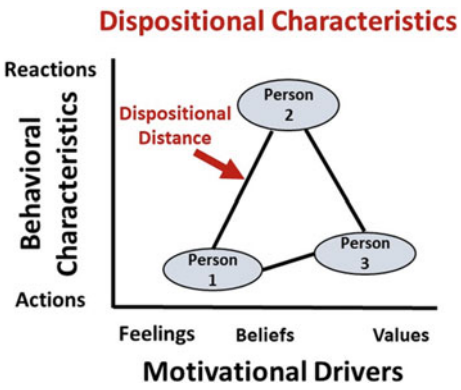

Fig. 4.3 Dispositional distance is a theoretical construct to describes the differences in the behavioral characteristics and motivational drivers of a group of team members. Modified from [16]

about others. Acknowledging these deeper needs initiates the development of trust and a win–win environment.

4.7.3 Integration of Disciplinary and Cognitive Expertise: Toolbox Dialogue Example

The objective of this strategy is to use information gathered from team members using the Toolbox Dialogue instrument in Table 4.3 as a framework for a discussion. The Likert-type scale used in this instrument encouraged participants to take a position on the probing statement as a springboard for discussion. The following example is from [16]. The responses to the instrument remain in the participant's possession and provide a framework for a minimum of a one-hour, participant-driven conversation involving all team members. One person is designated as timekeeper and reminds the group periodically about how much time remains to ensure that the conversation moves forward. It should be noted that the quality of the dialogue is paramount—not the number of prompts discussed. In most cases, there are more prompts than needed to allow for flexibility and exploration. A "talking stick" can be used to enable equitable participation by allowing only the person holding the stick to speak. Group guidelines should be established to support active listening. This conversation provides opportunities for individuals to describe and discuss their perspectives and assumptions regarding their discipline and expertise. Broadly, the topics covered include participant perceptions of the nature of reality and scientific inquiry, the tension between qualitative and quantitative approaches, the importance and type of communication, and other deeply engrained ways of thinking that can differ between disciplinary cultures and areas of expertise [20, 42]. For more on the Toolbox Dialogue initiative go to http://tdi.msu.edu/ [20, 23]. After the conversation, the group identifies what they learned from the activity about their team (See [43]).

4.7.4 Explore Surface-Level Characteristics of Team: TTI Success Behavioral Insights Wheel®

A person's interaction patterns and tendencies—behavioral characteristics—are readily observable. Figure 4.4 is an example of data from the DISC instrument described above for a soccer team plotted on the TTI Success Insights Wheel®. The wheel is divided into four quadrants based on the influence that the four primary behavioral dimensions—D, I, S, and C have on a person's overall behavioral characteristics. The stronger the dimension influences the behavior, the further the plotted point is from the center of the wheel. The wheel demonstrates the similarities and differences in behavioral characteristics among team members. It uses eight specific identifiers: conductor, persuader, promoter, relater, supporter, coordinator, analyzer, and implementer. A description of each identifier is provided in the text adjacent to it. A primary takeaway message from Fig. 4.4 is that there can be significant behavioral differences among team members on the field, classroom and the workplace. They need to be explicitly addressed because they will impact the effectiveness of the individuals and the organization. Diversity is important for a team, but differences also create challenges. Case in point, the behavioral tendencies of the two authors, one who is a conductor (#19), and the other is a coordinator (#7) (Table 4.4). The DISC instrument provides the authors with a mechanism to articulate and recognize behavior tendencies. It has heightened their awareness of how their behavioral tendencies are different. The authors have learned to navigate and negotiate the conductor's tendency to overpower, lack diplomacy, and be impatient and the coordinator's tendency to be risk averse and introverted lacking comfort verbalizing their concerns. Knowledge of these differences has contributed to their abilities to collaboratively work as a team. When used in groups, this information can create alignment and agreement among individuals. This helps build better relationships, more effective communication and produce better outcomes. For more details regarding the interpretation of the wheels, see [24, 34].

4.7.5 Explore Deep-Level Characteristics of Team: Motivational Team Wheel®

The top two motivational characteristics for a soccer team are plotted on a TTI Success Insights Motivational Team Wheel® (Fig. 4.5). Figure 4.5 presents the primary and secondary motivators for the players and coaches because it is typically the top two motivators that drive behavior. This graph illustrates that 80% of the players are driven by social concerns, that is, they thrive on: eliminating conflict and pain within the team; assisting with the needs and struggles of team members; and taking a personal interest in team members. Forty percent of the players thrive on solving team problems, identifying and systematizing team activities, and pursuing knowledge and truth. They are driven by learning.

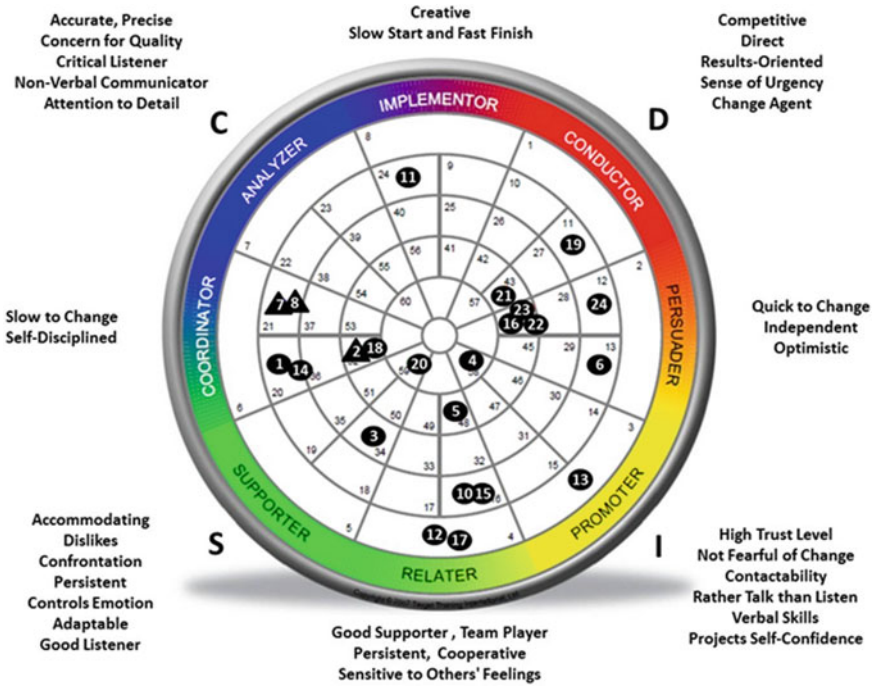

Fig. 4.4 Example of DISC behavior data presented on the TTI Success Insights Behavioral Team Wheel®. Used with permission from the author and publisher, Target Training International

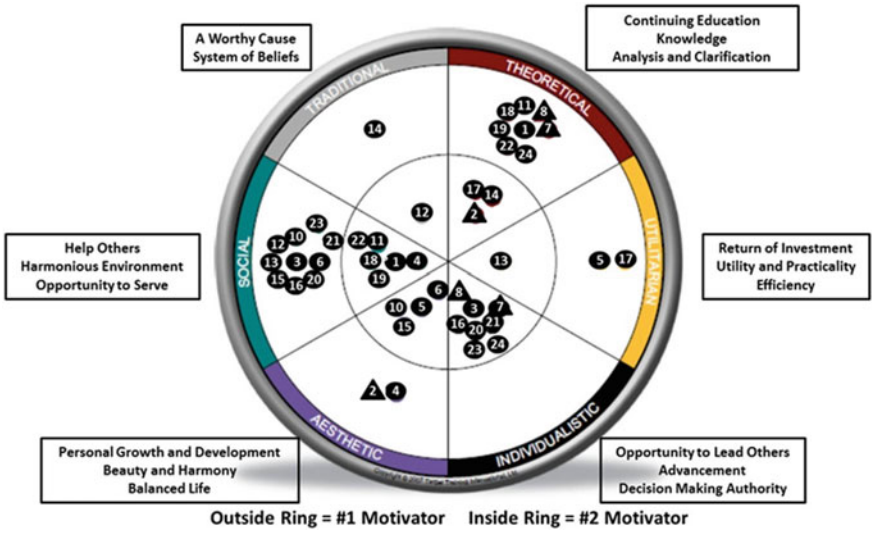

Fig. 4.5 Motivational driver data for soccer players (circles) and coaches (triangles) presented on the TTI success insights motivational team wheel. Used with permission from the author and target training international

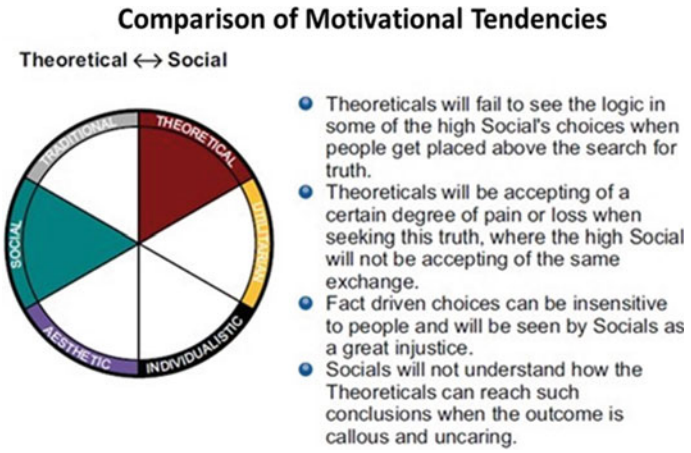

Fig. 4.6 An example of a team-blending resource from TTI that compares the motivational tendencies of people whose primary motivators are theoretical or social. Used with permission from the author and target training international

Table 4.4 Potential behavioral roadblocks between the two authors labeled 7 and 19 on the wheel in Fig. 4.4

Coordinator	Conductor
Slow pace	Quick pace
Introverted	Extroverted
Patient	Impatient
Avoids conflict	Enjoys conflict
Slow to anger	Quick to anger
Low risk	High risk
Tendencies	
Conductors tend to overpower. They must work hard to build up a trusting relationship before relaters/supporters/coordinators feel comfortable verbalizing their concerns. Conductors need to be mindful of their listening skills as well as their diplomacy	

The diversity in motivational drivers can lead to knowledge and social gaps between individuals that, in turn, can reduce team effectiveness [19]. Potential conflicts between the primary motivators of theoretical versus social can contribute to relationship problems as illustrated in Fig. 4.6. The players driven by learning and the use of facts were interpreted as being insensitive by teammates who are primarily concerned for the social well-being of the individuals and communities involved. To the aesthetic-dominated player, #15, the theoretically motivated player, #24, appeared to be a close-minded know-it-all. In addition, the secondary motivator for #15 was social that led them to have issues with those motivated by individualistic tendencies. At its most basic level, the socials have issues with the individualistic's

tendencies to place themselves above others. Using small group discussions, relationships between the players improved to the point where they began choosing to warm up with one another instead of avoiding one another. Without open discussion of the differences in driver behavioral change would not have occurred.

4.7.6 Explore Surface- and Deep-Level Characteristics of Team: Generational Differences

Whether it is business, coaching, teaching, research or community engagement, collaborative efforts will involve people who represent a continuum across the generational spectrum. A generation is "people within a delineated population who experience the same significant events within a given period of time" [44]. Much has been written about the differences between generations and the impact the differences have at different organizational scales (e.g., [45–47]). Evidence is mixed regarding the extent to which generational differences in preferences and values exist. Clearly, the current workforce consists of a continuum of ages that could exceed 60 years. As a result of their experiences, people of different ages have different lenses and filters through which they interpret the world and the people around them. This is challenging and at the same time exciting.

Marston [48] provides some examples of fundamental assumptions that may occur about different generations. Regardless of the generation, success, time, work ethic, styles and types of communication, experience with technology, and self-efficacy are valued in different ways. Early in your collaborative work, potential differences among the group related to generational differences should be explored and discussed so the skills of the multigenerational team can be effectively harnessed, and communication and relationship development can improve.

Table 4.5 provides a set of questions that can help explore generational differences among team members.

4.7.7 Explore Surface- and Deep-Level Characteristics of Team: Diversity, Equity, and Inclusion Perspectives

One of the main reasons for collaboration is to increase access to diverse ideas and perspectives to develop creative and novel approaches to solving problems. In the preceding paragraphs, the importance, exploration, understanding and integration of individual surface- and deep-level personal characteristics have been emphasized (Fig. 4.1). These characteristics are influenced by cultural setting (Fig. 4.2). It has been recognized for decades that intercultural interaction enhances creativity in the production of novel and useful ideas [49]. There are many opportunities to take advantage of the diversity in the community in an equitable and inclusive way.

Table 4.5 Example questions to explore the existence of generational differences

1. Self-perception in the world	How do you see the world in which you live?
	In 10 seconds, list words that you would use to describe your generation
	How is your generation different from others?
	How do you see yourself fitting into this team?
2. Future achievements, success, and sacrifice	What do you want to achieve in your life? Personal/professional
	What do you consider measures of your success? Long-term/short term
	To what extent are you willing to sacrifice free time, friendships, family, etc. to be successful?
3. Contributions, satisfaction, and relationships	What will you contribute to your team?
	What activities do you like to be involved in? Work/personal
	What makes you feel proud and satisfied?
	What do you value being on a team?
	What challenges do you have getting along with other people?
	How do you address these challenges?

Modified from [47]

Following the lead of [50] who focused on culturally responsive teaching, it is important to focus on understanding patterns and similarities across cultures related to collaboration. Hammond [50] refers to these patterns and similarities as archetypes. As is the case for developing culturally attuned teaching and learning environments, an archetype connected to deep-level cultural characteristics is the culture's orientation towards individualism or collectivism (Table 4.6).

Table 4.6 Characteristics of individualistic and collectivist cultures (from [50])

Individualism	Collectivism
• Focused on independence and individual achievement	• Focused interdependence and groups success
• Emphasis on self-reliance and the belief that one is supposed to take care of themselves to get ahead	• Emphasis on reliance on the collective wisdom or resources of the group and belief that group members take care of each other
• Learning happens though individual study and reading	• Learning happens through group interaction and dialogue
• Individual contributions and status are important	• Group dynamics and harmony are important
• Competitive	• Collaborative
• Technical/analytical	• Relational

An individual or group has individualistic or collectivist tendencies that exist on a continuum. Hofster et al. [51] presented the Cultural Dimensions Index that evaluated countries using a 100-point scale in which a high score indicates more individualistic tendencies, and lower scores indicate more collectivistic tendencies. In the U.S., and most European countries, cultures have roots in an individualistic culture. Whereas Latin American, Asian, African, and Middle Eastern cultures have a collectivist orientation. There is no question this is an oversimplified perspective and could certainly lead to stereotypes. However, it highlights the importance of learning about other members of your team in the context of the deep level characteristics of culture—values and worldviews, considering how these may influence interactions among team members, and resisting the tendency to impose your cultural values on others. The reader is referred to [52] for a series of strategies that can foster inclusion, equity, and meaningful engagement in your collaborations.

4.8 Final Words

The answer to the question of "who are the people that make up the team?" is not trivial. It needs to be continually asked, especially as new members join the team. The more time you can invest in learning about the surface- and deep-level characteristics of team members the better the team can collectively build on its strengths, talents, and perspectives. These characteristics are fundamental input parameters into any team and diversity among team members is important for team effectiveness [6, 7, 9, 11]. Learning about these characteristics is best done in the context of the project and learning to navigate and negotiate the compositional diversity among the team members as part of the collaborative process. Johnson [53] puts it best when he states that, "Healthy teams work to understand their own styles and the styles of the others on the team, so they can communicate and work with others."

Collaboration, in its simplest form, is the process of working with another person or group of people to create, produce, or complete a task. The key word is process. Collaboration emerges and grows as relationships develop among team members [24, 54]. Relationships take time to develop. It is important to intentionally facilitate the emergence of relationships using a variety of communication processes and learn about team member characteristics—behavioral characteristics, approaches to research, motivational drivers, world views, values, talents, and interests. Taking time to do this will create a safe environment that encourages the development of trust and respect crucial for effective teams [35]. The importance of having an intentional process for participants to explore the characteristics of themselves and their teammates is important to the emergence of collaboration [6, 7, 9, 11, 24].

Neuroscience Connections

Our brain is a social organ that works best when it connects to others. Addressing the question, "Who are the people that make up the team?" is foundational to developing the connections and relationships necessary for effective collaboration. Questions are powerful learning tools in collaborative teams. There are many things to learn about others, as represented in the Iceberg Model of Culture, that can promote learning and the exchange of ideas among team members. To value the diversity of team member experiences and perspectives, the practice of self-evaluation, reflection, wait time, active listening, curiosity, among other things, will help individuals and teams come to understand themselves better in all dimensions, reduce assumptions that contribute to implicit bias, and develop a "sense of we" and a "team rhythm" in which team members feel psychologically safe and that they belong. When this type of environment and all team members feel their contributions are valued, the team will perform at a higher level and be more effective.

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Chapter 5
Communication Practice for Team Science

Michael O'Rourke, Marisa A. Rinkus, Edgar Cardenas, and Chet McLeskey

Abstract Communication—the conversations, connections, and combinations that bring new insights to complex problems—is at the heart of successful crossdisciplinary collaboration (National Academy of Sciences, Committee on Facilitating Interdisciplinary Research and Committee on Science Engineering and Public Policy (NAS), (2004). Facilitating Interdisciplinary Research. National Academies Press, Washington, DC). In the spirit of "practice makes permanent", teams will benefit from practicing structured dialogue in which deep engagement with one's collaborators is the norm rather than the exception. This type of practice can help teams create a dialogical communication culture that establishes deep listening and close engagement as community norms. In this chapter, the authors describe the Toolbox dialogue method, a specific approach to structured dialogue designed to encourage a dialogical communication culture. Instructions are provided for using the Toolbox dialogue method, which can support teams in working through challenges and successfully pursuing project objectives in practice sessions as brief as 10 minutes.

Keywords Collaboration · Dialogue · Reflexivity · Perspective taking · Interdisciplinary · Toolbox

M. O'Rourke (✉) · M. A. Rinkus · E. Cardenas · C. McLeskey
Toolbox Dialogue Initiative Center, Michigan State University, East Lansing, MI, USA
e-mail: orourk51@msu.edu

M. A. Rinkus
e-mail: rinkusma@msu.edu

E. Cardenas
e-mail: carden61@msu.edu

C. McLeskey
e-mail: mcleskey@msu.edu

D. Gosselin (ed.), *A Practical Guide for Developing Cross-Disciplinary Collaboration Skills*, AESS Interdisciplinary Environmental Studies and Sciences Series, https://doi.org/10.1007/978-3-031-37220-9_5

CTeAM Connections

- Who makes up the team? (Individually/Collectively)
- How do you get them there? (Methods/Strategies)

5.1 Introduction

In this chapter, we examine the value of deliberately practicing dialogue to foster effective crossdisciplinary teamwork. We are motivated by a twist on the old adage, "practice makes perfect," namely, "practice makes *permanent.*" We understand why athletic teams practice regularly—they must prepare for the complexity and uncertainty that are central to their collective effort. If teams are to perform at the top of their ability, individual skill is not enough; they must understand how to combine that skill with the skills of other teammates. This requires a heightened sensitivity for how teammates communicate when engaged in a game.

Similarly, researchers operate under high levels of complexity and uncertainty in collaborative research. Since much of the knowledge production interdisciplinary researchers are engaged in requires combining their perspectives, they must develop effective communication strategies that apply to scientific knowledge as well as the process of working together as a team. Successful execution of these strategies must apply to static, transactional forms of communication (e.g., meeting updates) and more dynamic, dialogical forms of communication (e.g., collective brainstorming).

Drawing on the Toolbox dialogue method, developed by the Toolbox Dialogue Initiative (TDI), we focus in this chapter on how structured dialogue can be used to help teams develop a culture of deep, dialogical engagement [1]. This type of engagement has well-known benefits for research collaboration, such as improved reflection by collaborators on individual and team processes, or *reflexivity*, and enhancement of the ability of teammates to take each other's perspectives on the work of the team, or *perspective taking* [2, 3]. Building dialogue practice into team interactions can help create a dialogical communication culture that is conducive to team success.

5.2 Goals

In what follows, we begin by discussing team communication, emphasizing communication norms, communication culture, and communication difficulties that can undermine project success. We then turn our attention to *practice*, and in particular, *dialogue practice*, which we argue can help teams take control of their communication culture. We focus the rest of the chapter on the Toolbox dialogue method as a

vehicle that research teams can use to practice good communication, closing with specific suggestions that can be used to structure dialogue practice for a team.

5.3 The Challenges of Crossdisciplinary Team Communication

One thing that differentiates a *team* from a mere *group* is the coordination and interdependency that communication brings. For members of a crossdisciplinary team to combine their different perspectives in pursuit of project objectives, it is essential that they *build relationships* to support sustained engagement and *exchange information* to facilitate the integration of knowledge relevant to those objectives. This point echoes the National Academies, who tell us that "… the heart of interdisciplinarity is communication—the conversations, connections, and combinations that bring new insights to virtually every kind of scientist and engineer" ([4], p. 19).

We follow Hall and O'Rourke [5] in taking communication in crossdisciplinary team science to be the "co-creation of meaning in pursuit of a goal," which involves collaborative effort to build common understanding of the various aspects of a team's work together. So understood, communication consists in building relational infrastructure to support sustained and occasionally intense task work [6] and in exchanging information across these relationships to advance toward project goals [7]. So critical are these processes to successful crossdisciplinary team science that some take the "relationships and ideas" created by communication to be the "essence" of collaboration ([8], pp. 402, 376). One specific way to nurture crossdisciplinary communication is through dialogical mechanisms that foster the co-creation of meaning through reflexivity and perspective taking.

Of course, that communication is critical doesn't mean that it always gets the attention it requires [9], or that it is even so regarded by a team. Regardless, a team *will* have a communication culture, whether it explicitly acknowledges it or not. We understand a team's *communication culture* to consist in the routine practices and associated norms that structure the formation and maintenance of relationships and information exchanges among collaborators, often implicitly and without being noticed (cf. [10]). Over time, teams will settle into routines (e.g., using a particular messaging product to support internal communication, cc'ing the PI on all external communication, sending project messages at all hours of the day and night) that make certain communication practices the *default* practices for the team. These practices are what teammates come to expect, norming communication behavior in the context of the team.

Thus, communication norms can emerge from routine communication practices over time, without being intended as such. But, on the other hand, they can also be explicitly set in the early stages of a team's life cycle—e.g., in a collaboration planning process—and then influence what practices become routine by identifying them as

good or desirable in the context of the team.[1] The norms that regulate communication in a team correspond to stable conditions that affect a project by influencing how collaborators interact and how they share information. They determine what is right or wrong for the team when it comes to project communication.

If a team's communication culture isn't managed explicitly (and sometimes even if it is), the stable, communication-related conditions that form may not be conducive to project success. The literature in team science and organizational behavior is rife with examples of communication difficulties that teams could have avoided if they had been more cognizant of the need to manage their communication culture (see Table 5.1). For the purposes of this chapter, we organize communication-related conditions that can undermine project success into two groups: *chronic* conditions that afflict teams over time and are reflected in a team's communication culture, and *acute* conditions that arise in specific contexts but not in a way that reflects a fixed, stable feature of the team.

In Table 5.1, we present a number of these conditions, drawing from the literature and our own experience in facilitating collaborative communication in teams for the last 15 years [1]. The list of chronic conditions includes relatively stable characteristics of teammates or the collective (e.g., limited adaptability, inability to reach decisions), features of team culture (e.g., lack of respect, lack of trust), and team habits that undermine effectiveness (e.g., unhelpful updates). In many cases, chronic conditions are stable because they are an implicit part of the communication culture, making them harder to spot and remediate; once they are made explicit and rendered the focus of more intentional behavior, though, they can be changed. Acute conditions are more episodic in nature (e.g., negative messaging, listening without hearing, use of jargon), although they can become chronic if they are left unchecked and become part of the culture of the team; checking them, though, can be difficult if there aren't team norms that ground accountability and affirm alternative behaviors.[2]

For reasons we provide in the next section, a commitment to communication practice—and in particular, *dialogue* practice—can help teams create community-wide norms and ground accountability in ways that can help them address these conditions. Explicitly managing the formation of communication routines isn't a silver bullet, but it positions the team to avoid chronic communication conditions and address the inevitable acute conditions when they arise.

[1] Following Cialdini et al. [11], we can call the first type of norm *descriptive*, in that it specifies "what is done", and the second *injunctive*, in that it specifies "what ought to be done" (p. 1015). These can of course be the same, but it is not uncommon for a team to settle into a routine that is not what it would choose upon reflection.

[2] We acknowledge that there are other ways to organize these conditions. For example, one could sort them into cognitive, communicative, and motivational conditions, and further divide these categories into team and individual conditions. We have adopted the chronic/acute typology primarily because of its relationship with a team's communication culture, but also because it has implications for the use of structured dialogue as a remediation technique.

