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The Effect of Interdisciplinary Translation on Individual Differences, Teamwork, and
Productivity in Grant-Funded Teams

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ABSTRACT

Interdisciplinary teams are important for working on grand challenges that require diverse disciplines and perspectives to solve them. One way interdisciplinary teams may overcome communication challenges caused by distinct disciplinary languages is to include an interdisciplinary translator role. An interdisciplinary translator is someone who is knowledgeable about the background, values, and context of two or more disciplines so they can fulfill the role of helping members to understand the language and jargon of another discipline. Although a promising idea, little research has been conducted. Therefore, the purpose of this research was to examine the effects of interdisciplinary translation on interdisciplinary individual differences, teamwork, and team productivity. We used interview and survey data along with archival data from interdisciplinary team members who were awarded an NSF-funded grant.

We found that teams who reported having a translator role(s) were negatively correlated with unidisciplinary orientation and positively correlated with interdisciplinary orientation. Teams reporting having interdisciplinary translation were also positively correlated with reports of transdisciplinary behaviors and collaboration outcomes like satisfaction, productivity, and trust and respect. Given these promising results, interdisciplinary translators should be used and valued in interdisciplinary teams. However, because this was an introductory study, future research should continue to examine the role of interdisciplinary translators in interdisciplinary teams.

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Chapter 1

Introduction

Importance

Interdisciplinary teamwork is essential to solving grand challenges and wicked problems. Grand challenges and wicked problems are problems that are interconnected with others and thus are very difficult to solve. They are problems so big that no individual entity can solve them on their own (Ferraro et al., 2015). For example, poverty, sustainability, cybersecurity, and affordable healthcare, to name a few (Ferraro et al., 2015). Each problem is very intricate and involves multiple aspects of society. To illustrate, in areas overcome with poverty, there tends to be a lack of education (Fegeler, 2019) and a lack of quality healthcare (Levin, 2018). These three factors all overlap with each other and can be difficult to determine what causes what. Due to the cyclical nature and interconnectivity of these problems, it is crucial to have an interdisciplinary team working together to try to find a solution. This way the team can include many different areas of expertise that can offer a wide range of potential information that can lead to a solution. In this regard, interdisciplinary teams are critical for working on these world problems.

Interdisciplinary teams comprise people from different disciplines with diverse knowledge pools (Aboelela et al., 2007). For example, a diverse interdisciplinary team could be comprised of a computer scientist, psychologist, and historian. The ideal is to create an atmosphere of information sharing that promotes the creation of new ideas that would not have been produced without the mixture of knowledge (Abubakar et al., 2017). However, because the

team is full of people from different backgrounds, it comes with the challenge of communicating effectively (Ashby, 2022). People from different disciplines know and use different language and different jargon that people from outside of that discipline might not understand. This creates a level of separation between team members that might result in flawed communication (Ashby, 2022). Flawed communication could translate into barriers in producing solutions to grand challenges and wicked problems.

One way interdisciplinary teams may overcome communication challenges caused by distinct disciplinary languages is to include an interdisciplinary translator role (Knoedler, 2019). An interdisciplinary translator is someone who is knowledgeable about the background, values, and context of two or more disciplines so they can fulfill the role of helping members to understand the language and jargon of another discipline (Knoedler, 2019). To bridge the gap between team members' expertise, interdisciplinary translators facilitate understanding and communication by converting specialized jargon, technical language, and cultural references from one discipline into language that is comprehensible and meaningful to team members from other disciplines (Knoedler, 2019).

Knoedler (2019, *The Act of Translation*) describes translating as the practice of “enhancing and adapting the information with the context included.” Therefore, translating not only takes information from one discipline's language and converts it to another, but it also weaves information from multiple languages together and then combines it in a way that is understandable to other parties (Knoedler, 2019).

By improving members' understanding across disciplines, can the role of an interdisciplinary translator make a difference in solving these grand challenges and wicked problems? Unfortunately, research cannot yet answer this question. Although introduced by

Knoedler (2019) as a promising idea, the interdisciplinary translator role has not been empirically studied. However, it would be beneficial to investigate whether the interdisciplinary translator role delivers on its potential to enhance interdisciplinary processes, and outcomes. Therefore, the purpose of the present study was to examine the effects of interdisciplinary translation on interdisciplinary individual differences, teamwork, and team productivity. To capitalize on the strengths of multiple methodologies, this research used a mixed methods approach (Molina-Azorin, 2017). Specifically, we merged interview, survey, and archival data from a sample of interdisciplinary National Science Foundation (NSF) grant awardees.

