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Better Together: Enhancing Team Collaboration in Science (ETCSi) to Improve Well-being and Medicine Discovery

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Better Together: Enhancing Team Collaboration in Science (ETCSi) to Improve Well-being and Medicine Discovery

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Keywords

collaboration, science, well-being, trust, belonging, communication, innovation, problem solving, decision making, medicine, positive psychology

Disciplines

Industrial and Organizational Psychology | Science and Mathematics Education

Better Together: Enhancing Team Collaboration in Science (ETCSi)
to Improve Well-being and Medicine Discovery

Lara S. Kallander, Ph.D.

University of Pennsylvania

A Capstone Project Submitted

In Partial Fulfillment of the Requirements for the Degree of

Master of Applied Positive Psychology

Advisor: Prof. Allyson Mackey

August 1, 2018

Better Together: Enhancing Team Collaboration in Science (ETCSi)
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“The whole is greater than the sum of its parts” - Aristotle (Anderson, 2014)

1. Introduction

My fascination with scientific collaboration began after the publication of the work by Anita Woolley and co-workers almost a decade ago in *Science* (Woolley, Chabris, Pentland, Hashmi, & Malone, 2010). I had been working in the pharmaceutical industry for many years after getting my Ph.D., and I was thrilled to work in medicinal chemistry because I wanted to make a profound difference in the health of many lives. While my day job was creating effective teams out of groups of individuals, I discovered that there were people studying this phenomenon who had some specific insights. In this study, Woolley and co-workers examined newly created teams of 2-5 people; their effectiveness was measured by solving puzzles, brainstorming, or negotiating, all tasks that required interdependence (Woolley et al., 2010). What the researchers found is that the average intelligence quotient (IQ) of the team members involved in the task didn't correlate with successful outcomes; instead, success was correlated to social sensitivity and conversational turn-taking (Woolley et al., 2010). This struck a chord for me, because it matched my experience working in a technical field where these skills are not generally appreciated. This sparked a journey to study well-being through positive psychology and bring this mindset to identify skills critical to the success of collaborative research science teams. This thesis will explain the limitations of current science education, the opportunity of using positive psychology to address this gap, as well as the literature support and methods for pursuing skills-based training for scientists to improve their well-being and effectiveness for discovering new medicines.

2. The Problem

Science education is generally focused on individual knowledge building and discovery. My college experience was about learning information to explore in the laboratory and report back on tests, rather than doing group projects and presentations. Graduate school was an even greater departure into solitary work because to earn a degree in the physical sciences, I had to independently demonstrate a new discovery. Individual learning at the undergraduate level and original research requirements at the graduate level are the norm, and even the use of technical terms seems to isolate people in their specialty (National Research Council, 2015).

Not only is science lonely, it is also highly competitive. Competition is a common thread throughout scientists' careers that can negatively affect their work and their relationships. In academia, professors compete for grant money to do research studies, and students compete for fellowships to support their education. In a qualitative study of late career scientists in the United States, competition led to a reduction in the sharing of information, methods, and in some cases, even questionable research conduct (Anderson, Ronning, De Vries, & Martinson, 2007). Competition is a limitation to building a strong scientific community.

Science also struggles with diversity, intensifying isolation for women and minorities. There are many scientific researchers in the world, over 5 million total, with 1.2 million in the United States (United Nations Education, Scientific and Cultural Organization, 2017, Human Resources in R&D). Despite an effort to get more women into science, they still represent only 29% of the total worldwide (United Nations Education, Scientific and Cultural Organization, 2017, Women in Science). There appears to be a leaky pipeline for both minorities and women

working in the sciences, and the reasons for attrition have been studied considerably, with a lot of attention being paid to scientific education (Chen, 2013; Griffith, 2010).

Aside from a few exceptions, scientists are not taught to work in teams during their formal education (Deslauriers, Schelew, & Wieman, 2011). However, more than 90% of scientific publications and research studies are the result of collaborative efforts (Bozeman & Boardman, 2014). It has been shown that the production of impactful knowledge is dominated by team scientific research, as opposed to individual research (Wuchty, Jones, & Uzzi, 2007). Even though scientists are often characterized as loners, this perspective is not only incorrect based on my experience, but it is also misleading.

Along with this greater need to work in teams, a field has emerged called the science of team science, SciTS (Fiore, 2008; Stokols, Hall, Taylor, & Moser, 2008). This is research exploring the ways that scientists work together in teams, specifically considering scientists from different disciplines (Fiore, 2008; Stokols et al., 2008). Interdisciplinary research provides the ability to tackle huge global issues such as environmental concerns or public health (Börner et al., 2010). SciTS helps provide information for establishing effective collaboration amongst interdisciplinary scientists, a step in the right direction, however there is more to do since the education gap is large.

There is a significant disconnect between what scientists are taught to do and what they need to be able to do after their training, which leaves them under prepared. Since the work that scientist do is important to the public, this lack of training, as well as issues of competition, diversity, and personal isolation need to be addressed. Overall, this paper will show evidence that training tools from positive psychology to support scientific collaboration will cultivate individual well-being and success in the scientific workplace.

3. The Opportunity

Medical research is science directed toward improving human health, because there are still many life-threatening diseases that have no treatment such as heart disease, stroke, and respiratory ailments (Pietrangelo & Holland, 2017). The overall goal of medicine discovery is to improve the quality and quantity of lifespan, with a focus on the sickest individuals. Several scientists with different technical skills work together, often at a pharmaceutical company, biotechnology company, or academic institution. It was estimated that 165 billion dollars were spend on global pharmaceutical research in 2017 (Statista, 2018) and 46 novel medicines were approved the same year in the United States, some of which will save lives in cancer, diabetes, and neurologic diseases (Reuters, 2018). Clearly, efforts directed toward improving the outcomes of teams working in this field would have a significant impact on public health. Due to the lack of collaboration training that scientists receive, positive psychology can improve the outcomes of teams working in medicine discovery worldwide by enhancing collaboration.