Table 5.1 Conditions, both chronic and acute, that can create communication challenges for research teams, and ways in which dialogue can diminish the deleterious influence of these conditions on the communication culture of the team

Type	Condition	Description	How dialogue can help
Chronic	Conversational dominance	This is a tendency for a subset of project members (e.g., senior members, PIs) to dominate project-related conversations at meetings and other project-relevant contexts [12]	A dialogical culture can only be maintained if those with power in the group listen carefully and share the floor with their teammates—dialogue partners need to feel like they have equal access to the floor
	Different perspectives on the common problem	In a crossdisciplinary team, different perspectives are the whole point, be they disciplinary, professional, community-based, or sector-related, but failure to understand them can undermine communicative effectiveness [13–15]	Dialogue requires respectful engagement with articulated perspectives, which entails a willingness to learn about those perspectives and understand them in relation to one's own
	Inability to articulate and/or failure to recognize differences in assumptions	All experts make assumptions about the domain of their expertise, and expert assumptions differ across those domains in ways that are typically unknown by other experts, leading to confusion and miscommunication [16–18]	In a crossdisciplinary team with a dialogical culture, teammates will expect assumptions to differ, and they will be willing to engage in collaborative exploration of what is taken for granted by other experts
	Lack of respect for different perspectives	Teammates may lack respect for types of expertise in a collaboration (e.g., disciplinary, lived) that they believe won't contribute adequately to their common project, undermining relationships [19, 19–21]	People who engage in dialogue are willing collaborators in meaning co-creation, listening carefully and building on one another's contributions, and this creates conditions that encourage mutual respect
	Suspicion of collaborators—lack of trust	Teammates can be distrustful of one another and regard each other with suspicion, which will reduce collaborative capacity and undermine efforts to integrate different perspectives [22, 23, 15]	Engaging in dialogue means that you pay attention to your interlocutors, taking their contributions seriously and engaging with them respectfully, making it easier to be vulnerable with your collaborators

(continued)

Table 5.1 (continued)

Type	Condition	Description	How dialogue can help
	Differences in how power is perceived in the group	Variations in how power is distributed across subgroups in a research team can encourage different and potentially conflicting communication norms within those subgroups and so across the team [24, 23, 15]	By encouraging a more horizontal communication culture where those with power listen as much as they talk, dialogue can help enhance mutual understanding within a team about how power is distributed
	Limited ability to jointly reach acceptable solutions	Deliberation about project decisions can involve argumentation in support of different alternatives, and this can obstruct evaluation of options or even divide teams [5, 25]	Engaging in consistent dialogue trains a team to be productive in their interactions, listening carefully to one another, and understanding the different stakes that teammates have in project decisions
	Teammates not adaptable	If teammates are committed to their own individual goals or their own individual timelines, they can fail to adapt to changing circumstances as required for team success [26]	Lack of adaptability can be due to failure to see how one's project interests would be met if things change, but dialogue can help expand one's interests by encouraging investment in other possible project futures
	"Infrequent, distant, disorganized, simplistic updates"	Complex projects that involve coordination require updates that inform collaborators of the ongoing work; if these are inadequate, the project can stall or unravel [26]	Cultivating a dialogical communication culture means being responsive to the communicative needs of your collaborators, including what they need to feel suitably well-informed to do their work on the project
	Different audiences	Members of a crossdisciplinary team may have different audiences in mind for their contributions, which can undermine consensus around the message or dissemination plan [26]	Like adaptability, differences in preferred audiences can reflect the need to protect one's stake in the project; dialogue can build a more coordinated and mutual sense of who the proper audiences are for the work
Acute	Unchecked multitasking	It is difficult to avoid multitasking, especially on teams with very busy teammates, but communication that is always divided between tasks will not serve pursuit of project goals	A communication culture that incentivizes and rewards dialogical engagement serves as a foundation for meaningful, focused interaction and a commitment to listening and learning that undermines the appeal of multitasking

(continued)

Table 5.1 (continued)

Type	Condition	Description	How dialogue can help
	Listening without hearing	Related to multitasking, one can receive the verbalized messages of others (i.e., one can listen) without *hearing* them and integrating them into collective understanding	Participation in successful dialogue requires deep listening and a willingness to make sure that what you thought you heard was correct, since that will be an input into dialogical integration that is central to meaning co-creation
	Negative backchannel discussion	Backchannel discussions can be helpful, but they can also distract participants, discourage full participation, and make it difficult to hold those who violate team norms accountable	Negativity in communication can be caused by many things, not all of which can be avoided, but a dialogical communication culture in which collaborators commit to being creative together—thinking, listening, and talking—can encourage respect and trust and discourage divisiveness
	Negative messaging	Irritation with teammates can lead one to send an ill-advised email or exhibit passive-aggressive (or outright aggressive) behavior that undermines team cohesion and trust [27]	
	Negative humor or sarcasm	Negative humor and sarcasm can decrease "trust, morale, creativity, and communication" ([27], p. 290) by minimizing or demeaning another teammate's perspective	
	Communicating boredom	Boredom can arise from because a topic is too difficult or too easy, and this can lead teammates to doze off, get distracted, or otherwise communicate that they don't value the current topic of conversation [27]	In a dialogical culture, boredom signals that one should enhance the interest of the collective effort rather than something to be communicated to others who are there to entertain you
	Jockeying for power/ turf battles	Poorly managed power dynamics can lead to uncertainty among teammates about how their ideas are valued in the team, leading them to struggle for influence over other teammates and on the project [26, 27]	A dialogical communication culture encourages *we*-thinking in the context of a project, rather than *I*-thinking, and this can help collaborators think about what distribution of power and influence is most beneficial for the project

(continued)

Table 5.1 (continued)

Type	Condition	Description	How dialogue can help
	Debating expertise	If they meet with a lack of respect or appreciation, teammates may feel the need to carve out or maintain a role on the team by debating the relevance of their expertise with others who are dubious [27]	As with jockeying for power, debating expertise will be an option only if one does not feel included and so must fight for influence; dialogue engenders respect and incentivizes inclusivity since each teammate's expertise is understood to be part of a collective resource available to all
	Use of jargon	Experts acquire facility with a technical language that foregrounds aspects of a problem that are especially salient for them, and this language can become so natural that they slip into it without realizing it. [26]	Useful technical terminology becomes jargon when it is used without clarification, but dialogical engagement will make it safe for people to ask for clarification and incline collaborators to clarify their terms by encouraging perspective-taking behavior
	Interpersonal avoidance	Interpersonal difficulties, lack of respect, and lack of trust can lead people to avoid one another, which is a problem if the team needs those people to integrate their perspectives [26]	By building respect and trust, a dialogical culture can help people recognize the value of being part of a collective with one's collaborators, encouraging engagement even with people who aren't friends

5.4 The Importance of Practice for Team Effectiveness

Research teams are often outcome-driven, with decisions framed by the need to make progress toward objectives described in a project plan. Meeting these objectives often requires producing distinct, measurable outcomes that are easily communicated to others, such as publications, presentations, prototypes, and datasets. Successful pursuit of these outcomes will be facilitated by effective team processes, such as installing communication norms, implementing decision-making procedures, coordinating research perspectives, and creating a common technical vocabulary. All too often, though, insufficient attention is paid to these processes. In disciplinary teams, for example, collaborators can set aside explicit attention to process and instead rely on tacit understanding [28] of their discipline to coordinate research perspectives and normalize technical vocabulary. However, tacit understanding of one's discipline is unlikely to be a good foundation for crossdisciplinary teams. Given that crossdisciplinary teams are intentionally composed of different disciplinary orientations, defaulting to one's own disciplinary understanding of the collaboration will

almost certainly be a mistake. In teams like these, where experts from different domains (e.g., disciplines, institutions) come together to address research questions that require coordinated effort from all involved, explicit attention to collaborative process can be crucial.

Procedural aspects of team functioning may not be seen as directly related to project objectives and can strike members of the team as a waste of time. "We'll just figure it out as we go along," the team might say. So long as things go well, they may see no reason to reconsider this attitude. In our experience, this is a common mindset of research teams, whether they are successful or not (cf. [29]). It may not be clear that things need "adjusting" until it is too late. Even if a team avoids an implosion during the course of their collaboration there is still the possibility that their work could have drawn more deeply from the diversity of expertise in their ranks if they had explicitly managed their process, leading to greater creativity and innovation and more novel solutions and insights.

One way to foreground procedural aspects of collaboration and maximize diversity is for a team to deliberately practice skills that improve collaborative capacity. *Deliberate practice* comprises activities intentionally undertaken to facilitate skill acquisition and proficiency [30]. We are interested in communication skills, and in the next section we argue that deliberately practicing dialogue can enhance basic team functioning and improve prospects for producing high impact outcomes.

First, though, it is important to clarify how we understand *deliberate practice.* Our approach to deliberate practice aligns with that of Ericsson et al. [30], who identify the most important characteristics for proper practice. First, participants must be motivated to attend to the task, which in our case is open dialogue with other participants. Second, the task must be appropriate for the participants and should take into consideration pre-existing knowledge, i.e., participants must understand how to engage with the task and have the ability to pull from their existing knowledge to do so. Finally, participants must receive fairly immediate feedback if they are to understand when they are correctly or incorrectly engaged in the task.[3]

So understood, practice is different from both work and play. *Work* includes "public performance, competitions, services rendered for pay, and other activities directly motivated by external rewards" ([30], pg. 368). Because you are expected to give your best performance while working, work conditions can lead to risk aversion, creating a less than ideal environment for learning, reflexivity, and perspective taking. Practice, by contrast, reduces performance pressure and creates a lower-stakes space in which it is less costly to take risks. *Play* is inherently enjoyable and is often performed with no explicit end goal in mind. Practice, by contrast, requires goals and it may not be all that enjoyable. For example, although dialogue can be an enjoyable

[3] Feedback on a task can be straightforward if the task is simple and clearly defined; however, practicing dialogue is more complicated. Therefore, the feedback process often needs some facilitation until participants develop their dialogical skills. Facilitation is built into the Toolbox process, allowing participants to focus their energy on the dialogue and leaving primary feedback responsibility to the facilitator.

process, if practicing it is going to help teams develop a healthy communication culture, then it will need to focus on that as a goal; further, because dialogue can be exhausting and may also open up space for difficult conversations, dialogue practice will not necessarily be enjoyable.

For researchers, the modes of communication they prefer often derive from their graduate training; therefore, the act of deliberate dialogical practice can feel foreign and unnecessary. But as we noted above, disciplinary habits will not be a good foundation for crossdisciplinary communication. The ability to coordinate one's efforts with others from different domains of expertise may require the development of new cognitive and affective habits (e.g., a sensitivity to points of conceptual overlap with different disciplines, a willingness to defer to a colleague on a matter of their expertise). Differences in research worldview, lack of a common technical vocabulary, and other factors conspire to complicate and possibly undermine crossdisciplinary research [31]. Fortunately, as we will see in §4, there are skills that can be acquired and honed to mitigate the effects of the differences across disciplines, such as reflexivity and perspective taking.

Practicing skills like reflexivity and perspective taking makes it more likely that the customary, routine activities of a research team will be the ones they want, and it will increase the likelihood of identifying and correcting problematic communication patterns before they become ingrained in a team's culture. As we observed above, when you deliberately practice an activity to become proficient at it, there is feedback in the form of information you can use to make adjustments and enhancements that improve the overall research performance of your team. It gives you intentional control over the collaborative routines you form as a research team and puts your team in a better position to achieve your objectives. This type of practice does not have to be disconnected from the research project; in fact, it should be integrated into the context of the work and day-to-day activities. The Toolbox dialogue method provides a process for practicing dialogue in the flow of work that can develop reflexivity and perspective taking skills while contributing to the team's task and knowledge work, as we will see in the next section.

5.5 The Toolbox Dialogue Method as a Vehicle for Team Communication Practice

In this section, we focus on a type of communication culture—a *dialogical* culture—and the Toolbox dialogue method which can be used to structure dialogue practice. We begin by describing dialogue as we understand it, noting how a communication culture grounded in dialogue can position a team to address the communication challenges listed in Table 5.1. We then provide specific guidance for structured dialogue by introducing the Toolbox dialogue method, an evidence-informed approach to capacity building for crossdisciplinary research teams [1]. We conclude the section by providing suggestions that can help crossdisciplinary teams build a dialogical communication culture.

The Nature of Dialogue. We understand 'dialogue' to be a term for a specific type of communication modality; specifically, we follow Tsoukas [32] in taking dialogue to be "a joint activity between at least two speech partners, in which a turn-taking sequence of verbal messages is exchanged between them, aiming to fulfill a collective goal" (p. 943). Simply taking turns as the speaker does not qualify as dialogue [33], since if participants wait to express their thoughts without taking into consideration what others have said, their interaction is essentially "chunks of monologue stuck together" ([34], p. 170). Rather, dialogue is a *joint* activity, i.e., an interaction involving multiple actors in which success is dependent on interlocking and mutually dependent contributions that stem from listening to and considering one another's perspectives. Further, the interaction is goal-directed—dialogue participants work hard to achieve something together.

Dialogue is a mode of communication that requires concentration and focus, and it can be difficult to achieve, especially if there are distractions (e.g., email, social media) that divide one's attention. If it is achieved, though, dialogue is well known to support reflexivity [35] and perspective taking [36] among those who participate, that is, it encourages a type of interaction between participants that motivates them to reflect on their own assumptions and view the topic of the dialogue from each other's perspectives [2]. Productive dialogue involves "deep listening, meaning co-construction, mutual engagement, and constructive argumentation" ([33], p. 96).

By encouraging dialogue, so understood, a team can build a communication culture that prioritizes norms of collective effort and mutual respect. The more a team commits to engaging with one another dialogically—i.e., paying close attention to what is being said, working hard to collaborate in their consideration of the topic at issue, using elaboration and constructive criticism to strengthen the work of the whole rather than undermine it—the more dialogue can become a collective routine [37]. What can result is a dialogical communication culture marked by a collaborative, "we"-sensibility that places the collective above the individual, motivates conversational engagement that features deep listening, prioritizes constructive argumentation over destructive criticism, and rewards a "yes-and" approach to elaboration that drives collaborative creativity and co-construction.

It is important to recognize that dialogue is valuable *instrumentally,* in that it enables a team to collaborate more efficiently and effectively [38]. In particular, dialogue can remediate the chronic and acute communication conditions that can undermine project success, which are represented by the list in Table 5.1. Because it encourages a "we"-sensibility and underscores the value of thinking together with your teammates, dialogue structured around issues of interest to the team, such as Toolbox dialogue, can be especially helpful in remediating *chronic* communication conditions, such as lack of respect for different perspectives or limited ability to jointly reach acceptable solutions. And if the communication culture improves, there will be less motivation for and less tolerance of acute communication conditions such as sarcasm, communicating boredom, or debating expertise. In general, the communication routines a team forms can be intentionally and collectively controlled if the team forms them while interacting dialogically. A team can intentionally encourage a commitment to dialogue by practicing this type of joint activity while working

Table 5.2 A set of Toolbox dialogue prompts, along with the modules they figure into, that have been used to structure dialogue in Toolbox workshops; these are associated with 5-point disagree/agree rating scales, along with *don't know* and *not applicable* options

Module theme	Prompt
Values	Allowing values to influence scientific research is advocacy
Methodology	Scientific research must be hypothesis driven
Confirmation	There are strict requirements for the validity of measurements
Motivation	My research is driven primarily by intellectual curiosity
Reality	Models invariably produce a distorted view of reality
Communication	We will need to develop a common project language to achieve convergence

on central aspects of their collaboration, such as in meetings where objectives or research strategies are discussed. The Toolbox dialogue method can function as a vehicle for this sort of practice.

The Toolbox Dialogue Method. The Toolbox dialogue method involves the use of a survey-like instrument, the "Toolbox", to structure and stimulate dialogue [39]. This method was developed to address crossdisciplinary communication challenges reported in the literature summarized in Table 5.1 [13], and its effectiveness has been evinced by an independent evaluation [40] as well as several TDI-led studies [41–43]. The Toolbox consists of a series of statements or prompts that structure dialogue by supplying topics for discussion that are of interest to the participants, and by inviting reaction in the form of an associated 5-point response scale (disagree-agree), along with *don't know* and *not applicable* choice categories. (For examples of Toolbox prompts, see Table 5.2.) In a standard Toolbox workshop, participants are introduced to the Toolbox dialogue method in a brief preamble and then score a Toolbox instrument containing multiple prompts organized into thematically unified modules (i.e., the *pre-dialogue* responses). The participants then discuss their reactions to the prompts in a 60 to 90-minute dialogue, sometimes by explicitly using the scores to gauge reactions across all participants (cf. [39]). After the dialogue, they take a second trip through the instrument (i.e., the *post-dialogue* responses) and participate in a co-creation activity that builds on the dialogue.[4]

By design, a Toolbox dialogue is an exercise in reflexivity and perspective taking, prompting behaviors such as self-awareness, questioning, exploration, elaboration, analysis, negotiation, feedback-seeking, the use of explicit language, learning at a meta level, and challenging one's own assumptions and those of others [2, 3, 41]. Reflexivity and perspective taking are also related reciprocally: engaging in reflection

[4] The Toolbox dialogue method, including prompt development, is described in comprehensive detail in Hubbs et al. [1]. For details about running a full Toolbox workshop, see Rinkus and Vasko [44], as well as Looney et al. [45]. While it can help to participate in a formal Toolbox workshop facilitated by TDI, we have received reports from other groups that the do-it-yourself instructions in these publications provide enough detail to guide delivery of a useful workshop on the Toolbox model. Questions about conducting Toolbox-style structured dialogue can be directed to TDI at toolbox@msu.edu.

about one's own perspective makes one sensitive to alternative perspectives, and examining the perspectives of others foregrounds important aspects of one's own perspective [41].

However, team reflexivity is unlikely to occur organically [3], and without making time to reflect on current and desired processes it becomes easier for teams to revert to old habits [46]. Reflection requires cognitive energy and effort by all team members, and it could reveal the need for changes to behavior or even additional work. Time pressure combined with juggling multiple projects is likely to create resistance to reflexivity. It is also important to recognize that reflexivity will bring into focus past failures along with past successes, and it can be uncomfortable to discuss past missteps or unhappy aspects of the collaboration. On the other hand, though, if a team is not reflexive, it could stay locked in on current research processes, whether they are effective or not, and stifle creativity and innovation [47].

For the purposes of this chapter, we want to highlight the role that Toolbox dialogue prompts can play in focusing a conversation among teammates. These prompts are written to provoke, which can help disrupt old habits or "business as usual" communication by promoting deeper reflection [48].[5] They encourage participants to reflect on their own research worldviews, and the resulting dialogue helps them learn about the research worldviews of others, enhancing mutual understanding and the ability of the team to function in coordinated ways. Because the primary aim of the prompts is to stimulate dialogue, they are intentionally abstract, lending themselves to multiple interpretations and revealing different perspectives among collaborators. One question we ask when writing a prompt is: Will it incline the participant to think, "It depends…" and "It's not clear…"? These responses increase the likelihood that participants will have a multifaceted conversation about the topic, revealing the complexity of their perspectives. If participants view a prompt as too easy to agree or disagree with, then it's likely they will not see value in bringing it up for discussion. In what follows, we have this kind of engagement in mind when describing how the Toolbox dialogue method might be used to structure team dialogue practice.

Creating Conditions for Dialogue with the Toolbox Dialogue Method. In this section, we provide suggestions that can help create conditions for team dialogue. These are grounded in our experience running workshops using the Toolbox dialogue method. The first set of suggestions are general and apply across project contexts. The second set focuses on structuring dialogue *practice* and requires a commitment by the team to set aside time—from a few minutes to several hours—to engage with one another dialogically. In our experience, motivation to make this commitment is promoted by leadership that champions the value of a dialogical communication culture for the team. These engagements are for practicing communication, which is critically important for teams even though it can to some appear a distraction from the "real

[5] Because we aim to create a dialogical environment that stimulates a "we"-sensibility, we carefully craft these prompts so that provocations surface perspectives rather than demean individuals or their ideas.

work"; however, as we have noted, communication practice can address the main business of the project and thereby advance the team toward its project objectives, and it can also strengthen a communication culture, making it easier to spend even *more* time on project business.

General Suggestions for Project Communication

1. *Establish communication guidelines that encourage dialogue by emphasizing deep listening and open communication.* These guidelines could function as project norms that team members agree to abide by during meetings and other project interactions. They could be as simple as making sure everyone has a chance to speak, which can be managed through turn-taking, raising hands, and periodic check-ins that pause the dialogue to make space for those who have yet to contribute. An outside facilitator can also be helpful in monitoring participation and asking those who may be dominating the conversation to step back. Ideally the guidelines should be designed and agreed upon by the group, enlisting everyone to ensure an inclusive dialogue. The drafting of community guidelines for communication can help to build a sense of identity and collective responsibility (cf. [49]).
2. *Concentrate on how you listen to your teammates.* Perhaps even more important than what you say to your team members is how you listen to them. When you participate in project communication, keep these questions in mind: When you're not speaking, how are you engaged in the communication dynamic? Do you focus on what the speaker is saying or are you thinking about the point you want to make when they're done? Do you draw connections between your perspective and that of the speaker? Do others' comments cause you to reflect on and rethink your own position, or do you work to strike down their points to maintain your current position? In response to another's comments, do you lead by asking the speaker to elaborate on what they just said, or do you say what you had been planning to say all along, irrespective of what they just contributed to the conversation? By helping you monitor your own listening, these questions generate feedback and help teammates create an environment of co-inquiry and co-creation that stave off combative tendencies often instilled in us through formal education.

Specific Suggestions for Dialogue Practice

1. *Identify a time for dialogue practice.* Standard Toolbox dialogue workshops last anywhere from two to four hours, but blocks of time like these may be difficult to come by outside of designated project retreats or annual meetings. Commitment to a regular (e.g., annual) dialogue-based workshop can communicate to the team just how important this type of engagement is, and it can have a shaping influence on the communication culture; however, more frequent and shorter episodes of structured dialogue can be even more influential.[6] Although we have not formally evaluated this claim, groups that have practiced dialogue in 10 to 15 minutes at

[6] Just how many dialogue practices are required to have the desired effect on a team's communication culture will depend on the team, the context, and the nature of the practices. Although a single practice would be unlikely to communicate the importance of this mode of communicative

the start of a project meeting have reported that it helps people focus on the project and engage with one another, making the meeting itself more successful. Another site for dialogue can be brainstorming sessions that precede proposal development or manuscript writing.

2. *Develop themes for your dialogue.* These could revolve around the goals of the project, both short and long term. Be sure to identify themes that represent the scientific research aspects of your work as well as themes that represent team processes (i.e., how you plan to work collaboratively toward your goals). Good themes for dialogue practice will relate to the work of the team, engage everyone on the team, and support differences of opinion that can be explored in dialogue.
3. *Develop a set of dialogue prompts around selected themes that are relevant to the full range of potential perspectives in a group.* The prompts should be written as statements that promote reflection by leaving room for interpretation and allowing participants to position themselves differently in relation to the statements. (See Table 5.2 for examples.) The statements might include buzzwords or disciplinary jargon that could be jointly examined in dialogue, especially if the jargon is central to how the team thinks about its work. Strong language, such as extreme qualifiers like 'always', 'never', 'must', or 'only', can help reveal perspectives by motivating responses and encouraging more subtle re-interpretations. Be careful not to create statements that fail to promote dialogue because they are too easy to agree or disagree with. If these statements are going to structure dialogue practice (e.g., in a meeting or workshop), be sure to focus them on the goals and priorities of the team. See Rinkus et al. [48] and Rinkus and Vasko [44] for more details on developing dialogue prompts.
4. *Have participants respond to the statements immediately before the dialogue.* If you are practicing dialogue in the first 10 minutes of a project meeting, you might just project a prompt or two on a screen, along with the rating response scale, and invite people to score them in their minds. If the dialogue is designed to take longer and so will be structured by more prompts, you can print them out on paper with the rating response scale or use an online survey or polling tool. This allows for internal reflection on each statement before engaging in the dialogue. It is better not to share the prompts with the full group in advance of the session where the dialogue will take place so that they share their initial reactions and engage in dialogue about them for the first time in that session.
5. *Designate a facilitator to open the dialogue.*[7] In addition to opening the dialogue, the facilitator should be willing to interject and keep the dialogue on track, uphold the communication guidelines if necessary, create space for others to share ideas, and encourage people to consider multiple perspectives. The facilitator should be attentive to how power is distributed in the team, including how one's own

engagement to the team, it can nevertheless generate lasting insights and reveal the value of dialogue to those who are receptive.

[7] If you decide to proceed without a designated facilitator, it is critical that all dialogue participants know and be willing to uphold the communication guidelines for the community.

status and power may influence the dialogue, and act to ensure that it does not have a stultifying effect on participation. In a team setting you can alternate facilitators from one practice session to another, which helps establish norms for good facilitation and allows team members to practice facilitation skills that will be useful in future interactions and collaborations. Participants should be invited to choose any statement to start. Depending on how many statements you have created or how much time you have for the dialogue, you may not discuss all of them. The intention should be to discuss those that are most important to the team at the time of the dialogue. The statements can, and should, be revisited at different points throughout the team's work together. Periodic reflection can be a powerful tool for enhancing team performance. (It is helpful to review some of the published guidance concerning Toolbox facilitation, e.g., [44, 45].)

6. *Debrief!* Again, a critical part of practice is feedback. Unless the team debriefs after the dialogue—even if just for a few minutes—lessons learned during the practice session may be lost. A debrief conversation can be guided by the designated facilitator using questions such as:

   a. What did we learn from this dialogue? (This reinforces that even in a short dialogue, lessons can be learned that are important for the team.)
   b. How could we have made the dialogue include a wider range of participants? (This invites people to think about how to overcome communication obstacles that might make it difficult for some teammates to contribute.)
   c. Are speaking turns evenly distributed? (This can indicate whether people are as committed to listening to their teammates as they are committed to speaking.)

We have found that certain conditions can facilitate effective applications of the Toolbox dialogue method (e.g., a standard Toolbox workshop, or more limited and focused dialogue episodes), while others can limit effectiveness. Facilitating conditions include availability of time for project reflection, presence in an early stage of team development (e.g., in Tuckman's storming or norming stages—[50]), a collective ability to communicate openly in a way that is not threatened by differences in status or power (cf. [24]), and perceived relevance of the workshop to team function. By contrast, the following are limiting conditions: time urgency, presence in a later stage of team development, hierarchy (status or power) that is imposed in the workshop, and perceived irrelevance to team mission or identity.

5.6 Conclusion

Although it can be difficult to maintain, regular use of structured dialogue in meetings and project activities—even in small bursts—can encourage a *dialogical communication culture* in which deep engagement with one's collaborators is the norm rather than the exception. The Toolbox dialogue method can help a team create such a communication culture. It uses a structured dialogue activity with the explicit goal

of improving communication, specifically team reflexivity and perspective taking, which can enhance a team's collaborative capacity. In this chapter, we have introduced the Toolbox dialogue method and provided instructions for how one might use it to structure dialogue practice that could be as brief as 10 minutes or as long as a standard Toolbox workshop. Longer practice would profit from a review of published guidance for Toolbox workshops (e.g., [44, 45]), but the instructions supplied here should suffice for shorter practice sessions.

In the spirit of "practice makes permanent", we have argued that by practicing dialogue as a team, one can create a dialogical communication culture that establishes deep listening and close engagement as community norms. Of course, a dialogical culture doesn't solve every communication problem a team might have, but it creates conditions for collegially and collaboratively remediating communication problems when they arise. A dialogical culture serves as a constructive default that can assist teams in working through challenges and pursuing project objectives.

Neuroscience Connections

Practice does not make perfect; rather, practice makes permanent. Communication is a skill that needs to be practiced. From a neurological viewpoint, the practice of effective communication promotes neural synchrony in which neurons fire together and wire together. Communication is foundational to the development of positive relationships. Each team member brings different background knowledge, disciplinary jargon, and epistemologies to the team. These differences lead to different mental conceptualizations/mental models of the situation that need to be explored and integrated for more effective solutions. Exploring differences in mental models requires effective communication to strengthen the interconnections of neurons and the creation of a shared vision.