Literature Review

Communication Challenges in Interdisciplinary Teams

Dr. Iryna Ashby's (2022) dissertation outlines ten stages of interdisciplinary communication and the possible challenges and outcomes of them. The first stage is called "Singing the Old Songs." In this stage, team members from different disciplines get together for the first time. In this stage team members focus on presenting their own work. The second stage; "Everyone on the Other Side is an Idiot," is when team members start noticing and pointing out deficiencies in the disciplines of other members. This is the stage where most leave, as mutual understanding is at a low point. The third stage, "Retreating into Abstraction" is where team members use more abstract language to communicate because the more abstract the language is, the easier it will be for others to connect that language to that of their own. The fourth stage, "The Definition Sickness", is where team members start asking each other to define technical terms. While this looks like progress in a positive manner, it still may cause challenges. For

example, the team may develop group-specific jargon that could make it difficult for a new member to join and learn the language.

The fifth stage of interdisciplinary communication, “Jumping the Tussocks” is where real conversation and discussion can occur (Ashby, 2022). However, the challenge with this stage is that while meaningful discussions are taking place, they are being immediately followed up by another discussion without coming to an agreement on the previous discussion. The sixth stage, “Playing the Glass Bead Game”, is where more common ground is established between team members. While this is a positive stage, it moves incredibly slowly. The seventh stage, “Surfacing of the Great Failure”, is where members may start to feel that the results of their project are not worth the efforts put in. Thus, team members start to question the feasibility of interdisciplinary work and eventually give up on it.

The eighth stage of interdisciplinary communication, “What’s Happening to Me?” is where members start to realize how they have changed as a result of working with others from diverse disciplines (Ashby, 2022). They start to realize they themselves are starting to become more interdisciplinary in their outlook and also become advocates for interdisciplinary teamwork. The ninth stage, “Getting to Know the Enemy” is opposite from stage two. In this stage, team members are starting to understand the strengths of others and are more capable of asking the right questions to further their understanding and knowledge of the new field as it relates to their project. Finally, the tenth stage, “The Real Beginning” is where the teamwork can now really start. There is no longer such a huge barrier between the languages of the diverse disciplines and therefore the team members can communicate more effectively to work collaboratively on their project. Some interdisciplinary teams never get to the tenth stage (Ashby, 2022).

Given the lengthy process to arrive at effective communication in interdisciplinary teams, could the role of an interdisciplinary translator help members arrive at the tenth stage faster and better? Could a translator role prevent members from leaving the team because of frustrating language barriers and communication breakdowns? Because of the lack of empirical research on interdisciplinary translation, the answers to these questions are unknown. As most of these stages involve team members not working together very cohesively, it would be beneficial to have someone fill a role to improve understanding between members. An interdisciplinary translator may help alleviate some of the roadblocks to people coming together to solve problems from all types of different backgrounds and disciplines. Interdisciplinary translators can aid in converting jargon and making concepts more accessible to people of other disciplines (Ashby, 2022). All of the issues in the ten stages outlined by Ashby (2022) were communication problems. If someone were to fill the role of ‘interdisciplinary translator’ in an interdisciplinary team, their job would be to help facilitate and adapt the language being used and ensure that everyone is understanding each other effectively and also able to adapt different ideas into different contexts that fit the whole better.

Interdisciplinary Translator Role

In introducing the concept of interdisciplinary translation, Knoedler (2019) outlines the importance of teams and collaboration and how working together requires a knowledge transfer, especially between those of different disciplines. She then touches on context and how it is necessary for weaving concepts together, closing knowledge gaps, and translating information. That is what interdisciplinary translators are doing-- taking the context and using it to enhance and adapt the information, not just repeating the same information with different words. Knoedler (2019) writes that interdisciplinary translators notice and understand how information

holds relevance in other contexts which enables them to make connections between the contexts, allowing for new applications that would not have been seen without the translated information.

