Article

Collaborative Research: Techniques for Conducting Collaborative Research From the Science of Team Science (SciTS)

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Abstract

The Problem

The field of human resource development (HRD) is a multidisciplinary field of research and practice requiring collaboration. Unfortunately, the literature on how to conduct collaborative research is incomplete within HRD and other disciplines. Any breakdown in the communication, exchange of ideas, agreed-upon methodologies, or shared credit for dissemination has the potential of preventing research from moving forward. Promotion and tenure policies also hamper collaborative efforts in that these policies often reward individual initiative as opposed to collaborative outcomes. These behavioral patterns provide constraints to the improvement and betterment of efforts to changing of the guard.

The Solution

This article highlights new and improved methods for working in collaborative environments. During an academic's transition and professional development, these methods will help emerging scholars, new to collaborative research, when facing the team science revolution.

The Stakeholders

Scholars and scholar-practitioners engaged in collaborative research. Emerging scholars who are beginning their journey into collaborative research. Graduate students preparing for a career in academia.

Keywords

collaboration, multidisciplinary, team science

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Scientific research today has become more of a collaborative process to the point that it is viewed as a "team science revolution" (Bozeman & Youtie, 2017, p. 2). Others have termed this revolution a new *collaboration cosmopolitanism* (Bozeman & Youtie, 2017) to represent the fact that research is not only conducted by academics. It also involves practitioners from industry and stakeholders from the community. Scientific collaboration provides the benefits of promoting synergy across disciplines, holds the potential of solving larger and more complex problems, and potentially increases the impact of research outcomes due to its nature of being multidisciplinary (DeHart, 2017). Here, scientific collaboration is defined as "a form of interaction among producers of knowledge, allowing effective communication and exchange; sharing of skills, competencies and resources; working, generating and reporting findings together" (Ynalvez & Shrum, 2011, p. 205). Unfortunately, if any of these processes break down during the research effort (e.g., communication, sharing of skills), the scientific collaborative process could be hampered, or worse, could produce invalid outcomes.

The field of human resource development (HRD) is a multidisciplinary field of research and practice. Unfortunately, literature on how to conduct collaborative research is lacking within HRD. Conducting multidisciplinary research is challenging. Each discipline adheres to its unique definitions, theories, processes, procedures, and methodologies. Reconciling any conflict or disagreement between disciplines must be performed by the researchers during the initial stages of the study. Breakdowns in communication, exchange of ideas, agreed upon methodologies, and shared credit for dissemination also have the potential of preventing the research from moving forward.

Acceptance of multidisciplinary research efforts still has its barriers in that promotion and tenure requirements within traditional academic institutions continue to favor independent research over collaborative studies (Zucker, 2012). Multidisciplinary research presents a shift in traditional academic practices. Collaboration trumps individual achievement: "the scientific community realizes that to truly understand complex phenomena, we must transcend disciplinary boundaries" (Fiore, 2008, p. 258). To succeed in the future, researchers will need to transition efforts from individual achievements for promotion and tenure to the new emerging culture of collaboration. This transition can be difficult to achieve, both for the individual researcher and for administrators. Scholars and scholar-practitioners are beginning to realize the need to embrace multidisciplinary research. New requirements from grant funding agencies and the complexity involved in today's research require "both broad and in–depth expertise" (Zucker, 2012, p. 780).

Preparing the field of HRD for this new team science revolution is essential in providing scholars and scholar-practitioners with the necessary resources to aid them in this collaborative transition, which is innate to changing of the guard. This change will be essential for the discipline moving forward in today's increasingly complex landscape. Complexity requires multiple agents (multidisciplinary) coming together to resolve a complex problem that individual agents (interdisciplinary) could not accomplish on their own. The advantage of these collaborative methods, when practiced

correctly, is that their results produce unexpected and astonishing outcomes—known as the concept of emergence from complexity science. Emergent outcomes result from collaborative practices by autonomous agents that are self-organizing and free of constraints—the essence of changing of the guard. The current article focuses on the collaborative aspects that can lead to, or emerge into, successful outcomes when changing of the guard becomes essential.