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Chapter 6
Effective Collaborative Decision-Making Includes Stakeholder Analysis and Communication

Roderic A. Parnell and Amanda Gangwish

Abstract In collaborative endeavors like community decision making or adaptive management, the identification, recruitment, and engagement of diverse, representative stakeholders are critical to success. Representativeness, transparency, and the comprehensive gathering of diverse perspectives and information are critical to establishing the legitimacy of the process and its outcomes. Well-tested, established tools are described to aid conveners of a collaborative process in promoting stakeholder collaboration. A sequential, iterative process is outlined to provide conveners with a road map for integrating stakeholders in cooperative decision-making.

Keyword Community-based decision-making · Stakeholder recruitment and participation

CTeAM Connections

- Who will influence/benefit/be impacted? (Stakeholders)
- How do you get them there? (Methods/Strategies)
- Where are we going? (Goals/Vision) (Planning with the end in mind)

R. A. Parnell (✉)
School of Earth and Sustainability, Northern Arizona University, Flagstaff, AZ, USA
e-mail: Roderic.Parnell@nau.edu

A. Gangwish
Nebraska Conservation Voters, Lincoln, NE, USA

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6.1 Introduction

We draw on literature and our experiences in a variety of academic, community, governmental, and non-governmental organization settings, to provide well tested processes and case studies that promote collaborative decision-making. A careful balance between engaged leadership and collaboration with diverse parties interested in the outcomes (stakeholders) throughout the process of collaborative decision-making will improve the outcomes (e.g., [1, 2]). The process of collaborative decision-making requires the development of a competency to engage and collaborate with others in those leading such endeavors and in team members of the collaboration. A successful process develops ways to create expertise and the ability for team members to take action [3]. Effective collaborative activities find ways to solicit grassroots input while maintaining some level of effective administration and decision-making hierarchies [4].

6.2 Goals

In this chapter, our goals are to:

- provide a step-by-step guide that illustrates how to engage stakeholders in the use of collaboration tools described in earlier sections of this volume to design an effective collaborative decision-making process; and
- develop and effectively use a representative network of stakeholders to create a more just and equitable decision-making process.

6.3 Building a Collaborative Process

Efforts to address socio-environmental challenges require a collective understanding of heterogeneous stakeholder perspectives that include those impacted by the action(s) and those charged with enacting decisions [5]. Historically marginalized groups have often not had access to the language and procedures used in traditional government top-down decision-making [6]. However, creating a more inclusive decision-making process can lead to measurable improvements in representation [7, 8].

Using standardized, accessible collaboration and modelling techniques can assist in bridging different communities who have different vocabularies, techniques and priorities. Committing to making SMART (specific, measurable, achievable, relevant and time-bound) actions for each task can assist in clarifying participation, roles, and objectives [9].

To develop a broad-based community response to crossdisciplinary challenges, the identification of participants, including stakeholders, is a critical first step. Broad

stakeholder participation increases trust in decision-making, improves project design by incorporating local knowledge, integrates varied interests and perspectives, and fosters social learning [10]. Through collaboration of interested parties, initial participants can identify additional stakeholders and then develop a process to attempt to reach consent on possible actions. Consensus or unanimity is not always possible (see case study 1 below). However, these actions strengthen the collaboration process and improve the likelihood of success of the effort.

Building a collaborative effort requires addressing the following questions prior to working on the issue.

- Who participates and how do they do so? See tasks 1 and 2 below.
- How do you build an inclusive, representative, and effective decision-making community? See tasks 1 and 2 below.
- What drives the decision-making process? What communication procedures are agreed-upon and used? Are deliberations top-down, grassroots, or externally imposed, from government regulations or other mandates? See tasks 3 and 4 below.
- How do you choose strategies or approaches for decisions? Is the process question-driven, resource-driven (analyzing changes in specific, quantifiable resources), or stakeholder concern driven? Any narrative development (e.g., concept mapping) should strive to translate qualitative community narratives, experiences, beliefs and stories into models/maps or narratives that promote community learning [11]. See task 4 for how to develop these processes.

Only after addressing these questions can a group assess what they have accomplished (task 5) and then move on to identifying concrete actions. These actions must be developed through a collaboration team's communication and decision-making processes. Then broadly communicate the social and environmental impact of these actions to potential stakeholders, not yet engaged, and to the broader communities. This approach can generate an iterative and adaptive management plan.

This paper focuses on stakeholder selection and deliberation processes. To clarify the process, we address these issues through five iterative tasks shown in Fig. 6.1 (for simplicity, some circles in the figure contain multiple tasks). These five tasks comprise the next five sections.

6.3.1 Identify and recruit stakeholders to build a decision-making community

The first set of tasks is the initial identification of stakeholders by the conveners. The sequence of tasks is iterative across all stages, creating a dynamic process. Usually, the composition and number of stakeholders will evolve as individual

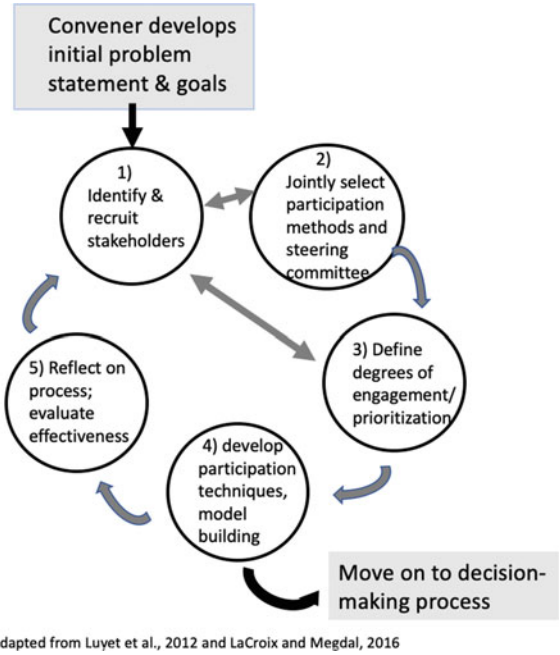

Fig. 6.1 The iterative process of selecting stakeholders and developing a process for stakeholder engagement in decision-making. The process should be initiated very early as you develop a concept to address a challenge. Move forward into the decision-making process only after assessment of the completed stakeholder selection and engagement processes

interest waxes and wanes and recruitment of new stakeholders creates new interactions and dynamics. Group participation in defining processes and prioritizing roles tends to increase engagement and participation [12].

Before beginning, one should recognize that leading or participating in a collaboration process seldom goes perfectly or as initially envisioned. A willingness to identify and learn from mistakes is crucial.

Any collaborative process adds complexity, time, and resource demands to decision making because identifying and including representative stakeholder input can be complex and sometimes challenging. The initial steps begin with identifying prospects while simultaneously developing plans to recruit, and then engage these stakeholders. Identifying stakeholders can be especially challenging in communities which traditionally have been ignored or underrepresented. These communities may not have a tradition of or connections for participation in many types of policy decision-making. Widen the potential pool of stakeholders through communication and outreach by social media and identification of potentially interested leaders of local and regional government and non-governmental organizations.

The process of identifying stakeholders can also raise conflicts and frustrations as new introductions, communications and interactions are established. Frustration

may occur in reaching out to unfamiliar parties, ineffective dialog may occur, unrepresentative participants may become involved, or those identified as important stakeholders may be overrepresented [10]. As potential stakeholders are identified, their interrelationships must also be recognized.

- As the process of stakeholder identification advances, prioritization, selection, analysis, and identification of bias must be performed first (step 1 in Fig. 6.1) [2, 13].

Criteria for choosing stakeholders, including identifying bias and ensuring representativeness, must be collaboratively established by the project facilitators and potential, interested, or affected stakeholders [10, 14]. These biases may include attitudes and interest toward project, access to resources and political power, scale of influence, sense of urgency felt, proximity, and perceived legitimacy [10].

Before committing to accepting the potential stakeholders as participants, it is important to identify their goals and perspectives to ensure a representative process [10, 14].

- Once stakeholders are admitted to the process, formally or informally, they can begin by jointly selecting participation techniques and frequency of interactions and advance to step 2 (Fig. 6.1).

In addition to striving for equitable representation, the process of selecting stakeholders should recognize the potential for conflicts or alliances between stakeholders. Identifying stakeholders' relationships can help to determine existing or evolving power dynamics within the group or between stakeholders and external groups. Although building relationships between stakeholders is essential to strong collaboration, these relationships should be transparent and constructive.

In addition to diverse and equitable representation, an effective process draws upon power sources to encourage participation and to enact outcomes. A power map is a visual exercise and tool to help decision makers understand the context and relationships between community leaders, and their supporters, allies, and opponents. Such a tool can assist organizers in identifying potential participants as well as prioritizing their participation in the process.

Create a Power Map. Power mapping can assist you in determining the most effective target (who can make the change you are seeking, for example, community leaders); who may influence and persuade that target to support your change; and through what pathways can you access your target [15]. Including these targets in your collaboration team should be a high priority**.**

- In task 2 (Fig. 6.1), a power map exercise in a group setting works to determine who might be effective and influential participants in the decision-making process.

The power holders to be influenced are those who can impact a desired action. Normally a power map is developed later in the decision-making process (steps 3 and 4), when desired actions are established, and consensus is reached. However, mapping can also occur in early stages and help to determine the targets (and allies)

whom you could engage as stakeholders. Hypothetical or generalized actions may be used for this early-stage activity. At the very least, participants should reach consent on whether the action to be implemented leans towards a policy intervention or towards a change in social behavior [16].

A power map is a physical representation of the collaborators and their connections. One can use software or simply draw it on a flipchart. The example in Fig. 6.2 was constructed in CMap (described in Sect. 6.3.2 below). Its authors were a group of environmental studies faculty. It was produced through the interactions and iterative consensus of the group. The first step is to determine the target(s) to be influenced. (Provost or President in Fig. 6.2). Second, identify the flow of power (lines of authority) that go to and emanate from the target(s). These are the pathways to access the target(s). These can include the flow of money and funding opportunities, connections to allies, connections to voters, volunteer, or other human resources (time, effort, communication, social media contributions), even how prestige or stature connects to the target.

Third, as these lines are being drawn, determine where these paths connect to people, money, and resources. Who are the key people connected to your target: allies and persuaders or influencers, and just as important, who and what are and barriers and blockers (they could be people, they could be economic, political, regulatory, cultural, etc.)? Who or what gatekeepers limit access to the target (administrative hierarchies,

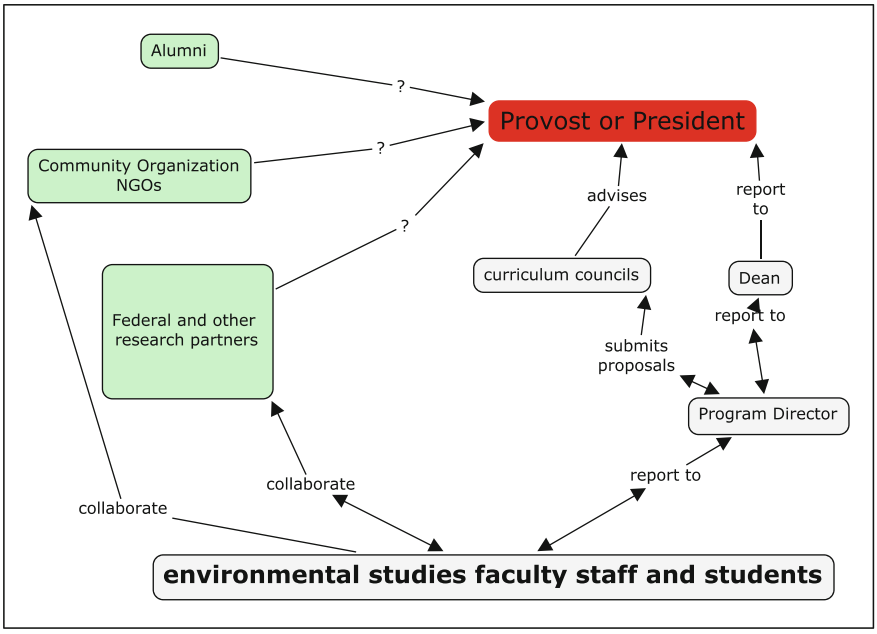

Fig. 6.2 A generalized power map describing pathways of influence for an environmental studies program attempting to influence their target, the power holder (Provost or President)

social or cultural connections, money)? Discover the gatekeepers' interests with respect to your initiative and what drivers motivate the gatekeepers.

Finally, the group can identify and show connections to similar or like-minded initiatives.

An extension of this exercise can be completed simultaneously:

- a "stakeholder map" can identify potential affected parties who may not be influential in traditional ways but need to be part of the process [17]. This map results from the visual process of laying out all the potential stakeholders and their interrelationships.

6.3.2 Select Participation Methods and a Steering Committee

Different stakeholders and communities bring a range of commitments and resources (time, connections, social media) to the process. As the size of the decision-making group increases, participation can be more challenging, especially for traditionally underrepresented groups less familiar with traditional government-based decision-making processes.

- Activities spanning task 2 and 3 (Fig. 6.1) include selecting the range of participation activities, and which stakeholders identified in task 1 will participate in which ways (i.e., identifying the degree of engagement by stakeholders in the decision-making process: task 3).

The choice to implement a steering committee overlaps tasks 2 and 3. A steering or executive committee may provide useful structure. Representation on it can depend upon the scale and complexity of the problem and the number of critical stakeholders identified. However, such a committee may be seen to add to the complexity of administering the process and may lead to issues of non-transparency or non-representation.

The broader your outreach across the community of potential stakeholders, the more legitimate, diverse, and equitable your process can become [10].

There are multiple potential roles for stakeholders, although it is not critical that each stakeholder play each role (e.g., [13]) including:

– provide information or consultation (presentations, reports, social media),
– collaborate and co-produce decisions through workshops, focus groups, model design and construction [10].

A basic summary of types and levels of participation is The International Association for Public Participation IAP2 Spectrum of Public Participation (https://cdn.ymaws.com/www.iap2.org/resource/resmgr/pillars/Spectrum_8.5x11_Print.pdf and https://www.iap2.org/page/pillars.)

- Citizen science participation can identify engaged community members through projects that use community members to gather scientific data. Such projects are

generally designed by scientists from state, local, tribal, or federal organizations or from non-governmental organizations. Members of the public primarily contribute data, but can also contribute to the iterative design, management, and evolution of the project. Members of the public may also analyze data, and/or disseminate findings. These can be co-created projects, designed by scientists and members of the public working together. Some public participants may be actively involved in most or all aspects of the research process [18].

Because these or other outreach efforts identify potential stakeholders, these efforts should allow stakeholders to participate in designing participation methods using activities described in the next section. The size and composition of the stakeholder group and steering committee (if used) may change over the life of a project, responding to the change caused by recruitment, engagement and participation processes.

6.3.3 Define the degree of engagement in the decision-making process by involving and prioritizing stakeholders

- In task 3 (Fig. 6.1), the power map can identify pathways to community leaders who can most heavily impact your desired actions.

Soliciting participation only begins the process of stakeholder engagement. Once a group of stakeholders has been identified, either through self-selection or a recruiting process (e.g., resulting from your group power mapping exercise), it is essential to communicate with, consult with, and empower them as part of the iterative decision-making process. This task can begin as soon as stakeholders are identified (tasks 1–2) and continue to evolve through task 3. Not all stakeholders desire or are capable of equal levels of participation [5, 11]. The use or re-use of the power map process can not only allow you to identify prospective participants but also assist you in prioritizing their role in the process (e.g., who should be considered for membership on a steering committee?).

- Task 3 requires recognizing how stakeholders have varying levels of interest, power, and influence in addressing your issue.

After these stakeholders are identified, and their levels of participation identified, successful engagement and outreach activities can keep them engaged. An excellent summary providing varied examples such as activities is Table 6.1 of LaCroix and Megdal [12] and includes general community presentations or open houses, surveys (roadmap/initial planning and/or community/watershed focused), focus groups, scenario driver workshops, key informant and expert interviews. How effective these activities may be in stakeholder engagement can be assessed by determining:

Table 6.1 Combining engagement (interest) and influence (power) characteristics of stakeholders. Mendelow [19] Adapted from [20] and

	Low power	High power
High interest	Significant interest and enthusiasm; limited ability to impact decisions **Keep them engaged**	Substantial interest and ability to influence events **They are central figures, manage them closely**
Low interest	Limited interest and power **These are fringe players, monitor their participation with minimum effort**	Powerful, influential but disinterested **Targets for power mapping, set context for decision-making**

- inclusiveness (how open and widely accessible they are),
- transparency (is material presented in a range of forums in non-technical language),
- commitment (on-going efforts dispersed geographical and temporally), and
- adaptiveness (changing outreach activities in response to stakeholder and community comments),

Additional criteria are in Conallin et al ([21], Table 6.1). Implementing and evaluating stakeholder participation is crucial for continued stakeholder engagement and also demonstrating the legitimacy of the process. Clear and transparent organization, communication and conflict resolution are necessary to ensure stakeholder commitment [10]. A proposed framework for how discussions will proceed, including ground rules for conduct, should define a specific role for each stakeholder. Ground rules include group consent on active and engaged listening, an assumption of good intentions on the part of all group members, and agreements on self-governance (meeting length and frequency, work sessions, communication between meetings, leadership/facilitation). Roles identified can be fluid as the process evolves.

The group or its facilitator(s) may choose techniques for stakeholder engagement based upon how committed the stakeholders are, local cultural norms, success of previous events, and time frame. Stakeholders are empowered through participation in the decision-making process, for example in the development of the use of shared constructs (e.g., shared boundary objects described in [22]) or other models. These do not need to be complex, computer hosted constructs.

6.3.4 Develop participation techniques such as a shared model of the issue and potential solutions by using stakeholders' ideas

Models can describe the group's understanding of the issue being addressed as well as its boundaries. Models are collaborative concepts integrating various sources of

data, perspectives, and knowledge. Cooperatively and iteratively building a shared model of your system is an effective way for stakeholders to share their ideas and to reach a consensus on steps to pursue [22]. For our purpose, a shared model is a tangible, physical (graphical, mathematical, and/or verbal) representation of the group's understanding of the problem's extent and boundaries, components, and interactions. Defining the structure and function of the system is a necessary prerequisite to problem identification and definition.

Before defining the nature and scope of an issue with a model, you must get organized. Collaborative models are developed through the iterative use of cooperative frameworks. Establish a framework for examination of the socio-environmental system within which your problem occurs. Here we use the term framework as a generalized, structured way of conceptualizing a problem. It provides the scaffolding for a model. To allow rigorous analysis, a framework should contain indicators, which are components or measurements of your system that can depict conditions or changes in conditions [23]. For example, in the case study on the Colorado River below, indicators include the size and location of sandbars and the populations and distributions of native and invasive fish species.

- Building a systems model using an agreed upon framework is an effective tool to iteratively achieve a representative consensus and assists in coalescing varied narratives and perspectives into an integrated overview [24]. Specific ideas can be discussed openly and relationships between them can be established ([25], Table 6.1).

Participating in model building facilitates stakeholder participation, and ultimately supports decision making. See previous chapters in this volume. Although complex models may have some predictive value, the primary use of a model can be to draw insights and recommendations. Decision-making success depends on the use of effective practices throughout model development, starting from defining the objectives of model development.

Broad categories of model approaches, their strengths and weaknesses and case study applications, are discussed by Kelly et al [24]. They include systems dynamics (e.g., causal diagramming in [16]), Bayesian networks, coupled component models, agent-based models, and knowledge-based models.

Participants in modelling exercises need not have any scientific, quantitative or computer science backgrounds. Effective participation can occur through the use of fuzzy cognitive mapping (combining fuzzy logic and cognitive mapping), which can produce qualitative models that can be translated into semi-quantitative dynamic models [25]. These diagrams relate elements of your system to each other and can be used to compute the "strength of impact" of these elements [26]. Widely used software employing this approach include mental modeler (https://www.mentalmodeler.com) and concept mapping or Cmap (https://cmap.ihmc.us). The structured format, transparency and ease of construction of these models are ideal for community-based decision-making. They serve as visual and quantitative representations of qualitative narrative descriptions [27] by making relationships between objects or events that are experienced during events explicit. This can include relating events spatially

and temporally. These models can extrapolate from individual anecdotes or specific quotes to broader concepts and relationships [25].

- The steps in model building and application to a problem are summarized below [16].

(i) Building a model begins with the group collecting and integrating individuals' mental models depicting the socio-economic-environmental system [22]. Identify the key biophysical and social components that interact to impact the system as well as scope, scale, extent, and relationships between the components. From your previous discussions, a preliminary outcome of the process you are modeling must include paths to reach that outcome sought. Clearly, extensive discussion is required to reach consensus on the focal outcomes (goals, vision, specific actions etc.) and on which system components are most important.

(ii) To achieve a useful outcome, the model must connect to concrete actions addressing specific group objectives. Identify points of social, political, regulatory or administrative leverage that could positively or negatively affect the outcome. Also identify any knowledge gaps that need to be addressed. Determine how the outcomes relate to specific policy, management, or behavioral interventions.

Many types of frameworks for modeling exist to address complex challenges, for example Actors-Resources, Dynamics-Interactions, Drivers-Pressures-States-Impacts-Responses, Press-Pulse Dynamics, and socio-ecological systems (SES). For its straightforward techniques and vocabulary and because of its widespread adoption, using a SES framework following Ostrom [28] is recommended (e.g. [29, 30]).

A framework such as SES defines a system in terms of its boundaries, components, and interactions between components. What external forces influence or are influenced by our system through inputs or outputs of energy or material? In the example shown in Fig. 6.3, our system boundary is the dotted line, separating our system from larger, encompassing or adjacent socio-economic-political systems (top, in bold) and larger, encompassing or adjacent socio-ecosystems (bottom, in italics). Components of ecosystems residing within our system are indicated by the boxes on the left. Components of socio-economic systems within our system are the circles on the right. The framework is designed to allow participants in the process to understand the conditions and indicators within the system. Participants pull together this information as they interact, resulting in joint decisions made and outcomes (e.g. management decisions) generated.

(iii) An important part of advancing efforts to achieve your outcome is to get widespread buy-in by identifying and communicating the social relevance of your efforts. Stakeholders interested community members and researchers and research teams should identify what is socially important about your issue and

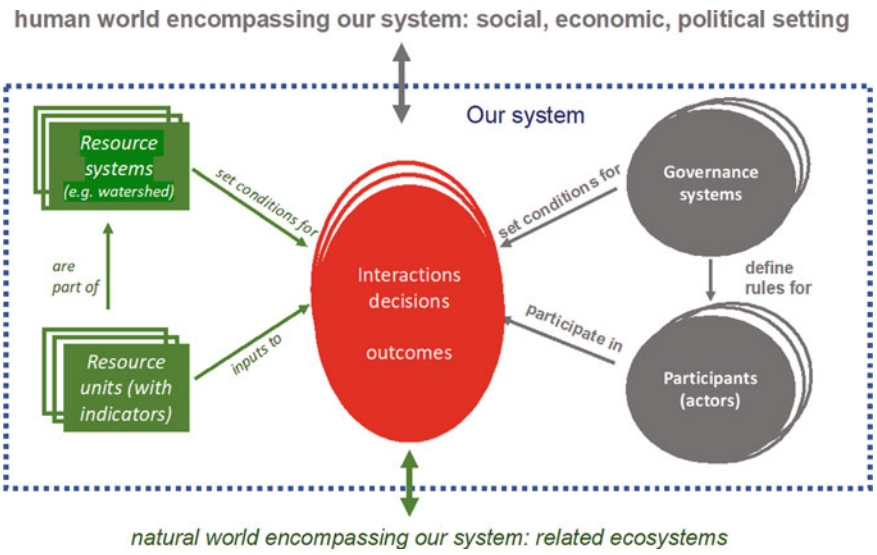

Fig. 6.3 A generalized social-ecological system (SES) framework model leading to initial outcomes produced by group decision making. The figure shows a SES framework with multiple components (solid boxes and circles). Resource Systems, Resource Units (with indicators), Governance Systems, and Participants are system variables that contain multiple variables at secondary or lower tiers. Actions (in center ovals) occur as inputs are transformed, through the participation of multiple participants, into outcomes. The dotted line that surrounds the interior system elements represents the concept that the SES can be considered as a logical whole, but that external influences from greater, related natural and human worlds can affect any component of the SES. The initial outcomes produced will have impacts on all four sets of system components, which trigger an on-going, iterative process as additional actions or decisions are implemented. These external influences might emerge at larger or smaller scales than that of the SES. McGinnis and Ostrom Adapted from [29]

any potential interventions you propose. What about your proposed actions are useful to or of interest to non-stakeholders?

(iv) Take the model forward. Unlike steps (i)–(iii), moving forward with decision-making and communicating results are beyond the scope of the paper. Identify responsible parties and interested parties who will continue to act on the proposed actions. What institutions, organizations, or individuals can be responsible for implementing the proposed actions. Which stakeholders tie their own on-going activities to actionable outcomes. To achieve broad support, these stakeholders must share a commitment to the outcome even though their diverse values, perspectives, and expertise may vary. As discussed in the case studies below, stakeholders must recognize that trade-offs will be required to implement specific actions because of possible differences in opinion or of economic, social, legal, policy or political constraints.

6.3.5 Evaluate the effectiveness of your stakeholder process and the potential social impact and outcomes to the larger community

To meet commitments to stakeholders and other interested parties, to enhance the validity and expertise of the stakeholder process, and to ease the progress of future stakeholder negotiations it is essential to have participants reflect upon the effectiveness of the entire process as well as the value of its outcomes.

The process and resulting outcomes can be widely broadcast only after such an internal assessment occurs (e.g. [31, 32]). Participants should come to some consensus about the effectiveness of the process, the utility of its outcomes and what needs to be done in the future. Techniques for engaging in individual and group reflection are described elsewhere in this volume. Methods to develop a communication process are beyond the scope of this paper. See O'Rourke et al. (This Volume) about communication practice.

6.4 Case Studies

To demonstrate how the principles discussed above can be implemented, two case studies of engaging diverse stakeholders in an interdisciplinary decision-making process are presented. The first case study illustrates a top-down driven process. It is a manager/scientist driven resource management process where primary authority, resources and responsibility come from federal agencies, in other words, a top-down mandate. The second case study illustrates a grassroots process, where stakeholders are actively recruited from the community.

