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Team Science: A Practical Approach to Starting Collaborative Projects

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Abstract

A collaborative approach to treating patients is well taught in medical training. However, collaboration and team building in clinical and laboratory research may have been given less emphasis. More scientific discoveries are now being made with multidisciplinary teams, requiring a thoughtful approach in order to achieve research goals while mitigating potential conflicts. Specific steps for a successful team science project include building the team, assigning roles and responsibilities, allocating rules, and discussing authorship guidelines. Building a team involves bringing individuals together and developing a common research goal while establishing psychological safety for all members of the team. Clear assignment of roles and responsibilities avoids confusion and allows each member's contributions to be acknowledged. Allocating rules involves discussing how decisions in the team will be made, how data and knowledge sharing will occur, and how potential conflicts will be resolved. Discussing authorship at the start of the project ensures that the entire team knows what work must be completed for authorship to be obtained.

Key words: team science; multidisciplinary; collaboration; authorship.

Introduction

> It is amazing what you can accomplish if you make sure that everyone shares the credit.
>
> Jonathan S. Lewin[1]

Collaboration is essential for innovation. Physicians collaborate on a daily basis in the treatment of patients and this form of collaboration is often the focus of education in medical school, residency, and fellowship. However, collaboration extends beyond daily clinical work into the realm of clinical and laboratory research. While scientific discoveries were traditionally attributed to one or two specific individuals, the last several decades have highlighted the team efforts involved in scientific discoveries (1). This collaborative effort to address a scientific question by using individuals from multiple specialties has been termed "team science" (2).

The advantages of team science from a clinical, patient-centered perspective are clear, as input from multiple people and disciplines can allow for multiple perspectives to assist in identifying and solving a problem (3). In the case of multi-institutional trials, team science allows for the compilation of larger data sets (3). However, these overarching advantages often collide with an individual's academic goals and requirements for career advancement. For example, a certain number of first- or last-author publications may be weighted more heavily in an institution's promotion requirements (1). Incentives such as promotions may thereby discourage individuals from participating in collaborative efforts. Additionally, the opposite effect may also

Key Messages

- Team science concepts represent a basic framework for multidisciplinary collaborations in radiology and breast imaging.
- Key components in planning multidisciplinary collaborations include building the team, assigning roles and responsibilities, allocating rules, and discussing authorship guidelines.
- Specific additional factors that contribute to more effective team science projects include increased institutional support, including clinical administrative support, and project managers.
- Ensuring that appropriate credit is given when due allows career advancement for all team members.

occur when individuals are given honorary authorship in order to meet the institution's publications requirement for promotion when they have made little contribution to a specific project (4). Therefore, instruction in how to use team science concepts to successfully complete a multidisciplinary project is needed, especially for those in training and early practice who are looking to build an academic career.

For those early on in their radiology careers, the basic principles of team science can be applied to smaller scale projects such as case reports and review articles, which are often collaborations between trainees and senior faculty members at a single institution. On a larger scale, team science is often used in collaborative projects involving breast radiologists, surgeons, pathologists, medical oncologists, radiation oncologists, medical physicists, radiologic technologists, and statisticians within one or more institutions. Many radiologists may have unknowingly participated in team science projects and seen the challenges firsthand. As experience grows, collaboration with research faculty who are not primarily engaged in the breast program, such as faculty members from endocrinology or cell biology, may further foster research endeavors. Furthermore, most radiologists have had little training on developing a successful team science endeavor. In a 2018 survey of medical and engineering students at a single university, both sets of students recognized that transdisciplinary experience was helpful professionally; however, limited opportunities existed for students to participate in such activities (5). Successful team endeavors may require institutional support, setting up of communication and data sharing processes, and specific collaborative skills (2). In this article, we aim to provide radiologists in training and early academic careers with an outline for a successful team science project, including building the team, assigning roles and responsibilities, allocating rules, and discussing authorship guidelines.

Building the Team

Building a team that is cohesive and highly efficient can be challenging. The inherent diversity in a transdisciplinary group can be a powerful asset. However, differences in disciplinary backgrounds, training, and scientific cultures may lead to obstacles in the collaborative process (6). There are several factors that need to be taken into account when creating a multidisciplinary team. The first is the establishment of a scientific aim and the goals of the collaboration (7). For junior faculty, this can be a daunting task. Performing a literature search on potential topics and using the references cited in those articles to develop the research question or topic is an important initial step. Often, there is pressure to publish rapidly, however, the question of what topic to write about can be challenging. At every stage in one's career, asking the question, "What do I know that can help others at or below my level?" may be helpful in identifying topics. Recognizing recurring patterns or associations in imaging findings is a good way to identify potential untapped topics for publication in breast imaging. Additionally, reading current literature and participating in journal clubs with faculty peers may foster new research or publication ideas through questions that may arise. This process can also identify gaps in the current publications in the field that can turn into collaborative projects.