The remainder of this article is organized by highlighting the burgeoning trends in collaborative research, primarily multiauthored research by disparate researchers. This article will also differentiate between the divergent types of cross-disciplinary collaboration research models (unidisciplinary, multidisciplinary, interdisciplinary, transdisciplinary). Teamwork and taskwork will be placed in context as collaborative research demands effective teamwork skills and the coordination and management of taskwork. Techniques on how to manage this teamwork along with evaluation techniques for collaborative research proficiency and accomplishment will be covered. Also provided will be recommendations for necessary changes to existing policies, funding, author contributions, and promotion and tenure guidelines. These recommendations should help support scholars and scholar-practitioners in HRD as they begin to navigate this new collaboration cosmopolitanism.

Collaborative Research

As researchers and practitioners are called upon to address increasing levels of complexity in their daily practices, collaborations will be necessary rather than being optional. Addressing complex problems requires identifying relevant causal modalities from multiple levels of analysis, requiring consideration of multiple environmental dimensions. For example, social ecology considers four environmental scales: natural, built, sociocultural, and virtual environments (Stokols, 2018). Natural environments involve nature, animals, and plants; built involves physical environments designed and constructed by humans; sociocultural environments involve organizational and institutional entities; and virtual environments involve computing and mobile technologies, the internet, and virtual reality (Stokols, 2018). In considering multiple environments to identify relevant causal mechanisms, collaborative research teams are essential. The expertise of these multidisciplinary teams must also be diverse enough to provide the requisite knowledge, skills, and experiences required to narrow down the causal mechanisms from each environmental scale to only a few that may be relevant to the phenomenon being researched. As problems become more complex, collaborative endeavors require multiple research partners (e.g., academics, lay people or community members, politicians, practitioners).

The Multi-ness of Cross-Disciplinary Research

In most disciplines, multiple-authorship research articles have been increasing (Huang, 2015; Katz & Martin, 1997) and the number of single-authored research articles have been decreasing (Huang, 2015). Earlier appraisals of authorship in the basic sciences

(chemistry, mathematics, physics) showed a decline in single-author papers and an increase in two-author papers. Following this trend over time, the number of two-author papers began to decline and the number of three-author papers began to increase. Currently, this trend has continued in each of the basic sciences in which four- and five-author papers are becoming the norm, above and beyond single-, two-, and three-author papers (Huang, 2015). Research of authorship has concluded that the increase in the number of co-authors is "ongoing and follows an exponential growth" (Huang, 2015, p. 2146) and can be attributed to "the explosion of knowledge in various fields" (Stokols, 2018, p. 330). These basic science findings are similar to what has been found in other disciplines. For example, in coronary heart disease (CHD) research, the number of multiauthored papers have increased "from 4.2 in 1981 to 6.4 in 2010" (Yu et al., 2013, p. 632), placing the average number of multiauthors per paper for this field around six. Also, in CHD research, it has been common to find that not only has the number of multiauthored research papers increased, but it also has been documented that the number of multi-institutional collaboration efforts have also increased, from 23% in 1981 to 56% in 2010 (Yu et al., 2013). In addition, the number of multinational (global) collaboration efforts have also increased, from 2% in 1981 to 19% in 2010 (Yu et al., 2013).

