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Gaetano R. Lotrecchiano, EdD, PhD
Assistant professor of Clinical Research and Leadership and of Pediatrics at the George Washington University School of Medicine and Health Sciences, USA

Review Article

Improving Collaboration: Guidelines for Team Training

Christina N. Lacerenza and Eduardo Salas*
Department of Psychology, Rice University, USA

***Corresponding author**
Eduardo Salas, Department of Psychology, Rice University, 6100 Main St, Houston, TX 77005, USA, Tel: 407-0882-1325; Fax: 407-882-1550; Email: esalas@ist.ucf.edu

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Abstract

Current issues require a team of experts with various backgrounds and expertise, and this has led to an increase in the importance of collaboration within medicine and science. However, a team of such experts does not ensure an expert team. Collaborative effectiveness is a function of both technical and teamwork knowledge, and the Science of Team Science needs to be integrated with the science of team training in order to promote successful collaboration. Meta-analytic evidence supports the use of team training for improving team cognition, performance, and overall effectiveness. The purpose of the current review is to identify team training guidelines for cross-disciplinary collaborative efforts in order to facilitate team functioning within translational medicine and related domains. This review also provides a discussion of challenges among these teams and insights on problem-solving strategies.

INTRODUCTION

"The myth of the solitary scientist in search of truth is a romantic notion whose continued existence serves as the major barrier to progress in bringing the collective weight of the sciences to bear on the problems of human kind. And the idea that all scientific progress takes place within the boundaries of current disciplines is historically invalid and currently counter-productive" [1].

Collaborative science and practice is necessary to solve critical scientific and societal concerns [2-4]. Prominent issues in all scientific domains (e.g., medicine, biology, psychology) are too complex for narrowly focused research groups to solve [5,6]. These issues require the conceptual and methodological capacities that arise from integrating multiple disciplines [7], and this has engendered the use of cross-disciplinary science teams (or cross-disciplinary collaboration). These teams advance science in ways that individual scientists and practitioners could not due to diverse perspectives and reduced project time [8]. There are several forms of cross-disciplinary collaboration, including multi-disciplinary, inter-disciplinary, and trans-disciplinary collaborations [3] and the focus of the current review includes all forms of cross-disciplinary collaboration.

Research on the topic of cross-disciplinary collaboration is still in its "prolonged developmental period" [6], and the present review contributes to the field by identifying empirically based team training guidelines in an effort to enhance collaborative functioning within translational medicine and other domains. First, we provide a discussion of the challenges to collaboration, and then leverage team training and effectiveness research to derive team training techniques for cross-disciplinary science teams. Team training is a theoretically grounded and scientifically validated practice that increases team effectiveness by systematically integrating teamwork Knowledge, Skills, and Attitudes (KSAs) into planned instruction [9]. This training has increased team performance and processes in various domains, including healthcare [10], the military [11], aviation [12], and medical education [13]. Further, team training has recently been named by Shakelle and colleagues [14] in the Annals of Internal Medicine as a top patient safety intervention [14]. Meta-analytic evidence also supports the effectiveness of team training on a variety of outcomes, and these results are identified in Table 1. Team training, if well executed, can deter threats to team effectiveness by educating clinical and scientific translational professionals on necessary teamwork competencies. In the following section, we discuss barriers to collaborative functioning, and subsequently provide solutions to such issues by means of applying team training guidelines to large-scale collaboration teams (Table 1).

Collaboration barriers

Cross-disciplinary science teams display a multitude of expertise in various domains, which increases problem-solving ability [15, 16] yet introduces barriers to successful team functioning. These barriers are present before team inception (i.e., antecedent factors), during team performance (i.e., process factors), and after the team disbands (i.e., outcome factors), and relate to both team- and organization-level elements [7].