Once the scientific aims and goals have been established, potential participants in the team may be identified. If a senior faculty member will be involved as a collaborator, this person may serve as a useful mentor in selecting additional team members with whom they have collaborated successfully in the past. Listing the required functional roles and then pairing the names with the job titles is beneficial. For example, if analyzing a novel breast MRI technique is the goal of the study, a physicist and an MRI technologist may be needed. In this scenario, talking to others in the department to identify a physicist and a technologist who have served as collaborators in the past would help. Thinking ahead to include collaborators who may be needed in all phases of the project will allow for a more successful endeavor. For example, having the input of a statistician during the planning phase of a project will ensure appropriate data collection from the start and avoid potential subsequent duplication of efforts. For those new to a particular institution, presenting some material on the project at another department's meeting to identify collaborators may also be helpful. For example, if a radiation oncologist would be required, asking for time to do a five-minute presentation on the topic of interest at the radiation oncology department meeting may help to identify collaborators who are genuinely interested in the proposed project. While the identification of potential collaborators can be based on specific skill sets, the most important consideration is selecting team members who demonstrate positive attitudes and possess the basic skills to work with one another (8).

When building a team, including collaborators who may assist on a broader scale can be beneficial. In a recent initiative by the Mayo Clinic to more easily facilitate the translation of biomedical research to clinical practice, increased

success rates were found when using principles of structured project management, including dedicated project managers, in the research project (9). A project manager may help with organization and communication while also keeping the project moving along in a timely manner. Additionally, based on the project manager's background, he or she may also assist in the research project itself. For example, a project manager with a background in finance may provide assistance in obtaining grant funding.

Engaging clinical administrators may help to remove barriers in projects and can result in administrators recognizing the importance of all aspects of academic work, including patient care– and research-related work, instead of focusing only on patient care–related goals and outcomes (9). An example of this may be a quality improvement project for the breast center that touches on patient experience. Collaborating with the patient experience administrator at the facility could develop a symbiotic relationship and ultimately may improve the project itself. The support of a patient experience administrator may facilitate approval of portions of the project. For example, if a patient survey is needed, the patient experience administrator may know how to expedite approval of the survey. Additionally, this collaboration allows junior faculty to build relationships with administrators, which can be beneficial in their career development.

Once the team has been assembled by the team leader, it is imperative to engage all participants in a discussion regarding the vision or the goal of the research project. While the scientific aim established by a team leader provides a foundation, it is the brainstorming that occurs between all members of the team that allows for elaboration and fine-tuning of the scientific goals and, ultimately, the development of a shared vision (8). It is during this phase in the team-building process that the roles and responsibilities of each team member are delineated; and it is also when the group members' diverse backgrounds may lead to dissent and friction. For example, although the team leader may have an initial vision for the research project, once the idea is presented to the team individual members may have different interpretations based on their past research, clinical, or work experiences. This may take the project in multiple different directions. One team member may have a technology background and be more inclined to use the original research idea to create an application or clinical decision-making tool, whereas another team member may have an educational background and envision the project going in the direction of an educational exhibit. A third team member may envision an initial efficacy study with a subsequent grant-funded randomized controlled trial. It is important to welcome all ideas, discuss them as a group, and finally come up with an approach that may focus on one idea or develop multiple projects on a related topic.

Understanding how each member of the team prefers to operate, his or her personality and communication style, and each person's preference for future feedback may assist in overcoming additional obstacles (8). For example, team members may have preferences regarding methods of communication, with some preferring e-mail or text communication and others preferring in-person or telephone communication. Utilizing web-based video conference applications can be beneficial in long-distance collaborations or even in local collaborations when in-person meetings may be restricted. Ensuring that each member feels comfortable sharing his or her preferences, and making sure those preferences are acknowledged, can be facilitated by the team leader.

Developing team awareness fosters psychological safety. As described by Amy Edmonson, a professor at Harvard Business School (10), psychological safety is "a sense of confidence that the team will not embarrass, reject or punish someone for speaking out" (10). It is in the establishment of psychological safety that trust and cohesiveness are developed. This is an essential process in team science, as the ultimate goal of scientific productivity cannot be attained without cohesiveness (8).