Positive psychology is a field that developed out of a desire in psychology to consider not only disease and mental illness, but also the improvement of well-being and flourishing for healthy individuals (Seligman, 2004). Well-being is supported by five key constructs: positive emotions, engagement, relationships, meaning and accomplishment (PERMA), according to Martin Seligman (2011). For example, positive emotions such as joy, hope and serenity can enhance a person's experience in the moment and, based on the broaden and build theory, can also enhance positive emotions in the future (Fredrickson, 2009). Engagement, the E in PERMA, is a flow experience where the activity one is doing matches their skill, so time passes

very quickly (Csikszentmihalyi, 1990). One way to measure well-being overall is to use the subjective well-being test which captures positive affect, lack of negative affect, and life satisfaction (Diener, 1984). This test has been administered in more than 55 nations around the world and is positively correlated with human rights and societal equality (Diener, Diener, & Diener, 1995). Since we have tools to measure well-being worldwide, the overall goal of positive psychology is to improve it (Seligman, 2011).

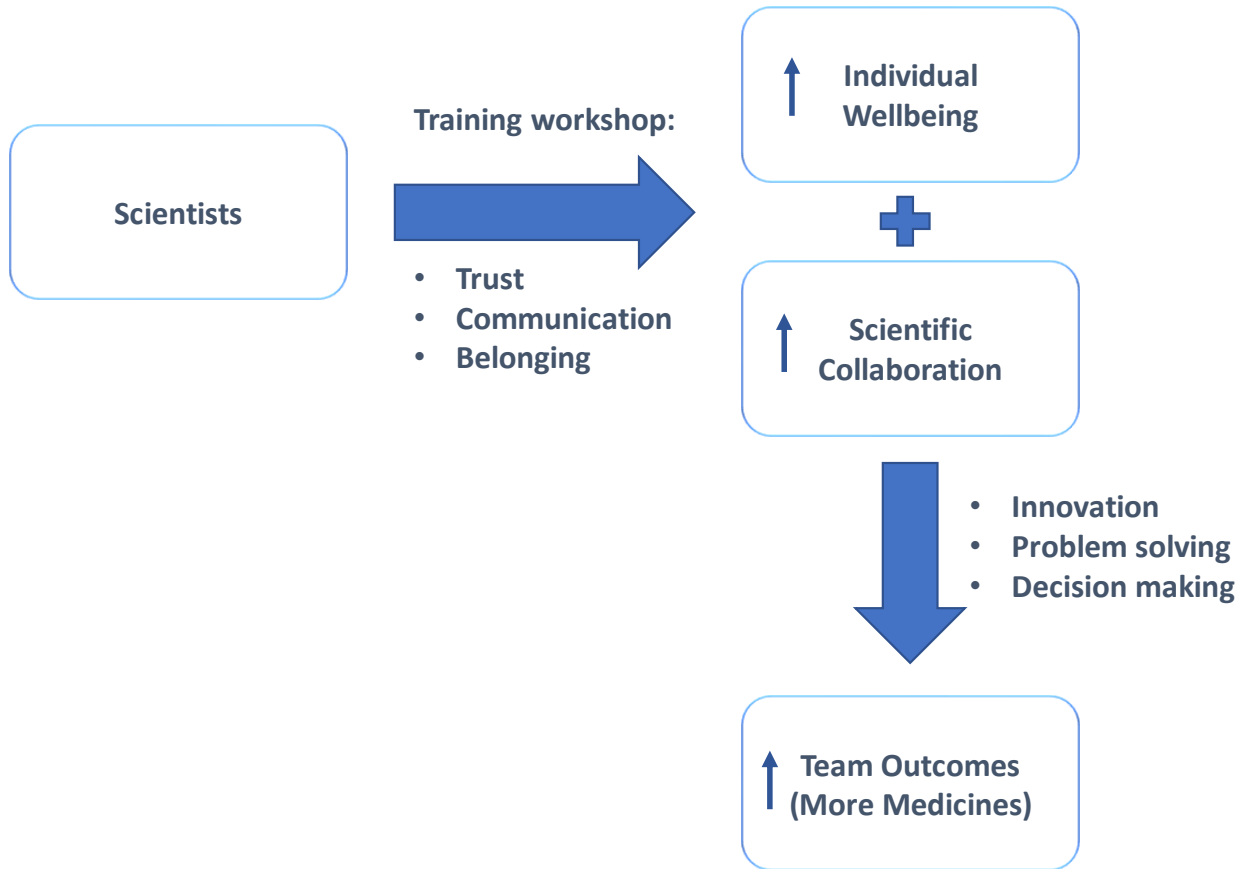
Positive psychology and medical research both seek to improve people's well-being. What is proposed in this thesis is a training workshop targeted to scientists working in medicine discovery research that will improve both their well-being and their ability to collaborate with each other (Figure 1). The increase in scientists' well-being is an end goal itself, and yet this approach has the added benefit of improving collaboration, which will lead to better team outcomes such as an increase in the number of medicines discovered. This will occur by better utilizing innovation, problem solving and decision making to lead to more medicines being discovered with the same investment.