During the nascent stages of team formation, antecedent factors represent those that are of concern before a cross-disciplinary collaboration performance period begins. These factors include the lack of collaborative readiness, preparation and planning, and institutional support. Collaboration readiness, or the degree to which a team or institution expresses preparedness for multi-disciplinary action [17], includes the display of organizational support for collaboration (e.g., number of departments within an institution), the presence of technologies allowing for effective communication, and the degree to which team members have previously engaged in collaborative activities across organizational boundaries [18]. Organizations may not display a high degree of collaboration readiness despite the critical role this factor plays in determining cross-disciplinary success. For example, within the academic setting, university administrators typically reward individuals for work published within their field and may even count research outside ones department as a demerit in the tenure process [16]. Fiore [16] suggests institutions to nurture collaboration by giving cross-collaborative researchers more credit for their collaborative efforts. In addition, cross-disciplinary science teams require, but often lack, strategic preparation and training among team members [18,19]. This leads to ambiguity of team goals, lack of a shared timeline of achievement, and unrealistic expectations for group harmony. A lack of institutional funding for cross-disciplinary collaboration also poses as a barrier to collaborative success. This is because departments typically provide funding for narrowly-focused, short-term projects where collaborative science projects require a longer timeline and broadly-focused goals [7].

Process factors represent issues that arise during the collaborative performance period as a result of poor team functioning and typically include differing disciplinary perspectives, poor leadership, ineffective communication, and interpersonal issues [15]. As previously mentioned, cross-disciplinary science teams consist of experts with different backgrounds. This diversity can create conflict due to a lack of consistency between various disciplines regarding language, methodology, and theory [18]. Challenges are also likely to arise regarding leadership within collaborative efforts because team leaders may lack teamwork skills and management experience [18]. Leading a large-scale collaborative effort may be challenging, and Stokols and colleagues [18] recommend leaders to display extensive experience in managing similar projects. Although the above stated process factors are prevalent, after spanning the current literature base, we argue that the most critical issue is ineffective communication. Cross-disciplinary science team members are likely to be distributed across departments and institutions and the lack of collocated members can lead

Table 1: Meta-Analytic Evidence for Team Training Effectiveness.

Source	Outcome	k	Effect Size
Salas, Nichols, and Driskell [86]			
	Overall performance	28	.29*
	Objective measures	22	.28*
	Supervisor ratings of performance	6	.33*
Salas, DiazGranados, et al [29]			
	Cognitive outcomes	12	.42**
	Affective outcomes	16	.35**
	Process outcomes	25	.44**
	Performance outcomes	40	.39**
	All outcomes	52	.34**

Note. k = number of primary studies included in meta-analysis. *Effect size is reported as the r correlation coefficient. **Effect size is reported as the estimated true correlation between the predictor construct and the relevant criterion (fully corrected for measurement error in both the predictor and criterion).

to ineffective communication (e.g., lack of face-to-face contact, reliance on virtual tools) [18]. Differing scientific and discipline-bound language also hinders communication, and interpersonal discrepancies can arise due to conflicting scientific theories, increased workload, and distrust [15,16,20,21].

Issues may also arise as a result of team outcomes [2,15,22]. Team members may not see a direct benefit of collaboration because of the nature of cross-disciplinary science team outcomes. We refer to these issues as outcome factors and they include career development conflict, advancement goal conflict, and identity threats. Investigators may see other investigators as a potential threat to their career advancement because a small amount of credit may be given to each investigator and certain investigators may be given more recognition than others. For example, Rosalind Franklin, a great contributor to the discovery of the DNA structure, was not a Nobel Prize recipient like the other three scientists involved and an ongoing debate exists on who should officially receive credit for this discovery [90]. In addition, researchers are traditionally rewarded for individual work such as a single-authored publication in their fields' top-tier journal [16]. When on a large team, there may be few opportunities for first-author publications which may lead to poor collaboration because investigators who are not high on authorship may not feel the need to actively participate in team tasks [16]. In addition to these career development issues, some scientists may feel their professional identity is at risk because they are bridging to a new area of research [2,22].

Medical and scientific communities traditionally focus on technical and conceptual training; however, prevalent issues in large-scale collaboration teams, as seen above, are also due to poor team functioning (e.g., lack of trust or a shared vision) [15]. A team of experts does not necessarily make for an expert team as a large body of research suggests that a highly functioning team exerts exceptional teamwork skills in addition to technical or task-related skills [23-26]. In short, an expert team requires teamwork proficiency *and* task aptitude [27]. Moreover, training in task work skills is no longer sufficient as the need for collaboration within science and medicine increases. As previously stated, teamwork skills reflect the cognitive, behavioral, and attitudinal actions that team members need to function successfully within an interdependent team [28]. In the following section, we identify critical teamwork skills and describe team training guidelines which may negate collaboration issues and improve team functioning.

HOW CAN THE SCIENCE OF TEAM TRAINING IMPROVE COLLABORATIVE FUNCTIONING?