6.4.1 Glen Canyon Dam Adaptive Management Program

One of the most mature adaptive management programs in the country, the Glen Canyon Adaptive Management Program uses active adaptive experimentation geared to identify methods to improve natural habitat conditions [33]. This large-scale adaptive management program, involving scores of stakeholders from state, tribal, federal and non-profit organizations, has run for over 25 years. It is an example of a highly defined, regulated and continuously funded effort to manage physical, biological, and cultural resources along the Colorado River system in Northern Arizona.

Building an Adaptive Management Program Driven by a comprehensive environmental impact statement and federal legislation, the stakeholders group charged with decision-making concerning the Glen Canyon Dam and the regulation of the

Colorado River downstream is a well-resourced and well constrained example of stakeholder engagement in environmental management and policy [34].

Structures defining the program include the federal Grand Canyon Protection Act of 1992. It is an extensive body of laws, regulations and interstate agreements collectively called the Law of the River, and the federal Endangered Species Act. This scaffolding calls on resource agencies to govern from a common vision developed by stakeholders and requires articulation of stakeholder values and legal and policy boundaries [35]. Section 1802 of the Grand Canyon Protection Act directs the Secretary of Interior to establish and implement long-term monitoring programs and activities to ensure the Glen Canyon Dam is operated "… in such a manner as to protect, mitigate adverse impacts to, and improve the values for which Grand Canyon National Park and Glen Canyon National Recreation Area were established."

The managers who established the stakeholder groups (Adaptive Management Work Group or AMWG and the Technical Work Group or TWG) drew upon their extensive experiences to address tasks 1 and 2 (Fig. 6.1). A pre-existing federal organization, Glen Canyon Environmental Studies in the 1980s and into the 1990s established working relationships between stakeholders including state, tribal, and federal organizations. A team of managers led by GCES director Dave Wegner, as well as the inaugural director of GCMRC, Lawrence "Dave" Garrett, brought their extensive multi-agency and interdisciplinary experience to the formation of stakeholder group composition and procedures. Although guided by general statements in the Grand Canyon Protection Act, the resulting stakeholder processes were ad hoc, iterative and inclusive. The AMWG's charter stipulates that membership shall come from federal and state agencies, Native American tribes, the basin States, environmental groups, recreation groups and power-purchasing contractors (AMWG 1997).

In addressing tasks 3 (defining degrees and forms of stakeholder engagement) and 4 (establishing participation and modelling techniques) of Fig. 6.1, these professional resource managers worked with stakeholder groups to establish vision and goals within the regulatory requirements set by The Grand Canyon Protection Act and other regulations. With guidance from stakeholders, managers operate through a single decision-making science center (GCMRC) [35]. The Center conducts research and monitoring needed to evaluate operations. The Program receives $9 M per year from federal power revenues generated by Glen Canyon Dam to support activities [34]. Guidance comes from the AMWG (https://www.usbr.gov/uc/progact/amp/amwg.html). The Technical Work Group from within the dozens of AMWG members (https://www.usbr.gov/uc/progact/amp/twg.html) provides detailed guidance on objectives and protocols for monitoring and research.

Task 5 (reflection on effectiveness) of Fig. 6.1, was accomplished through multi-day stakeholder conferences resulting in annual reports from the TWG, AMWG and GCMRC. Five-year reviews by National Resource Council panels of experts provide external perspectives and additional guidance.

Lessons Learned A well-defined process of stakeholder inclusion does not ensure continuous success. In spite of extensive structures to guide the process, a failure to set priorities among the competing concerns for water management, power generation,

environmental, cultural and recreational resources reduced the effectiveness of group decision-making. It is critical to establish clear overarching goals and concrete objectives against which progress can be measured [36]. Stakeholders and their specific goals should be prioritized. It may be necessary to provide tools and incentives, such as the appointment of qualified mediators and the offer of financial support for the process, to encourage participation and foster collaboration in the prioritization of goals.

In spite of extensive efforts to define the roles of participants in the adaptive management program, the group's efforts to resolve regulatory confusion and inconsistency remain inconclusive, and considerable discord remains [36, 37]. One example is the tension that exists between large scale goals and specific monitoring objectives. Should focus concentrate on monitoring the status of specific resource parameters or on progress towards large scale goals? Debate remains over the need for annual assessment focusing on readily quantifiable system parameters versus focusing on tracking larger scale goals like "restoration" of a sustainable river system. Further complicating consensus on actions is the on-going drought in the Southwest US and the primacy of obligations under the Law of the River (e.g., [38, 39]). Furthermore, the adaptive management program has no procedure requiring that information gleaned over time be used to adjust its management protocol, so extensive, long-term monitoring data remain underutilized [36].

Because no protocols are in place to resolve conflicting priorities or to create a more level playing field for all stakeholders, a revisiting of the original AWMG charter may be necessary to improve stakeholder equity in the decision-making process.

Through more than 25 years of monitoring and research, using management actions as experiments can best be communicated by having a conceptual model to organize and communicate understandings and develop management alternatives. In highly complex systems these models can be effective communication tools even though they are not highly predictive.

More specific recommendations for improving the adaptive management process come from researchers, program administrators and adaptive management program reviews.

(1) *"Delineate clear roles and fact-finding protocols that promote shared learning"* (task 2 in Fig. 6.1). Large-scale complex systems with many stakeholders lead managers to attempt more complex manipulations that have more ambiguous results. Often, stakeholders will interpret data sets in their own ways without reaching consensus from other stakeholders, scientists or managers [36].
(2) "*Create well-defined processes and triggers for monitoring, assessing and adjusting provisional management strategies"* [36] (task 3 in Fig. 6.1).
(3) Adaptive management should be seen as adaptive learning [36]. Stakeholders should learn to recognize that serendipity/surprise may arise and present new management opportunities (task 4 in Fig. 6.1).
(4) Participants in collaborative processes need to be convinced that, if they can reach near unanimous agreement, formal decisions are actually likely to follow

their recommendations [40]. Decision makers need to make an explicit commitment that stakeholder deliberations will weigh heavily on decisions made. Without such assurance, stakeholders may step away from the collaborative process, become more entrenched in existing perspectives and maneuver outside the process [41] (task 5 in Fig. 6.1).

6.4.2 *Nebraska First Republican State to Set a Target of Net-Zero Carbon Emissions*

This case study explores how a grassroots, community-driven process achieved the specific goal of setting a net-zero carbon emissions for the state of Nebraska. The process began with the commitment to achieve net-zero carbon emissions from Omaha Public Power District (OPPD) in 2019, then Lincoln Electric System (LES) in 2020, and Nebraska Public Power District (NPPD) in 2021. Close to 80% of Nebraskans are now living in a district that is committed to going net-zero carbon by 2050 or earlier.

Getting to Net-Zero Nebraska is the only state in the country where all electric utilities are publicly owned, meaning the people of Nebraska elect those who represent them onto public power boards [42]. This gives Nebraskans the unique power of voting for the future of the state's electrical generation. On top of its unique publicly owned utilities, the state of Nebraska has always been primed for renewable energy development. According to the U.S. Department of Energy and the Office of Energy Efficiency and Renewable Energy, Nebraska ranks in the top 10 states for potential wind capacity and top 15 for potential solar capacity. Furthermore, 91% of rural Nebraskans agreed or strongly agreed that more should be done to develop renewable/alternative energy sources [43].

The shift towards a net-zero carbon future in Nebraska's came through grassroot efforts over the course of several years. The principal convening organization, Nebraska Conservation Voters (NCV), utilized the groups previous grassroot campaign efforts to address tasks 1 and 2 (Fig. 6.1). Working with a large group of stakeholders, pro-renewable candidates were elected to public power boards and then held accountable for passing strategic directives that pushed the state forward. This group of stakeholders included: other conservation and environmental organizations, non-profit and for-profit organizations in various sectors, community members, and a handful of other interested and vested parties. These stakeholder groups were identified and recruited in a variety of manners: previous collaboration, door-to-door canvassing, direct outreach via phone, mail, or electronic communication, partnership building in which other stakeholders brought others to the table, etc. After the identification of these stakeholder groups tasks 3, defining degrees of engagement, and task 4, determining levels and kinds of participation, were established. With the establishment of these goals and next steps, the stakeholder group was able to move forward with the following processes.

Starting with candidate recruitment, a selection of the larger stakeholder group, comprised of non-profits, local community members, and other organizations worked to find candidates who were committed not only to renewable energy advancement but who were also respected members of their local communities. Through many stakeholder meetings, potential candidates were recruited by their peers and potential voter base. Once a candidate was committed to running, grassroot efforts to drive voting occurred. Focusing on the importance of effective communication as it relates to environmental and sustainability issues, voters received a variety of messaging campaigns, which as discussed in task 3 was a method of engagement for a large stakeholder group. Yale's Center for Climate Change Communication and Columbia University's Center for Environmental Decision-Making have conducted extensive research based on case studies, focus groups, and surveys and found that for most individuals to make decisions on environmental issues, the communication must come from a trusted local messenger and the information must be relevant to their lives.

Over the course of several years and through the efforts of many stakeholders, the makeup of the public power board of directors shifted towards what we see today. Through these collaborative efforts, Nebraska has joined several other states in our country in progressing towards a cleaner, healthier future.

To address task 5, the stakeholder groups reconvened after each major election cycle to review and reflect on the processes implemented in that cycle and envision the process for the next election cycle.

Lessons Learned The importance of effective communication cannot be downplayed. When communicating with large and diverse groups of stakeholders it is key to remember that each group has a different interest or reason that has brought them to the table. Specifically, it has been found, that for people to make environmentally sustainable decisions, the information should come from a trusted, local messenger and should be clearly relevant to their own lives. It should be understood that throughout this process there were stakeholder groups who were opposed and not interested in participating. Continued conversations and communication was the best approach to handling these groups, in the hopes that through further relationship development, trust building, and constant communication, the various stakeholder groups would either become engaged in the process or change opinion on the various matters.

Throughout the process described above several different messaging techniques were utilized and, oftentimes, the stakeholders heard the same core message but through a variety of frameworks depending on their background.

6.5 Summary and Conclusions

To be effective, any stakeholder-driven decision-making process should be transparent and flexible. Openness begins during the initial recruitment process of stakeholders and continues throughout. To provide transparency and give prospective stakeholders a realistic sense of their roles in the process, a well-structured series of steps should be developed as early in the process as possible. Clearly defined roles for stakeholders, conveners, steering committee, and other parts of the process should be collaboratively established and open to evolution over time. Solicitation of and respect for diverse perspectives is essential to maintain legitimacy.

This paper focuses on the early stages of advancing collaborative decision making. We propose five sequential, iterative tasks to perform as a proven way to guide a transparent, diverse, and representative process. The first task is to identify and recruit stakeholders including targets; creating a power map can ease this task. Once an initial set of stakeholders is collaboratively selected, they can proceed to develop participation methods for the group. Third, processes to enhance engagement by participants, including the prioritization of stakeholders and their concerns, can enhance participation. Fourth, effective participation occurs by sharing of individual mental models and construction of a consensus model describing the system of concern. Finally, assessment by the group of the tools and processes developed to engage participants and to reach consensus decisions contributes to transparency and legitimacy. Iteratively revisiting each step as appropriate helps the process to evolve and can bring in new perspectives and participants. An action plan with authority to enforce decisions also helps to maintain stakeholder commitment.

Neuroscience Connections

At the core of collaborative decision-making is the art of negotiation. Effective team dynamics are compromised when different viewpoints are at odds. In such situations, there is increased stress, heightened emotions, and basic dysregulation of our nervous system. But if a win–win approach can be established by using activities that are inclusive and promote transparency, then neural systems of team members and stakeholders begin to synchronize, including participant heart rates and breathing. Key strategies to accomplish this level of collaboration include the use of active and engaged listening, positive non-verbal language, development of shared goals, and a focus on learning other team members perspectives by using open-ended questions to learn concerns and issues of note. The result is a lowering of anxiety, a heightening of emotional harmony, and an increasing sense of psychological safety.

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Chapter 7
Addressing a University Department Challenge: Applying the CTeAM Key Question Matrix

Richard S. Moog, Mark T. Baillie, and David Gosselin

Abstract This case study provides an example of how the Collaborative Team Action Model (CTeAM) Key Question Matrix (KQM) provides a robust framework for undertaking a process designed to produce change at an organizational level. The KQM was modified for the context in which it was used. The modified KQM guides an information-gathering process that engaged with various stakeholders at the institution, provided a consistent and effective structure for interactions with individuals and groups, and uncovered common themes and areas of concern. The C-TeAM KQM can be analogously modified to serve as a framework for developing and achieving organizational goals or visions.

R. S. Moog (✉)
Department of Chemistry, Franklin & Marshall College, The POGIL Project, Lancaster, PA, USA
e-mail: rmoog@fandm.edu

M. T. Baillie
Department of Chemistry, Director, STRIVE Program, STEM Education Center, University of Arkansas Little Rock, Little Rock, AR, USA
e-mail: mtbaillie@ualr.edu

D. Gosselin
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

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Keyword Collaboration · Collaborative team action model · Key question matrix · Equity gap · Higher education

CTeAM Connections

- Who will influence/benefit/be impacted? (Stakeholders)
- How do you get them there? (Methods/Strategies)
- Where are we going? (Goals/Vision) (Planning with the end in mind)

7.1 Introduction

The Collaborative Team Action Model (CTeAM) framework can be utilized in a variety of settings. In this chapter, we provide an example of how the CTeAM framework was used to guide an initial consultancy intended to begin a process of change in an academic department. To reach the goals of this consultancy, we modified the CTeAM Key Question Matrix (See Gosselin, This Volume) to provide an enhanced and effective framework for this work. This case study provides an exemplar of how this framework can be adapted and used to guide the process of change.

7.2 The Context

The authors constituted a consultancy team under the auspices of a federally funded project focused on supporting the implementation of evidence-based teaching practices at several post-secondary institutions. These institutions each identified a particular issue or problem to be addressed. This case study involves a STEM department (referred to as the Target Department) at a large, public, four-year, primarily nonresidential comprehensive university [from Carnegie classifications] in the United States. This institution had recently been designated a Hispanic-Serving Institution as a result of changing demographics in the undergraduate student population over the previous decade. The university had recently initiated an institution-wide effort to reduce the substantial difference in outcomes between students who are historically underserved (including Hispanic students), first generation, and/or Pell grant recipients and those students who are not. That is, to reduce the achievement gap that had become apparent in recent years, termed the "equity gap." Through this federally funded project, the Target Department requested a consultancy to assist in beginning the development of actionable strategies to eliminate the equity gap in their undergraduate courses, particularly at the introductory level. The authors were

selected as consultants for this project from a cohort of trained professionals with a wide range of experiences, content expertise, and prior professional development activities. The consultants were not necessarily content experts in areas related to the Target Department. A member of the institutional leadership team served as the "institutional coordinator" of the consultancy. This coordinator arranged the various meetings that were held and provided requested background information and other support during the campus visit.

The role of the consultancy team was two-fold:

1. Collect information about the challenges and opportunities that exist internally and externally to the institution related to their goal; and
2. Provide suggestions to the Target Department regarding actions they could implement that build on and complement already existing structures on their campus and take advantage of resources available to them through this federally funded project.

7.3 The CTeAM Key Question Matrix

The CTeAM Key Question Matrix (KQM) provides a useful framework for collaborating teams to work towards a common goal (See Gosselin, This Volume). A crucial aspect of this approach is its implementation of a version of Backward Design, a process where the team begins by envisioning their end goal and then identifies specific measurable outcomes or accomplishments (outputs) that indicate progress toward that goal [1]. This process is called Backward Design because only after determining the desired end goals and outcomes do you ask the question of "what" your organization will do to achieve those end goals.

The central question that was being addressed by the consultancy in the KQM was: "Where are we going?" The department we worked with identified their goal as "Eliminate Equity Gaps Between Students" (Fig. 7.1).

The four quadrants of the KQM were adapted to reflect the specific context of this effort:

Upper right: Who is the department?

The general question for the upper right quadrant of the KQM is "Who is on the team?" In this context, the "team" is the group of people who will be working to reach the overall goal. Although other constituencies at the institution will be involved in eliminating the equity gap, we decided to focus on the department members themselves as the "team" that would be working together. This includes faculty at all levels (including adjuncts, visiting professors, lecturers, and tenure-track professors), and represents a wide range of sub-disciplinary expertise. This diverse group of faculty members comes with disparate views of what is needed to support these students based on their varied levels of knowledge of how people learn, evidence-based teaching practices and their lived experiences. The CTeAM framework allowed us to help the department build a common vision for addressing issues for incoming

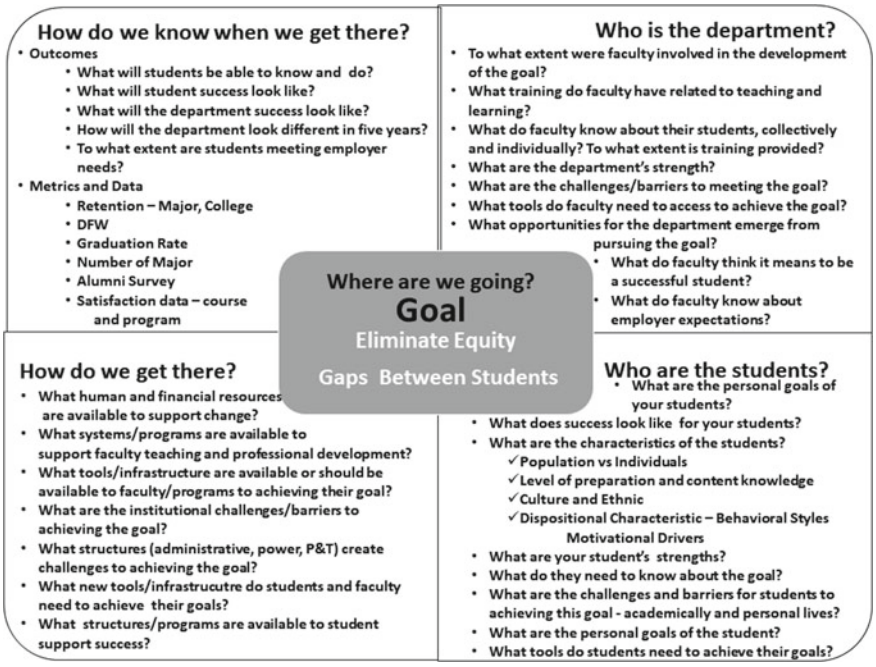

Fig. 7.1 CTeAM key question matrix applied to consultancy effort. Details for its use are described in the text. The CTeAM model evolved from Gosselin [2, 3]

students and beginning majors. The questions that appear in this quadrant of the matrix reflect important individual and collective aspects of the knowledge, experience, opportunities, and perspectives that define the context of this effort and the type of information that will be essential to the eventual development of a true "team" approach.

Lower right: Who are the students?

The general question for the lower right quadrant of the KQM is "Who will influence, benefit and/or be impacted?" Although there are other stakeholders (e.g., student support services, faculty members) who will be affected by the process (and outcome) of decreasing equity gaps, in the context of this effort, the clear answer to this question was "the students." When making changes to a system, it is critical to think about the impact on key stakeholders and allow for their input. In academia, it is common for students not to be included in the process of curriculum development or other changes even though these changes have a direct (and indirect) impact on them and their experiences. To ensure that student perspectives and experiences were a central part of the process, we elected to focus on the students as key stakeholders by phrasing the lower right quadrant question as "Who are the students?" The subquestions in this quadrant attempt to address various aspects of student experience and their characteristics. Answers can come from various perspectives including those

of faculty members, student support personnel, and—of particular importance—students themselves.

Lower left: How Do We Get There?

The general purpose of the lower left quadrant is to identify the methods and strategies that will be used to reach the designated goal. In some sense, the purpose of this initial consultancy visit was to propose initial steps to begin the process of change—that is, provide suggested answers for the possible first steps to take to address this broad goal based on the information gathered throughout the visit. Thus, for our purposes, the questions in this quadrant focus on collecting data related to the resources (broadly defined) that were currently available to faculty and students, and to identify potential levers and barriers for achieving change. For these reasons, it was important to meet with various constituencies outside of the Target Department to better understand the context in which the effort was taking place and the existing resources (and barriers) available to both students and faculty to support and assist in any changes that might be made.

Upper left: How Do We Know When We Get There?

The general purpose of the upper left quadrant of the KQM is to know what measures will inform you if and when you achieve the goal and outcomes. Assessment of progress toward achieving a goal is crucial in maintaining the effectiveness and efficiency of the effort. The institution within which the department resides has been investigating the issue of equity gaps on an institution-wide basis for several years. Hence, they had already begun collecting a large amount of data specifically identified in the "Metrics and Data" section of the "How do we know when we get there?" quadrant. In our context, we recognized that our role was to encourage the faculty to consider what the outcomes of the process might be from a holistic and qualitative perspective as evidenced by the questions listed under the "Outcomes" section in Fig. 7.1. These types of questions had not been addressed or discussed explicitly by the Target Department as part of—or in response to—the university data gathering efforts. Given that our visit was the beginning of the process, we focused on having stakeholders envision these final outcomes as a way of moving toward consensus and common vision. Utilizing the structure of Backward Design, and to get a sense of what the visions of various stakeholders were and whether they were consistent, in many cases one of the final questions we asked was "If the effort to eliminate the equity gap is successful, what will this department look like in 5 years?"

Informed by the previous experiences and expertise of the consulting team, our KQM became a living document that was approximately 90% complete before the first consultancy conversation. Further questions were added, and changes made to the document, during the visit.

7.4 The Consultancy: Application of the Key Question Matrix

Our consultancy visit extended over one and a half days. We worked with the institutional coordinator to arrange a series of information-gathering meetings involving many of the stakeholders who were involved in the undergraduate academic experience for students in the Target Department. These included students, faculty within and external to the department, academic leadership including those within the college and outside the college at the university level, and units involved in supporting the improvement of inclusion and equity at the university.

Within the context of Backward Design, our task as consultants was to help the Target Department begin the process of uncovering information and insights about the current state of the department that could help them build a path towards achieving their specified goal. The four outside quadrants of the modified KQM describe the types of questions that needed to be answered and information that needed to be gathered to lead the Target Department toward that goal. Our task was to ask appropriate questions, listen to the responses, and then synthesize a report that we shared back to them summarizing what we heard in an organized and coherent way. Thus, each of our interactions with stakeholders was guided by questions from our KQM that we used to gather relevant information with a secondary goal of prompting them to think about the goal of increasing student equity in the department. We did not seek to answer every question; rather the questions helped us frame the discussion with various stakeholders. At the same time, we acknowledged that as we gained additional information and new insights we might need to revise or refine the questions in our KQM. In addition, we recognized that there could be as-yet-unidentified issues that underlay the stated goal of addressing equity gaps.

7.5 Information Gathering with the Key Question Matrix

The modified framework was used to guide discussions with various groups across campus in a series of one-on-one and group discussions. Having completed a strong first draft of the KQM framework (Fig. 7.1) allowed us to enter each meeting with antenna raised, using each stakeholders' voice to help paint a picture of the current state of the Target Department. While many of the questions helped directly answer the questions in the "Who is the Department?" and "Who are our students?" quadrants, much of the "How do we get there?" questions were addressed when discussing realities of the department and visions of stakeholders.

The following section details how our meetings with each group of stakeholders, informed by the KQM framework (Fig. 7.1), were used. Meetings generally ranged in length from 45 to 75 min.

1. ***Students***

We spent about 75 min over lunch talking with seven students about their experiences and impressions of the Target Department. Students ranged from first-year students to upper-class majors and included one transfer student. These students came predominantly from historically underserved groups in science fields and included several first-generation college students. To allow for honest and frank conversation, we split the group of students into three smaller groups, with each of us talking with just two or three of the students. To open up dialog in these small groups, we let students know that we had been brought to campus to help the Target Department achieve the goal of decreasing the equity gap; we then proceeded to dig into the questions in the "Who are The Students?" quadrant of the framework. Once a rapport was established, we brought the small groups back together and had a whole-group conversation. After building trust with the students in small groups, our large group discussions were wide-ranging; the students were open and willing to share their thoughts and ideas.

These conversations provided significant insight into the overarching questions "Who are the students?" and "Who is the department?" Although there were some comments about curricular issues (related to both specific courses and overall structure), the main themes that emerged related to classroom and departmental culture—and the roles of students and faculty members in those cultures.

Students talked about introductory courses being too large, and even when faculty tried to implement evidence-based teaching practices the students felt uncomfortable asking questions or even interacting with other students. While we were aware that some faculty were trying to incorporate active learning in class, these student voices highlighted the mixed experiences students had in the implementation. Students discussed the vast resources available from the department (mentoring and research opportunities for undergraduate students) but highlighted that there was a lack of transparency for how to access these resources—highlighting barriers of belonging for students from historically underserved groups, first generation, and transfer students who don't have a parent at home telling them to seek out these opportunities. Other students described how their personal financial situations and outside commitments have a significant impact on their ability to take advantage of departmental opportunities, even if they were aware of these opportunities. Students also mentioned their perceptions of the range of perspectives held by faculty members concerning issues of diversity and inclusion. Hearing directly from the students, the constituents whose outcomes were the target of this change effort, provided insights that complemented and expanded those provided by other stakeholders and provided us with a more complete picture of the current environment.

2. ***Institutional Stakeholders***

To provide a broader context to our efforts, we met with a variety of individuals who play a role in the experiences of the students and faculty, including the leader

of a program providing support to underrepresented students in STEM, and the director of the First-Year Experience program. We also met with individuals involved in promoting diversity and equity across the institution, a leader of institutional advising, and the Dean of the College of Arts and Sciences. The meetings with individuals involved in student support services helped address some of the questions in the lower half of the diagram: "How do we get there?" and "Who are the students?" For example, we learned that there are many university-wide programs in place providing student support services, particularly for students from underserved groups and first-generation students. We also learned that, unfortunately, in many cases, these programs do not have sufficient funding to serve all of the students who qualify for inclusion. In our conversations with faculty and students we discovered that knowledge about these programs—what they did and how students could access them—was uneven across department members and students. Conversations with institutional administrators provided some insights into these aspects but also into issues in the upper right quadrant: "Who is the department?" Among other things, we learned about ongoing on-campus opportunities for faculty professional development (including a diversity and inclusion summer institute) and a perceived need for additional faculty training to better support students who are experiencing mental health issues. The perspectives of these "outsiders," especially those in positions that provide access to both student and faculty views, were very valuable in providing information and context for our work.

