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Translational Science Project Team Managers: Qualitative Insights and Implications from Current and Previous Postdoctoral Experiences

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Abstract
The development of leadership and project management skills is increasingly important to the evolution of translational science and team-based endeavors. Team science is dependent upon individuals at various stages in their careers, inclusive of postdocs. Data from case histories, as well as from interviews with current and former postdocs, and those supervising postdocs, indicate six essential tasks required of project managers in multidisciplinary translational teams, along with eight skill-related themes critical to their success. To optimize the opportunities available and to ensure sequential development of team project management skills, a life cycle model for the development of translational team skills is proposed, ranging from graduate trainees, postdocs, assistant professors, and finally to mature scientists. Specific goals, challenges and project management roles and tasks are recommended for each stage for the life cycle.

Keywords: multidisciplinary science teams, postdoctoral leadership development, project management, team science, translational science

Postdoctoral Experiences of Translational Science Project Managers: Qualitative Insights and Implications from Current and Previous Postdoctoral Experiences

The increased emphasis upon translational science has placed tremendous pressure upon graduate schools in clinical and biomedical education programs to recalibrate their educational competencies and educational processes. The National Institutes of Health (NIH), through the Clinical and Translational Science Awards (CTSA), is reshaping how biomedical science is conducted. The NIH has articulated a road map (Zerhouni, 2006) calling for a redefinition of the ways in which medical research is conducted, which is intended to produce significant improvements in health. At the center of this movement is the use of research teams.

Recently, CTSAs have been purported as exemplary frameworks for development of team science (Calhoun, et al., 2013). Specifically, multidisciplinary translational teams, or MTTs, are utilized not only to generate collaborative science, but also provide fertile training arenas for emerging translational scientists. In the MTT model, graduate students, postdoctoral students, and junior faculty are recruited and deployed along with mature scientists from many disciplines. Frequently, postdoctoral students and trainees operate as team project managers, under the directive and mentorship of the principal investigator. However, recent literature (Campeggi, 2013; Kolb, Klappstein, & Tonner, 2012) involving the need for team leadership training and preparation for postdocs suggest there is much to be gained from more formalized efforts.

The purpose of this paper is threefold. First, we examine the growth of team science and the importance of developing team skills for those engaging and preparing for careers in the translational sciences. Second, the importance

and contextual significance of team skills will be explored through first-hand case experiences of translational team project managers. Through cases and interviews we shall explore the essential tasks and needed skills for team project leaders and managers. These shall be explored in relation to traditional project management and team science literature. Last, we shall propose a life cycle model for the development and enrichment of translational team competencies, isolating how this would impact the postdoctoral experience and education. Building on this, specific roles and tasks appropriate for postdocs assuming project manager responsibilities will be explored.

Team Science

Growth of Team Science

Team science can be defined as "ambitious multiyear initiatives to promote cross disciplinary collaboration in research and training" (Stokols, Hall, Taylor, & Moser, 2008, p. S77). Evidence suggests that the use of teams in the production of science is the fastest growing authorship structure (Jones, Wuchty, & Uzzi, 2008), and that research products from scientific teams are more frequently cited and have greater impact than that of single authored research (Wuchty, Jones, & Uzzi, 2007). As noted by Wuchty, Jones, and Uzzi (2007), the data trends over a five decade period are profound, "suggesting that the process of knowledge creation has fundamentally changed" (p. 1036). Reviews of the literature (Börner, et al., 2010; Cummings & Kissler, 2005; Fiore, 2008; Spring, Moller, Falk-Kresenski, & Hall, 2012) all indicate that team science is becoming increasingly prominent. However, Hall, et al. (2008) and Stokols, Misra, Moser, Hall, & Taylor (2008) suggest a great need to develop models and formal training in team science.

Developing Team Skills

Whereas the research base on team effectiveness and development has progressed (Cohen & Bailey, 1997; Kozlowski & Ilgen, 2006; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Burke, Stagl, Salas, Pierce, & Kendall, 2006; Morgan, Salas, & Glickman, 1994), so too has the identification of specific team-based competencies. General team competency models (Cannon-Bower, Tannenbaum, Salas, & Volpe, 1995) and virtual team competency models (Hartel, Konradt, & Voss, 2006) depict a broad range of complex social, behavioral, and cognitive skills required for effective team member performance. Recently, literature has been emergent relative to team skills related to translational science. For example, the NIH's CTSA (2009) Education and Career Development Key Functions Committee has developed core competencies for graduate (Master's) programs in translational research. Among the 14 defined competency areas are two specific to team science, consisting of translational team work (i.e., managing interdisciplinary teams of scientists, group decision making, managing conflict, etc.) and translational team leadership (i.e., fiscal and personnel responsibilities, fostering innovation, etc.).