Similar trends have been realized within the HRD academic journals (see Figure 1). The number of authors per published research article (not including editorials, reviews, reaction articles, etc.) were coded for each of the four HRD journals as shown in Figure 1. The number of single-authored research papers for *Human Resource Development Quarterly* (HRDQ) decreased from 87 articles between 1990 and 1999 to 57 between 2000 and 2009, and down again to 25 between 2010 and 2018. This journal increased the number of articles with more than three authors substantially after 2000 and first published articles with six and eight authors within the time frame of 2010 to 2018. *Human Resource Development Review* (HRDR) showed similar trends with a total of 73 single-authored articles between 2002 and 2009 with a decrease to 51 single-authored articles from 2010 to 2018. This journal, HRDR, had published articles with one to five authors during the period of 2002 to 2009 and expanded to include articles with six and seven authors from 2010 to 2018. *Human Resource Development International* (HRDI) decreased single-authored articles from 122 between 1998 and 2009 to 68 between 2010 and 2018. Authorship in the time frame between 1998 and 2009 included articles with one through five authors and one article with eight authors. Between 2010 and 2018, more articles were published with multiple authors with a range between one and nine authors with one article having 11 authors. As a special issue journal and one that promotes collaboration, *Advances in Developing Human Resources* (ADHR) showed similar trends. Single authorship reduced from 192 published articles between 1999 and 2008 to 119 published articles between 2009 and 2018. Both time frames represented multiple-authored articles with as many as six authors, and one article included nine authors in the earlier period between 1999 and 2008. The trends for each of the four journals highlight the point that single-authored research is becoming less common and that the trend of multiple-authored research has impacted the field of HRD and is expected to continue to grow.
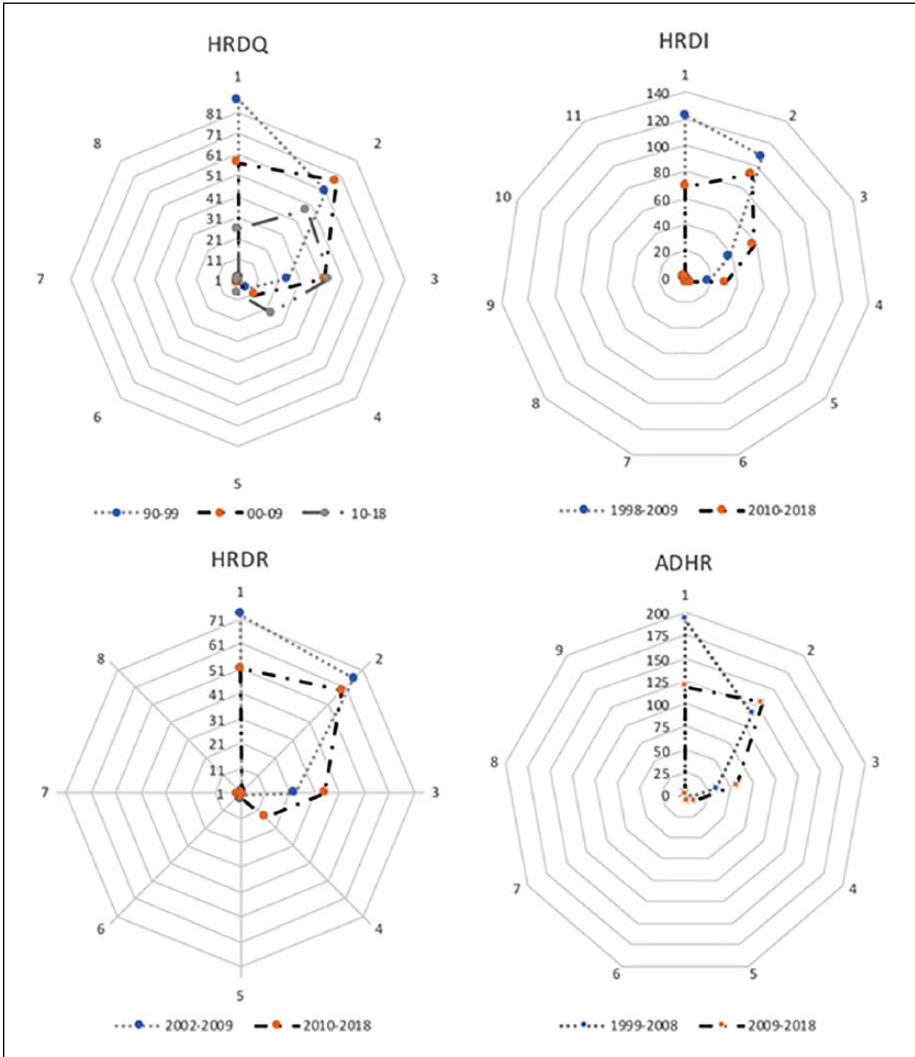
Figure 1. Authorship trends in HRD journals.
Note. HRD = human resource development; HRDQ = *Human Resource Development Quarterly*;
HRDI = *Human Resource Development International*; HRDR = *Human Resource Development Review*;
ADHR = *Advances in Developing Human Resources*.