Cross-disciplinary collaboration is sometimes criticized by those who believe team members may actually be *more* successful working individually [16]; however, this is not the case due to the magnitude and nature of the projects executed by these teams [6]. We argue that the issue is not that unsuccessful science teams should operate individually, but would be more effective if they improved their teamwork processes. Moreover, research supports the implementation of team training programs to improve team processes, performance, and overall effectiveness [29]. Meta-analytic evidence [29] suggests the correlational relationships between team training and team outcomes range from .34 to .44 (unadjusted values ranging from .32-.39), - depending on the outcome type (i.e., cognitive, affective, process, performance, or overall). Team training is theoretically grounded and consists of systematic practices comprised of strategies and tools targeted to enhance teamwork competencies and processes [30,31]. Team training is designed to improve teamwork and has a strong empirical base supporting its success in enhancing overall team effectiveness [29]. Team training is utilized by teams spanning across a variety of diverse domains such as medicine [32], aviation [33], and the military [34]. For these reasons, we recommend implementation of team training for cross-disciplinary collaboration in order to enhance team effectiveness, and subsequently improve translational medicine and science as a whole. We turn now to a more specific discussion of how to develop a well-executed team training program, and present scientifically based and theoretically grounded guidelines in a temporal framework; those to be conducted before, during, and after team training. These guidelines were extracted from seminal research articles within the team training literature base [9,28], and then refined to align with current research on cross-disciplinary science teams [8,18]. Each guideline and corresponding implementation tips are outlined in Table 2.

Before team training

It is essential for an institution to plan, prepare, and complete certain processes before a team training program commences. Specifically, as recommended by team training experts [28], the needs of the institution must be identified, the characteristics of trainees should be taken into account, and the organizational climate should reflect the goals of the team training program. For example, in the case of cross-disciplinary science teams, this climate should foster trans-, multi-, and interdisciplinary collaboration and learning. Based on a critical appraisal of the cross-disciplinary collaboration and team training literature, we have identified team training guidelines important for cross-disciplinary science team efforts. These guidelines are described in the following section.

Guideline 1: Conduct a team needs analysis

In order to identify necessary teamwork KSAs, and identify training content, a needs analysis should be conducted [28]. The needs analysis process consists of identifying what competencies need to be trained, who needs to be involved in training, and whether the organization is ready to conduct training [35]. This process is also congruent with Baldwin and Ford's [36] training input model consisting of work environment (i.e., organizational analysis), training design (i.e., task analysis), and trainee characteristics (i.e., person analysis). A traditional needs analysis is a three step process consisting of organizational, task, and person analyses [35]. However, the task analysis becomes a *team* task analysis during a team training program [28]. While conducting a team needs analysis, it is important for the team to be considered as an individual unit [37]; in other words, the focal point is the team and not its individual members [38].

Organizational analysis: The focus of this analysis is to identify the degree to which the organization provides a supportive climate and facilitates team training effectiveness [39]. Questions to ask include: Has the institution communicated team

Table 2: Team Training Guidelines.

1. Conduct a Team Needs Analysis • Conduct an organizational, team task, and person analysis • Identify critical teamwork KSAs needed for the organization and team tasks • Identify interdependent tasks • Consider and understand the impact of trainee characteristics • Think of the team as one unit when determining necessary KSAs
2. Create an Institutional Climate Supportive of Collaboration and Learning • Stress the value of the training to trainees • Do not provide training for infrequently used or unnecessary KSAs • Present training as an opportunity for advancement
3. Develop Team Training Content • Build training content from the critical KSAs determined from the needs analysis • Draw content from empirically supported teamwork competencies
4. Utilize Appropriate Instructional Delivery Methods • Utilize multiple delivery methods • Information-based methods are more helpful for displaying declarative knowledge; demonstration-based for procedural; practice-based for conceptual • Demonstrate positive and negative examples when using a demonstration-based approach
5. Provide Team Development Aids • Utilize evidence-based team development aids • Provide feedback throughout training • Feedback should be clear, concise, and constructive • Foster the use of debriefs on the job • Train leaders to be successful coaches
6. Evaluate Team Training • Measure reactions, learning, behavior, and results • Record team-level and individual-level data • Assess performance during multiple time periods
7. Promote Transfer of Team Training • Provide opportunities to use teamwork skills on the job • Continue to stress the importance of the trained concepts • Encourage networking amongst employees • If needed, offer refresher training

training value? Are incentives in place for trained participants? Will the institution reward trainees who utilize the teamwork concepts during a performance period?