The proposal is therefore to use positive psychology to improve medicine discovery by cultivating collaborative teams, which will be discussed in section four, and enhancing researcher well-being, which is discussed here. Relationships are one of the five pillars to enhance flourishing (the R in PERMA), because other people can buffer negative experiences and help build positive ones (Seligman, 2011). Positive interpersonal relationships are a key component of well-being (Peterson, 2006) and happiness has been characterized to exist between people rather than with an individual (Haidt, 2006). Mattering to others is another way to cultivate well-being (Prilleltensky, 2016). Relationships make life more enjoyable and are an important correlate for long term well-being.

Beyond individual relationships, there is an important component of well-being that resides in communities. Thriving communities have always been one of the goals of positive psychology (Seligman & Csikszentmihalyi, 2000). Being part of families, schools, workplaces, and places of worship are all important ways to achieve the feelings of mattering (Prilleltensky, 2016) and meaning (Smith, 2017); meaning is one of the five pillars of human flourishing. Human flourishing also comes from letting go of the self and participating in shared communal activities (Haidt, 2006). Community is important in joyful times because it spreads happiness to others (Fowler & Christakis, 2008), and in times of challenge, when social support is associated with post-traumatic growth (Prati & Pietrantonio, 2009). Since community is important to personal well-being, and scientific research creates small communities in the form of teams, nurturing these teams can contribute to scientist's well-being.

The overall goal of this work is for scientists to thrive both in their work and in their lives. Investing in collaborations through building trust, communication, and belonging will improve personal well-being for scientists. There is also data indicating that these same skills lead to better science, which also impacts accomplishment, the fifth pillar of well-being. Combining these outcomes, this paper will show how improving the well-being of scientific researchers through positive psychology will lead to better science which translates to more medicines in the future. Specifically, what is proposed here is a one-day training program for scientists to be successful in a work environment where collaboration is needed. This is an exciting opportunity to improve public health through the discovery of new medicines by addressing the well-being of the scientists who discover those medicines.

Figure 1.



4. Theory - Enhancing Team Collaboration in Science (ETCSi)

Collaboration is defined as members belonging to a group that work together, reach consensus, and have frequent communication between trusted team members (Frey, Lohmeier, Lee, & Tollefson, 2006). This is distinct from coordination or networking, both of which have a reduced level of sharing and decision making (Frey et al., 2006). In a scientific team, it is helpful to define expectations to avoid the misunderstanding that collaboration is adding a bunch of authors to a paper or stapling CVs to a grant proposal (Ledford, 2015). Collaboration is an investment of time and effort; however, it is important to be mindful to ensure team work adds value rather than just adding to the workload (Cross, Rebele, & Grant, 2016). That is why three specific areas of focus for enhancing collaboration in the research and discovery of medicines will be the focus of this paper: trust, communication and belonging.

A. Trust

This section will focus on the theoretical understanding of what trust is and what it can do to help scientists thrive both at work and in life. Before getting into why trust is important, let's first define trust and how it will be addressed in this context. Trust has been defined in management literature as the willingness to take risk by being vulnerable to the actions of another person (Mayer, Davis, & Schoorman, 1995). This is distinct from taking a risk, because it is instead the willingness to do so, and it is also distinct from being able to monitor or control the behavior of the other party that is being trusted (Mayer et al., 1995). A more recent definition from organizational psychology defines trust as acting toward others with integrity, dependability, and benevolence (Dutton, 2006), so trust also reflects how one behaves towards

others. This is important because trust occurs between people, and the recognition that being willing to take a risk on others and behave as worth taking a risk on, are both represented by the word trust.

Trust and its role in performance is a topic that has garnered more attention over time. For example, there were hundreds of studies published in 2015 focusing specifically on the correlation between intra-team trust and team performance (De Jong, Dirks, & Gillespie, 2016). One study that looked at trust and team performance defined four different trust scales that measure: propensity to trust, perceived trustworthiness, monitoring behaviors and cooperative behaviors (Costa, 2003). Effectiveness was measured by asking about three areas: perceived task performance which measures how the team thinks they did, team satisfaction which measures how satisfied people were with the team's work, and attitudinal commitment where the values of the individual match the organization (Costa, 2003). In this study, there was a strong positive correlation between trust and team effectiveness (Costa, 2003).

To consider multiple studies in tandem, a meta-analysis has been done in this field that demonstrates team performance is higher when there is greater team trust (De Jong et al., 2016). These studies cover several types of work such as project, management, and service work, and showed that trust is most important for interdependent teams with differing levels of authority (De Jong et al., 2016). This is the case in medicine discovery work, where there are a variety of scientific experts who work together despite different job levels.

The question then becomes, how does trust apply specifically to scientific research teams? "Indeed, there is much agreement that trust is a key ingredient in the success of research collaborations" (Bozeman & Youtie, 2017, p. 116), a conclusion which was drawn after extensive analysis of successful and unsuccessful research collaborations. In order for teams to

be effective in their research goals, trust is a key to success because scientists have different skills that are interdependent. Think about the solution of the DNA helix, which required considerable study and ingenuity by Watson and Crick, as well as a crystal structure from Franklin (Klug, 1968).

One distinct area where trust may be even more important is in collaborations that occur over large physical distances. On virtual teams, trust is even more highly correlated to team effectiveness, due to the risk of misunderstanding or exploitation (Breuer, Hüffmeier, & Hertel, 2016). When dependent on communication by phone, email, or webcam, trust needs to be a focus for creating effective research opportunities (Gilson, Maynard, Jones Young, Vartiainen, & Hakonen, 2015). Trust can be quickly established with new teams when there is early communication and a positive tone (Gilson et al., 2015). Key aspects of maintaining that trust then become knowledge sharing, transfer, and exchange of information (Gilson et al., 2015). Global collaborators need to be aware of the limitations of communication over physical distances and try to establish and maintain trust through sharing and knowledge transfer.