This increasing trend in multiauthor, multi-institutional, and multinational research collaborations has been found in other disciplines (Rahman et al., 2017; Yu et al., 2013). This increasing trend is beginning to raise some concerns as well. For example, as the number of multiauthor research studies increase, researchers should be trained on how to collaborate more effectively, especially when working across other

disciplines, across different institutions, and across various countries and language barriers. This increasing trend falls under the umbrella of cross-disciplinary research in which a shift in traditional academic practices involving collaboration trumps individual achievement, creating a culture of collaboration, a collaboration cosmoplitanism, or a team science revolution (Bozeman & Youtie, 2017).

Cross-Disciplinary Collaboration

When dealing with cross-disciplinary research, multiple agents from differing disciplines are involved in exchanging multiple perspectives, philosophies, and theories aimed toward the phenomenon and research problem. Some of the benefits of conducting cross-disciplinary collaboration research follow:

- Complex modern problems such as climate change and resource security are not amenable to single-discipline investigation.
- Discoveries are said to be more likely on the boundaries between fields.
- These encounters with others benefit single disciplines, extending their horizons (Rylance, 2015, p. 313).

However, even with the numerous benefits, cross-disciplinary research comes with many challenges as well. Addressing these challenges and issues when conducting cross-disciplinary research is the focus of the field of the Science of Team Science (SciTS; Falk-Krzesinski et al., 2010). Building upon knowledge gained from the field of Team Science (TSci), SciTS has concentrated efforts primarily on conducting cross-disciplinary research. The field of SciTS is "concerned with understanding and managing circumstances that facilitate or hinder the effectiveness of collaborative cross-disciplinary science, and the evaluation of collaborative science outcomes" (Falk-Krzesinski et al., 2010, p. 263). TSci views cross-disciplinary research as a "process of teamwork to be mastered" (Fiore, 2008, p. 256).

Depending on the level of complexity in a research problem, there are generally four different types of cross-disciplinary collaboration research models (i.e., unidisciplinary, multidisciplinary, interdisciplinary, transdisciplinary). Unidisciplinary includes research that is conducted within a single discipline. Multidisciplinary includes research that involves contributions from multiple disciplines (DeHart, 2017), defined as the "coordinated efforts of some set of disciplines designed to achieve some common goal or goals" (Fiore, 2008, p. 254). Interdisciplinary involves integrative contributions from multiple disciplines; this integration is necessary as no single discipline can address the issue alone (DeHart, 2017). The outcome of interdisciplinary research often involves new ways of understanding, new lexicon to describe an emerging phenomena, and new techniques in developing new theories (Fiore, 2008).

Transdisciplinary research, in contrast, involves multiple disciplines bringing novel contributions to a study (DeHart, 2017). One example of transdisciplinary is when a new method needs to be developed to address a problem because existing methods are

not adequate for the stated problem. Transdisciplinary also involves, at times, stakeholders and community members as part of the research effort (DeHart, 2017).

The following sections identify what teamwork and taskwork entail along with an introduction of the critical components that a researcher should concentrate on when working in a team setting. Then, team contracts are discussed along with collaborative research agreements that need to be decided in advance of beginning research. Last, an introduction of contextual factors for conducting cross-disciplinary collaborations is presented.

Teamwork and Taskwork

For teams, processes are divided into two types, teamwork and taskwork. Teamwork identifies the interactions required among team members to achieve their tasks, whereas taskwork involves the activities that must be completed to complete the team's task or objective. Teamwork relates to team member interactions, the sharing of information required at any point in time for team members to complete their tasks, the knowledge of who has what skills so that they can easily be identified when required, and basic communication among team members throughout the process. Taskwork refers to the actual activities (technical, physical, procedural) involved in completing a task or subtask.