According to Knoedler (2019), translation “can be learned, but must be practiced.” She outlines a list of skills that are necessary for successful interdisciplinary translators, including observation skills, being able to notice and relate ideas and information. Furthermore, it is important for the interdisciplinary translator to be aware of their audience and perspectives outside of their own. An interdisciplinary translator also must be comfortable taking risks and making jumps from one idea to the next, or one context to the next.

Though interdisciplinary translators have their own ideas and contributions, their most important contributions are when they are using their skills to bridge other ideas together and finding the relevance of others’ original ideas in new contexts. They always give credit where credit is due but offer their own spin on the original idea as well (Knoedler, 2019).

Knoedler (2019) also explains the difference between an interdisciplinary translator, facilitator, and a knowledge broker. A facilitator is typically someone who is in a team meeting with the goal of providing a space where everyone feels they can share their ideas and their opinions will be heard. Whereas a facilitator makes sure that ideas are flowing, and discussion can continue, it is not part of their role to translate these ideas and make them more accessible to those from different backgrounds or disciplines. A knowledge broker has a role one step deeper than a facilitator. Their job is to connect ideas and relate concepts to one another. Their role also includes advancing understanding through inviting others to contribute and address possible gaps in information, rather than adapting or changing ideas like the interdisciplinary translator might. Beyond facilitators and knowledge brokers, interdisciplinary translators adapt and change

original ideas to fit into new contexts and offer new meanings. This is not to say that one role is better than another, they are all useful in their own contexts.

Knoedler (2019) ends with an acknowledgement that there is no published work relevant to this idea of an interdisciplinary translator but affirms that it is a role critical to teamwork, especially that of interdisciplinary teamwork. In response, the purpose of this research was to examine the effects of interdisciplinary translation on interdisciplinary individual differences, teamwork, and team productivity using mixed methods.

Chapter 2

Overview of Data Collection and Research Sample

Mixed-Method Data Collection

The data shown in this article is part of a larger research project utilizing a mixed-methods approach including archival, interview, and survey data from interdisciplinary research teams. An inductive methodology was used to begin with due to the scarcity of theory on interdisciplinary teams (Edmondson & McManus, 2007).

A mixed-methods approach can be very useful for integrating qualitative and quantitative data. Because every approach is going to have strengths and weaknesses, by using mixed-methods, we can compensate for the weaknesses of one method with the strengths of another (Molina-Azorin et al., 2017).

A mixed-methods approach allows for a greater degree of comprehensiveness. By combining qualitative and quantitative data, we can collect more and richer data for analyses. Quantitative data provides numerical data that can help establish patterns and generalizations. Qualitative data provides a deeper exploration of more individual experiences, perspectives, and context (Gibson, 2016). A mixed methods approach also allows for triangulation because it provides researchers with multiple perspectives and points of view, leading to greater validity and credibility in the results (Gibson, 2016). The process of triangulation involves cross-

checking the findings from different methods to confirm or refute results. This leads to a more robust and accurate understanding of the results found.

Mixed-method data collection also allows for improved generalizability. It allows researchers to explore more in-depth while also establishing broader trends and patterns that can be applied to a larger population. Overall, mixed-methods data collection can provide researchers with a more comprehensive and flexible approach to studying new and complex phenomena (Gibson, 2016).

Research Sample

We used a purposeful approach to select cross-disciplinary researchers who were more likely to give the information pertinent to our research focus. This research is supported by the National Science Foundation under Award No. 1939163.

We interviewed and then surveyed researchers who had been awarded a National Science Foundation's (NSF) EAGER (Early-concept Grants for Exploratory Research) grant. First of all, EAGER grants support a diverse knowledge pool by requiring that research teams consist of cross-disciplinary collaborations. NSF has seven directorates (e.g., biological sciences; computer and information science and engineering; engineering; geosciences; mathematical and physical sciences; social, behavioral and economic sciences; and education and human resources). Thus, EAGER teams provide a good fit of diverse research collaboration.

Second of all, [nsf.gov](https://www.nsf.gov) publishes the names of Principal Investigators (PIs) and co-Principal Investigators (co-PIs) who have been awarded funding so that information is publicly available. This allowed us to collect the names of the PIs and co-PIs and thus other public

information, for example, emails from university websites and collaboration publications from google scholar and Curriculum Vitae (CVs). This is how we created our archival database. However, this means that our sample was limited to just the EAGER PIs and co-PIs and did not include the possible larger team including potential postdocs, graduate students, or undergraduate research assistants. Finally, the EAGER awards have a two-year time limit which gives us a reasonable time frame to collect post-EAGER collaboration award outputs (including publication, conference presentations, etc.)