Assigning Roles and Responsibilities

Forming a team with members of varied backgrounds can be intimidating; however, diversity is a powerful resource which can be also used as an advantage in assigning roles and responsibilities (11–14). Each team member will have different interests and skills that should be assessed prior to assigning roles. This allows for a solid team foundation. The easiest way to accomplish this is for the team leader to speak individually to each member prior to asking if they want to participate to make sure that the project is a good fit for all participants. While this may involve more work, it will also serve to establish the junior faculty member as the team leader. It is important for all members of the team to understand how their contributions fit into achieving the overall research goals. Each member must be able to answer the question, "What's in it for me?" (8). This question will have different definitions for every member depending on their career aims and their current career status (8). In general, the team leader should delineate the benefits of participation to each team member. Emphasizing the importance of exposure to each collaborator may assist in helping each team member answer this question. For example, while a team member may feel that they are having to put in more work relative to the recognition they may receive, reminding them that other collaborators will be observing how positive and flexible they are is helpful. Team members who demonstrate that they are team players and show flexibility are likely to be sought after to participate in future collaborative projects. And, while a particular project may not bring a team member the most recognition, their work may serve as an entrée to future higher profile projects.

Ensuring that all responsibilities are sufficiently outlined is important. This may include responsibilities specific to the project, and also any research-related tasks. For example, ensuring that e-mail and meeting communications

are documented and made available to the entire team is not only important in achieving the ultimate research goal, but such transparency of the process also contributes to building trust within the team (8). Similarly, continuous meeting cycles with specific tasks assigned for each meeting ensures that the project is able to move forward. Clearly communicating deadlines at the beginning of and during the project will help to guide team members in their own time management, ultimately resulting in a smoother experience. Explicitly discussing how decisions will be made regarding public disclosure of project details, including who will give public talks, respond to media inquiries, and handle intellectual property and patent applications, is vital in avoiding conflicts (8).

Allocating Rules

Allocating rules refers to the processes of decision making, data and knowledge sharing, and conflict resolution. It is important to remember that there are differences in group decision making versus individual decision making. Intellectual restrictions and personal inclinations are more likely to impact the decisions of individuals (15). Interactive group decision making has been shown to result in more rational decisions, as individuals are able to overcome or contain their potential biases (15,16). It is important for the team to specifically discuss its process of decision making. This can be initiated by the team leader once the team has been built and responsibilities assigned. Various methods of decision making include the following: the team leader makes the decision and informs the team, the team leader hears input from all parties and then makes the decision, a consensus decision is made with a possible second option, or the decision is delegated to a specific team member by the team leader (17).

The exact method of decision making may vary based on the decision. For the team leader, taking into consideration the size of the team and the question at hand is important. The team leader should aim to identify clearly the decision and the time frame in which it must be made. For example, the need to add additional collaborators to a project may arise and discussing how they will be added and what authorship credit they will receive will avoid potential conflicts further into the project.

Collaborative efforts in the team science setting provide the early-career radiologist with the opportunity to develop relationships with colleagues of like intelligence through problem solving around shared scientific interests. A component of this involves sharing knowledge and ideas with other team members. Data and knowledge sharing are fueled by high levels of trust (8), which can be built by safeguarding the integrity of the data, including protecting the identity of patients and the traceability of any team members using the data (18). Trust can also be built by safeguarding the ideas of each team member and ensuring appropriate attribution. Although knowledge hoarding or hiding can and does occur, cognitively complex jobs in which a large amount of information is processed using complex problem solving tend to foster knowledge sharing (19).

As with any cognitively demanding endeavor involving collaboration amongst a diverse team, conflicts may arise. A tool to assess the cause of team dysfunction is the Goals, Roles, Processes, and Interpersonal Relationships approach developed by organizational theorist Beckhard (20). This approach examines conflict in the following pyramidal order, described from top to bottom: goals, roles, processes, and interpersonal relationships (20). In this model, the team works from the top down to specifically identify causes of dysfunction (20). Rarely, though, are conflicts entirely due to the bottom tier of interpersonal incompatibility (20,21). Potential sources of conflict may include personal differences in project priorities, ambiguity regarding roles and responsibilities, inadequate funding or resources, and unrealistic deadlines (22). During team building, the participants can decide how to manage team dysfunction (21).