Rubio, et al. (2010) note that communication skills and negotiation skills are paramount for functioning in translational teams, along with critical thinking skills, and the ability to work and lead collaboratively in team management systems. Bennett, Gadlin, and Levine-Finley (2010) have provided a field guide for collaboration and team science with identification and recommendations involving team competencies. Among these are building a team, fostering trust, developing a shared vision, communicating to others, sharing recognition and giving credit, handling conflict, strengthening team dynamics, and navigating and leveraging networks and systems. Jackson, Gabriel, Pariser, and Feig (2010) also note the need for translational scientists to receive training in teamwork and communications skills. Weaver, Rosen, Salas, Baum, and King (2010) have as well suggested a model for team science which involves specific attitudes (e.g., mutual trust), specific behaviors (e.g., communication), and cognitive attributes (e.g., shared mental models).

There is some limited research (Feldman, Divoll, & Rogan-Klyve, 2013) suggesting that graduate training in specific team competences (e.g. data dissemination) is helpful in developing team based behavior in research groups. However, Begg, et al. (2014) have recently examined training and education practices in CTSA institutions related to team science. They report that 86% of the respondents suggested training in team science was important, but unfortunately only 52% of the institutions sampled offered such training.

What then can be concluded from the studies articulating the need for team related training? It is clear that training in team skills is important**,** and changes in translational science require competence in multidisciplinary and transdisciplinary environments. There is strong evidence from general team training research and meta-analysis reports (Delise, Gorman, Brooks, Rentsch, & Steele-Johnson, 2010; Salas, et al. 2008) suggesting that team training not only improves team skills, but also improves objective performance. Thus, formal team training needs to be integrated as both an educational and experiential intervention in the preparation of future translational scientists. Obviously, much work needs to be done in this regard.

Qualitative Methods Used

In order to propose a grounded model for developing translational science project managers, we utilized both case analyses and interviews using faculty, researchers, and students at the University of Texas Medical Branch at Galveston (UTMB). We focused on how junior researchers have actually achieved and experienced these roles, as well as identified specific competencies and needed training for postdoctoral trainees. The interviews and analysis followed the logic of discovery suggested by the grounded theory model of qualitative research (Charmaz, 2006). We also employed auto-ethnographic case histories (Ellis, 2009) utilizing two of the more experienced and successful team project managers discovered during the interview process. (See Kotarba, Wooten, Freeman, & Brasier 2013, and Kotarba, 2014, for an extensive discussion of the qualitative methods used in our research at UTMB).

Subjects

The auto-ethnographic case histories used two prominent team project managers. The first (Sara Dann, Ph.D.) is currently an Assistant Professor of Internal Medicine - Infectious Disease, and the second (Celeste Finnerty, Ph.D.) is an Associate Professor in the Department of Surgery, and is affiliated with the Shriners Hospital for Children Burns Center. Due to their first-hand knowledge and team science experience, both were asked to serve as collaborators and co-authors for the study.

We focused our interview investigation upon project managers for the twelve multidisciplinary translational teams currently operating at UTMB. A total of eighteen individuals were interviewed, inclusive of nine assistant professors who have served as project managers, but who began this job while serving as postdoctoral trainees; five postdoctoral trainees currently serving as MTT project managers; and four associate and full professors who work extensively with postdoctoral teams, and have experience in mentoring project managers.

Procedure

Each case history and interview was audio-recorded and transcribed. A total of twelve interview questions were asked, and were generated from the existing literature on translational research teams. These involved: 1) history with the institution, 2) team involvement, 3) perceptions of translational science, 4) promotional experience, 5) managerial self-perception, 6) prior leadership/managerial experience, 7) mentoring received, 8) skills acquired, 9) managerial responsibilities, 10) experiential reflection, and 11) best

practices/advice. The two senior authors reviewed, content analyzed, and coded the interview data for purposes of exploring emergent themes.

Data Analysis

Following the narrative case history methodology (Ellis 2009), all four collaborators reviewed the case histories in conversation to resolve differences of view in order to generate the analysis presented below. The authors conferred on their analyses to arrive at consensus. Given the relatively small number of interviews, we decided not to utilize any qualitative coding software. Interview data was subsequently content analyzed and coded for purposes of exploring emergent themes.