Since trust is important for scientific performance, the next area to explore is trust and well-being. Using data from the Gallup World Poll, the more people feel that they live in a trustworthy environment, the higher is their subjective well-being score (Helliwell & Wang, 2011). Trust was measured by asking respondents if they lost their wallet, do they think it would be returned, and under what conditions (in a store or at work, by the police or a stranger) (Helliwell & Wang, 2011). Trust as measured here is not about what you offer, but what others offer you, so trusting those around you is a critical component of well-being.

Using data from thousands of people in the World Values Survey, trust was measured by asking if certain groups (e.g. neighbors, other religions, other countries) in general can or can't

be trusted (Poulin & Haase, 2015). Trust was positively correlated with life-satisfaction, happiness, and self-rated health (Poulin & Haase, 2015). By measuring data over time, increases in trust predicted future increases in well-being, but not vice versa (Poulin & Haase, 2015). This indicates causation, which means that increasing trust contributes to an increase in well-being.

Understanding now that trust improves well-being and the effectiveness of teams, there must be ways to nurture it in a scientific context. There are specific steps that can be taken to begin building trust as a new team is formed; by starting with small wins, partners can begin to build trust with modest joint activities (Vangen & Huxham, 2003). Managing risk can also be an important part of starting to build trust (Vangen & Huxham, 2003). Once some level of trust is established, then continuing to nurture those effective working relationships still takes effort but provides the opportunity for the team to take on larger tasks (Vangen & Huxham, 2003). And more ambitious collaborations can be achieved when trust is reinforced (Vangen & Huxham, 2003). Understanding the steps required to build trust are critical in situations where trust is a key determinant of team success. See section five of this paper for an application plan to help scientists build trust on medicine discovery teams.

What has been described here is why trust is so critical in a scientific context for team success and personal well-being. Trust is something that is cultivated between people because it requires offering trust and being trustworthy. Teams with more trust are more effective, especially when they are interdependent and have varying power levels. Trust is directly linked to well-being when studied across hundreds of thousands of people and increasing trust can increase well-being. Therefore, increasing trust among scientific teams should be good for both scientists and the scientific outcomes.

B. Communication

Can you imagine work situations where communication has gone awry? People could be talking over each other, or not at all, or address conflict poorly by arguing. Communication skills have been highlighted as a desirable quality in employees in a recent job outlook survey, only second to being able to work in a team structure, and much higher than technical knowledge (National Association of Colleges and Employers, 2012). The need for effective communicators in the work place is critical.

Ideal communication may look different at a restaurant, a school, or a scientific research site, so guidance provided here will be based upon literature most relevant to medicine discovery research. Organizational psychologists analyzed a specific health research team of interdisciplinary scientists collaborating from multiple institutions, and highlighted communication as an important tool contributing to success (Guise, Winter, Fiore, Regensteiner, & Nagel, 2017). For this interdisciplinary team of scientists, meetings were scheduled face to face once a year to avoid ambiguity, and seminars, workshops, and mentoring occurred outside of this meeting (Guise et al., 2017). Ensuring that all fields were represented at the yearly meeting fosters cross-disciplinary exposure to help scientists on the team learn from each other (Guise et al., 2017). Additionally, written communication was an important tool to clarify complex information and clarify future work (Guise et al., 2017). The key needs for communication, as captured by the organizational psychologists, were to have some face to face interactions, off line meetings with specific people as needed, and written communication to clarify the future vision.

To test interventions related to communication and teamwork in the healthcare industry, one research team used a program called TeamSTEPPS (Gittell, Beswick, Goldmann & Wallack, 2015). The program includes communication training such as information exchange and consultation with others, in addition to leadership training, situation monitoring and mutual support (Gittell et al., 2015). This training led to improved outcomes for the employees such as increased confidence, openness, team trust and morale (Gittell et al., 2015). The benefits for patients included reduced infections and mortality, although the quantity of change compared to a control group was not reported (Gittell et al., 2015). These are dramatic outcomes and although it is difficult to differentiate which specific training led to which specific outcomes, this intervention clearly makes a significant impact using communication as one of the key training areas.

In addition to thinking about the quantity of communication, such as meetings and consultation, management literature recommends also considering quality (Cross, Ehrlich, Dawson, & Helderich, 2008). Efficient communication can occur when there is awareness of the expertise of team mates, called skill profiling, because issues can be directed to people who can best address them (Cross et al., 2008). It is not efficient to involve all team members in every discussion; in many cases, an issue can be most efficiently solved with the team members who have the appropriate skills or background, which increases the quality of the communication.

There is evidence to indicate that more communication leads to more effective teams, however, it is also worth considering whether more is always better. Some research has tested the extreme of very intense networks of people, specifically with travel agents where the tasks are similar and financial outcomes easy to measure; in this study, very high group cohesion and

team performance eventually led to diminishing returns (Wise, 2014). In this work, it was speculated that teams that are too close lack the diversity of opinion and focus too much on internal relationships to the detriment of the client. That said, it is unlikely that skilled scientists from a variety of different backgrounds would have reduced effectiveness due to intense group cohesion.