The field of team science has identified nine core processes that make up teamwork. These nine core processes have been categorized as being either an emerging state (coaching, cognition, conflict, cooperation, and coordination) or an influencing condition (context, composition, and culture; Dihn & Salas, 2017; Turner et al., 2018). Emerging states relate to internal team dynamics that can be managed, whereas influencing conditions are external dynamics in which the team has little control.

Identifying the conditions that can be managed compared with those that cannot be managed would support the efforts of scholars and scholar-practitioners in any collaborative endeavor. For example, it is important for new scholars to identify what the context is for their new academic home. Comparing a department's research interest with one's own research agenda would aid new scholars to identify better with their colleagues and the department. In the short-term, the new scholar would not be able to make changes if their research agenda was not in line with their new academic home. This new scholar would most likely have to alter an existing research agenda to meet the department's needs. This is an example of having little to no control over the influencing conditions. Scholar-practitioners would benefit from identifying with the emerging states that they can contribute to in a positive manner. By better contributing to some of these emerging states will place a scholar-practitioner in the role of a team player and potentially as an appointed team leader. This is just one example of how scholar-practitioners can influence teamwork by identifying with the emerging states.

Techniques for Collaborating

Teamwork activities requires each team member to work both independently and interdependently. Team members are required to work interdependently to "the extent

to which a job is contingent on others' work" (Cordery & Tian, 2017, p. 111). Resulting in team members being dependent on other team members completing their tasks. Task interdependence requires decisions at the team level involving "the specialization and differentiation of activities and tasks within teams, where the separation of activity elements generates explicit coordination requirements, or through the application of formalized routines that specify particular task and work flows" (p. 111). Essentially, successful teaming requires monitoring and managing these emergent states (coaching, cognition, conflict, cooperation, and coordination) by all team members.

Planning a team's activities/goals/tasks takes work. One common mistake that is often realized when beginning cross-disciplinary collaborations is in underestimating the level of commitment and personal relationships required in such an effort (Ledford, 2015). Each of the emerging states of teamwork must be managed throughout the process. One tool for managing these emerging states can be found in Figure 2. Figure 2 provides a brief example of a team agreement contract that each team member contributes to. A team or collaborative agreement should cover a team's goals and schedule, information pertaining to who will perform which tasks and when, credit for task accomplishment acknowledged by peers (other team members), contingencies around communicating, and any conflicts of interests (Bennett & Gadlin, 2012).

The team agreement contract in Figure 2 provides information on who is on the team along with the team's name. When completing this form, team members will have an opportunity to get to know the other team members as well as their knowledge, skills, experiences, and area of expertise (discipline). The action of including a name for the team helps to begin forming a sense of team identify among the team members. These initial activities will help in developing transactive memory systems for the team members, identifying who knows what and who has which skills. This exercise also begins to develop the team's cognition, the organized understanding of collective knowledge among team members (Mohammed & Dumville, 2001).

The second section requires group members to identify what the team's task goals and process goals are. During this stage, if this was being used for a multidisciplinary research effort, it would be recommended to include a row on problem identification. Identifying the problem is a critical step prior to assigning tasks and process goals. This step initiates the communication and coordination steps of teamwork by requiring each team member to identify and agree on the listed goals. The following section of the form identifies who will do what along with who is appointed as the team leader. Not all teams operate with a team leader, some utilize shared leadership models or incorporate a blend of coaching and leadership. Either is fine; it is more a matter of what works best for the team. Also, this section identifies who is to complete what assignment or task.