3. ***Faculty***

(a) Outside of the Target Department

Based on typical programs of study, many students taking courses in the Target Department also regularly engage in courses in other departments; in particular, at the introductory level there is significant overlap with courses in another STEM department that we will refer to as "Department Z." We met with three members of Department Z, one of whom was the current Chair. Insights were gained on the overall institutional context ("How do we get there?"), particularly as it relates to STEM departments, including ways in which the university administration has supported Department Z's implementation of more active learning instructional approaches to take advantage of a new building designed for that purpose. Because many of the students are common to the two departments, these faculty members could provide their own perspective on the "Who are the students?" quadrant.

(b) Within the Target Department

We met with small groups of departmental faculty members over the course of the first day, primarily focusing on the questions on the right side of the diagram: "Who is the department?" and "Who are the students?" Faculty members provided insights into their perspectives on who their students are, particularly noting perceived strengths and weaknesses.

The final session of the visit was a meeting to which all members of the Target Department—both core and peripheral—were invited. This session used a process

designed to elicit individual perspectives that could be discussed collectively. Faculty members were first asked to write responses to the prompt "What are the challenges and supports for reaching the goal of decreasing the equity gap in this Department?" on individual sticky-notes, one idea per sticky note. After generating these responses, individuals were asked to place their individual notes one at a time on one of five different boards with these categories: Students [lower right quadrant], Faculty [upper right quadrant], Administrative/Institutional, External, [lower left quadrant] and Other.

To build a better understanding of each other, all participants completed a gallery walk, rotating among the five boards to read what others had written. We then asked them to respond individually to a second prompt: "What are some ideas of how to maximize success for all students?" After these ideas were generated on sticky notes, they were again placed in a separate space on the large boards. Participants were given time to read all of the responses, followed by a discussion of what they saw and what insights they gained from the experience.

4. ***Across all groups***

One of the final questions for our meetings with all constituents across our visit was taken from the Outcomes section of the upper left quadrant ("How do we know when we get there?"). We asked people with whom we met to describe what the Target Department would look like in five years if effective changes were made. We received answers both as statements and as questions, and shared representative responses with the department in a way that shielded the identity of the respondent and their position within the institution. A few examples include:

- All faculty participate in training to support students dealing with transition to college, mental health, and development of study skills.
- Students would be aware of available resources very early on.
- Revisions to laboratory curriculum, including support for quantitative skill development.
- Shared understanding of culture among faculty and students.
- A shared departmental vision of what constitutes "success" in terms of addressing the equity gap and overall student outcomes.

The full list provided an excellent starting point for the department as they plan for any changes and assess progress toward their goal.

7.6 Recommendations

After the consulting team left the institution, we synthesized what we had learned from the entire consultancy into a cohesive summary report of our findings and recommendations. Having used the CTeAM KQM framework to structure and frame our experiences, we were readily able to recognize themes that arose and triangulate across different constituencies. The report summarized the information that we had

obtained from various stakeholder groups within and outside of the Target Department, including the results of the final "gallery walk" exercise described above. Finally, we provided a set of recommendations for next steps that would move the department forward from where we observed them to be towards where they want to be in five years.

We noted that the Target Department was well positioned to begin the process of addressing the challenge of an existing equity gap. We suggested that they could be better situated to achieve that goal by working together to:

1. develop a stronger (and collective) understanding of best practices in inclusive instruction and high-impact practices; and
2. obtain a collective vision of the department and its members view of their roles in eliminating the equity gap.

The federally funded project that supported this visit also provided additional financial support for relevant professional development activities. This enabled us to recommend some additional professional development experiences to the Target Department:

- host a professional development workshop for faculty that would provide a broad background in evidence-based practice and inclusive instruction, helping to provide a foundational understanding of issues of diversity and equity in a STEM department; and
- follow this experience with a one-day department retreat led by individuals with extensive experience in facilitating departmental strategic planning and vision-building discussions.

We reasoned that the initial workshop would provide a unifying and common experience for the Target Department, allowing future discussions to be based on a similar knowledge base. The second experience would help reinforce the outcomes of the initial workshop and would begin the process of building a departmental vision for a future in which the equity gap had been reduced or eliminated.

7.7 Summary

The CTeAM Key Question Matrix provides a robust framework for undertaking a process designed to produce change at an organizational level. Our consultancy team made modifications to the KQM that were appropriate for our context. We then used this modified KQM to guide our information-gathering processes with various stakeholders at the institution, providing a consistent and effective structure to our interactions with individuals and groups and allowing us to uncover common themes and areas of concern. In other contexts that involve actions undertaken by collaborative teams, the C-TeAM KQM can be analogously modified to serve as a framework for achieving any goal or vision.

Neuroscience Connections

At the core of the CTeAM Key Question Matrix is goal setting. The model recognizes that setting specific goals make the invisible path visible. The process used to create group outcome goals benefits from input from individual stakeholders. Integrally involving individuals in establishing project goals can literally alter the structure of the brain in such a way that allows for behaviors that ultimately lead to successful achievement of the goals. Buy-in from individuals leads to an emotional connection to the envisioned outcome. In addition, challenging goals that have strong emotional components alter the brain more quickly and therefore create an even stronger drive for success.

Another key component of application of the CTeAM Key Question Matrix is that it promotes the use of extensive "conversations." Social constructivism suggests that shared dialog leads to deeper understanding and at the same time activates a number of shared neurological and biological team functions including; activation of mirror neurons, brain wave synchronization, as well as shared heart rates and even breathing rhythm alignment.

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Chapter 8
EMBeRS Model for Facilitating Crossdisciplinary Learning and Systems Thinking

Deana Pennington, Kate Thompson, Shirley Vincent, and David Gosselin

Abstract This chapter will introduce the Employing Model-based Reasoning in Socio-Environmental Synthesis (EMBeRS) Framework for facilitating learning across disciplines and integrating those perspectives to address specific wicked problems.

Keywords Knowledge integration · Interdisciplinary teamwork · Interdisciplinary learning · Systems thinking

CTeAM Connections

- How do you get them there? (Methods/Strategies)
- Where are we going? (Goals/Vision)

(Planning with the end in mind)

D. Pennington (✉)
University of Texas at El Paso, El Paso, TX, USA
e-mail: ddpennington@utep.edu

K. Thompson
Queensland University of Technology, Brisbane, QLD, Australia
e-mail: kate.j.thompson@qut.edu.au

S. Vincent (✉)
Vincent Evaluation Consulting LLC, Tulsa, OK, USA
e-mail: shirleygvincent@gmail.com

D. Gosselin
Environmental and Sustainability Studies and School of Natural Resources, University of Nebraska-Lincoln, Lincoln, NE, USA
e-mail: dgosselin2@unl.edu

D. Gosselin (ed.), *A Practical Guide for Developing Cross-Disciplinary Collaboration Skills*, AESS Interdisciplinary Environmental Studies and Sciences Series, https://doi.org/10.1007/978-3-031-37220-9_8

8.1 Introduction

In view of the many, complex socio-environmental systems challenges confronting humans, the need to work together across disciplines on wicked problems has become a central challenge. Although the need is clear, the school of hard knocks has taught us that it is not easy to accomplish this work. To date, many teams that attempt this kind of work use approaches that have been learned from their own experiences. Yet interdisciplinary teams have been studied for a number of years, and much is known from those observations. Science should inform our understanding of interdisciplinary research teams. One element of interdisciplinary teamwork that has proven to be extraordinarily difficult is integration of deep knowledge across diverse disciplines [9]. Palmer et al. [13] note that without intervention many teams do not develop a shared vision of the research problem and how to integrate their expertise to address it. They also note that skilled facilitators can be effective in this area but are in short supply. The EMBeRS Framework is an attempt to synthesize high-level, generalized understanding of knowledge integration across disciplines and generate a theory-based, systematic approach for effectively facilitating group work across disciplines that can be followed by instructors and team leaders without facilitation training. Its import lies in its provision of a basic "recipe" for early interactions among team members that has the capacity to be replicated in many contexts.

8.2 Goal

The goal of this chapter is to introduce the EMBeRS framework in a straightforward, understandable way that can be easily implemented without needing to understand the learning, social, organizational, and cognitive science background that went into its formulation.

8.3 Approach

The EMBeRS Framework draws on learning, cognition, organizational and social theories to provide a template for developing interdisciplinary team-based activities that helps teams overcome the barriers to knowledge integration, in order to generate integrated conceptualizations of the problem and a shared vision for the research that a team is undertaking [14]. The Framework uses a generative, organic process whereby a shared vision is collectively created (co-created) by all team members. The process is facilitated with light structuring of discussion that targets learning key concepts of the research interests of participants from different disciplines. Although there are other strategies for designing co-creative activities with learning among the participants being one intended outcome, EMBeRS is unique in its explicit focus on

enabling such learning, guided by current understanding of how learning, which is an individual cognitive process, is impacted by group experiences.

The EMBeRS Framework conceives of knowledge integration across disciplines as dependent on the interplay between multiple individual and disciplinary factors (Fig. 8.1). Following Misra et al. [8], we subdivide these factors as concepts, skills, and behaviors (CSB) and values, attitudes, and beliefs (VAB). CSBs are factors that are most readily observed in individuals (e.g., knowledge, skills, interests) or disciplines (e.g., phenomena of interest, theories, methods, vocabulary). VABs (Values, Attitudes, and Beliefs), conversely, are deeply embedded factors that may be difficult to observe or articulate but, nevertheless, drive the way individuals and groups interact [1]. EMBeRS activities typically focus on development of individual and group CSB, while recognizing the importance of surfacing and managing VAB [2] provide approaches to exploring the VAB of team members in more detail. The Toolbox Dialogue Initiative (TDI) provides a research-based, tested mechanism for surfacing disciplinary VAB (see O'Rourke et al., This Volume). The remainder of this chapter describes EMBeRS activities that target the integration of individual and disciplinary CSB among team members. For a more comprehensive description of the EMBeRS Framework see Pennington et al. [14].

EMBeRS activities aim to generate creative, integrative new conceptualizations that leverage individual and disciplinary differences and expertise among team members using co-creative, model-based reasoning. Model-based reasoning theory posits that human's reason by constructing an internal mental model of the situations, events, and processes that they encounter, and that external representations can be used to facilitate construction of these mental models [10]. External representations include the use of visual models, diagrams and/or other representations for abstraction and communication of complex concepts. Such external representations have been studied in a wide variety of disciplines, and have been called boundary objects [16] and material artifacts [4], among other terms. We use the vocabulary of boundary objects because that terminology is in widespread usage. When boundary objects are

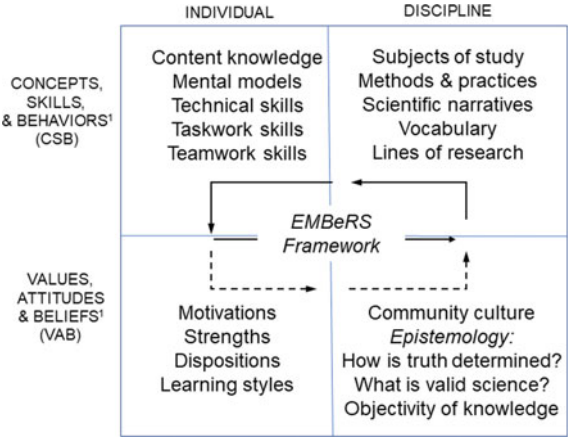

Fig. 8.1 The EMBeRS Framework, showing examples of individual and disciplinary factors that influence group dynamics in research teams [14, 8]. Modified from Pennington et al. [14]. CSB and VAB categories are from Misra et al. [8]

Table 8.1 Characteristics of activities developed using the EMBeRS Framework

Problem- and place-based
• Problem-based—Small groups learn and share content knowledge about the problem, with the goal of developing a shared vision for defining and addressing the problem
• Place-based—Socio-environmental research teams are more successful when they focus on a particular geographic place. The place becomes a boundary object
Attention to process
• Participatory—Facilitation ensures that everyone has a turn
• Semi-structured, experiential activities, potentially sequenced
• Co-creative—Everyone puts forth new ideas and draws on others' ideas
• Provide time for individual thought about the task followed by group co-creation
• Cycle divergent (exploratory) and convergent thinking
• Iteration and progressive refinement
• Purposeful individual and group reflection on the process
Incorporation of boundary negotiating objects
• Every activity includes drawing, diagraming, charting, etc.
• These are co-created through the above process

used in a co-creative way to generate linkages across perspectives, they are referred to as "boundary negotiating objects," [6]. Hence, the EMBeRS Framework provides a template for the co-creation of boundary negotiating objects using a structured negotiation process that facilitates the sharing of and reasoning across perspectives. Specifically, the EMBeRS Framework includes the elements in Table 8.1

8.3.1 Facilitation and Structure

A key feature of the EMBeRS Framework is lightly structured individual and group activity around any kind of visual representation. The facilitator must ensure that all participants are contributing, actively listening to each other, and trying to make sense of how the differing perspectives contribute to a larger picture of the problem, all of which are essential for group learning to occur. This requires a careful balance between top-down structuring of activity and bottom-up group processing. There should be some guidance and instruction, but the bulk of the time should be dedicated to individual work and teamwork designed to organize, represent, and share knowledge within the group.

8.3.2 Sequence

EMBeRS activities have been used in research team meetings, graduate training workshops, and formal classes. They are "recipes" that can be modified as desired for a range of contexts.

Each activity follows a six-step pattern that together last roughly 3 h, if done in entirety and with a short break in the middle. Depending on the context an activity can be completed during a half-day workshop or split over two class periods. The typical pattern is:

1. Introduction to the activity (10 min);
2. Time for individuals to develop a visualization that organizes each person's thinking (15–20 min);
3. Share individual visualizations within small groups (45 min):
4. Discussion of ideas (15 min);
5. Co-creation of an integrated visualization (60 min); and
6. Reflect/debrief about the activity (10 min).

8.3.3 Activity Templates

The EMBeRS project currently provides fifteen standard activities, available on the EMBeRS website. These activities can be sequenced to achieve the progressive iteration required to integrate team knowledge and understanding so a shared vision and an integrated conceptualization of the problem can be developed. A logical order for using the activities is provided, but they can be combined in different sequences to meet team needs. Two activities, "Share Your Research" and "Mock Solicitation" that have been used sequentially in many different contexts are described next. Precise step-by-step instructions are given in the Supplemental Documents for Pennington et al. [14].

8.3.4 Share Your Research

The goals of this EMBeRS activity are: (1) team members learn about each other's research interests at a high level, acquiring foundational concepts and vocabulary necessary to develop integrated objectives for crossdisciplinary research projects; and (2) identify challenges commonly encountered while attempting to learn deep knowledge from other disciplines and develop strategies for overcoming the challenges.

A facilitator assigns participants to groups of three to five people, with a view towards achieving diversity among multiple dimensions, especially discipline and gender. Prior to meeting the first time, each participant is asked to submit a one slide description of who they are, where they work, research keywords, and something interesting about themselves.

The activity begins with a ten-minute ice breaker based on the slides. Concept mapping is introduced with examples provided (See [11] and subsequent publications for more details on concept mapping). Participants are given large sheets of paper, markers, and sticky notes with which to draw a concept map of their research. They are told to start by listing six to ten keywords on separate sticky notes, place them on the paper and start drawing linkages between them, adding keywords as needed. Sticky notes facilitate moving concepts around on the map, although linkages are difficult to change. The free online tool Miro provides this functionality digitally and has also been used effectively. In some contexts, participants have been given written instructions on concept mapping and Miro in advance, so that they come to this activity with their diagram of their research already complete.

A 30-min presentation is given about mental models and reasoning with external representations, using concept maps as an example. Key interaction concepts such as turn taking, jargon avoidance, active listening, and questioning for understanding are emphasized. Participants are told they will be explaining their research to each other, and that it is very important that they stay focused, do their best to explain and listen well, and not be distracted by text messages, email, or worrying about what they will say when it is their turn to explain. They are also instructed to jot down a few words whenever a teammate says something that they connect with, even if the connection is vague, to spur their memory of the idea later in the activity.

The team activity begins with timed turn taking as each team member explains their research to their team, using their concept map as a visual aid. Generally, eight to ten minutes is sufficient for each person. After each has presented, they are instructed to pass their visual to the person on their right, and one at a time, in one or two minutes, explain the research of the person's visual they are holding! This always generates groans and laughs. Once that is finished, the point is made that because they are learning new information, even if they understand what is being said at the time it is said, it is difficult to retain it—much less connect it to their own mental models. Vague connections that are identified during the discussion that could provide a basis for making important linkages across disciplines are lost. This is an opportunity to talk about mechanisms to improve retention, such as listing potential connections the moment they are thought of, sharing visuals afterward in a way that is accessible to all team members through time, and re-summarizing research often.

The post-activity group reflection consists of each team working together to generate two lists: (1) what made this activity difficult; and (2) what things helped overcome the difficulties. The lists are compiled into two comprehensive lists. This can be accomplished a number of ways, either verbally or if time allows, having the teams use sticky notes for each item and do a collaborative clustering activity on a whiteboard. Each cluster is discussed as a group. Then lists of factors influencing teamwork drawn from the teamwork literature are provided for comparison [9, 17].

In most cases, participants identify most of the factors from their own experience, although student participants may not recognize the importance of institutional and societal factors.

8.3.5 Mock Solicitation

The goal of this activity is for team members to identify and begin to develop potential linkages between their areas of research. This activity is always used after Share Your Research, either immediately after or sometimes separated by one or two other activities.

The facilitator presents vocabulary, including the terms multidisciplinary, interdisciplinary, transdisciplinary, and cross disciplinary, emphasizing the continuum of increasing conceptual linkages across disciplines. The presentation should point out that all new teams from diverse disciplines begin as multidisciplinary and strive to develop into inter- or transdisciplinary by growing linkages between team members. This is an organic process that takes time and results in the *emergence* of integrated conceptualizations. The presentation can optionally go over system terminology and collaborative teams as distributed cognitive systems (sensu [4]). This is especially useful if participants have had prior discussion of socio-environmental systems and systems thinking. The facilitator explains that in this activity, team members will search for potential linkages between their areas of research. These are not necessarily intended to be researchable linkages, but rather, a starting point for identifying interesting linkages that could contribute to framing collaborative research. They should be reminded of the best practices for engaging across disciplines, namely turn taking, jargon avoidance, active listening, and questioning for understanding without distraction by cell phones, email, or thinking about what they will say when it is their turn.

Team members retrieve their concept maps and list of potential linkages from Share Your Research. Each team member is given two or three minutes, in turn, to review their visual from Share Your Research with their team. After each has presented, they work individually drawing a new diagram (on paper or in Miro) illustrating their ideas of potential linkages between their research and the research of other team members. They are given approximately 15–20 min for individual work. Then, they go through another turn taking round, each sharing their ideas about potential linkages with their team and discussing the different ideas.

Once that is complete, they co-create a new concept map that combines their different ideas. The facilitator should remind them that they should strive for interdisciplinary conceptualizations that link concepts across disciplines—rather than multidisciplinary which juxtaposes research they could each do by themselves. An hour (or more) is typically allocated for this. When the teams have finished, each team reports out, using their co-created concept map as an aid for explaining the way they have integrated their research.

Group reflection, similar to that in Share Your Research, focuses on the group articulating the difficulties they encountered in this activity and things that helped overcome those difficulties. This can be accomplished in many ways: open dialog, small group brainstorming, or a full group clustering activity.

8.4 Implementation Stories

Educational implementation stories are described in Habron (This Volume) on using EMBeRS in undergraduate courses and workshops, and Pennington (This Volume) on using EMBeRS in a graduate course.

The two highlighted activities, Share Your Research and Mock Solicitation, have been used in almost every workshop provided by the EMBeRS team. These are considered core EMBeRS activities that establish a fundamental base of skills needed for knowledge integration from which other activities can be developed to meet unique workshop goals. Examples of implementation of these two activities include:

- Graduate training workshops for interdisciplinary research programs. The EMBeRS project was funded by the NSF to develop and implement two, ten-day workshops for Ph.D. students from around the U.S., recruited from large, NSF-funded water sustainability projects. Students were from many different institutions and represented a wide range of disciplines. They were assigned to teams of three or four students from different disciplines and with different research interests. They were coached through sequences of activities based on the EMBeRS Framework and taught how to design their own EMBeRS-based activities. Follow up contact indicated many, if not most, students were excited about the approaches they learned and applied them in many different contexts. These workshops are described in detail in Thompson et al. [18] and outcomes from evaluation in Pennington et al. [14]. Students published their perspectives in Killion et al. [5]. Shorter graduate and undergraduate workshops have been conducted in conjunction with the NSF-funded Urban Water Innovation Network (https://erams.com/UWIN/) and the NSF-funded Interdisciplinary Training, Education and Research in Food-Energy-Water Systems (InTERFEWS) project (https://erams.com/interfews/).
- Postdoctoral Research workshops. EMBeRS grew out of a National Center for Socio-Environmental Synthesis (SESYNC; https://www.sesync.org/) initiative (https://www.sesync.org/project/pursuit/embers). After the SYSYNC project ended, in several subsequent years an EMBeRS workshop was included in their Immersion Workshops (https://www.sesync.org/resources/sesync-immersion-postdoctoral-program). In 2020 the workshop was held virtually due to the pandemic. Presentations were videotaped in advance and are available through SESYNC's YouTube channel (https://www.youtube.com/watch?v=BiyHgvJ9v50).

- Faculty training. Early in the development of EMBeRS it was implemented in two faculty training events. The first was at Texas Tech for the Provost's Interdisciplinary Academy and the second was at Louisiana State University. Faculty training has also occurred through numerous conference workshops at the Annual Meeting of the Association of Environmental Studies and Sciences.
- Research teams. These are responsive to requests for facilitation and are implemented in a less formal manner. Examples include work with a USDA-funded research team studying water resources in a semi-arid region; a community of researchers seeking to build research networks around water resources, and group initiating work on a large National Science Foundation grant proposal.
- Stakeholder workshops. The EMBeRS Framework is currently being used to develop and implement activities during NSF-funded stakeholder participatory modeling workshops, centered around investigation of the combined use of concept maps and online models that generate future scenarios of environmental change as BNOs for integrating stakeholder perspectives.

The EMBeRS Framework has been used by people outside of the EMBeRS team. Most notably many of the students whom we have trained in workshops have contacted us and reported using their new knowledge and skills in a wide diversity of applications: developing and communicating their dissertation research plans to committee members; preparing collaborative research proposals; working with teams and stakeholders engaged in transdisciplinary research projects; in everyday communications with colleagues; and in undergraduate and graduate courses they teach.

Neuroscience Connections

The EMBeRS model provides a process by which team members can explore the different mental conceptualizations/mental models for complex problems that each person brings to the team. Differences in mental models can be significant between team members. These conceptual differences result in challenges to creating a shared vision. Through the use of model-based reasoning, experiential learning, reflection, and reflective discourse, team members can learn from each other and increase neural connections (i.e., neural synchrony) among team members. EMBeRs promotes divergent thinking along with convergent thinking. Divergent thinking, a thought process, or method used to generate creative ideas, is employed for the generation of new ideas and solutions. Opportunities for convergent thinking focuses on the application of these new ideas and solutions.

The use of concept mapping to share conceptual understanding takes advantage of the fact that approximately 68% of our sensory neuro networks are dedicated to vision. Vision trumps all other senses. "We are incredible at remembering pictures. Hear a piece of information, and three days later you'll

remember 10% of it. Add a picture and you'll remember 65%" [7]. The integration of concept maps is in some respects a way of storytelling. Our brain is basically a pattern seeking organ. Concept maps create patterns. This along with the inclusion of case studies in this chapter is a powerful tool for building understanding and neurological connections. When we see or hear a story, the neurons in our brain fire in the same patterns as the presenter, a process promoting neural synchrony and powerful connections among team members.

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Resource Collection

19. Employing Model-Based Reasoning in Socio-Environmental Synthesis (EMBeRS) website: http://embers.cybershare.utep.edu/ (see the Resources menu item).
20. SESYNC YouTube channel videos (https://www.youtube.com/watch?v=BiyHgvJ9v50).

Chapter 9
Implementing EMBeRS in Graduate Courses

Deana Pennington

Abstract This Chapter will help those designing interdisciplinary graduate-level environmental courses to incorporate evidence-based approaches using the EMBeRS Framework (see Chap. 8, This Volume) exemplified by a graduate course developed over seven years at the University of Texas at El Paso (UTEP).

Keywords Graduate education · Interdisciplinary education · Interdisciplinary collaboration · Integrated conceptualization

CTeAM Connections

- How do you get them there? (Methods/Strategies)

9.1 Introduction

Graduate students being trained today will almost certainly be expected to work in teams throughout their careers, whether those careers are in academia, industry, government, or non-governmental organizations. Recent surveys and reports indicate that students are not graduating with the requisite skills needed for this work [2]. Although most (if not all) interdisciplinary graduate programs offer interdisciplinary courses, these are most often designed in ad hoc, although thoughtful, ways. This Chapter provides a relatively generic starting point for faculty designing such courses, yet adaptable to the thematic focus of their course.

D. Pennington (✉)
University of Texas at El Paso, El Paso, TX, USA
e-mail: ddpennington@utep.edu

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9.2 Goal

The goal of this chapter is to provide a template for designing a graduate level course using the EMBeRS Framework (see Chap. 8, This Volume) to develop student competencies for interdisciplinary teamwork and systems thinking, applied to any thematic focus of the course. An implementation example focused on water sustainability in semi-arid environments will be given.

9.3 Approach

Overview of EMBeRS. The EMBeRS Framework synthesizes theories from the learning, social, and organizational sciences, among others. It takes a constructivist stance, which posits that learners construct new understanding through experience and social discourse. The Framework structures social discourse by iterating between individual reflection and group dialogue, incorporating (co- construction) of "boundary negotiating objects" to enable exchange of information across perspectives [9, 10].

As described in Pennington et al. (This Volume), the typical pattern of an EMBeRS activity is:

1. Introduction to the activity (10 min);
2. Time for individuals to develop an external representation that organizes each person's thinking (15–20 min);
3. Share individual representations within small groups (45 min):
4. Discussion of integrative ideas (15 min);
5. Co-creation of an integrated boundary negotiating object (60 min); and
6. Reflect/debrief about the activity (10 min).

The Framework was developed and tested at the University of Texas at El Paso (UTEP) through two NSF-funded Ph.D. student workshops held in 2016 and 2017.