From SciTS, we know that teams can be studied to understand the ideal amount of intra-team communication which leads to innovation and discovery, as well as the importance of conflict resolution (Börner et al., 2010). By studying effective teams, one factor for success is to promote scientific disagreement, without degrading the trust and shared goals of the team (Bennett & Gadlin, 2012). Looking objectively at the science and discussing different perspectives will lead to better solutions, but needs to be done respectfully, and one way to do so is to establish a collaborative agreement early in the work (Bennett & Gadlin, 2012). The collaborative agreement should address how credit and recognition will be shared, as well as setting expectations about communication and performing the work (Bennett & Gadlin, 2012). Scientists that work at the same company can often establish open levels of communication, though constructive disagreement really requires additional communication skills.

One way to establish open communication and have honest discourse is to cultivate psychological safety. Psychological safety is the belief that members of a team can take risks by bringing up topics or ideas that may not be well received (Edmondson, 1999). Two factors that are markers of psychological safety were mentioned in the introduction, conversational turn-taking and social sensitivity (Woolley et al., 2010). If people are taking turns during a conversation, everyone contributes, and everyone is listened to. Social sensitivity speaks to reading each other's non-verbal communication so that issues get addressed and viewpoints are

incorporated. Together, these traits lead to a feeling that it is safe to speak up. To cultivate psychological safety, it is recommended to generate conversations where all people get a chance to speak, and everyone is encouraged to pay attention to unspoken cues that may indicate a need for the conversational direction to change (Jehlen, 2016). Creating a high level of psychological safety is not necessarily easy for leaders because it requires patience and openness for where the conversation will go, however, it will lead to better scientific decision making.

Let's now turn our attention to how communication is not only good for science but is good for the scientists themselves. There is correlational evidence that peer social support is predictive of reduced mortality, twenty years in the future, controlling for variables such as age and current health status (Shirom, Toker, Alkaly, Jacobson, & Balicer, 2011). Peer support was measured by asking participants in the study if they had immediate co-workers that were helpful and friendly to them, which is cultivated by communication (Shirom et al., 2011). Another area where communication is linked to well-being is through social capital, which is correlated to subjective well-being (Helliwell & Putnam, 2004). What this means is that people who rate their lives higher on social interactions also report having higher well-being (Helliwell & Putnam, 2004). To distinguish social ties in the workplace from social ties with family and friends, unemployment was studied in the US and Canada (Helliwell & Putnam, 2004). The loss in subjective well-being for unemployment is significant across several large samples, which likely represents social aspects above and beyond loss of income and self-esteem (Helliwell & Putnam, 2004). Although causation has not been shown, there is correlational data that employment and peer support is positive toward immediate subjective well-being and long-term health.

Psychological safety can also predict long term engagement and psychological health. This was determined by measuring the psychological safety climate (PSC) for teachers and administrators in multiple educational programs, then measuring one year later the engagement and psychological health of the workers, which were both correlated with PSC (Dollard & Bakker, 2010). Specifically, psychological capital predicted changes in psychological distress, with emotional exhaustion as a moderator of job demands and employee engagement influenced by skill discretion (Dollard & Bakker, 2010). Even more compelling, a psychological safety intervention has been studied in a hospital setting (Curry et al., 2017). In this study, five components (one of which was psychological safety) of workplace culture were trained and reinforced over a two-year period, and the hospitals with greater culture change had reduced rates of risk-standardized mortality (Curry et al., 2017). This example shows that psychological safety is a trainable skill and that it can affect outcomes, although in this case there were other cultural changes as well. What is compelling is that every workplace would like high engagement and psychological health, and this can likely be achieved by increasing psychological safety.

In sum, communication is clearly an important skill in the workplace, something that hiring managers desire and co-workers need from each other. Health care workers have been pioneers in the research to indicate which parts of communication are critical to outcomes, such as the frequency and quality of communication. Specifically turning to scientific literature, cultivating discussion and disagreement is a key skill to get to the best decisions. One way to facilitate this is through building psychological safety, by listening to everyone on the team, and creating an open forum for feedback and honest discourse. Communication and psychological support are also important for employee well-being because peer support and

social capital has been linked to lifespan, subjective well-being, and psychological well-being. Therefore, encouraging communication is important for scientific outcomes and the well-being of the scientists.

C. Belonging

The human need to belong has been identified as a powerful, fundamental and pervasive motivator (Baumeister & Leary, 1995). Belonging can be defined as forming and maintaining positive bonds with others that includes both frequent interaction and mutual concern for each other's welfare (Baumeister & Leary, 1995). Belonging with others can occur in several contexts, at home, at work, or in other community activities. Regardless of the source of that belonging, however, it is correlated with many other health and well-being factors. One example is that social connections improve health and wellness by making healthy activities sustainable such as smoking cessation, exercise, and healthy eating (Martino, Pegg, & Frates, 2017). Conversely, social isolation leads to greater likelihood of mortality by 29% over a 25-year period, according to a meta-analysis of multiple studies (Holt-Lunstad, Smith, Baker, Harris, & Stephenson, 2015). Although causation has not been demonstrated, creating a feeling of belonging is likely to be beneficial to both physical and mental health.

Looking more carefully at how belonging can impact well-being, there are links to both mattering and meaning. Mattering, a key component of well-being, is defined as being able to add value and feeling valued, which cannot occur without close connections to others (Prilleltensky, 2016). Thus, belonging is needed to support thriving because it provides opportunities to matter. Feeling that there is meaning in life, one of the five pillars of PERMA (Seligman, 2011), has also been studied in relationship to belonging and there is both

correlation and causation among college students (Lambert et al., 2013). Meaning in life correlates positively with feelings of belonging, both of which are self-report measures (Lambert et al., 2013). What is more compelling is that by encouraging reflections of belonging and writing about it, as compared to control groups that recalled social support or social value, the belonging group had an increase in their meaning scores (Lambert et al., 2013). It is powerful to know that feelings of belonging can be enhanced, and in doing so, there is also an increase in life meaning.