Results and Qualitative Insights
Case History: Sara Dann, Ph.D.

Leading and managing a team of transdisciplinary researchers is an amazing experience, but not an easy task. It is different from running your own lab, in which you have autonomous control over everything. Leading and managing a team of strong individuals, trained to work independently, requires a unique skill set to overcome challenges and to successfully achieve goals.

A little more than a year ago, I transitioned from being a participant to leader and manager of an extraordinary team consisting of 20 researchers from various disciplines (structural biochemistry, molecular biology, immunology, physiology, engineering, epidemiology and clinical sciences). I've learned that there is no formal training that can fully prepare junior faculty for leading a team of incredibly intelligent and established researchers. To be a successful leader, you must be committed to the team. You need to invest time learning about what makes a great team and what is needed to maintain productivity. There are numerous resources to help make a great team, but one of the most valuable is finding a committed mentor with strong team leadership experience. As leader, it is your responsibility to keep everyone focused on the team's goals and provide direction. In order to do so, you need be knowledgeable about the work of each member, and willing to take risks to drive the science forward. These activities will help generate respect and trust in you as a leader and team's mission.

To become an effective leader you do not need to be the most intelligent person in the room, however you must be able to inspire and nurture talent and empower others to succeed. The best way to learn this is through observation and communication. As a graduate student and postdoc, I took the opportunity to observe leaders in action. I also discussed with my peers their experiences with their mentors and took time to reflect on my own experiences as a mentor and mentee. It was through these activities that I learned about different leadership and management styles and determined what styles and characteristics promote success. The strongest leaders, managers, and mentors are actively, but not overly, involved in projects and provide nurturing environments through encouragement and support. During my training, I actively sought out numerous mentors who provided me with many views on management styles. I gleaned what I thought were the best qualities from each and try to incorporate them in my everyday life. Becoming a great leader and manager is an evolving and continual process. You learn from your mistakes, failures and successes, and use that knowledge to fine-tune your style and use in future endeavors. Learn everything you can from every style that you can and in the words of my greatest mentor: "take heed, take notice, go forth and conquer!"

Case History: Celeste Finnerty, Ph.D.

For the last ten years, I've served as a project manager for the large-scale, multidisciplinary collaborative efforts for a Burns research group associated with a Shriners Hospital. The position did not exist at the beginning of my postdoctoral

experience; the need to rapidly expand the scope of our research, however, made this leadership role a necessity. Throughout this period, the requirements of the job, my view of my role in team and project management, the barriers to success, and team management styles have changed significantly.

In my early postdoc years, I lucked into a project that was associated with a multi-institutional grant; the grant was divided into separate subgroups including patient oriented research, sample analyses, and data analysis. The PI that I worked with was the leader of one of the divisions based on clinical population. During our early quarterly meetings, I played a mostly secretarial role – taking minutes, keeping track of the deliverables that each person was responsible for, and reminding people of these deadlines during monthly phone calls. This role quickly morphed into one to facilitate communication between several teams – our clinical team and the statistical and analytical teams. At this point, my role expanded to include project management. Connecting analytical folks – those running tests and those analyzing the data – with the clinical team was necessary to ensure that all projects moved ahead. From this stage, we quickly moved to developing and assigning new projects, and monitoring progress beginning with patient selection and data evaluation through manuscript production. With the transition to junior faculty, I became responsible for writing and presenting group progress reports, making sure that projects were progressing on a monthly basis, and running the group face-to-face meetings when the PI was absent.

At the same time, we recruited research fellows who were either M.D.'s or Ph.D.'s to train in translational science at the multi-center level, and had them each lead a project under the direction of myself or one of our site clinicians. They would then attend the quarterly meetings to present their progress – gaining experience in disseminating information to audiences with diverse backgrounds, and to accept constructive criticism designed to help them improve as translational scientists. This project management paradigm developed throughout this time was the basis for our multi-disciplinary translational team (MTT) within the CTSA.

In my role as the Burns MTT manager, I was the point person for organizing and directing the meetings and projects along with the MTT director. The Burns MTT included clinicians, basic scientists, fellows, students, biostatisticians, and advisors. Projects were led by faculty or fellows and were reviewed intensively by the individuals and small groups during the two weeks between meetings and then presented to the entire group at the MTT meetings for review of the analyses and results, and discussion about how to better evaluate the data sets or what the next step should be. In order to prepare our trainees to lead translational science efforts, we are now transitioning to having the fellows and postdocs run the meetings. We anticipate that this change will provide leadership and communication experiences that will give these energetic team members an advantage in their future endeavors.