Overview of the Graduate Course. Beginning in fall 2018, a graduate level course on Interdisciplinary Environmental Problem Solving was developed at UTEP, incorporating the EMBeRS approach and the activities developed through the workshops. The course, which UTEP's Environmental Science M.S. and Ph.D. programs both require, draws students from the natural sciences, social sciences, and engineering. It has been repeated eight times to date with positive student feedback each time.

The course uses an active learning pedagogy, with limited time allocated to lectures and most classroom time spent working in teams. The instructor assigned the teams at the beginning of the course, maximizing diversity along multiple dimensions—especially with respect to discipline, gender, ethnicity, and graduate level. Experience has shown that three team members are optimal, but four can also be effective.

Facilitation Strategies. The instructor employs a variety of scaffolds to facilitate effective teamwork, which are supporting structures that are gradually removed as knowledge and skills are gained. Scaffolds are based on research findings that shed light on key practices that promote creative teamwork. These include equitable turn-taking among team members [11, 17]; making eye contact and correctly interpreting facial expressions [11, 17], and active listening [16]. Class discussion focuses on practices that impede these, such as sending texts, checking email, and working on other tasks. Early in the course the instructor facilitates through prompting each step in an activity; timed turn-taking; reminders about active listening; and guidance regarding the construction of a particular boundary negotiating object to be produced during an activity. During the early activities the instructor carefully scripts the activity using PowerPoint slides that specify what exactly is to be done and the time allotted. For example, the instructor may specify that students have ten minutes to construct a diagram representing their research interests. When the ten minutes ends, the next slide specifies that they will take turns in their teams presenting their research interests. Two slides remind students of the behaviors that should be in place when they are presenting (Fig. 9.1a) and when they are listening (Fig. 9.1b). They may be told they each have six minutes to present their research interests to their teammates using their diagram as a boundary negotiating object. The instructor enforces the six minutes, indicating when it is time to switch to the next team member. Post-activity reflective discourse is used to aid students in identifying the behaviors being facilitated and reasons for encouraging those behaviors. Facilitation is decreased through time as participants progressively monitor their own behaviors and interactions.

Course Design. The course is designed in three major segments (Table 9.1): (1) building generic interdisciplinary teamwork skills (heavily facilitated); (2) developing systems thinking skills applied to a thematic topic (lightly facilitated); and (3) developing the thematic topic (unfacilitated). Activities during the first two segments apply the EMBeRS Framework, although the Framework becomes less explicit

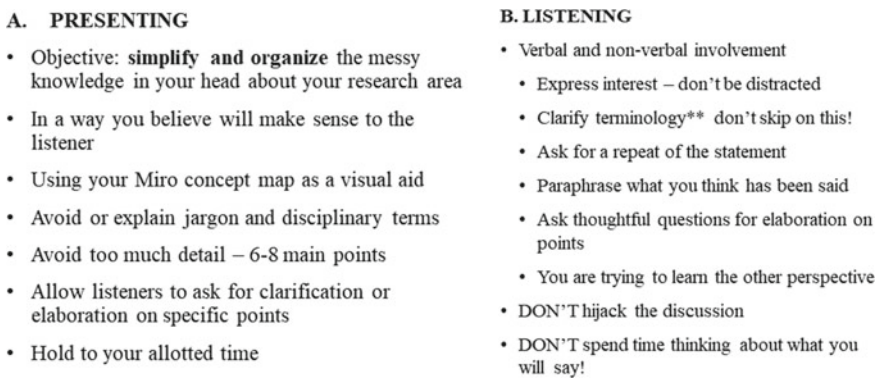

Fig. 9.1 Reminders of beneficial interdisciplinary teamwork behaviors shown to students prior to an activity. **a** Reminders for presenting. **b** Reminders for listening when others present

Table 9.1 Structure of a generic fifteen-week graduate course teaching interdisciplinary teamwork skills and systems thinking using the EMBeRS Framework, embedded in thematic content

WK	Topic	Activities	Reading
Segment 1: Heavily facilitated team and group interactions			
1	Characteristics of interdisciplinary research	Challenges and Opportunities in IDR	
2	Learning across disciplines	Share Your Research; Mock Solicitation	Pennington [8]
3	Individual dispositions; Disciplinary cultures	Trimetrix[Ra]; Toolbox Dialogue[b]	Pennington et al. [10]
4	Group presentation of Mock Solicitation product		
Segment 2: Lightly facilitated team interactions			
5	Thematic introduction	Stakeholder Analysis	Thematic reading
6	Complex problem solving	Explore the Problem Space	Thematic reading
7	Causal mapping	ER Table; Mental Modeler[c]	Gray et al. [3]
8	Causal loops and systems dynamics	Mental Modeler[c]; Loopy[d]	Systems reading tied to theme
9	Group presentation of products from week 5–8		
Segment 3: Unfacilitated team interactions			
10–14	Thematic topics	Thematic activities	Thematic readings
	Group interdisciplinary proposal		

[a] https://www.ttisuccessinsights.com.au/profiling-tools/trimetrix-eq?hsLang=en
[b] https://tdi.msu.edu/
[c] https://www.mentalmodeler.com/
[d] https://ncase.me/loopy/

through time as students progressively acquire the relevant skills and behaviors and automatically begin incorporating them into their teamwork.

9.4 Description of Activities

Segment 1

The first segment focuses on interdisciplinary teamwork skills and is the most heavily facilitated segment. Week 1 begins with a short presentation on the need for interdisciplinary research, drawing on the United Nations Sustainable Development Goals (SDGs) as examples of pressing societal problems that require such collaboration. Students self-select into small groups and discuss the SDGs, commenting on which ones they think are most compelling. A discussion among the entire class ensues, focused on disciplines required to work on one of the goals. Students are directed to move to different sides of the room based on their primary disciplinary affiliation (physical science, social science, engineering, or "other"), to give them a sense

of the disciplinary makeup of the class. A few slides on vocabulary are presented, including the terms "multidisciplinary", "interdisciplinary", "transdisciplinary", and the newest term "convergence." There are many discussions of these terms in the literature; the reader is referred to [4] for one description. This is followed by several slides on the challenges and opportunities afforded by interdisciplinary research (IDR), drawing on relevant literature [6, 7, 12]. Students self-select into small groups for the EMBeRS activity "Challenges and Opportunities in IDR," which directs students to first make a list of several examples of challenges individually in IDR, then combine their lists within their group. The groups then work together to construct a comprehensive list of factors influencing IDR. Their final list is compared with elements from [13], who subdivided factors into individual, teamwork, institutional, technological, and socio-political categories. Usually the combined student list includes most of these, although they may group them differently and they rarely consider the socio-policital factors that impact IDR. The weekly discussion board assignment asks students to write a brief statement about their identity, their discipline, and one interesting fact about themselves. This information will be used to make team assignments, which are emailed to students. They are encouraged to look at the postings by their teammates before the next class. Secondly, students are asked to choose one of the SDGs, comment on its importance, and note the kinds of expertise that might be essential to address it. Students are assigned a light reading that uses a breadmaking metaphor to help them understand the many different factors that impact interdisciplinary research [8]: ingredients with different characteristics (disciplines), mixing bowl (collaboration space), a force to get the ingredients in the bowl (motivation), mixer (team activities), yeast (person/technology spanning boundaries), rising and baking time (collaboration incubation and development time).

Week 2 begins with team meetings. For the remainder of the semester, they will sit at a table with their team and complete all activities with the same team members. They are given a few minutes to introduce themselves to one another, referring to their "one interesting thing" mentioned in the discussion board posting. This week focuses on how we learn perspectives that are different from our own, especially different disciplinary perspectives. It includes a lecture about mental models, how they develop, how they impact the way we see the world, and how different mental models are an impediment to integrating across different perspectives while simultaneously being a source of creative thinking in teams. A video lecture is available from the National Center for Socio-Environmental Science (SESYNC) YouTube channel (https://www.youtube.com/watch?v=BiyHgvJ9v50). Pennington et al. [10] is the assigned reading. Students are walked through the "Share Your Research" and "Mock Solicitation" activities described in Chap. 8 (Pennington et al., This Volume). These activities make use of concept maps, which are keywords connected by links that form propositional statements. Concept maps are widely used in education to externalize student understanding. See Chap. 8 for more information on concept mapping (Pennington et al., This Volume). This culminates with the team co-creating external representations (concept maps) showing their different research interests, and how they were able to integrate them. Experience has shown that in any given class, most student teams struggle with integrating their perspectives and a minority

succeed. However, whether they successfully integrate their research at this point is not the goal; developing their skills for interacting across disciplines is the goal and this approach seems to be quite effective for that. They may or may not succeed in integrating their research, but from the first week they know what is being sought and the challenges they need to overcome, and in this week, they are given tools to do it. They experience how the tools help, and group reflection at the end of these activities reinforces their understanding of that.

Week 3 presentations focus on internal factors impacting IDR including our individual personality, the culture in which we were brought up, and the disciplinary culture into which we have trained making use of a wide variety of studies on these topics. The first activity is focused on surfacing personal characteristics and can make use of any freely available tools. The Myers-Briggs tool or other survey instruments could be used to reveal learning, communication, or interaction styles. The TriMetrix® tool listed in Table 9.1 (Gosselin and Bonnstetter, Chap. 4, This Volume) is another possibility. Students may need to take the survey before class, depending on the tool and time involved. Most of these tools generate a categorical assignment. The point is made that there is no better or worse category. Students are asked to share their category with their teammates and mention to what degree they agree with the category assigned. Then they move to different parts of the room depending on which category the tool indicated they belong in. The point is made that students are all over the room and they need to be aware these differences exist. The next presentation introduces the idea that disciplines have their own culture and that students' perspectives are shaped by their disciplinary background and training. The class uses selected questions from the Toolbox Dialogue [1] to drive class discussion around disciplinary differences in motivation, communication, methodology, values, and views of the nature of reality.

Segment 2

Segment two is still facilitated in terms of activity design, but individual behaviors are only lightly facilitated, mostly by reminding students of the principles in Fig. 9.1, sometimes verbally and sometimes using the same slides. This segment focuses on systems thinking, a principal goal of many environmental science courses. Environmental systems require thinking comprehensively. Yet, how does one do that? Many courses jump into systems dynamics and causal loops. Students may not be ready for that jump. First, they must embrace the complexity of the system they want to analyze. In this course, we prompt a free flow of ideas about all the things that might be important to the system. We do this first by looking at the problem from different stakeholder perspectives. Students are assigned stakeholder roles, which they play with the Stakeholder Analysis activity. Each team member is assigned a different stakeholder role. They learn about that perspective using whatever media are available about the theme of interest. Newspaper media have been quite effective at achieving this, rather than journal articles. They each develop a visual representation of the problem from their stakeholder's perspective. They get into new groups representing each stakeholder role and take turns explaining their understanding of that stakeholder's perspective. They have group discussions to develop a more comprehensive understanding. Then,

they return to their original groups, take turns explaining their stakeholder's perspective, and develop a table that integrates all stakeholder perspectives. Next, they are asked to find and read a recent research article from their discipline that is related to the thematic topic. In the "Explore the Problem Space" activity they co-create a comprehensive team concept map of all aspects of the theme they are collectively aware of, including research and stakeholder perspectives. Subsequent weeks work towards progressively structuring their comprehensive understanding in different ways. First, they transform their free-form concept map into a structured causal map that forces them to specify entities and measurable properties of the entities using the free online tool Mental Modeler. Then they add additional structuring by generating a systems dynamics model using the free online tool Loopy. These activities are largely unfacilitated. At the end of the second segment, teams give group presentations that show the different representations the team produced and talk about each of their contributions to the representations.

Segment 3

The third segment draws on the prior team interactions and representations and is mostly unfacilitated. At this point during the course, students are almost all interacting well across disciplines and there is no longer the need to facilitate interactions. The third segment continues hands-on, active learning activities that consider the EMBeRS framework without explicitly using it. Activities still provide time for individual reflection before team co-creation. All activities continue to have a boundary negotiating object. The specific activities used have varied substantially through time. However, every implementation of the course has ended with students being given two weeks to work with their teams to create a short interdisciplinary research proposal. They are given guidelines about what should be in the proposal (e.g., introduce the problem and question of interest, state its significance, methods, and an explicit discussion of linkages across disciplines), its length, and its structure. This written proposal serves as their final exam.

Purposefully leading students to the point where they can produce an integrated proposal without the need for facilitation is where this course deviates from most other interdisciplinary environmental science courses. The course structure seems to be very effective for that. Almost all teams (~40 over eight implementations) are able to produce a final proposal that is truly integrative. In fact, they often comment during the final class discussion that they do not understand why there is such difficulty conducting research across disciplines. The entire course has been composed of well-thought-out scaffolds to help them come to this conclusion. Engaging across disciplines has become ingrained in their perspectives and their culture during the course. Based on the outcomes from the original NSF-funded workshops, it appears that students can translate that learning into a wide range of other contexts [10].

Assessment. Assessment is based on both individual work and products from teamwork. In the middle and at the end of the course they are required to do formal evaluations of their teammates. There are several online free tools available for this. Reading assignments are given each week except when group presentations are due.

Students do reflective writing about the reading. The course also requires students to use a discussion board throughout most of the semester. Team products are more challenging to assess. Since each individually constructed external representation is unique and the team co-creates completely unique products, grades are not based on the exact content incorporated into these products. Instead, evidence of effort towards fulfilling the instructional requirements is considered. In most cases, students receive an A on the group products unless it is clear that a particular student has not contributed, or the group proposal does not follow the guidelines. Since the learning outcomes for this course are inherently focused on behaviors, skills, and attitudes rather than specific content, students who participate and do the work receive an A in the course.

Among other measures, a validated pre- and post-training survey was used during the workshops, the Transdisciplinary Orientation (TDO) Scale [5]. The TDO measures change in two dimensions: (1) concepts, skills, and behaviors (CSB); and (2) values, attitudes, and beliefs (VAB). Students participating in the prior workshops showed statistically significant increases in their TDO scores [10]. The TDO survey was given during Spring 2018 at the beginning and end of the semester, with results similar to those of the workshops. Of the ten graduate students who took the course and completed both surveys, nine showed an increase in TDO, four with gains exceeding 4 points on a scale of 1 to 12, with only one student showing a 4-point decrease in TDO.

9.5 Implementation Stories

The UTEP implementation of this has revolved around water resources in semi-arid regions. This is a critical issue in the El Paso region, which many local students are somewhat familiar with. But that is not the main reason for choosing this topic. Almost all environmental science research topics can be related to water in some way. It is a unifying topic for the course to focus on, recognizing that some students may have difficulty translating their research to a water-related problem. The course has built in scaffolds to help them do that, in terms of assigned readings that have them look for water-related research in their area and guest lectures from experts in these issues (Table 9.2). Although it is not perfect, few other topics can connect with so many research interests. Yet it is essential to have a focal topic around which teamwork skills can be developed. This is consistent with anecdotal observations that interdisciplinary environmental research teams gain traction more easily when working on place-based problems.

The implementation of the course, especially Segment 3, has changed dramatically over time. This is in part due to the rapidly changing availability of new methods and tools, but also the difficulty finding methods and tools that are both useful and also quickly learned by students. Undoubtedly that will continue to be the case. Nevertheless, the generic framework has been mostly stable through time. Students need to first learn how to interact, how to communicate across disciplines, how to

Table 9.2 Structure of a customized fifteen-week graduate course teaching interdisciplinary teamwork skills and systems thinking using the EMBeRS Framework

WK	Topic	Activities	Reading
Segment 1: Heavily facilitated team and group interactions			
1	Characteristics of interdisciplinary research	Challenges and Opportunities in IDR	
2	Learning across disciplines	Share Your Research; Mock Solicitation	Pennington [8]
3	Individual dispositions; Disciplinary cultures	Trimetrix[Ra]; Toolbox Dialogue[b]	Pennington et al. [10]
4	Group presentation of Mock Solicitation product		
Segment 2: Lightly facilitated team interactions			
5	Guest speaker introducing water resources in the Middle Rio Grande	Stakeholder Analysis	Albuquerque Journal Series "Two Nations One Aquifer"[c] and Texas Tribune blog "When a River Runs Dry"[d]; Self-selected research article
6	Complex problem solving	Explore the Problem Space	Vollmer and Harrison [15] on the global water crisis
7	Causal mapping	ER Table; Mental Modeler[e]	Gray et al. [3] on modeling with citizen scientists
8	Causal loops and systems dynamics	Mental Modeler[c]; Loopy[f]	Turner et al. [22] on systems dynamics modeling of natural resources
9	Group presentation of products from week 5–8		
Segment 3: Unfacilitated team interactions			
10	Scenario analysis	Developing scenarios for the future of water resources in this region	Van Dijk et al. [14] on scenarios
11	Guest speaker on decision making and governance	Serious game implemented for this region	Ostrom 2009
12	Integrated water modeling	Sustainable Water through Integrated Modeling (SWIM) regional water models to conduct scenario analysis	
13–15	Group interdisciplinary proposal co-creation		

[a] https://www.ttisuccessinsights.com.au/profiling-tools/trimetrix-eq?hsLang=en
[b] https://tdi.msu.edu/
[c] https://abqjournal.exposure.co/two-nations-one-aquifer
[d] https://riogrande.texastribune.org/blog/2014/9/30/
[e] https://www.mentalmodeler.com/
[f] https://ncase.me/loopy/

work with their teammates' specific dispositions, and understand their teammates' research interests. Then they need to embrace the complexity of the system they are trying to understand and how their expertise maps onto that landscape. Then they can scope an integrated research project that leverages the strengths and interests of each team member while tackling a meaningful problem. This is true in class, but it is also true in real interdisciplinary research teams. Understanding both the problem and the team contributes to research design that achieves the truly synergistic, convergent results that are sought.

Neuroscience Connections

At the core of this graduate course design is the EMBeRs model and it's neuroscience connections are outlined in the previous chapter. The course provides students with the opportunity for experiential learning while practicing model-based reasoning and reflection. This approach to learning provides the participants with the opportunity to acquire new knowledge that is stored in a way in which it can be recalled and then be put to use in a new context in the future. This course provides novel experiences that stimulate the pattern seeking function of the brain, results in building more neuro connections with others, and enhances and strengthens memories. The approach can be used with any team to empower team members to plan, structure, and execute their work individually and collectively.

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Chapter 10
Application of Model-Based Reasoning Across an Undergraduate Sustainability Science Curriculum

Geoffrey Habron

Abstract As described by Pennington et al. (this volume) model-based reasoning with the EMBeRS Framework can be used in a range of settings. This chapter describes two applications from a core second-year undergraduate sustainability science course to a culminating senior sustainability science practicum experience. This approach creates opportunities to blend iterative and sequenced individual and group work, generate boundary negotiating objects, and create a shared vision for group projects.

Keywords Sustainability competencies · Undergraduate · Systems modeling · Experiential learning · Stakeholders · Scaffolding

CTeAM Connections

- How do you get them there? (Methods/Strategies)

10.1 Introduction

It is important to recognize the role of prior knowledge in affecting student's ability to view and process new information. One way to assess prior knowledge is to surface the internal mental models of how student's view or understand a given topic, concept or issue. Model-based reasoning seeks to reveal this internal thought

G. Habron (✉)
Department of Earth, Environmental and Sustainability Sciences, Furman University, Greenville, SC, USA
e-mail: geoffrey.habron@furman.edu

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process by using various forms of external representations such as the use of analogies, metaphor, visual models, diagrams and/or other representations for abstraction and communication of complex concepts [4–6]. Using model-based reasoning (MBR) can surface assumptions as well as misunderstandings. It also reveals the level of knowledge capital within a group that can be leveraged for future learning and action. When multiple people have a range of understanding the creation of tangible external representations can be used as boundary objects so that each member can more easily see and grasp how others understand. They can then work jointly to modify these representations which then serve as boundary negotiating objects since they are then iteratively adjusted and manipulated collectively [6]. Model-based reasoning provides a faster and more valued group process that develops collaborative competence [2, 9] during the creation of shared goals. Collaborative competence comprises one of several key competencies needed to develop sustainable practices and processes. Other competencies include anticipatory (futures) thinking, systems thinking, strategic thinking, values thinking and others [2, 9].

Model-based reasoning can surface and explore the underlying values of learners and group participants. Even when a shared goal is not desired, MBR provides an inclusive process whereby group members recognize that not everyone thinks or views the situation the same way and there are diverse ways of approaching a situation. MBR also fosters anticipatory competence such that potential future conflicts can be revealed earlier in the process and addressed before they become a problem. As a process to reveal prior knowledge, baseline information developed regarding what students know can be used to structure learning or action processes accordingly. From a learning perspective, MBR enables students to make their learning visible, that in turn, can be used to document changes in learning through metacognition and reflection.

10.2 Goal(s)

There are four overarching goals for the use of MBR:

1. Reveal individual understanding of a problem or situation;
2. Use initial understandings to structure and enhance a process;
3. Develop a shared understanding that can lead to action to resolve or address a situation or problem; and
4. Increase individual learning.

10.3 Approach

The approach mirrors and illustrates the Employing Model Based Reasoning for Socioenvironmental Synthesis (EMBeRS) framework described in the earlier chapter by Pennington et al. [6] (Tables 10.1 and 10.2).

Table 10.1 Key Components of the EMBeRS framework (Pennington et al. this volume)

• Problem-based
• Place-based
• Attention to Process
– Balancing individual and group work – Sequencing of activities – Co-creation of shared vision; and – Non-jargon explanations and active listening
• Use of boundary negotiating objects
– Every activity includes drawing, diagramming, charting, etc. – Co-creation of outputs

Table 10.2 Typical Sequence of EMBeRS activities

1. Introduction to the activity
2. Time for individuals to develop an external representation that organizes each person's thinking
3. Share individual representations within small groups
4. Discussion of ideas
5. Co-creation of an integrated boundary negotiating object; and
6. Reflect/debrief about the activity

10.4 Implementation Stories

The EMBeRS approach supports the work in a range of classes as part of the B.S. Sustainability Science (SUS) major at Furman University. The major emphasizes preparing students to address the challenge of meeting global human social foundations such as food, water, and housing without exceeding planetary boundaries such as climate change, freshwater withdrawals and biodiversity [7, 8]. The program seeks to prepare students to engage in such work by focusing on the major sustainability competencies of systems thinking, futures thinking, values thinking, strategic thinking and collaboration [2, 9].

The major consists of a required general education class open to all students, SUS 120 Principles of Sustainability Science. Students then enroll in two required 200-level courses SUS 241 Social Systems and SUS 242 Dynamic Systems Modeling. Students then select 6 elective courses that align with student interests and pathways from inside and outside of the program. The experience culminates with either an individual research thesis working with an individual faculty member or a group community-engaged practicum experience, both including a corresponding writing intensive course (SUS 472 or 473) and a final capstone synthesis class (SUS 474). To prepare students for the senior experiences the program follows a scaffolded applied learning approach [1] by bringing the world into the classroom in introductory courses, modeling the world in intermediate courses, and having students engage the

world in their capstone experiences. The examples here include a sample from the intermediate and capstone levels of courses (200 and 400 levels).

10.4.1 SUS 242 Dynamic Systems Modeling

In the SUS 242 Dynamic Systems Modeling class EMBeRS was used to assess student prior-knowledge through an activity to animate and spark place-based engagement (Table 10.1) around understanding socio-ecological systems. The activity also serves to help students get to know each other on the first day of class as it is the first class they might have that includes exclusively sustainability science majors. It also serves to begin to get them to think about a system and eventually bridges into system modeling that they will undertake using computer modeling software (Stella) later in the course. The activity begins with explaining the desired learning goal for students followed by an opportunity for students to decide on the specific site for the learning to occur (Table 10.2). These are examples of inclusive and learner-centered pedagogy (Box 1).

Box 1. Exercise Overview Provided to Students

Goal:

- Explore current understanding of systems thinking, models and dynamics.
- Get to know each other and perspectives.

As a class, which campus system would you want to visit and model today: Little Creek Forest (behind the Chapel), Furman Lake, Trone, Duke Library?

Once the students selected a desired site (e.g., Little Creek Forest), they engaged in the next stage of the EMBeRS process (Table 10.2) by exploring their individual pre-conceived ideas of the forest system (Box 2). Some of the students may have visited the site, while most have not. The EMBeRS Framework and its stages are explained to students throughout the process.