Team task analysis: A team task analysis consists of identifying collaborative tasks and corresponding teamwork competencies needed to complete these tasks [28]. The overall goal of this analysis is to determine which teamwork processes and competencies are important for the team and organization and which of these should be incorporated in team training [39]. Successful strategies for identifying this information include: reviewing relevant organizational documentation, related scientific literature, organizational performance standards, and interviewing Subject Matter Experts (SMEs). In addition, Gregory and colleagues [39] suggest conducting a task analysis, identifying which tasks require collaboration, and then generating a list of competencies necessary for successful completion of the interdependent tasks. Examples of teamwork competencies include communication, back-up behavior (i.e., team members' ability to assist one another with roles and responsibilities), and conflict management (i.e., the prevention, controlling, or guiding of team conflict) [40]. Teamwork competencies that we feel are necessary for cross-disciplinary collaboration, based on a critical review of the team effectiveness literature [41] and cross-disciplinary collaboration literature [18], are identified in Table 3.

Person analysis: It is important to consider that not all trainees equally benefit from training opportunities [42]. Moreover, the goal of this analysis is to identify who should attend training and what their characteristics are [28]. Do certain team members display negative teamwork behaviors or specific attributes that may impact training needs? It is important to identify and understand such trainee characteristics because they may impact team training effectiveness [43,44]. A team training program is designed to improve teamwork skills, not task work skills, and it is important that team members demonstrate the ability or potential ability to perform the task before being trained to operate within the team [45]. Teamwork skills, or competencies, refer to the KSAs needed for effective team performance (e.g., communication and adaptability); whereas task work skills represent the technical competencies needed to complete job duties (e.g., knowing the scientific method) [46]. For example, surgeons on an operating team must display a proficiency in the surgical procedure before attending team training - where the goal is to teach teamwork skills and not technical skills. Research also suggests that certain personality variables predict team performance [47-50], and thus may impact team training effectiveness. Other individual traits influencing team training outcomes include training specific self-efficacy, goal orientation, and motivation to learn [44,51-56]. Training specific self-efficacy (i.e., the belief in one's ability to understand and learn training content [45]) increases motivation to learn and improves learning outcomes [51-55]. An individual's goal-orientation (i.e., the mental framework used to

Table 3: Teamwork Competencies for Successful Collaboration.

Competency	Behavioral Marker	Suggested Application to Cross-Disciplinary Scientific Teams
Communication [87]	Information sharing Information protocol utilization Communication quality Information quantity	Develop strategies for communicating effectively such as a checking-in routine where each team member sends a weekly update on their task progress Establish a communication protocol for when conflict or other issues arise
Leadership [88]	Clarify team member roles and responsibilities Engage team in regular meetings Motivate team members Synchronize individual task work Provide situation updates Self-correct	Establish a nonthreatening environment where team members feel comfortable bringing up issues and providing one another feedback Establish a team climate that promotes collaboration Organize reoccurring meetings and make the location and time easily accessible for all team members
Interpersonal relationship development [89]	Share information amongst team members Admit mistakes and accept feedback Establish rapport with team members	Hold frequent social outings for team members Plan a research symposium where all team members present their own work unrelated to the team's project
Goal specification [54]	Identify team goals and performance objectives Prioritize team goals and sub-goals	Explicitly identify the goals of collaboration Establish and stick to a project timeline Prioritize goals in a way that adheres to all team members concerns
Monitoring progress towards goals [87]	Track progress toward team goals and tasks State what needs to be done for goal attainment Share progress with all team members	Have team members update one another regularly Identify progress at every meeting and keep track of where the team is on the project timeline
Team monitoring [87]	Provide backup behavior Anticipate team member needs Understand team member roles and responsibilities Shift workload during high periods of stress or workload	Assist other team members with their tasking if they ask for help Have team members communicate with one another during times of high workload or long absences Shift workload if necessary
Conflict management [87]	Before conflict occurs, establish conditions amongst the team which prevent, control, or guide team conflict Work through task and interpersonal disagreements	Address authorship and credit during team inception Explicitly identify how conflict will be dealt with(e.g., have conflicting team members contact the leader before addressing the whole team)
Adaptability [88]	Anticipate team member actions Alter course of action if needed Integrate new team members	Ensure that all team members input is taken into account when altering course of action Provide new team members with all necessary information about the team, including team member roles and responsibilities and team goals and sub-goals
Shared mental models [88]	Coordinate without overtly communicating Anticipate other team members	Communicate regularly with one another and ensure that each team member is aware of how they and the other team members fit into the overall team goal Identify team members' expectations, responsibilities, and accountabilities
Team/collective orientation [88]	Ensure teamwork is valued Ensure a strong collective efficacy	Team members should display an interest in working with one another and value each other's diverse expertise Communicate team achievements