The Thomas–Kilmann Conflict Mode Instrument can assist teams in times of conflict. The instrument divides behavior into two dimensions: assertiveness on the y-axis (one works to accommodate his or her objectives) and cooperativeness on the x-axis (one works to accommodate the objectives of another) (23,24). With respect to assertiveness on the y-axis, unassertive behavior is given a lower value than assertive behavior. With respect to cooperativeness on the x-axis, uncooperative behavior is given a lower value than cooperative behavior. Placed on the same graph within these two dimensions are five methods (also called modes) for handling conflicts—avoiding, collaborating, competing, accommodating, and compromising—that all differ in their degree of assertiveness versus cooperativeness (23,24). On the graph, methods may share in either their degree of assertiveness (y-axis) or cooperativeness (x-axis), but not both (23,24). Avoiding is the most uncooperative and unassertive method, while collaborating is the most cooperative and the most assertive. Competing shares in being most assertive but is also uncooperative, while accommodating is the most cooperative but is also unassertive. Compromising is considered to be in the middle of the spectrum for both assertiveness and cooperativeness.

A potential source of conflict in a breast imaging project would be two separate teams working on a similar project. While the two groups may choose to continue working in parallel, an alternative idea would be for them to join together using the collaborating and compromising modes. This may involve each team member having to give up a little as the team grows; however, collaboration may bring fresh perspectives and allow two papers to come out of one project. While groups or individuals might place value judgements on a particular mode, Thomas and Kilmann assert that there is

no right or wrong mode. The appropriate conflict-handling mode depends on the situation and the skills of the team members (21) and Thomas and Kilmann outline scenarios where each of the five different modes may be utilized (24).

Authorship

Authorship matters as it confers credit and has academic and social implications (25). It is vital for collaborators to discuss and agree on criteria for authorship on abstracts and manuscripts, including the exact authorship order. Generally, early in a career, the junior author is typically the first author. They then transition to the last author as they start overseeing projects. While middle authorship may be considered less valuable at some institutions, the experience gained and connections made provides valuable groundwork for future projects that may be led by a junior author. While this has historically been the framework for decisions related to authorship order, the exact criteria to determine authorship order should be decided by the authors as a group and may vary (25). This will help to obviate potential future arguments and disagreements (8,26). In the early-career setting, this can be one of the most difficult discussions to make, especially in the setting of a power imbalance. It is recommended that authorship orders are openly discussed at the start of the project. These discussions may empower junior faculty members and trainees to communicate in an open, transparent manner.

The International Committee of Medical Journal Editors recommends that authorship be based on four directives. All participants should meet the criteria and all who meet the criteria should be considered as authors. Authors should conceive or design the work or help with acquiring, analyzing, or interpreting the data; prepare, modify, or revise the work; approve the final version for publication; and agree to accept responsibility for the entirety of the work (25). A corresponding author should be designated and act as the member of the team who communicates with the journal during submission, peer review, and publication. In some instances, authorship order may be determined by the amount of work performed by each person who qualifies to be an author, with the exact method of quantification decided by the authors. Individuals who contribute to the work but do not meet the criteria for authorship should have their specified contributions noted in an acknowledgments section (25). Authorship may be a source of conflict in multidisciplinary collaborations in breast imaging. For example, in a multidisciplinary research project, assistance may be requested from a breast radiologist in performing extra biopsies that provide clinical trial data or in reviewing images for the medical oncologist, the surgeon, or the radiation oncologist. The lead breast radiologist should ask for a clear description of how the breast radiology collaborators performing the study biopsies or reviewing the images will be recognized.

It is important to note that many junior collaborators have reported that participating in interdisciplinary work is risky. Therefore, it is important for the team to also discuss how junior faculty members will be appreciated and protected, such as by giving appropriate credit and recognition when due, and how the project will help promote their careers (8,27,28).

Conclusion

Building a research team that brings together people from different stages in their careers, from various disciplines, and sometimes from different organizations is dependent on embracing diversity and managing differences (8). For those beginning an academic career, understanding the components of team science, including how to build the team, assigning roles and responsibilities, allocating rules, and discussing authorship at the start of the project assists in ultimately achieving research goals while minimizing conflicts.

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Conflict of Interest Statement

G.J.W. is an editor of UpToDate. Otherwise the authors have no conflict of interest relevant to this article.