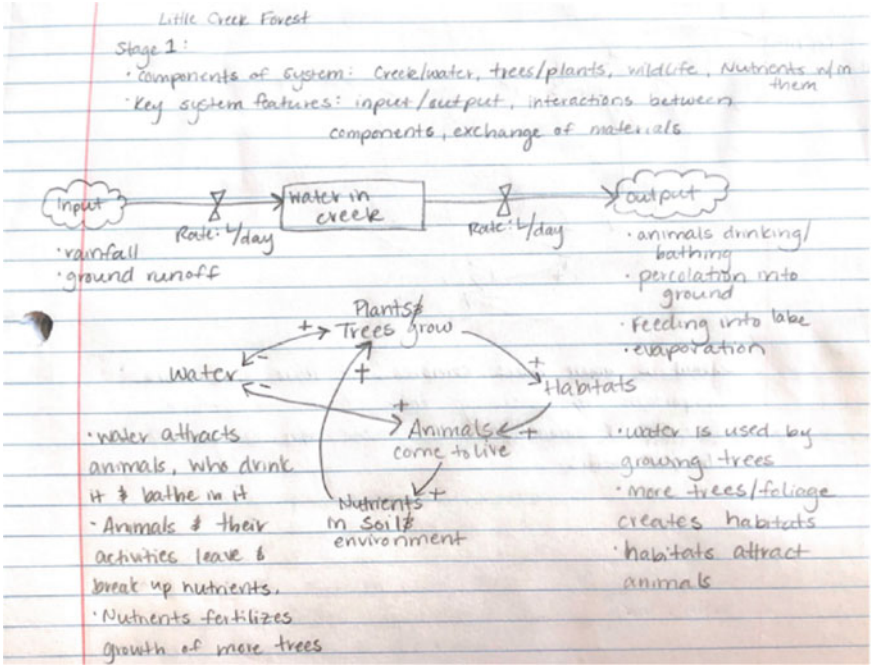

Fig. 10.1 Student Stage 1 individual system visualization and explanation. The diagram identifies key components of a forested stream system such as water, trees, nutrients, and animals. System diagram includes directional arrows to indicate inflows and outflows as well as plus and minus signs to indicate positive and negative feedback

Box 2. Instructions for Stage 1. Students develop an initial systems diagram

Stage 1

- For the system that we selected:
  - List the components of the system.
  - How do the components interact?
  - What are key systems features?
  - How would you visually display the system and its interactions?
  - Create a visualization (Fig. 10.1)
- Keep these elements separate and do not update

This generates the first external representation (boundary object) of the student's mental model and begins to reveal their individual understanding of the situation or

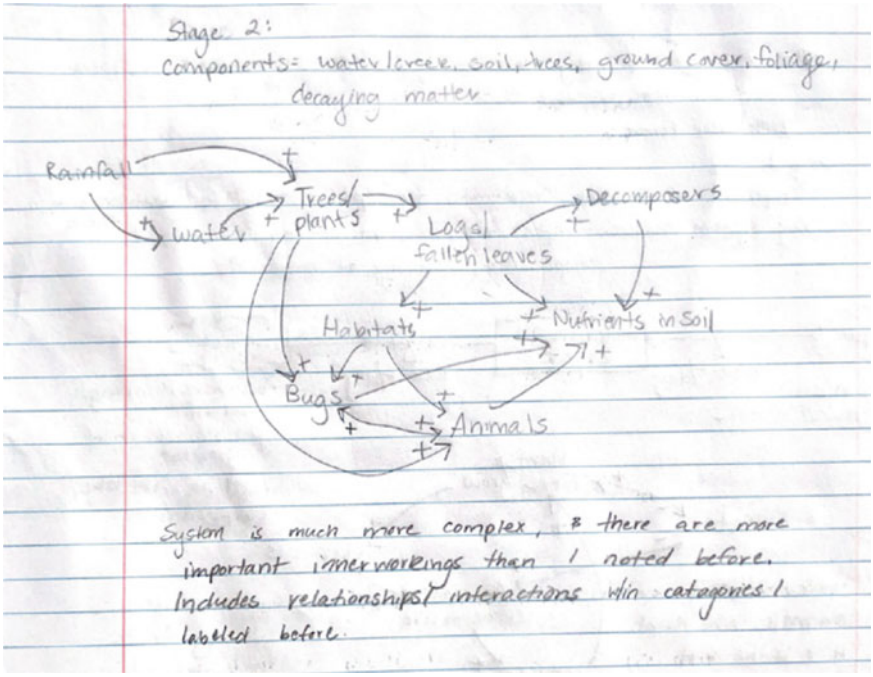

Fig. 10.2 Stage 2 individual student post-observation system visualization and explanation. The diagram identifies key components of a forested stream systems such as water, trees, nutrients, decomposers, animals, bugs, and rainfall. System diagram includes directional arrows to indicate inflows and outflows as well as plus and minus signs to indicate positive and negative feedback

problem. After 15 min, students moved to stage 2 that involved visiting the selected forest site and recording observations (Box 3).

Box 3. Instructions for Stage 2 Students visit field visit

Stage 2

- Observe site for 30 min.
- By the end of the 30 min of observations students will have addressed the following items:
  - List the components of the system.
  - How do the components interact?
  - What are key systems features?
  - How would you visually display the system and its interactions?
  - Create a visualization (Fig. 10.2)

- Reflect: what did you learn through observation? What led you to any changes to your first visualization and understanding?

While onsite, students utilized phones and notebooks to collect observations through photographs and written notes as well as conversations among themselves to help each other see organisms and other phenomena. After 15 min of observation, students returned to the classroom for the remaining stages. Inside the students shared their observations in a pair (Box 4).

Box 4. Instructions for Stage 3. Students share their visualizations

Stage 3

- In pairs:
  - Share and discuss your first 2 responses from stages 1 and 2.
  - Identify and document similarities and differences between your first 2 responses.
  - Generate a new shared visualization of the system (Fig. 10.3)

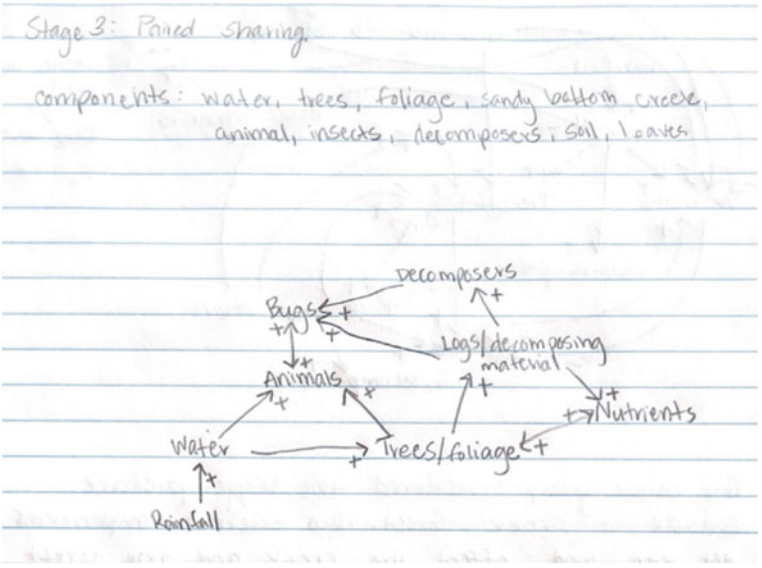

Fig. 10.3 Stage 3 paired student shared visualization. The diagram identifies key components of a forested stream systems such as water, trees, nutrients, decomposers, animals, bugs, and rainfall. System diagram includes directional arrows to indicate inflows and outflows as well as plus and minus signs to indicate positive and negative feedback

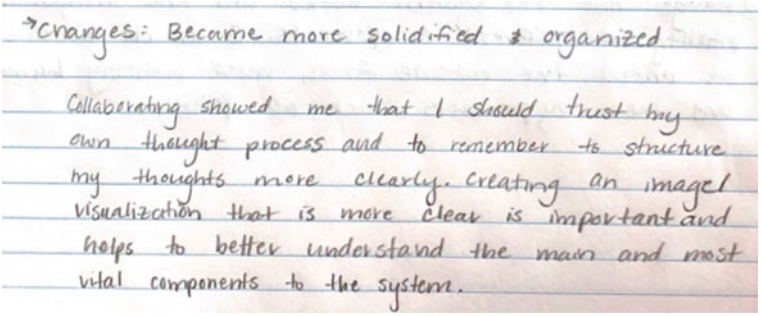

Fig. 10.4 Stage 3 individual student reflection on changes in visualization. Students identified trust in their own thought process as an important outcome of the process

- Reflect: What did you learn through this sharing? What led you to any changes to your individual visualization and understanding? (Fig. 10.4)

The sharing of their initial observations and diagram (Table 10.2) represents a shift toward use of boundary negotiating objects because they can see other conceptions of the situation and use that visual representation as a basis for dialogue and seeking to understand each other's conception. This step indicates a balance between individual and group work through active listening (Table 10.1). Students then work jointly to generate a new external representation as a boundary negotiating object that illustrates shared understanding (Table 10.2). Student reflections (Table 10.2) reveal the outcome of such collaborative sharing and the impacts of co-creating a boundary negotiating object which reveals shifts in mental models (Fig. 10.4).

Each pair joined another pair to complete stage 4 during which they generated a new shared visualization of the system (Box 5). This expands on the level of mental models and diversity of thinking with the addition of another boundary negotiating object this time generated by two additional people. It also illustrates the importance of sequencing activities (Table 10.1) as the level of complexity increases with each step, but instead of having to negotiate among four individual boundary objects, the four students only have to work with two boundary negotiating objects in order to then generate their own shared representation among the group of four (Fig. 10.5).

Box 5. Instructions for Stage 4. Groups of 4 students generate a shared visualization

Stage 4

- Combine with another pair of students to form groups of 4.
- Document and explain similarities and differences among your 2 visualizations.

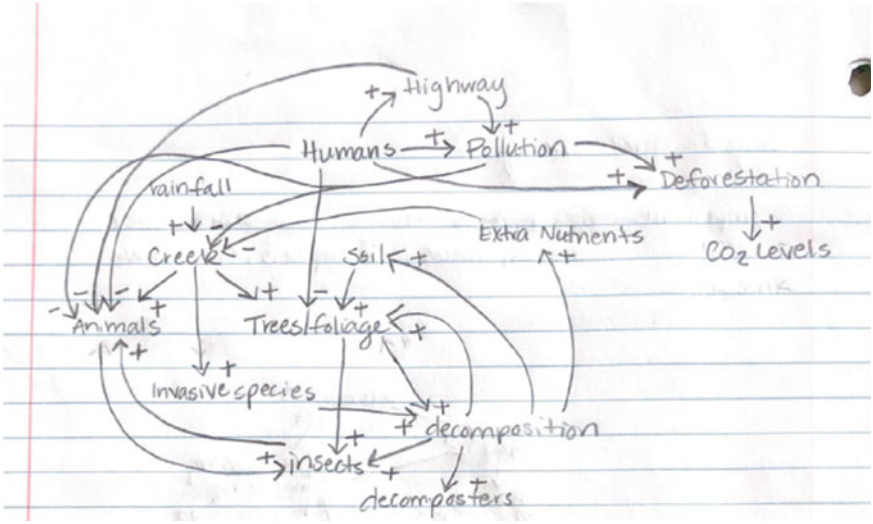

Fig. 10.5 Stage 4 Small Group 1 visualization. The diagram identifies key components of a forested stream system such as water, trees, nutrients, decomposers, animals, insects, invasive species, carbon dioxide, soil, highway, humans, and rainfall. System diagram includes directional arrows to indicate inflows and outflows as well as plus and minus signs to indicate positive and negative feedback

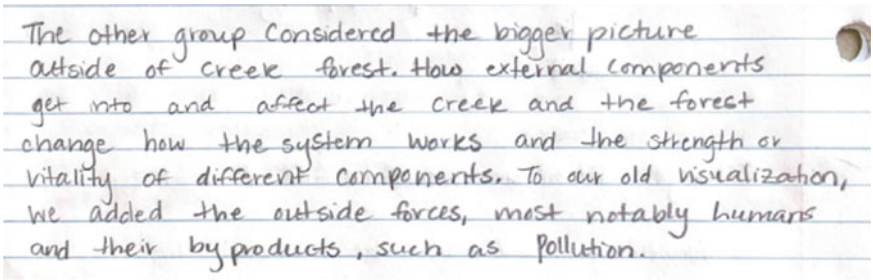
The other group considered the bigger picture outside of creek forest. How external components get into and affect the creek and the forest change how the system works and the strength or vitality of different components. To our old visualization, we added the outside forces, most notably humans and their by products, such as pollution.

Fig. 10.6 Individual student reflection on Stage 4 small group visualization. Student identified new learning that other groups contributed to such as the role of outside forces including humans and pollution

- Generate a new shared visualization for the group (Fig. 10.5)
- Individual Reflection (Fig. 10.6)
  - What did you learn through this sharing?

What led you to any changes to your previous visualization and understanding?

In this case, one can see the development of understanding of the system as the diagrams expand in both content of system components as well as the detail of the diagram in terms of identifying connections and feedback among the system. So, this process uses collaborative competency to aid students in their development of systems thinking competency in an integrated process [2]. It illustrates their initial understanding of a specific site (Little Creek Forest), specific process (forest ecosystem), but more importantly systems thinking literacy in the form of how they construct and explain their systems diagrams in terms of causal loop diagram format and labeling. The student reflection illustrates the metacognitive processes and outcomes whereby the student identifies the roles of their peer's contribution to their own learning (Figs. 10.6 and 10.7) which also provides evidence of growing student collaborative competency and values thinking. It also reveals the specific components of systems thinking that emerged for the student such as the important role of external inputs and factors (pollution) on the focal system (Little Creek).

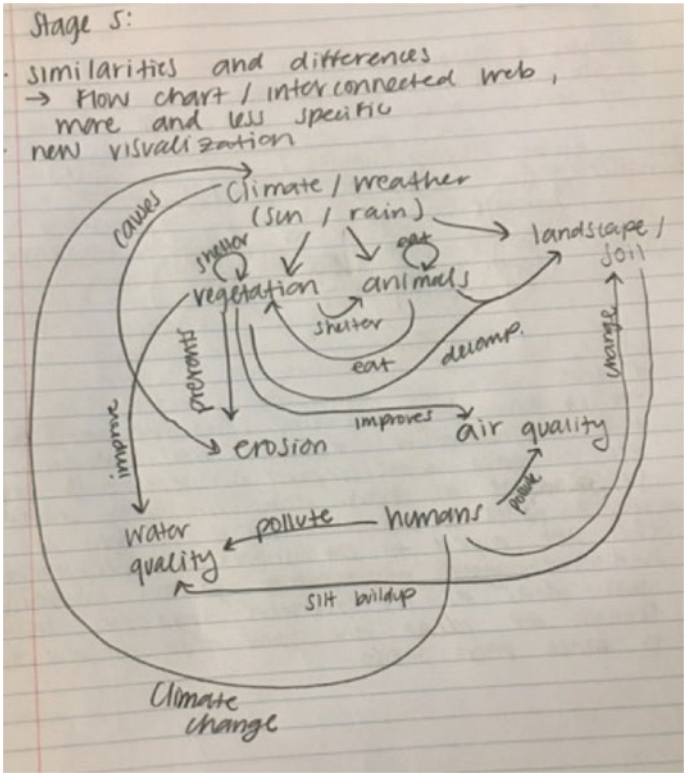

Fig. 10.7 Stage 5 Small Group 2 visualization. Causal loop diagram identifies key components of a forested stream systems such as how climate and weather affect soil, animals, vegetation, erosion and water quality. System diagram includes directional arrows to indicate inflows and outflows

Next, each group shared their visualization (Figs. 10.5 and 10.7) digitally on the class projection screen and explained how their system operated (Box 6). The class then engaged in spoken reflection about the process, what they learned and gained from the process. This illustrates the importance of utilizing a purposefully scaffolded approach of generating and sharing external representations of mental models through boundary negotiating objects (Tables 10.1 and 10.2) as well as the use of technology. Given the scaffolded approach, it builds confidence and capacity for students to share in a larger setting after first generating individual, then pairs, then as a small group of four before sharing with the whole class. It also reduces the cognitive load required of students compared to starting the process with the whole class which would require overcoming trust, confidence as well as having to address a wider range of mental models in contrast to one's own. The whole class oral reflection provides an additional way to generate and identify shared understanding where students could discuss the similarities and differences among the two diagrams. It also enables students to speak in their own language (Table 10.1) unencumbered by notions of other vocabulary imposed by books, articles or the professor.

Box 6. Instructions for Stage 5. Class discussion of group visualizations developed during stage 4

Stage 5

- Present your updated shared visualization (Fig. 10.7)
- Class discussion
- Individual Reflection
  - What did you learn through this sharing?

  What led you to any changes to your previous visualization and understanding?

Reviewing the final two visualizations (Figs. 10.5 and 10.7), one can see similarities and differences with respect to both content of the systems as well as the form of the visualizations. In terms of content both diagrams included vegetation, animals, decomposition, and rain despite slight differences in specificity. However, they differed in terms of content with respect to scale and processes in that the second visualization addressed topics such as climate change as well as processes such as erosion and pollution. In terms of format, both visualizations utilized causal loop diagrams with directional arrows connecting components. However, Group 1 (Fig. 10.5) identified feedback polarity of positive and negative feedback, whereas Group 2 (Fig. 10.7) indicated relationships and feedback among components through textual descriptors such as improves, causes, and pollute.

In sum, the exercise accomplished the desired goals of helping students make their thinking visible to reveal individual understanding. This activity unveiled their current understanding of the system and unlocked their previous knowledge. The

process also facilitated them getting to know each other and their perspectives (collaborative competency). It also served as an initial example of determining the extent of shared understanding of both systems content, but more importantly shared understanding of system visualization, models and dynamics (systems thinking competency). In the larger final class discussion and reflection, students indicated an appreciation for working in groups where someone had a better grasp on how to construct causal loop diagrams. They also recognized that others in the group had better diagramming skills even if the other student had a firm grasp on system concepts. Others remarked that it helped to review with others and revive concepts covered in previous courses, most of whom had only completed one of the two required introductory courses (Sustainability Science or Environmental Science) in the previous academic year.

10.4.2 SUS 473 Senior Sustainability Science Practicum

Model-based reasoning is also used in the senior Sustainability Science Practicum (SUS 473) during which a group of senior Sustainability Science students assist a community partner on a project undertaken for a 15-week semester. Given the students have little knowledge of the project prior to the first day of class it is important to quickly get students immersed into the scope of the project. The project focused on developing approaches to build community resilience to the increasing flood vulnerability of the African American community of Bucksport, South Carolina which situates it squarely into the EMBeRS framework as it is both problem-based and place-based (Table 10.1). The first step in the process involves asking students to identify their project goals, concerns and expectations of themselves, their peers and the professor. This represented a pre-Stage 1 phase that differed from the previous example given that this class requires students to work collaboratively for the entire semester on a single project. Then the students are given a brief overview of the topic by the professor (Table 10.2) and provided a list of 45 media links to the community issue.

To use inclusive and learner-centered pedagogy, students decide how to allocate the list of 45 links. This mirrors the previous example of providing student choice, wherein the previous example students selected the ecosystem that they wanted to explore. In this case, one student recommended assigning 5 links to each student and posted a proposed distribution via the Microsoft Teams platform. Students then engaged the links and returned to class and uploaded their synopsis of the links (Box 7) as well as shared their findings verbally. This illustrates Stage 1 of students generating their own external representation of their mental model of the situation, as well as Stage 2 with the sharing of their summaries with others (Table 10.2). In contrast to the first example, the process proceeded to share digitally and prior to a subsequent class. This illustrates the adaptability of the EMBeRS process to fit the context both in terms of task but also the setting. In this case, the class represents

senior students with prior collaborative competency given their shared curriculum, as well as greater familiarity with each other.

Box 7. Example of student summary of media link shared on class learning space

https://wpde.com/news/local/200-low-income-horry-county-families-are-waiting-for-their-homes-to-be-rehabilitated (Aug 6, 2019)

- 5-year plan to rehabilitate homes of low-income families
- Rehabilitated 25 homes in the past year.
- Plan to help 105 families in 5-year span.
- 200 families waiting for help.
- Spent nearly $970,000 of grant money from the US Department of Housing and Urban Development
- There is a greater need than funds available.
- Hopes to move 30–40 homes off the waiting list this year.

Students spent the following class identifying and discussing key themes from the links (Box 8). While discussing in class students arranged and rearranged those themes collaboratively in real-time using the Teams platform. This illustrates Stage 3 with the generation of a boundary negotiating object (Table 10.2).

Box 8. Class Summary of Key Themes

Bucksport Articles Themes

(1) Flood
(2) Heirs' Property
(3) Community Change
(4) Potential Solutions/Policy
(5) Local Governance
(6) FEMA
(7) Cultural Importance
(8) Flood Cleanup
(9) Ordinances
(10) Other Communities

The next stage of the process involved use of a set of worksheets developed by the Resilience Alliance whereby students utilized their knowledge gained from the previous exercise and media links to begin to describe the socio-ecological system of the project. In contrast to the prior example, the initial phase of generating themes in a non-jargon format, the forms required students to apply their prior knowledge and shared understanding to a pre-existing set of discrete concepts and categories.

After discussing and agreeing upon an overall set of issues, they decided to break into three groups of three students to complete a set of forms. This sequence represents a condensed EMBERS process focused on using model-based reasoning and shared understanding to generate action (Table 10.1). The following class period, they finished their group forms and uploaded the forms to Teams where everyone could see how each group viewed the issues (Table 10.2). This also involved students discussing their understanding of the concepts and categories themselves (e.g., direct vs indirect use) in addition to how they would apply them to the specific situation itself. One can see a repeat of the initial model-based reasoning process but instead of having initial individual external representations of mental models, the process produced initial small group boundary objects to foster discussion (Table 10.2). The process illustrated a previously identified shared set of issues to begin (Tables 10.3, 10.4 and 10.5), differences did emerge around identifying the stakeholders that align with the corresponding issues (Tables 10.6, 10.7 and 10.8).

These worksheets served as boundary negotiating objects that they discussed as a whole class. They then simultaneously attempted to generate one shared set of forms by having one student upload a blank set of forms on the class projector. Subsequently, students as a whole group discussed and called out the proposed responses. Once on the screen the class discussed and revised until the forms were complete (Table 10.9). While certain items appeared from the original small group stakeholder's worksheet (e.g., Agricultural as Inside Direct Users, tourists as Outside Indirect Users), the first draft of the shared table illustrates a breadth and depth of new and modified uses and stakeholders. This illustrates the constructive collaboration of the iterative process facilitated by the visual boundary negotiating object through proper sequencing of activities that can lead to co-creation of a shared vision and product (Table 10.1).

This latter exercise (400-level class) shared the same overall model-based reasoning approach as the first exercise (200-level class) that aligns with inclusive

Table 10.3 Group 1 issues worksheet

Issues	Main Issue of concern for the assessment	Valued attributes of the system
Issue 1	Flooding	Water, property
Issue 2	Population displacement/environmental injustice	Community, heritage, culture
Issue 3	Good governance	Agency, transparency, voice

Table 10.4 Group 2 issues worksheet

Issues	Main Issue of concern for the assessment	Valued attributes of the system
Issue 1	Flooding	Housing/property
Issue 2	Displacement/environmental Injustice	Community/culture
Issue 3	Lack of good governance	Agency, voice, transparency

Table 10.5 Group 3 issues worksheet

Issues	Main issue of concern for the assessment	Valued attributes of the system
Issue 1	Flooding	Water, property
Issue 2	Population Displacement/ environmental Injustice	Community, heritage, culture
Issue 3	Lack of good governance	Agency, transparency, voice, accountability, inclusivity, participatory, effectiveness, equity

Table 10.6 Group 1 stakeholders worksheet

(Natural) resource uses	Stakeholders
Direct uses	*Inside focal system*
Water quality	Residents of Bucksport
Roads	
Rivers	
Indirect uses	*Outside focal system*
Utilities (sewer infrastructure, electricity)	Those outside of Bucksport but interested/providing help Policymakers

Table 10.7 Group 2 stakeholders worksheet

Natural resource uses	Stakeholders
Direct uses	*Inside focal system*
Agricultural usage	
Residential usage	
Indirect uses	*Outside focal system*

Table 10.8 Group 3 stakeholders worksheet

Natural resource uses	Stakeholders
Direct uses	*Inside focal system*
Drinking water	Community members
Road system	Local businesses
Grass lands/parks	Inhabitants of horry county ecosystem
Indirect uses	*Outside focal system*
Habitat/ecosystem disruption	Duke energy
Change in economic flow	Coastal tourism
Traffic disturbances	Institution engaging in trade

and learner-centered pedagogy by having students work as individuals and in small groups to address a task (Table 10.9).

From a scaffolded applied learning framework, model-based reasoning to support collaborative learning as preparatory as illustrated in the 200-level class should scale up and build student capacity to engage in more high-stakes real-world learning (Engaging the World) in the senior level Practicum course. In both cases, EMBeRS served to examine prior knowledge as well as served to help students get to know themselves, know each other, as well as generate and surface shared knowledge and understanding about a given topic and task. In the latter example, the visual outputs served as boundary negotiating objects for students to view, discuss, draw upon, edit; but most importantly to produce generative output and understanding beyond the sum of the individual three earlier tables. To further add to the complexity, the worksheet outputs were then shared with a collaborating sustainability class at Coastal Carolina University to further the process. Once the shared understanding was achieved, students then allocated their research tasks to explore further and elucidate the details of the system in consultation with the community partner.

Table 10.9 Whole class stakeholders worksheet

Natural resource uses	Stakeholders
Direct uses	*Inside focal system*
Agriculture	Farmers, Consumers, Vendors
Residential	Residents, Property Owners, Tenants, dependents, heirs,
Water	Community Members, Residential members, Commercial members, Industrial members, Agricultural members, Inhabitants of Horry County Ecosystem
Road systems	Taxpayers, Community members, Policy makers, County officials,
Grasslands	Inhabitants of Horry County Ecosystem
Pee Dee River and Waccamaw River	
Utilities (sewers, electricity, water, etc.)	Consumers, Vendors, Grand Strand Water and Sewer Authority
Indirect uses	*Outside focal system*
Economic flow	Tourists, Horry County, Myrtle Beach
Traffic system	Road users, Transit-goers, through traffic,
Utilities (sewers, electricity, water,)	Duke Energy, Consumers, Vendors, Grand Strand Water and Sewer Authority
Recreation/Tourism	Tourists, Tourism associations, Developers, Myrtle Beach convention and visitors' bureaus, Grand Strand

10.5 Conclusion

Both of these course examples illustrate the strategies of using EMBeRS (Table 10.1). The examples also illustrate the flexibility of the approach as described by Pennington et al. (this volume): "These activities can be sequenced to achieve the progressive iteration required to integrate team knowledge and understanding so a shared vision and an integrated conceptualization of the problem can be developed. The logical order for using the segments is provided, but they can be combined in different sequences to meet team needs." Regardless of class level or depth of activity (single class or whole semester), students engaged in a series of individual and group work (Table 10.2). In the process they practiced active listening to share their own mental models, understand others and then synthesis and utilize that understanding to generate new shared boundary negotiating objects. In both cases, students produced a shared understanding of the socio-environmental system. This also helps students with their collaborative, values thinking and systems thinking competencies. The 200-level course outputs led to a space for internal learning of dynamic systems modeling as well as building a space for inclusive collaborative learning, which also served as the entry point for learning the software and techniques for actual dynamic systems modeling. The 400-level course outputs led to an applied community-engaged project where the outputs were shared with community residents and led to an actual funding proposal that achieved success through the county appropriation process (Table 10.1). The applied nature of the project illustrated how MBR facilitated strategic and futures thinking in addition to the other competencies achieved in the intermediate level course. As such, the hope is that using MBR in scaffolded learning across our academic levels of courses will better prepare students to achieve our overall program outcomes. Other programs can also see the varied approaches of MBR and how it can be modified based on level of learner and intensity of task involved.

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This course recognizes the crucial role of accessing prior knowledge as part of the learning process as individual or a team. By taking the time to uncover assumptions and possible misunderstandings, participants become aware that not everyone thinks or views a situation in the same way. They all have different mental models. The application of learning through model-based reasoning, metacognition, and structured individual and group reflection provides opportunity for divergent thinking and expanded creativity as the team develops convergent solutions. The inclusion of requested visualization of concepts takes advantage of neuro processing by activating the visual cortex, thus expanding and reenforcing neuro-networks connecting ideas and people. The approach used can be used with any team and provides the team an environment that is open and safe for transparent sharing. It is psychological safe—a sense of confidence that the team will not embarrass, reject, or punish someone for speaking

up with ideas, questions, concerns, or mistakes. There is a shared belief that the team is safe for interpersonal risk taking. It describes a team climate characterized by interpersonal trust and mutual respect in which people are comfortable being themselves.