shape behaviors within a learning environment) also influences training success [44]. Goal-orientation can either be mastery (i.e., learning) or performance oriented [57], and research suggests trainees with a strong leaning goal-orientation express a higher desire to acquire new skills, effort to learn [56], and an increase in grasping learning outcomes [58]. In contrast, those with performance goal-orientation are less likely to engage in tasks requiring risk and are more concerned with seeming adept, which causes a decrease in learning and transfer during training [44]. In conclusion, measuring and being aware of trainee characteristics can increase team training success.

When it comes to large-scale collaboration efforts, a needs analysis is particularly important as it clarifies what the team needs to accomplish collaboratively. In particular, by making factors explicit such as interdependencies and aptitudes, training can be better tailored for the science and research at hand. Similarly, understanding attitudinal requirements will increase team leadership effectiveness and management during team dynamic emergence, especially when training attitudes alone will not suffice. During a needs analysis, it may also be beneficial for institutions to measure their current level of collaboration readiness; thus, if the organization, team, or individuals are lacking collaboration readiness this issue can be addressed. Hall and colleagues [59] recently developed and validated a collaboration readiness measure, and we recommend incorporating this assessment in the needs analysis process.

Guideline 2: Create an institutional climate supportive of collaboration and learning

To ensure successful team development and the transfer of trained concepts, it is necessary for the organizational climate to support collaboration and learning [60,61]. The perception of an organization's procedures, norms, and practices constitutes the organizational climate [62], and this climate should align with the focus and goals of the training program. The organization should communicate training value to employees, and implement policies, practices, and procedures that reflect and encourage desired attitudes, cognitions, and behaviors [43, 63]. Expectancy theory states that the value of the training program must be conveyed to trainees in order to motivate them to learn and actively participate in training [64]. To convey value, employees should be informed as to why they are attending training and the benefits offered [44]. Although most scientists and medical professionals may place significance on educating themselves on new topics and learning new skills, they may not be willing to devote their time to complete a team training program. If this occurs, we recommend the organization to advertise and incentivize team training attendance to such professionals. In addition to stressing the significance and utility of the training content, organizations should communicate the specific program content. Doing so will enhance trainees' value of and learning from the training [45]. Advance organizers (i.e., outlines of preliminary training information and pre-practice briefs) are tools that can be distributed to trainees and supervisors in order to increase their conceptualization of the training purpose [44]. It is also important for the organization to communicate to employees what to expect from the training [45]. Research suggests that if trainees' expectations are unfulfilled, they exhibit lower post training commitment, self-efficacy, motivation, [65,66] and reduced performance [67].

Considering this guideline in the context of cross-disciplinary collaboration teams, we can identify what factors might be particularly important. First, investigators would benefit from understanding how the training can improve their research programs. For example, making explicit the value of goal-setting in scientific research, and how the training will improve the likelihood of better scientific outcomes, may instill a supportive climate. Related to this, the particular rewards or incentives would need to be clearly established. For example, given that scientists are motivated in ways unique to other personnel, one could explore how participating in training programs could count towards tenure review or other promotional procedures.

During team training: Several principles should be implemented during team training to ensure training effectiveness. Specifically, the appropriate delivery method and team development practices should be utilized. The following principles are rooted within the sciences of training [41,68], team effectiveness [40], and cross-disciplinary collaboration [18] and are described below.