References

1. Lewin JS. Interdisciplinary teams and the road to discovery. *Radiology* 2010;254(1):26–30.
2. National Cancer Institute. Team science toolkit: about team science. Available at: https://www.teamsciencetoolkit.cancer.gov/Public/WhatIsTS.aspx. Accessed September 17, 2020.
3. Fontanarosa P, Bauchner H, Flanagin A. Authorship and team science. *JAMA* 2017;318(24):2433–2437.
4. Bonekamp S, Halappa VG, Corona-Villalobos CP, et al. Prevalence of honorary coauthorship in the American Journal of Roentgenology. *AJR Am J Roentgenol* 2012;198(6):1247–1255.
5. Brazile T, Hostetter Shoop G, McDonough CM, Van Citters DW. Promoting innovation: enhancing transdisciplinary opportunities for medical and engineering students. *Med Teach* 2018;40(12):1264–1274.
6. Tobi H, Kampen JK. Research design: the methodology for interdisciplinary research framework. *Qual Quant* 2018;52(3):1209–1225.
7. Morss RE, Lazrus H, Demuth JL. The "inter" within interdisciplinary research: strategies for building integration across fields. *Risk Anal* 2018. doi:10.1111/risa.13246.
8. Bennett LM, Gadlin H. Collaboration and team science: from theory to practice. *J Investig Med* 2012;60:768–775.
9. Pitzen JH, Dieter HL, Gronseth DL, et al. Transforming the practice of medicine through team science. *Health Res Policy Syst* 2020;18(1):104. doi:10.1186/s12961-020-00619-4
10. Edmondson A. Psychological safety and learning behavior in work teams. *Adm Sci Q* 1999;44(2):350–383.

11. Burbules NC, Rice S. Dialogue across differences: continuing the conversation. *Harvard Educ Rev*. 1991;61(4):393–416.
12. Mannix E, Neale MA. What differences make a difference? the promise and reality of diverse teams in organizations. *Psychol Sci Public Interest* 2005;6(2):31–55.
13. Bammer G. Enhancing research collaborations: three key management challenges. *Res Policy* 2008;37(5):875–887.
14. Coller BS. Translational research: forging a new cultural identity. *Mt Sinai J Med* 2008;75(5):478–487.
15. Charness G, Sutter M. Groups make better self-interested decisions. *J Econ Perspect* 2012;26(3):157–176.
16. Kugler T, Kausel EE, Kocher MG. Are groups more rational than individuals? A review of interactive decision making in groups. *Wiley Interdiscip Rev Cogn Sci* 2012;3(4):471–482.
17. Stein J. *Decision-making models*. Available at: https://hr.mit.edu/learning-topics/teams/articles/models. Accessed November 3, 2020.
18. Yang G, Yu J, Shen W, Su Q, Fu Z, Hao R. Enabling public auditing for shared data in cloud storage supporting identity privacy and traceability. *J Syst Software*. 2016;113:130–139.
19. Gagne M, Tian A, Soo C, Zhang B, Ho K, SB, & Hosszu K. Why employees don't share knowledge with each other. *Harvard Business Review*. Available at: https://hbr.org/2019/07/why-employees-dont-share-knowledge-with-each-other. Published 2019. Accessed September 7, 2020.
20. Beckhard R. Optimizing team-building efforts. *J Contemp Bus* 1972;1(3):23–32.
21. Wolfe AD, Hoang KB, Denniston SF. Teaching conflict resolution in medicine: lessons from business, diplomacy, and theatre. *MedEdPORTAL* 2018;14:10672. doi:10.15766/mep_2374-8265.10672
22. Guan D. Conflicts in the project environment. Paper presented at PMI® Global Congress 2007—Asia Pacific; January 29–31, 2007; Hong Kong, People's Republic of China.
23. Kilmann R, Thomas K. Developing a forced-choice measure of conflict-handling behavior: The "mode" instrument. *J Educ Psychol Manag* 1977;37(2):309–325.
24. Thomas K, Kilmann R. Thomas-Kilmann conflict mode instrument: profile and interpretive report. Available at: http://www.lig360.com/assessments/tki/smp248248.pdf. Accessed September 22, 2020.
25. International Committee of Medical Journal Editors. Defining the role of authors and contributors. Available at: http://www.icmje.org/recommendations/browse/roles-and-responsibilities/defining-the-role-of-authors-and-contributors.html. Accessed September 22, 2020.
26. Bennett LM, Gadlin H, Marchand C. National Cancer Institute collaboration and team science: a field guide. Available at: https://www.cancer.gov/about-nci/organization/crs/research-initiatives/team-science-field-guide. Accessed September 22, 2020.
27. Curtin C. Works well with others. *Genome Technology*. Available at https://www.genomeweb.com/archive/works-well-others#.YJv8-bVKhPZ. Published 2008. Accessed September 7, 2020.
28. Klein J. *Creating Interdisciplinary Campus Cultures: a Model for Strength and Sustainability*. 1st ed. San Francisco, CA: Jossey Bass and Association of American Colleges and Universities; 2010.