Interview Data

What emerged from the data was a taxonomy of six essential tasks required of MTT project managers. These are: 1) maintain all reports and team documents, 2) call team meetings, 3) keep minutes of team meetings, 4) assemble meeting agenda, 5) assemble quarterly reports, and 6) accomplish billing. Respondents indicated that approximately 10% of their overall work time was devoted to engaging the tasks involving project management. By themselves, these tasks can be fairly easily routinized, resulting in the ability to stay within the 10% limit. Respondents seem to understand two types of management style: operations vs. leadership. Which style is pursued depends on several factors, inclusive of team size, research topic, the Principal Investigator, and the background of the project manager.

With respect to job skills of project managers, thematic analysis of these data indicated eight different cognitive or skill-based themes. These are depicted in Table 1. These eight categories represent not only complex integrative skills, but also traditional administrative skills, political skills, and continuous learning skills and capabilities.

Discussion and Implications for Postdoctoral Training of Project Team Managers

Review of the case analysis narrative as well as the emergent task and skill themes from interviews suggest that they are likely context specific findings. Previous reports of UTMB's research culture (Kotarba, Wooten, Freeman, & Brasier, 2013; Kotarba, 2014) provide evidence that changes in funding, research team participants, and research foci give rise to situation specific perceptions. Thus, the data reported here are most genralizable to the approximately 60 CTSA funded sites. While it is questionable whether these results are applicable beyond the biomedical sciences, given the growth in team science, collaborative teams, and funding priorities for translational efforts, these results may be most useful in addressing future training needs.

The case study results, which are based on two highly successful project managers who were previously postdocs, suggest that serving as a project manager in a multidisciplinary translational team is a very helpful career development opportunity. As noted by Collins (2010), young scientists need a shorter pathway to success. Perhaps serving as a project manager while a postdoc may facilitate early career achievement, as it has been suggested that early exposure to collaborative projects can be helpful to career success (Johnson 2011), and more importantly to later stages of one's career (Hu, Chen, & Liu, 2014). Given the longer developmental trajectories due to the complexity of collaborative science, exposure to translational projects has become all the more critical (Nash, 2008). Recently, Lee et al. (2013) has suggested that the metrics for successful scientific careers should involve team leadership. Thus, as evidenced by the two case reports in this study. participation as a project manager may play a big role in later career advancement.

The identified six essential tasks required of MTT project managers may be unique to both translational science teams and to the administrative structure of UTMB. These six tasks can however be compared to the commonly reported tasks and taxonomies reported in the general project management literature (Cleland, 1998; Kerzner, 2013; Morris, Pinto, & Söderlund, 2012). While translational science as practiced through a project management framework is no doubt more complex (Curlee & Gordon, 2010), includes scientific criteria (Archibald, 2003), and engages stages of development that are unique (Calhoun, et al, 2013), there does exist some similarities to traditional project management. The Project Management Institute's (PMI) Guide to the body of knowledge (2013) is considered the universal taxonomy of project management. This body of knowledge has identified 47 different project management processes in five broad groupings. The six essential task groupings identified by this study relate most specifically to PMI's process grouping of planning (i.e., documentation, time and cost, communication), and the process grouping of control (i.e., tracking of progress, reviewing performance, and monitoring). This suggest that project managers on translational teams have a limited role in the overall management of the team.

The emergent project management skills identified in Table 1 are also similar to those reported in the project management leadership literature (Burke & Barron, 2014). Here, collaboration and network skills as expressed by dealing with other teams as well as leaning how to work with upper level administrators are illustrative. These emergent skills are also similar in nature to previously cited literature involving team science skills. Specifically, Bennett, Gadlin,

Table 1. Skill-related themes important to project managers on multidisciplinary translational teams.