Guideline 3: Develop team training content

The overarching goal of a team training program is to further develop cognitive, behavioral, and attitudinal skills associated with effective teamwork [69]. Team training programs are not designed to enhance task-based KSAs, and it is advised to train individuals on task-based KSAs prior to teamwork KSAs [33]. This ensures complete efficiency during team training as the trainees will already be familiar with the tasks they need to complete. Based on the information obtained from the team needs analysis, the organization should have a general idea of the elements to include during team training, and the organization should refer back to the team needs analysis to conclude which competencies should be the focal point. Drawing from reviews of the team literature [41] and cross-disciplinary collaboration literature [15,18], we identify several teamwork skills pertinent to cross-disciplinary collaboration. First, we identified validated teamwork competencies and then extracted the competencies that most fit the need of the intended audience - cross-disciplinary science teams. These competencies are described in Table 3.

Guideline 4: Utilize appropriate instructional delivery methods

The method(s) used to deliver information to trainees is a critical training component in addition to the content presented [9]. Validated delivery methods include information-based, demonstration-based, and practice-based modes [28]. As each method displays both strengths and limitations, successful team training programs typically incorporate all methods [29]. Moreover, certain strategies are more efficacious in presenting different levels and types of information and knowledge to trainees [68]. In a recent review on training strategies, 59% of studies (n=26) utilized a mixed method approach to content delivery [29]. Most programs begin with an information-based method and/or demonstration-based method and conclude with a practice-based method [29]. Furthermore, the results of the team needs analysis will provide better insight as to which method may be more beneficial or feasible based on organizational resources and necessary teamwork skills. In regards to training cross-disciplinary science teams, it is likely that information-based delivery will be better suited for this context. While demonstration-based methods will also be helpful, the kind of behavioral coordination typically trained with such methods occurs less frequently in these teams. As such, knowledge of teamwork competencies might be better trained through less labor-intensive methods.

Guideline 5: Provide team development aids

In order to aid longitudinal team development and increase collaborative success, job-aids and tools that foster team development should be presented during training. Specific job-aids include feedback [70], debriefs [71], and coaching [72]. Feedback is a vital component of demonstration- and practice-based delivery methods of team training, ensures proper training and development of teamwork competencies, and promotes increased comprehension of individual and team-related deficient and exemplary KSAs [70,73]. Regardless of feedback presentation (i.e., either information- or demonstration-based), it should be accurate, delivered in a timely manner, focused on team processes (vs. outcomes), relevant, and both positive and negative [73,74]. In addition, feedback should be clear, concise, and constructive [69].

Another useful job-aid includes debriefing. Debriefs reinforce learning, and are typically conducted during training (e.g., after an exercise or simulation) or after training in the post-training work environment [44]. Debriefs are an effective tool for improving team performance, and recent meta-analytic evidence reports a 25% performance improvement for those using this job-aid [71]. During a team debrief, the team reviews a prior experience and identifies successes, failures, and improvement factors [71]. A successful team training program should not only implement debriefs within the training, but also provide trainees with the knowledge necessary to conduct debriefs on the job [44]. The ultimate goal for a training program is for the concepts trained to be implemented on the job [75]; as such, it is useful to introduce a coach to the team in order to facilitate this transfer [74]. Specifically, during training, team leaders can be transformed into coaches by providing them with tools, training, and support to increase their coaching skills.

In regards to cross-disciplinary science teams, it is important to emphasize who on the team would be responsible for feedback, debriefing, or coaching. It is reasonable to expect that the Principal Investigator or team leader should manage these roles. Nonetheless, ensuring that all cross-disciplinary science team members are well versed in, and accepting of feedback, debriefing practices, and coaching, will help to ensure the effectiveness of the training program.

After team training: Logically speaking, it would seem as if the termination of the team training program denoted the end of the institution's 'to-do list' in terms of ensuring team training success. However, this notion is inaccurate as it is essential for the institution to take several steps after training occurs in order to ensure effectiveness [9,28]. These steps are reviewed below.