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Chapter 11
Evidence-Based Strategies for Improving Project Outcomes

Shirley Vincent, Kate Thompson, and Deana Pennington

Abstract The purpose of this chapter is to provide general concepts, principles and methods for planning and implementing evaluation processes for collaborative team projects. Evaluation is a process that involves collecting and analyzing information about a project or program's activities, characteristics, and outcomes. Its purpose is to make judgments about the outcomes, improve effectiveness, and inform decisions. The terms assessment and evaluation are seen as distinct in some contexts such that evaluation is described as summative, occurring at the end of a project, and designed to pass judgement on the results based on predetermined criteria or standards; and assessment is described as formative, occurring during the project as it is implemented, and designed to improve performance. However, in project and program evaluation practice, these two processes are often intertwined with a focus on continuous improvement and adaptation of a project as it unfolds, as well as collecting evidence of achievement of the goals at specific points in the project timeline and at the end of the project. This type of evaluation is called developmental evaluation and it's an iterative, ongoing process that combines both formative and summative aspects to support ongoing project design modifications as the project unfolds [19].

There are many approaches to evaluation based on the specific context of the project to be evaluated and the purpose of the evaluation. These can include judging the performance of the project based upon expert or user defined criteria, evaluating the functional characteristics of the project including processes and outcomes, providing evidence to support decision making relevant to the project's operation and results, and/or supporting the participation and role of stakeholders in the project

S. Vincent (✉)
Vincent Evaluation Consulting LLC, Tulsa, OK, USA
e-mail: shirleygvincent@gmail.com

K. Thompson
University of Texas at El Paso, El Paso, TX, USA
e-mail: kate.j.thompson@qut.edu.au

D. Pennington
Queensland University of Technology, Brisbane, QLD, Australia
e-mail: ddpennington@utep.edu

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(Fitzpatrick et al. in Program evaluation: alternative approaches and practical guidelines, Pearson, New York, 2011). To determine the best approach, start with key questions:

- What do you want to do and why?
- Who will participate and how?
- What is the timeline for the project?
- What are the goals of the project?

Developmental evaluation is a type of evaluation often used to support collaborative initiatives, especially in complex and dynamic situations [21]. In this type of evaluation, periodic evaluations are performed to assess the impact or influence of the collaboration, while also continuously and iteratively assessing the strategies and activities designed to achieve the desired outcomes. Developmental evaluation is used to provide feedback on the project design as it is being implemented and is useful for innovative projects.

Evaluation and research have different purposes but may overlap. Evaluation supports improvements, judgements, and actionable learning while research generates knowledge about how the world works and why. Research informs evaluation—the more information that exists about the goals of the collaboration and how the various strategies and activities will achieve the outcomes, the more the evaluation can draw on that knowledge. However, the primary purpose of evaluation is to determine the effectiveness of the project activities and strategies in achieving pre-defined outcomes. Evaluation outcomes may include research-related outcomes. Success is determined by results from validated instruments used in evaluation, the participants' perspectives, other experts in the field, and/or peer-reviewed publications. If the design of the project itself is based on research questions, then evaluation can serve to test specific theoretical frameworks.

Keywords Developmental evaluation · Program evaluation · Collaboration success

CTeAM Connections

– How do we know when we get there? (Outcomes/Assessments)
– How do you get them there? (Methods/Strategies)

11.1 Introduction

Evaluation is important for collaborative projects to:

- demonstrate and support achievement of the intended outcomes;
- support adaptive management of the project;
- develop a successful team culture; and
- effectively communicate with participants and stakeholders.

A large body of literature exists on supporting successful collaborations, especially for team science (e.g., [10, 11]). Three considerations are important to ensuring the success of a collaboration [1]:

- develop and maintain clear expectations;
- promote, and model effective communication; and
- establish shared goals and a mission for collaboration.

Developing a practical comprehensive collaboration plan can benefit teams of any size but are crucial for larger and more complex collaborations [11].

Successful collaboration is achieved when all members of a team are working towards a common goal. Collaboration work often aims to connect disparate data to answer a specific question. Understanding the processes necessary to ensure that a project is as broad as necessary without losing the focus of the question to be answered is key to not only the success of the project but the ability of the team to translate findings into action. Monitoring progress towards the intended outcomes of a collaborative endeavour is important because the iterative nature of interdisciplinary collaboration provides many opportunities for disruption. Identifying the question and the ways in which a project will be judged to be successful are important steps to ensure project success.

11.2 Goal

The overarching goal of evaluation work is to identify ways to measure and compare the achievements of the team—for learning, self-management, and accountability (outcomes, strategies, and activities). There are two primary evaluation questions for collaboration:

- how can collaborative teams gauge progress toward their goals; and
- how can they know if they have been successful?

In an education context, evaluation will also include the question how can educators know if their teaching of knowledge and skills relevant for collaborative teams has been successful? To answer these questions, the expected outcomes (i.e., results, the end-in-mind) must be identified, a strategy of how they are to be achieved formulated, the types of evidence needed to demonstrate progress toward the outcomes

determined, and a timeline created for evaluation checkpoints to ensure the collaboration remains on track. The role of the evaluator is to assist in designing the evaluation plan, collect and analyze evidence related to the progress towards desired results, and work with the collaborative team to adjust the process design based on the evidence. The evaluation process itself may also change based on evidence. Tracking evidence of progress toward outcomes and obtaining participant feedback on how the collaboration is functioning and how the activities and strategies are working is an ongoing and iterative process.

11.3 Strategies and Approaches

There are four common principles used to design an evaluation process:

1. define project outcomes;
2. propose a theory of change that explains the reasoning for using specific activities and strategies to achieve the outcomes;
3. create a logic model that links inputs, activities, outputs/measures, short/medium term outcomes and longer-term impacts (Fig. 11.1); and
4. determine outputs from activities and strategies that will be used for evaluation (usually a mix of quantitative and qualitative measures).

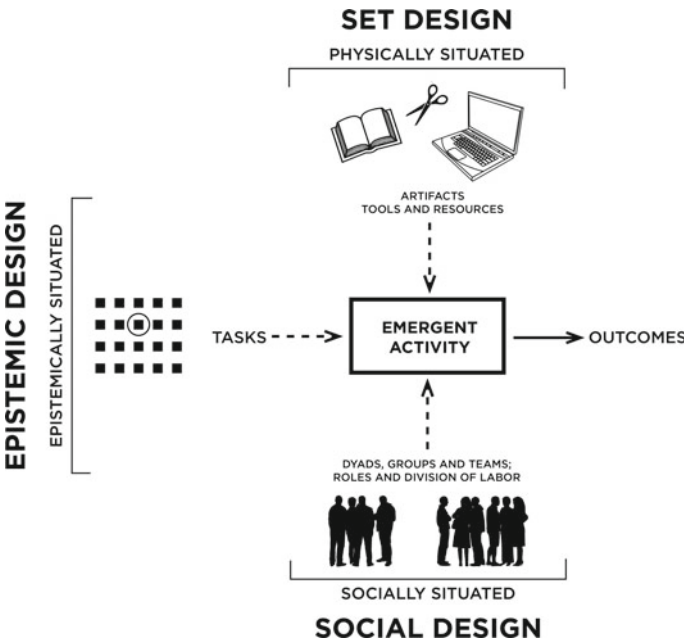

Fig. 11.1 The ACAD framework (Modified from [7])

Each of these is discussed in more detail below. The *Evaluation Flash Cards: Embedding Evaluative Thinking in Organizational Culture* provide an overview of these and other key evaluation core concepts [20]. Planning for evaluation is a backward design process where you consider the desired long-term goals and vision, identify the intermediate outcomes/results that will show progress toward the impact, define the actions that will achieve the outcomes, identify how you will measure progress toward the outcomes, and determine the inputs and resources needed to successfully implement the project activities and strategies. The use of backward design is an iterative process that provides opportunities to reconsider the boundaries around the project in terms of time, resources and human capital, the types of results desired, and the types of activities and strategies the team will employ.

11.3.1 Define Expected Outcomes

Results for programs, courses or activities designed to develop collaboration competencies are often defined in terms of the capacities to be developed. Table 11.1 illustrates an example of capacity-based outcomes for a generic transdisciplinary graduate training program. Note that there are three overarching goals with specific outcomes for three participant groups: the graduate students, the faculty and the higher education institution, and the external stakeholder partners. The desired outcomes for a collaboration process should reflect the development of long-term capacities for collaborative teamwork for each of the major groups of participants in your collaboration (Table 11.1).

11.3.2 Propose a Theory of Change to Determine Activities and Strategies

Once the overarching goals and related set of outcomes for each important group involved in the collaboration are determined, the next step is to develop a theory of change that justifies and explains what the program will do to develop the capacities described in the outcomes. Theory-driven design and evaluation requires that project designers explicitly explain what is being implemented and why, making clear connections between a given activity or strategy and its outcomes [24]**.** A project's theory of change is based on observations and evidence from research and theoretical frameworks that explain how the collaborative project's activities and processes will produce the desired outcomes. For example, drawing upon activities from the chapter on Employing Model-based Reasoning for Environmental Synthesis (EMBeRS) Model, an activity within a collaborative project could be designed to develop the capacities for participating in and facilitating work across disciplines based upon the EMBeRS framework [21]. Developing a theory of change provides

Table 11.1 Example student, institutional, and partner goals and outcomes

Trainee Goal: *Develop professionals with a transdisciplinary perspective, complex problem-solving skills, and key competencies for addressing transdisciplinary research and practice*
Student Outcomes
Develop an intellectual and personal orientation toward interdisciplinary research that values collaboration and includes diverse disciplinary perspectives
Develop conceptual skills and behaviors required for effective integration of perspectives and methods
Develop skills in communication and knowledge integration across disciplines and diverse perspectives
Develop deep knowledge of issues related to a specific area of research and practice
Demonstrate key competencies for transdisciplinary research and problem solving
Faculty and Institutional Goal: *Build faculty and institutional capacity for transdisciplinary research and training in a specific transdisciplinary area of research and practice*
Faculty and Institutional Outcomes
Develop new innovative courses and internships that provide training to work effectively on transdisciplinary research in collaboration with stakeholders
Enhance institutional capacity to develop student competencies in transdisciplinary research and solutions development that specifically address complex societal issues
Engage diverse groups of students and faculty in transdisciplinary training and research, fostering a culture that leads to novel research collaborations and networks
Enhance capacity for faculty, staff, and students to conduct real-world transdisciplinary research and develop professional skills through sustained engagement in research co-designed with stakeholders
Partnership Goal: *Create enduring capacities through researcher-stakeholder networks*
Stakeholder Outcomes
Strengthen university-cities partnership to co-design and co-produce transdisciplinary research and training
Establish, sustainable model for transdisciplinary graduate education that can be adopted for other units/themes across the university

a way to describe assumptions and then test those assumptions as the collaborative project unfolds. Using a diagram to illustrate your theory of change is very useful for explaining the project to the participants, funders, and others. Many examples of theories of change are available via a Google search.

11.3.3 Logic Model to Link Inputs-Activities-Outputs-Outcomes

The next step is to create a logic model. A logic model illustrates the project by specifying inputs/resources, activities/processes, outputs/products, short- and medium-term outcomes, and long-term impact (Table 11.2; [27]). Some key questions for the logic model are: (1) Are the inputs (resources) sufficient to support the activities? Inputs are resources like funding, staffing, willing participants, location, etc., (2) What outputs are expected from the activities that can provide evidence of progress toward the outcomes? Outputs are products produced during the collaboration or attributes such as increased confidence in collaboration skills measured by pre-project

Table 11.2 Logic model framework with example row from the EMBeRs project

Inputs/Resources	Activity/ Strategy	Outputs/Measures	Outcomes	Long-term impacts
EMBeRS project Funding, individuals to lead workshop activities, location, stallholder interviews	Design and implement EMBeRS collaboration workshop with stakeholder interviews for PhD students in diverse disciplines	– Diversity of students in universities, disciplines, demographics – Self-evaluation survey pre- and post-workshop (first year interviews post workshop), follow-up survey 9 months post-workshop, end of project survey – Analyses of audio, video, and material artifacts data (drawings, writings) collected from each cohort workshop	– Demonstrate improvement in abilities to externalize one's own disciplinary knowledge in ways that improve the ability of others to understand – Demonstrate improvement in abilities for active listening and individual reflection – Understand the importance of iterating between divergent and convergent thinking activities Diversity of students included in the project Participants use what they learned and disseminate to others in diverse contexts	– A validated framework for teaching inter-disciplinary collaboration skills to PhD students and for use in diverse collaboration contexts – Individuals trained in the EMBERS framework use the skills and knowledge in their work and disseminate to others

and post-project surveys, (3) Will successful outcomes lead to the desired impact? Evidence provided by the outputs is used to evaluate progress toward the outcomes. For example, agreement that a co-created product is a useful tool for achieving future objectives or that there are statistically significant increases in participants' confidence in collaboration readiness criteria. Long term impact is the change the project will contribute to in the world such as creation of a sustainable transdisciplinary graduate program or a generation of students trained in transdisciplinary collaboration skills. Using a logic model table or figure is very useful for explaining the project to the participants, funders, and others. Many diverse examples and templates for logic models are available via a Google search.

11.3.4 Outputs from Activities and Strategies

Example: Tools and Strategies for Collaborative Practice Evaluation has multiple goals of focusing on continuous improvement and adaptation of a project as it unfolds, as well as collecting evidence of achievement of the goals of the collaboration. It is useful to engage in the explicit design of situations to ensure that team members can engage in opportunities for productive collaboration through interaction with each other, with knowledge objects, and with the processes of knowledge production. Design for learning is a tool for the continuous reframing of practice [9]. It occurs at several stages of an intervention and influences that intervention in an iterative process. One design strategy is called the Activity Centered Analysis and Design (ACAD) framework (see [17] for a review of design frameworks). Carvalho and Goodyear [7] describe the Activity Centered Analysis and Design (ACAD) framework (Fig. 11.1).

Carvalho and Goodyear [7] state that there are four elements to consider while designing learning activities: the social, set, and epistemic design (roles and rules, tools and digital and physical learning environment); and the processes of knowledge building (the tasks). The fourth element occurs during the enactment of the design (*learn time*). This fourth element is referred to as the co-configuration and co-creation of the learning environment and describes what learners and teachers do. The ACAD framework is used to aid in the design of both formative and summative assessment of interdisciplinary projects. It focuses on the processes and outcomes associated with social interactions, the use of tools and knowledge creation practices. Pennington et al. [21] used the ACAD Framework to design meetings and collaborative tasks to support interdisciplinary collaboration through the progression of the following phases: (1) identification of an appropriate research question; (2) agreement on a shared vocabulary; (3) the co-creation of boundary negotiating objects; (4) tools for visualizing and combining data, with the aim of (5) producing a new, connected model of understanding.

To explain how the ACAD framework can be used to inform the explicit design of situations for interdisciplinary collaboration, we provide an example. If we consider a collaborative research project, we may imagine a variety of ways in which the phases

of interdisciplinary collaboration are supported. Consider a series of meetings in which in which researchers are asked to come to a consensus on the research question. We would assume that we would see in participants' conversations (social) evidence of them articulating their values in terms of the potential topics and processes of science (epistemic). We might expect that they will make attempts to find connections between the different ideas to find an area of common interest (epistemic). If we provide them with resources (set), we could expect that they would produce a shared (social) representation (set) of the problem space (epistemic). We can assist team members to engage in these practices by building assessment or evaluation into these steps to obtain evidence of progress (emergent activity) toward a shared conceptualization (outcome) and feedback on how the process is working.

The use of the ACAD framework supports the design of opportunities for the development of multiple collaboration, learning, and research skills in parallel and connects these to activity and outcomes. Ultimately, teams need to be able to evaluate and assess their own progress. In order to build the collaborative skills of the participants, it is important to provide them with opportunities and tools to reflect on the complex nature of their collaboration. This can be done by encouraging reflective practice in collaboration which can serve as an important evaluation tool for both individuals' self-assessment and group assessment of the process. Reflective practice draws on Schon's work in reflection on professionals' learning [23]. It is defined by Boud et al. [5] as "intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understanding and appreciations" (p. 19). There are three stages identified in the process of reflection [2]: an experience of revelation at something that has happened to the participant while participating, a critical analysis of the situation; and the development of a new perspective on the situation. Reflective practice is considered essential in professions such as teaching (e.g., [14]) and nursing (e.g., [12]), but is not as commonly discussed in science or research [3]. Common approaches to reflection include debriefings and writing tasks. One approach is to debrief, as a team, using support tools (such as the ACAD framework). To illustrate with an example, at the end of the meeting in which team members determined the research question, one member would ask all to identify what they learned (learning outcomes), what they did (emergent activity) and consider what was available to support this activity and learning (the design). Reflective writing can either be free-style or with specified prompts. Beginning with prompts helps to focus the attention of the practitioner and are useful to begin with while the practice of reflection is established.

Example Collaboration Evaluation Measures A large body of literature exists on supporting successful collaborations, especially for team science (e.g., [10]). Three characteristics are often identified as being important to the success of a collaboration: (1) developing and maintaining clear expectations, (2) promoting and modelling effective communication, and (3) establishing shared goals and a mission of the collaboration [1]. Developing a practical comprehensive collaboration plan can benefit teams of any size but are crucial for larger and more complex collaborations

[11]. Ten components have been identified for guiding comprehensive collaboration planning [11].

Key collaboration competencies have also been described for individuals and teams [13]. These include competencies in five domains:

- facilitating team affect (emotional bonds between team members that are grounded in genuine care and concern for the welfare of others)
- team communication (exchanging and integrating knowledge and expertise)
- managing team efforts (integrating efforts)
- collaborative problem-solving (the cognitive and social skills to develop a shared vision)
- team leadership (processes that influence team performance)

An evaluation plan should include ways to obtain feedback and perceptions from team members on the extent to which these domains are being addressed so that adjustments can be made to address concerns and ensure success. Surveys, interviews, and focus groups are useful methods for gathering feedback on team processes. The use of an external evaluator helps alleviate confidentiality concerns. The International Network for the Science of Team Science provides extensive resources for collaboration planning and assessing team parameters on its website at https://www.inscits.org/scits-a-team-science-resources.

Example: Measures for Collaboration Outcomes *Measures* for evaluating the outcomes of collaborations often use a mixed methods approach that integrate both qualitative and quantitative analyses. Outputs used for assessment can include products developed during the collaboration processes, survey assessments that participants complete pre- and post-program/activities, written reflections of participants, group discussions, and individual interviews. The types of assessments used will vary based on the collaboration context and the desired outcomes. A combination of participant and team self-assessment methods (surveys, interviews, group discussions), and methods of assessment used by others—experts, researchers and/or stakeholder partners—together provide a rich perspective by triangulating assessment results to create a comprehensive understanding of the collaborations progress and ultimate success. Transdisciplinary orientation scores, self-confidence assessment in complex problem-solving skills, and social network analyses are examples of measures used in evaluation of collaborative projects.

Transdisciplinary Orientation Scale. Transdisciplinary orientation (TDO) is defined as the values, attitudes, beliefs conceptual skills and knowledge and behavioural repertoires that predispose an individual to effectively collaborate in transdisciplinary research teams [16]. TDO is measured using a twelve-item (question) scale that assesses two dimensions—values attitudes and beliefs (VAB) and conceptual skills and behaviours (CSB). The CSB dimension includes the ability to approach problems holistically from different vantage points. integrate concepts across perspectives and communicate effectively with colleagues from other perspectives. The VAB dimension includes predisposition of the participants towards collaboration; openness towards learning other paradigms and worldviews; willingness to invest time;

and beliefs about the benefits of collaboration compared with the costs. Misra et al. [16] found that higher scores on the TDO scale are significantly and positively correlated with higher levels of interdisciplinary publications with greater societal impact and with experience working in transdisciplinary teams. When used as an evaluation tool, collaboration participants indicate their levels of agreement with the twelve TDO items pre-participation using a five-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree), and then again after participation by retrospectively assessing their levels of agreement before participating and after participating. Participants are asked to assess their pre-participation agreement retrospectively because they learn more about the items and adjust their pre-participation agreement levels based on their new knowledge. The Wilcoxon Signed Ranks test is used to test significant differences for Likert scale data at three points: pre-program, retrospectively pre-participation, and post-participation. The effect size of the program on the change in TDO can also be calculated. TDO has been used by Vincent as an evaluation measure for several undergraduate research and graduate training programs to demonstrate the effectiveness of the programs in developing transdisciplinary collaboration capacities (e.g., [21]).

Complex Problem-Solving for Sustainability Competencies. An education framework describing key competencies for complex problems-solving for sustainability was first elucidated based on an extensive literature search by Wiek et al. [25]. These key competencies include systems thinking, futures (anticipatory) thinking, values (normative) thinking, strategic (action-oriented) thinking, interpersonal (collaboration) competence and the sixth meta-competence of integrating the five competencies. The competencies have since been operationalized and extended and recommended for sustainability-focused education programs in the 2020 National Academies of Science Engineering and Medicine report on *Strengthening Sustainability* Programs and *Curricula at the Undergraduate and Graduate Levels* [6, 18, 22, 26]. Participants indicate their levels of confidence in the six competencies pre-participation, retrospectively pre-program and post-program using a five-point Likert scale (confident, moderately confident, somewhat confident, minimally confident, not at all confident). When used as an evaluation tool, collaboration participants indicate their levels of competency confidence pre-participation using a five-point Likert scale (strongly agree, agree, neither agree nor disagree, disagree, strongly disagree), and then again after participation by retrospectively assessing their levels of agreement before participating and after participating. Participants are asked to assess their pre-participation agreement retrospectively because they learn more about the items and adjust their pre-participation agreement levels based on their new knowledge. These competencies have been used by Vincent as an evaluation measure for several undergraduate research and graduate training programs to demonstrate the effectiveness of the programs in developing complex problem-solving capacities (e.g., [21]).

Social Network Analysis. Social network analysis (SNA) is a collection of methods and tools used to study the relationships, interactions, and communications of networks of participants [4]. SNA visualization methods illustrate relationships between individuals in networks by graphs known as sociograms; the sociogram

portrays individuals or groups of related individuals (nodes in SNA terms) as points, and relationships (edges in SNA terms) as arrows originating from the source of the interaction and pointing to the target of interaction. SNA visualizes the interactions among participants and how they participate in interactions. SNA may be used as an evaluation method to investigate team development, progress over time, and success [15]. Many diverse examples of collaboration process social network analyses are available via a Google search.

11.4 Implementation Story—The EMBeRS Project

The EMBeRS project (NSF IGE award #154404) described in *Exploring the Problem and Solutions: EMBeRS Model for Facilitating Interdisciplinary Learning and Systems Thinking* provides an example of an evaluation that combined overall project evaluation with assessment of competencies for transdisciplinary collaboration to test the research hypotheses relevant to the project design [21].

The EMBeRS project used a developmental evaluation approach to continuously inform activity design and development. An evaluation framework was constructed during proposal development and further developed early in the program and revised as needed. The evaluation framework included project goals and target outcomes for both students and faculty, which focused on developing skills for leading and participating in interdisciplinary research efforts and preparing students to engage in societal-relevant problem solving. It included a theory of change based on a synthesis of research findings from learning, social, and organizational sciences that evolved into the EMBeRS Framework [21], which incorporates changes in both individual and group practices. It used a mixed method approach for evaluation and research, combining these to assess outcomes for participants. Surveys were given pre- and post-workshop that assessed changes in targeted outcomes, including the competencies identified by Wiek et al. [25]. Semi-structured interviews were held with workshop participants at the end of each workshop to identify additional outcomes based on the perspectives of the student participants. All co-created external representations of the research problem conceptualizations were photographed and analysed together with synthesis writing, ACAD reflective discussion, and final written proposals to assess changes in students' ability to integrate knowledge across disciplines. In the second year of the project both dimensions (VAB and CSB) specified in the TDO evaluation metrics [16] were measured. The combined evaluation results indicated that the student workshops had high impact and achieved the desired outcomes [21].

The EMBeRS model framework and similar evaluation processes have been applied in several transdisciplinary team research contexts, undergraduate and graduate student workshops, and courses for training students in interdisciplinary collaboration competencies (unpublished results). Please contact the chapter authors for more information about these applications of the EMBeRS framework and related evaluations.

11.5 Summary

Evaluation of collaborative processes is at its core a way of thinking. Evaluation is important for staying on track and ensuring success, demonstrating results both in how the collaborative project performs and testing research questions, and developing the desired long-term collaboration abilities and project impacts. There are a common set of methods often used for evaluation planning—defining outcomes that often are in the form of capacities gained, using a theory of change to select methods for conducting the collaboration based on literature and other evidence, using a logic model to define outputs linked to tracking the progress toward outcomes, and using an iterative approach to adaptively managing the collaboration process as you learn from evaluation. Evaluation benefits from triangulating results from mixed methods (qualitative and quantitative) that include self-assessments, validated measures (such as the transdisciplinary orientation scale), and assessments by others (science of team science researchers, education and learning researchers, other experts). Two core resources to learn more about evaluation of collaborative process are the International Network for the Science of Team Science (https://www.inscits.org/) and the American Evaluation Association (https://www.eval.org/).

Neuroscience Connections

A key aspect of evaluation is to collect and analyze data and information in the context of improving outcomes and effectiveness and informing decisions. During analysis individuals engage their brains in reflective practice that involves learning, the creation of meaning and relevancy. This initiates growth and change. Successful collaboration provides the opportunity for collective reflective practice that takes advantage of the social nature of human interaction to enhance opportunities for social thinking and learning. As a result, team members connect at deeper emotional levels as they reflect on the evaluation data and information in the context of their shared values, beliefs, and expertise as they focus on continuous improvement and adaptation of a project**.** Taking the time to connect, enhances team communication, contributes to psychological safety, and enhances synchronization of brainwave activity. Creating structured opportunities for reflection allows team members to gain common understanding of areas of success, identify opportunities for adaptation, and modification of expectations. research suggest that adults can only integrate around seven different constructs at a time. Recognizing this characteristic supports the structuring of team efforts around smaller problem components. This allows for incremental progress and ultimately successful collaboration.

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In the original version of the book, the following belated correction have been incorporated: The volume editor name "David C. Gosselin" has been changed to "David Gosselin" in the entire book.

The updated version of the book can be found at https://doi.org/10.1007/978-3-031-37220-9

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