Skill Themes	Description
Learning how to work with people	Scientists working in translational areas must know how to communicate well with an increasing range of other workers, such as patent consultants, attorneys, business managers, entrepreneurs/fundraisers, and so forth.
Learning how to deal with CTSA administrators	CTSA administrators can be differentiated from other traditional scientific administrators. They are more committee based and somewhat parallel to if not independent of traditional academic lines of authority.
Learning how to write letters of recommendation/support	Enlightened P.I.s mentor their team managers in the art of effective letter writing. This art is especially important today in a climate of extremely tight competition for grants, faculty positions, traineeships, and so forth
Learning how to deal with "Big Guns"	The team research concept, especially at centers like UTMB that pay special attention to team structure and function, result in high powered, veteran researchers sharing the status spotlight on inter-disciplinary teams. Respondents note that a successful team manager must learn how to support egos while simultaneously stoking creativity and innovation.
Learning how to take advantage of the Coordination Committee	The Coordination Committee is the top group of CTSA administrators at UTMB. It is composed of esteemed scientists and grants persons, clinical administrators, and university leaders. The well-trained team manager learns not only how to interact with the Coordinating Committee, but also learns to see it as a great role model for managers.
Learning how to take advantage of research resources	Research resources are yet another great resource to learn about and to utilize. The research resources at UTMB are available to all CTSA funded teams, and consist of help with ethics, education, community engagement, bioinformatics, and so forth. As with the Coordination Committee, the team manager can serve as the liaison between the scientists and the resource.
Learning from other MTTs by visiting other teams	Respondents note that the team managers can and should be responsible for generating and maintaining reciprocal relationships among teams. For example, one team manager noted how valuable it has been for her to schedule visit for the team to one of the more successful, large and established teams
Learning how to manage one's personal and professional time	Team managers learn a range of skills that will be valuable in the future, and time management is one of the more practical skills. In general, this is an illustration of how the team manager experience is a great resource for learning how to be a P.I.

and Levine-Finley's (2010) identified team science competencies of navigating networks, along with Weaver, Rosen, Salas, Baum, and King's (2010) identification of targeted communication skills are noteworthy. These emergent skills also relate to Cannon-Bowers, Tannenbaum, Salas, and Volpe's (1995) identification of situation awareness, adaptability, and interpersonal relations as related to our findings of dealing with administrators from many constituents that change over time. The political nature of many of the skills identified relate directly to the popular notions and literature of influencing without authority (Cohen & Bradford, 2005), and to upward influence tactics (Yukl, Guinan, & Soitolano, 1995). The skill area of time management relates to much popular literature as well as empirical findings (Claessens, van Eerde, Ruttle, & Roe, 2007; Richards, 1987) suggesting that effective time management is important to managerial success and well being.

Analysis of the narrative from the case reports and interviews indicates two clear implications for postdoctoral training and team project management. First, respondents made the point that tenure track researchers are generally best equipped to serve as team managers. Assistant and associate professors are already aligned with on-going research groups. Their assigned managerial tasks coincide well with their personal scientific interests. There was agreement that a managerial assignment can seriously interfere with a postdocs main priority: focusing on a research problem, possibly publishing follow-up studies from one's dissertation, learning how to write grants, and in general move along with one's career. The implication is that a tenure track scientist has the experience and, hopefully, maturity to know how to exercise formal leadership (e.g., dealing with team members from all ranks and generating constructive communication across disciplines and specialties as expected in team science). Thus, perhaps assignment of formidable team project management responsibilities should be restricted to the most mature postdoctoral students.

To address the issue of when one should assume team project management responsibilities, Figure 1 proposes a life cycle model for the overall development of translational team skills. Rather than rely on serendipitous acquisition of team and leadership skills, we propose that such acquisition be specifically phase related. As shown, we propose that a lifecycle continuum for the development of translational team skills be considered. This continuum is initiated as a graduate student, progressing to the postdoc status, to assistant professor, and culminating in the status of mature scientist. At each stage, we propose that there is a different training purpose, differing developmental challenges, and different roles and tasks that might be appropriate.

The graduate school level (i.e., Master's and Doctoral) would be the optimum time for acquisition of formalized knowledge covering the basics of team science and leadership skills. Here, basic self awareness is of great importance, with the goal of acquiring the basic knowledge and skills. As a graduate student, performing the roles of observer (e.g., observing the roles and skills of team members and leaders) and evaluator (e.g., diagnosis of scientific issues and team dynamics) seem most advantageous as a developmental building block.

- Self-Assessment and Awareness
- Basic Knowledge and Skill Acquisition
- Observer and Evaluator Roles

- Leadership Skill Development
- Knowledge and Skill Development
- Record Keeper and Scheduler Roles

- Leadership Skill Enactment
- Knowledge and Skill Refinement
- Presenter and Coordinator Roles

- Visionary Leadership and Collaboration
- Mentorship
- Liaison and Facilitator Roles

Figure 1. Life cycle continuum for the development of translational team skills.