There are potential barriers to belonging when studying and working in the sciences, that have to do with gender and ethnicity. Social belonging, as studied in a large set of high school students, was a mediator for interest in studying STEM (science, technology, engineering and mathematics) fields in a positive way for males and a negative way for females (Tellhed, Bäckström, & Björklund, 2017). This means that female high school students in Sweden were less likely to choose to study STEM fields due to a perception of not belonging. There also appears to be a preference for collaborating in sciences with others of the same ethnic background, even though homophily leads to lower-impact journals with fewer citations (Freeman & Huang, 2015). The need to belong is an important consideration when trying to build effective scientific teams, where gender or ethnicity can be an isolating factor.

Belonging is not the only issue facing minorities, stereotype threat can also negatively impact performance. Stereotype threat, first disclosed in the 1990s by Claude Steele, explains that women and minorities performance suffers in situations where they feel pressure due to a risk of supporting stereotypes. If reminded of their gender just before a math exam, women do more poorly because women feel the extra pressure of being judged by a negative stereotype (Spencer, Steele, & Quinn, 1999) and the results are similar for African Americans students

taking an intellectual performance test (Steele & Aronson, 1995). When worded differently, indicating that the test had nothing to do with gender abilities on math, women performed better on the math test. Additional pressure that minorities feel when stepping into an area without their peers puts them at a disadvantage from a performance standpoint, because they feel pressure to do well to disprove the stereotype. Interestingly, this work evolved more recently with a solution to address stereotype threat, by increasing belonging.

Belonging has been directly linked to academic achievement for diverse students in undergraduate education in a few different contexts. The first study was with African American and European American students in college, where a one-hour intervention halved the achievement gap for the African American students (Walton & Cohen, 2011). Causation was demonstrated by having a control group, and the belonging intervention normalized the challenges of belonging in a new environment by introducing the idea that transitions to school are hard for everyone, and then asking students to write a letter to the next year's class explaining that sometimes it takes a while to feel like you fit in (Walton & Cohen, 2011). This simple intervention improved grades and health for African American students three years later (Walton & Cohen, 2011). Importantly, the European American student's grades were unchanged in the treatment group, so there is no detrimental effect to having all students go through belonging training (Walton & Cohen, 2011).

The belonging intervention has also been shown to be effective with women engineering students (Walton, Logel, Peach, Spencer, & Zanna, 2015). The study explored two interventions and a control group in this causation study, where one intervention was similar to the belonging intervention explained earlier, and the other was an affirmation training which reinforces diverse aspects of their self-identity (Walton et al, 2015). Affirmation training

reminded me of the way I found support in graduate school, which was to build close ties with other women chemists. In this study, both intervention groups were successful with respect to grades, however, the social belonging group had the advantage of the students becoming more integrated with male classmates and mentors, which supports long term success (Walton et al., 2015). It is important to note that belonging interventions also work with socioeconomically disadvantaged students and has been replicated with thousands of students (Yeager et al., 2016). It is amazing that such a simple intervention, a one-hour investment, can transform the success and personal lives of students, years into the future.

Stereotype threat is not limited to educational environments, as it is also relevant in the workplace; it can lead to reduced engagement, career aspirations and feedback receptivity (Casad & Bryant, 2016). In a review paper, several workplace interventions were recommended to address belonging, including environmental cues (location of restrooms, white male leadership photos) and the presence of diversity among co-workers and leaders (Casad & Bryant, 2016). In the absence of a diverse workforce, articulating a clear diversity mission such as an inclusive multicultural value which recognizes the contributions of all employees, can communicate a value of diversity (Casad & Bryant, 2016). The belonging intervention previously described by Walton & Cohen (2011) could also be powerful for supporting long term success and integration of diverse scientists when there is a transition to a new workplace, such as the onboarding of new employees.

Belonging is important for individual well-being and to support diverse contributors in science. What we will discuss in the next section is that the reason belonging is important for all scientists is because diverse teams are more effective at innovation and problem solving. By comparing the top 1,500 S&P firms, presence of women in leadership roles improved financial

performance when innovation was a key part of the firm strategy (Dezsö & Ross, 2012). This is believed to be due to improved managerial task performance, which leads to better outcomes for the firm (Dezsö & Ross, 2012). Looking specifically at research and development firms (>4,000), higher gender ratios fosters innovations such as new ideas for the markets in which the firm operates (Díaz-García, González-Moreno, & Jose Sáez-Martínez, 2013). Clearly these large studies can't differentiate whether employees are in a supportive or antagonistic environment, so factoring in the risk of stereotype threat at some of these companies, it is impressive to see that the overall outcome is positive with respect to women improving innovation. Innovation is clearly needed in medicine discovery research.

Turning now to problem solving, diversity (defined here as differences in ethnicity as well as experience) enhances financial outcomes. Companies in the top quartile for diversity have better financial performance by 35% worldwide (Hunt, Layton, & Prince, 2015). This is believed to be due to improving decision making, for example, fostering creativity and considering more perspectives and approaches to problem solving (Hunt et al., 2015). Diverse teams are better problem solvers than teams of top performers, because as a team grows, each person's added value becomes what they can uniquely contribute to the collective mix (Hong & Page, 2004). Scientific research team size can range from a few up to several dozen people, so the addition of each person needs to add unique value to make the team stronger.