Next in the form is a section on the team's rules of conduct. The team decides on how they wish to conduct business. The section on evaluation includes a debriefing session after a milestone or after a set of subtasks have been completed. This debriefing is part of a continuous learning cycle; team members identify what worked and

TEAM AGREEMENT CONTRACT	
Team #	
Team Members:	
	1
	2
	3
	4
	5
	6
Goals that will serve as a unifying force in the work ahead.	
Task goals (what we'll accomplish):	
Process goals (how we'll work together):	
Roles we've identified to ensure performance:	
Assignments/Roals/Tasks:	Names:
Team Leader	
Rules of conduct:	
Meetings	
Communication	
Decision making	
Managing tasks	
Managing relationships	
Evaluation - Reflective Analysis at end of assignment	
What worked?	
What didn't work?	
Adjustments to be made for next assignment.	
Team member evaluation agreement (by placing your name you agree to make the recommended adjustmen	
	1
	2
	3
	4
	5
	6

Figure 2. Team agreement contract.

what did not work as well as planned, then discuss options to make the teamwork processes work better during the next cycle. The last section involves each team member agreeing to the information on the form and willing to adopt the changes recommended by the team for the next cycle.

This process of having the team agree to the team's goals, coordination, communication, and leadership begins the process of managing the emerging states of teamwork. Scholar-practitioners can utilize this form when working in team settings with their customer, whereas scholars can easily modify this form for use in any type of cross-disciplinary research activity. Furthermore, this form has been used successfully in a number of team tasks in the classroom, which can benefit both scholars and students. Utilization of this form addresses each of the critical techniques of strengthening teamwork to (Bennett & Gadlin, 2012)

- Foster an environment that is collegial and nonthreatening.
- Openly recognize strengths of all members of the team and discuss how these different strengths contribute to advancing the project.
- Take a few minutes at regularly scheduled group meetings to do a check-in. Ask how everyone is doing.
- Encourage open and honest discussion by establishing trust.
- Jointly develop a process for bringing issues and disagreements forward for early resolution.
- Assure that when decisions are being made, which require everyone's input, that each person has an opportunity and understands the process for providing comment.
- Schedule periodic assessments and feedback, including opportunities for collaborators to discuss what is going well, what is not, and what needs to be improved.

Implications for HRD Practitioners

Practitioners will need to be even more aware of how to gain credit when contributing to a collaborative research project, how to gain funding for collaborative research projects. In addition, scholar-practitioners will also need to know how to show impact from their collaborative efforts to better advance one's self for promotion and tenure. These items are discussed in the following sections.

Author's Contribution

Additional questions have been raised as to how to account for each author's contribution to a multiauthor research paper. This collaborative contribution record aids in displaying an individual author's impact to their field, typically by citation counts, but it also contributes to the author's evaluation for promotion and tenure. Contribution should be decided upon the following criteria set by the Committee on Publication Ethics (COPE):

1. Substantial contributions to conception and design, or acquisition of data, or analysis and interpretation of data;
2. Drafting the article or revising it critically for important intellectual content; and
3. Final approval of the version to be published (Albert & Wager, 2003).

Authorship contribution should be based on each author meeting all three conditions throughout the research and writing processes. Discussions relating to the order of authorship should begin during the start of any research project rather than later as well as publication and conference intentions of the final output (Albert & Wager, 2003).

Contribution can be evaluated in two general methods: the full counting approach and the fractional counting approach (Rahman et al., 2017). Full counting provides credit to each author for an article's citation, whereas fractional counting partitions the citation into a part per each author such that each author would receive one (citation) divided by the number of authors (n; $1/n$). Different variations of this fractional approach can be found in the literature (see Rahman et al., 2017). The point remains, however, that attribution for an author's contribution in multiauthored papers is currently being considered within academia. These discussions have the potential of negatively impacting one's academic career if, for example, one's contribution was unfairly measured using a fractional measure that assigned the researcher little to no credit for participation in the multiauthored contribution. This could deeply impact one's chances of being promoted to a tenured faculty position, further highlighting the need for scholars and students (emerging scholars) to be able to counter such practices.

Funding

Other problems that accompany this trend of cross-disciplinary research is that national and international funding agencies are beginning to require that research be conducted by cross-disciplinary teams, typically of the variety of multidisciplinary or transdisciplinary research teams due to the complexity involved in today's environment and problems (Zucker, 2012).