During the postdoc phase, we recommend that the opportunity for expanded skill development be provided. In this postdoc phase, we suggest that leadership skill development can be accomplished by the limited roles suggested by this study in a project management position. Thus, knowledge and skill development is the primary goal. Here, engaging the roles of record keeper (e.g., keeping minutes, tracking progress) and scheduler (e.g., agenda communication) seem most appropriate. This provides opportunities for short term and specific assignments involving team and project management without the full responsibility of administrative authority. This of course would be contingent upon the maturity of a given postdoc, the stage of the project, and the size of the team. The postdoc then can test out and refine their leadership capacities without conflict with publication and funding requirements or career consequences.

We propose that after the postdoc phase, it is appropriate in the assistant professor phase to then make project and team management responsibilities more prominent. At this stage, more formal responsibility would allow for skill enactment and refinement. It is at this stage that the roles of presenter (e.g., active participation in presenting research results) and coordinator (e.g., arranging for participants and external disciplines to collaborate, prioritizing agendas) might be most legitimate.

As an individual becomes a more mature scientist, and possibly be designated as Principal Investigator, they would assume full leadership and managerial responsibility for a scientific team. Here, the developmental challenge is one of being a visionary leader, fully capable of collaboration, and the mentoring of young scientists. Thus, the roles of liaison (e.g., reporting and coordinating with other teams as well as upper administration) and facilitator (e.g., meeting and discussion leader) seem to be most aligned at this stage.

The types of team roles suggested by Figure 1 are generally supported by the available literature. Here, preferred team behaviors (Rousseau, Aube, & Savoie, 2006), as well as effective team meeting procedures and functions (Leach, Rogelberg, Warr, & Burnfield, 2009; Nixon & Littlepage, 1992), and group based roles (Belbin, 2010; Benne & Sheats, 1948) can be drawn upon to construct phase based development plans.

A second clear implication from the data is that future team leadership and project management

preparation perhaps should be addressed by both formal and experiential means. The skills depicted in Table 1 are largely a function of experience, and many of these involve understanding the complexities of institutional politics. However, a postdoc position should also address needed formal education and training in team science. As noted by Wildman and Bedwell (2013), team science education "should provide students not only with declarative knowledge regarding the science of teams, but also with practical experiences that will develop skilled team scientists-practitioners" (p. 381).

There are a few good examples of formal education programs addressing team science skills and knowledge. Northwestern University (2014) provides an on-line program of team science basics and it is available for behavioral, medical, and clinical medical students. Another option is for postdocs to acquire a certificate in team related skills. For example, the University of Texas Medical Branch (2014) offers a Postdoctoral Certificate in Translational Research Team Management. Here, on-line modules are offered involving six specific areas of team science. These six modules include: Team Building and Meeting Management, Effective Leadership, Conflict Resolution and Negotiation, Personal Influence and Communication, Problem Solving and Decision Making, and Translational Project Management. These six modules require assessment of learning, and utilize case analysis, literature review, and personal application projects to ensure transfer of training.

Conclusion

While the results of the current study are generally limited to CTSA funded scientist and translational team science, and possibly to the institutional sample used, the critical reviews of the field (Börner, et al., 2010; Cummings & Kessler, 2005; Fiore, 2008; Spring, Moller, Falk-Kresenski, & Hall, 2012) all suggest that systemic problems in team science education and training are an impediment across all scientific disciplines. Thus, it is suggested that what has been recommended for the biomedical sciences may, at least in part, be applicable to the postdoctoral needs of many other fields.

Findings from this study suggest that, at least for postdoctoral students involved with managing multidisciplinary and transdisciplinary translational teams, that training in project management and team science should be customized to the needs in the biomedical academic environment. In addition to the teamwork and communication basics, results from this study suggest that a developmental emphasis should be placed on upward influence and time management. These findings may be generalizable to other similar type of research teams (e.g., engineering and information technology), particularly if it requires changing membership, innovation, management of multiple disciplines, and numerous constituencies with institutional power.

Overall, our analysis of available literature and from case and interview data suggest four key conclusions. First, team science leadership and project management skills are critical for developing future scientist. Second, development of team leadership and project management skills should be conducted as part of an overall career life cycle process, starting with graduate students and culminating in mature Principal Investigator's engagement of multidisciplinary and transdisciplinary teams. Third, both knowledge and skills of team science are required of future scientist, and therefore both formalized and experiential opportunities must be developed and provided to enable the development of complex skills and contextual learning. Last, postdoctoral experiences to develop leadership and project management competencies should be sequential relative to roles and tasks required, in accordance to the maturity of each postdoctoral student.

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