Belonging is a critical psychological need, something that if nurtured, supports physical well-being and feelings of mattering and meaning in life. Belonging can be challenging to achieve when working in scientific fields, particularly with regard to gender or ethnicity, because of stereotype threat. However, belonging interventions have been created to support building diverse peer and mentoring relationships. By supporting belonging for diverse groups

of people in scientific research areas, innovation and problem solving will be enhanced and this will improve scientific outcomes. In this way, belonging which is an enabler for women and minorities to thrive, will also deliver better scientific research, which is better for scientists and society at large.

5. Application - Enhancing Team Collaboration in Science (ETCSi)

The intention of the application section here, coupled with a one-day workshop for teaching collaboration skills to scientists (Appendix A), is to improve team effectiveness by initiating team training to facilitate collaboration. The focus will be on the three core skills which were presented in the previous sections: trust, communication and belonging. Team development interventions (Shuffler, DiazGranados, & Salas, 2011), a term coined to capture training to improve team effectiveness, have been created here specifically for teams working in medicine discovery.

To make the learning more effective, the training workshop will incorporate information, demonstration, and practice (Lacerenza, Marlow, Tannenbaum, & Salas, 2018). The information section of the training will build upon the theory shared in the previous section of this paper, and since scientists like data, it will give them a reason to buy in to the training. The information part of the training will be followed by demonstration and practice exercises with each topic before moving on to the next topic. Workshop training can help teams improve their outcomes significantly, by as much as 12-19%, based on a meta-analysis of team training in several settings such as the laboratory, classroom, military and other workplaces (Salas et al., 2008). The workshop is intended as a training for scientists in medicine discovery, those just joining the field and workers already working in that environment, to create a common language and skill set to nurture collaboration.

Since the intention is to build team work skills, we need a way to measure these skills to determine if improvements have been made. Fortunately, a review covering 39 teamwork

surveys has been published and they contrasted those with and without psychometric validity, bounded and unbounded teams, and ones for which there are success outcomes (Valentine, Nembhard & Edmondson, 2015). The most relevant survey for application to medicine discovery would be one designed to address the quality of success for innovative projects (Hoegl & Gemuenden, 2001). This teamwork quality survey (TWQ) correlates with team performance as rated by the team, managers, external managers, and team members' work satisfaction and learning (Hoegl & Gemuenden, 2001). The TWQ measures six areas of interest: communication, cohesion, balance of member contributions, effort, mutual support and coordination (Hoegl & Gemuenden, 2001). What is ideal about this assessment measure is that it captures both team processes such as how the team is interacting, and outcomes such as what the team is delivering (Lacerenza et al., 2018).

Overall, what is proposed here is a one-day workshop (ETCSi) to upskill scientists working in discovery on research teams to improve their ability to collaborate using trust, communication and belonging. These changes would improve not only their personal well-being but also their work effectiveness through better team collaboration, making better use of innovation, problem solving and decision making to lead to the discovery of more medicines.

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Appendix A: Workshop - Enhancing Team Collaboration in Science (ETCSi)

For trust, the information section will focus on how trust impacts scientific outcomes. One of the key references for this topic is the recent meta-analysis on trust and team performance (De Jong et al., 2016).

Trust Theory	Time
Introduce the conceptual model that intra-team trust is linked to team performance, and it has moderators and covariates. Share details on the work done by De Jong et al., 2016.	10 minutes
Discussion about this data and approach. Does this information ring true in your experience? What thoughts do you have about why this is true? What other variables do you think might be important? Collect group feedback on a white board or chart.	10 minutes
Share an example from my work experience where trust was important for success. I've worked on teams where colleagues second guess the data generated by their teammates. Not only does this slow the team down by generating unnecessary discussion, but it leads to resentment of the people doing the work. I've also worked on teams where trust is cultivated, which allows meeting time to be used for brainstorming and the synergy of ideas that build off each other to lead to creative solutions.	5 minutes

The following trust exercise was inspired by the trust definitions and descriptions in a book called Energize Your Workplace (Dutton, 2006).

Trust Exercise #1. Identifying Trust	Time
Think of three people who supported you when you were young and write down their names. They could be parents, teachers, coaches, religious leaders, etc. You will not be sharing the names.	5 minutes
Describe the way they interacted with you. We will be sharing out loud these descriptive terms. Collect group feedback on a white board or chart.	10 minutes
Trusting relationships have terms like: believe in you, convey confidence, support, etc. Non-trusting relationships have terms like: lack of communication, being guarded, micromanage. Can you recognize places in your work situation where there is trust or a lack thereof? Collect group feedback on a white board or chart.	5 minutes

The following trust exercise will use high quality connections to build trust in the workplace (Monica Worline, personal communication, March 3, 2018):

Trust Exercise #2. Building Trust	Time
Trust is both a giving and a receiving act. We will discuss ways that we can offer and accept trustworthiness by discussing the following questions in small groups (e.g. three people).	5 minutes
Can you think of a way to be vulnerable or give others the benefit of the doubt on your team? Give a few examples like when do you decide to	20 minutes

check up on others you are dependent on? When do you volunteer information even when you are not sure of the conclusion? Discuss the answer to the above questions with your group and consider whether it is easier for you to give or receive trust. Then consider ways you could practice improving trust in the context of a work situation.	
Debrief about this example with the full group. What did you learn talking with your group about how you could trust others more, or be more trustworthy? Collect group feedback on a white board or chart.	10 minutes

This concludes the trust section (80 minutes), take a break.

The communication section will start with a video exercise as a tool to help recognize good communication skills.