Funding agencies have been encouraged to support cross-disciplinary efforts. One example of this is in the Global Research Council's (GRC) report on interdisciplinarity. Regarding recommendations to funding agencies, the GRC provided the following:

- Our research and much of the literature suggest that top-down thematic funding programs are one of the most common approaches adopted by funders to encourage interdisciplinarity.
- There is also a consensus that researcher-led "bottom-up" approaches are required and funding agencies should support such approaches despite the potential risks associated with the most innovative ideas.

- At the same time, interdisciplinary research should be viewed as a means to an end and not an end in itself. Several funding agencies emphasized that practices and policies toward interdisciplinarity should be driven by the required outcomes and scientific demand (Gleed & Marchant, 2016).

Promotion and Tenure Practices

Typically, academic institutions' promotion and tenure policies still favor individual research (Rylance, 2015). Also, current bibliometrics favor individual efforts as opposed to providing collaborative measures. This results, in many cases for early career academics, in advisement against cross-collaborative research in favor of concentrating one's time and effort on research that is individual, unidisciplinary, or both (Rylance, 2015). Future changes in promotion and tenure practices will need to be considered, especially with current and future changes to the requirements from grant-funding institutions. Scholars and scholar-practitioners will be better served to collaborate, joining academia with practice, to gain future funding for research. Receipt of such funding could potentially be the catalyst to change the requirements for promotion and tenure, at least at one's current institution.

Evaluation Techniques

There are various evaluation measures for collaboration and transdisciplinary research projects. One such tool is the research orientation scale provided by the National Cancer Institute (NCI; Fload Expert, 2010). This tool is available free and is included as part of the Team Science Toolkit sponsored by NCI (https://www.teamsciencetoolkit.cancer.gov/Public/Home.aspx). Another evaluation tool is the transdisciplinary orientation scale provided by Mirsa et al. (2015). The transdisciplinary orientation scale provides "a reliable and preliminarily validated tool to measure scientists' and scholars' personal disposition toward transdisciplinary research" (Mirsa et al., 2015, p. 6).

These evaluation tools could be tested and validated for collaborative research within the HRD community. Future research could entail utilizing either of these evaluation tools to identify the level of collaboration among collectives along with extending HRD's knowledge base by introducing new evaluation tools that could be used by scholars and scholar-practitioners within the field of HRD.

Conclusion

Research is a collaborative process. Advances in science rely partially on social interaction among other scientists (Katz & Martin, 1997). These interactions have, in some cases, formed into larger, organized, collaborative networks such as the Academy of Human Resource Development (AHRD) and the SciTS. Funding agencies have also begun to require applicants to show collaborative efforts when documenting research compared with single-discipline research. Part of this drive for more cross-disciplinary research is because "it has a key role to play in addressing the grand challenges that

society faces" (Gleed & Marchant, 2016, p. 5). Multiauthorship research is more common in many disciplines and has been shown to already be acceptable in HRD.

This shift toward collaborative research identifies with the theme of this special issue in that it identifies the shifting roles that scholars and scholar-practitioners will face shortly regarding cross-disciplinary research. The potential changes in policies required from the new demands of cross-disciplinary research to gain funding will indeed impact the future of current and emerging scholars.

Managing and adjusting the collaborative processes, current practices, and policies will take time. These items are critical and must be realized for scholars and scholar-practitioners to advance into the future of collaborative research. Achieving emergence, through collaborative research practices, is essential for those who practice HRD as it is a multidisciplinary field of study. This emergence addresses the theme of this special issue, *Changing of the Guard*. Scholars and scholar-practitioners need to be responsive and adaptable to this transformation. They must be capable of participating in managing and evaluating new collaborative efforts. These efforts will benefit HRD scholars and scholar-practitioners and could begin a new field of study within HRD, TSci, and Cross-Disciplinary Research.

Declaration of Conflicting Interests

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