Guideline 6: Evaluate team training

Kirkpatrick's evaluation metric [76] continues to be utilized as the gold standard for evaluating training effectiveness. As such, we recommend team training programs to be evaluated on each Kirkpatrick level: reactions, learning, behavior, and results. The evaluation levels are grounded within one another such that the former levels are precursors to the latter; however, positive outcomes within one level do not imply positive outcomes in subsequent levels [76]. *Reactions* are normally assessed immediately after training, and include trainees' attitudes towards training. This evaluative process consists mostly of self-report questionnaires with questions focusing on whether individuals found the training to be useful, enjoyable, and valuable. *Learning* is assessed by accounting for the maximum performance change by trainees during the training, and is referred to as what trainees *can do* following training [77]. Learning focuses on the declarative knowledge acquired by trainees and should be assessed pre- and post-training in order to identify the change associated with the training. Keep in mind that there may be a delayed effect on learning, and behavioral transfer may still be effective even if learning improvements are not discernable [78]. Moreover, *behavior* outcomes, in comparison to learning, are not what the trainee can do, but signify what the trainee *will do* [79]. Behaviors are assessed by investigating whether trainees utilize trained KSAs on the job. *Results* are outcome-oriented variables and assess the overall effectiveness of a training program. Results are assessed following all previous training evaluation levels and consider external variables that feed into utility (e.g., a cost-benefit ratio) of team training [76].

In addition to Kirkpatrick's [76] training evaluation process, team training programs should also assess certain team-based elements (e.g., leadership, team processes). Specifically, Salas and colleagues [79,28,9] recommend the following: (1) develop team process and outcome assessment tools, (2) record team-level and individual-level data, and (3) assess performance during multiple occurrences.

While there are many challenges associated with evaluating team science [18], much of the above can be leveraged for evaluating collaboration teams. For example, at a micro level, evaluation of team processes includes evaluating scientific tasks such as designing and executing experimentation. Similarly, the evaluation of scientific products (e.g., collaborative papers, research reports, ground-breaking results, product development) provides an opportunity for assessing team effectiveness.

Guideline 7: Promote transfer of team training

As previously noted, there is no guarantee that trainees will utilize trained concepts on the job or during collaborative efforts. In fact, Robinson and Robinson [80] contest that individuals use less than 30% of trained concepts on the job. Organizations can aid in the transfer of training (i.e., the use of trained skills on the job) by providing practice, support, and real-time opportunities for trainees to utilize newly trained teamwork after the training program [45]. Ford and colleagues [81,82] have found that trained skills are retained longer as a result of the amount of opportunities provided to utilize these skills. Organizations should ensure that the KSAs trained are needed to execute team tasks, and that these tasks will be completed soon after training – this will increase the training transfer. As previously noted in Guideline 2, it is also important for the organizational climate to promote collaboration and learning in order to intensify training transfer [60,61].

When considering training transfer for cross-disciplinary collaboration teams, it is clear that the concepts to be trained are those that will be utilized. For example, if a team of scientists recently received a collaborative grant, it is likely that they will quickly be able to make use of teamwork training. Similarly, if a new research center is being developed (e.g., funding for a large scale collaborative project like the National Science Foundation "Science and Technology Center"), team training programs should be part of the planning. This, too, will increase the acceptance as well as enhance the probability of training transfer.

SUMMARY

In summary, the identified guidelines are designed to increase the effectiveness of a team training program tailored for cross-disciplinary collaborative efforts. Although we recommend these guidelines as a shell for a team training program, we stress that these programs are not offered as a one-size-fits-all approach.

Moreover, the institution's team training program should be modeled after the core goals and objectives of the organization and the results of the needs analysis.

CONCLUSION

In this review, several guidelines were identified in order to advance the effectiveness of collaborative efforts. First, we presented the issues associated with cross-disciplinary science teams, and then identified and described several empirically based guidelines that when incorporated within a team training program may ameliorate these issues. This paper contributes to translational medicine in a number of ways. Cross-disciplinary collaboration engenders challenges to action, and overcoming these issues is necessary for success. As Stokels [18] stated, "… efforts to foster greater collaboration among scientists trained in different fields are not only a useful but also an essential strategy for ameliorating these [e.g., heart disease, AIDS, diabetes] problems." In other words, the need for cross-collaborative, multifaceted science and medical teams increases the demand for methods to aid these teams in problem-solving, performance, and overall effectiveness. In order to advance current team functioning within cross-disciplinary collaborative efforts, we introduce an empirically based and scientifically grounded strategy to the field: team training [28,29,83]. Team training has been validated across multiple domains (e.g., healthcare [84]; medical education [85,86]), and we argue its use in cross-disciplinary collaboration efforts. It is our hope that the above guidelines will provide a framework for integrating team training programs within these teams. Ultimately, by increasing the productivity of cross-disciplinary collaboration, we will simultaneously advance translational medicine as a whole by increasing the capacity to which scientists and clinicians can solve multifaceted science and healthcare issues.

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