Communication Exercise #1:	Time
Watch this video, then discuss the instances where there is a lack of communication. Collect group feedback on a white board or chart. https://www.youtube.com/watch?v=kNz82r5nyUw&t=1s	10 minutes
Choose a partner and have a conversation about what each of you think is the best city in the United States. Argue with the intention of convincing your partner, each person gets 5 minutes.	10 minutes
Working with the same partner, use the same topic but have the conversation in a different manner. Your goal is to listen to the other person and repeat back what you heard in your own words about the city they think is best.	10 minutes
Debrief about this communication exercise. Notice how you listen differently when the goal is to understand the other person. How could this apply in a work situation? Collect group feedback on a white board or chart.	10 minutes

The theoretical communication section will introduce several broad topics, then get into more detail on the role of psychological safety for conflict resolution.

Communication Theory	Time
From other research teams, we know that the amount of time spent in meetings is important. Consider the ratio of face to face interactions, off line meetings with specific subsets of people, and written communication on your team and whether that needs to be modified.	5 minutes
Promoting scientific disagreement is good for scientific outcomes but needs to be shared in a respectful manner. How can you cultivate a sense of safety among the team so that ideas can be shared, even if unpopular? Collect group feedback on a white board or chart.	5 minutes
Does your team practice conversational turn-taking? You will know this is true if you hear from most folks in most settings. This is not happening if you hear from only a few folks, most of the time.	5 minutes
Does your team understand each other’s non-verbal communication? You will know this is happening if someone asks another to comment when they look confused or as though they want to speak up. Video calls can facilitate	5 minutes

<p>this when teams are at a distance physically.</p>	
<p>Share an example from my work experience where communication was important for success. I've worked on teams where there was infrequent communication, such that people were still working on tasks that were no longer relevant due to a new direction the team was taking. I've also worked on teams where members made a clear effort to really listen to each other's work and ideas, which led to efficiencies.</p>	<p>5 minutes</p>

The following communication exercise builds upon the idea of active constructive responding (Reivich, Seligman, & McBride, 2011) and is adapted here to foster psychological safety with negative information.

Communication Exercise #2 Cultivating Psychological Safety	Time
<p>Active constructive responses to positive experiences leads to better relationships. An example will be given when good news is followed up with enthusiasm and questions versus being passive, ignored, or destructive</p>	<p>10 minutes</p>
<p>Consider how this could play out with disappointing news on a team. Working with a partner, tell them about something that happened (fictional or real) and practice ways to respond that would be active and constructive in this situation. Take turns.</p>	<p>20 minutes</p>
<p>Debrief about this example, did you learn new ways to respond to the news that was not flippant or condescending, but was accepting and helpful? Collect group feedback on a white board or chart.</p>	<p>10 minutes</p>

This concludes the communication section (105 minutes), take a break.

The belonging section will start with an exercise used to cultivate feelings of belonging (Lambert et al., 2013).

Belonging Exercise #1 Cultivating Belonging	Time
<p>Think of a time in your life when you felt that you belonged and write about it for 5 minutes.</p>	<p>5 minutes</p>
<p>Discuss in pairs how this experience came about, what enabled you to feel this way. Also consider how you can help someone on your team have that feeling of belonging. Take turns.</p>	<p>20 minutes</p>
<p>Debrief about this example. Did you think of new ways to help your team mates feel that they belong? Collect group feedback on a white board or chart.</p>	<p>10 minutes</p>

The belonging theory section will introduce stereotype threat, diversity in science and outcomes, then belonging as a tool to establish more effective diverse teams.

Belonging Theory	Time
<p>Stereotype threat leads to reduced contributions by women and minorities in schools and the workplace.</p>	<p>10 minutes</p>
<p>Diversity in the workplace leads to greater innovation and problem solving.</p>	<p>10 minutes</p>
<p>Belonging is a tool that can bring out the best in all workers, regardless of educational background, country of origin or diversity status.</p>	<p>10 minutes</p>

Share a belonging story and how it impacted your ability to contribute. My chemistry education occurred in multiple schools and locations. In a predominantly male educational environment, I felt that I stood out and was less comfortable contributing to scientific discussions. In a gender-mixed educational environment, I felt more comfortable taking a chance with an idea that was not fully formed so that my classmates could help me refine it.	5 minutes
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The second belonging exercise is related to the belonging work where a one-hour intervention led to improvements three years later (Walton & Cohen, 2011).

Belonging Exercise #2 Cultivating Belonging on a Team	Time
Read aloud some of the experiences of scientists joining new teams. What were the feelings of those new members and how did they adjust?	5 minutes
Ask the audience to imagine that there is a new member on their team. Think about what it was like to be new to this team and how it took some time for you to adjust. Ask each person to write a letter to this fictional new member on a notepad to help explain the changes that take place and how it takes some time to adjust to being a member of the team. Make sure to highlight anything that was helpful to you when you were a new member.	10 minutes
Debrief about this example, did you learn new ways to help your team mates feel that they belong? Collect group feedback on a white board or chart.	10 minutes

A third belonging exercise, a positive introduction, will be used in this training and can also be repeated with the intact team at a later time (Peterson, 2006).

Belonging Exercise #3 Positive Introduction	Time
Introduce the idea of a positive introduction by giving a brief example of a time in your life when you were being your best self.	5 minutes
Work in groups of three to share a positive introduction. Discuss with your small group the strengths and skills you demonstrated in this example. Take turns.	15 minutes
Debrief about this example with the full group, did you learn new ways to capture the skills and strengths of your small group? Did it help build a connection with someone in a new way? Collect group feedback on a white board or chart.	10 minutes

This concludes the belonging section (125 minutes), the workshop is complete.