Our sample was taken from EAGER awardees in the Secure and Trustworthy CyberSpace (SaTC) program between 2013 and 2019. Specifically, 13 EAGER grants were awarded in 2013, 12 in 2014, 14 in 2015, 0 in 2016, 7 in 2017, 0 in 2018, and 12 in 2019.

The individual sample overall included 149 PIs and Co-PIs. These individuals had a median of 17 years since earning their Ph.D. (Mean=19.83 years, range of 2-54 years). The sample consisted of mostly males, representing 66% of the total sample. There were over 50 different disciplines represented in our sample, including 34% computer science, 6% psychology, 4% communication, and 4% electrical and computer engineering.

The team sample included 58 EAGER-funded team projects containing 76 awards. The mean team size was 2.81, median team size was 3.00, with a range of 2-5 person teams, and a standard deviation of .91. Fifty-nine percent of the sample was made of PI/co-PI dyads, 28% of the sample was three-person PI/co-PI teams, 10% was four-person teams, and 3% was five-person teams. Team members were from the same university in 67% of the teams. Forty-six percent were mixed-gender teams, 40% were male-only, and 14% were female-only teams. The mean grant award amount was \$219,153.57, the median amount was \$224,675, with a standard deviation of 75,610.71, and a range of \$31,579 to \$316,000.

Chapter 3

Interview Methodology and Results

Interview Recruitment and Sample

We contacted all 149 EAGER PIs and co-PIs in the sample via email to ask them to participate in an interview for our study on multidisciplinary team collaboration in their PI/co-PI EAGER team. We interviewed 33 of the 149 EAGER PIs and co-PIs, representing a 22% response rate. Seventy-six percent of interviewees were male, 21% were female, and 3% were unreported. There was an average of 20.87 years since interviewees received their Ph.D. (median = 17, SD = 11.23), with a range of 5 to 53. There were 19 universities represented in the interviews, and two interviewees were from private industry.

The interview sample consisted of 26 different EAGER projects (45% of the larger sample of 58 EAGER grants). Seven interviewees (21%) overlapped with other interviewees from the same EAGER grant. There was an average of 5.61 years since the EAGER grant was awarded (SD = 2.16), with a range of 2.65 to 8.61 years. The award amount ranged from \$31,579 to \$316,000 with an average of \$225,272 (Median = \$227,709, SD = \$84,594).

The average PI/co-PI team size represented by the interviewees was 2.33 members (SD = 0.54), with a range of 2 to 4. The teams were mostly male-only (48.48%) and mixed (42.42%), and 9.1% of the teams were female-only. Most of the PI/co-PI teams ($\frac{2}{3}$) were from the same university.

Interview Protocol

Between the months of February and November of 2020, 33 PIs and co-PIs participated in a 30-minute to one-hour interview conducted over Zoom. All the interviews were recorded with the consent of the interviewees. The interview covered four broader categories, including cross-disciplinary training and experiences; the history, workload sharing, and ongoing writing and communication practices of PI/co-PIs collaboration; the factors that facilitated and hindered interdisciplinary collaboration; and knowledge convergence and divergence. We describe our sample as including interdisciplinary researchers because most interviewees characterized their EAGER project as interdisciplinary (as opposed to unidisciplinary, multidisciplinary, or transdisciplinary).

For the purpose of this research, we focus on the following interview question:

“In teams, members fulfill different roles. I am interested in this idea of a multidisciplinary translator who can speak the language of multiple disciplines and help members of the team understand the perspectives of the other discipline. Is there a member or members of your team who fulfill such a role?”

Though 33 PIs and co-PIs participated in the interview, only 23 responded to the above question. Ten respondents either were not asked the question or did not answer the question. Thus, our sample size is minimized to 23 responses.

Coding Process

Interviews were transcribed verbatim externally and then imported into NVivo (Release 1.5.2) software (QSR International, 2021) for data analysis. We used a thematic analysis approach which is foundational to qualitative analysis. According to the thematic analysis approach, we first familiarized ourselves with the interview data, generated initial codes, searched for patterns in the data, and then defined and labeled essential themes so we could establish relationships within and between them (Braun & Clark, 2006).

To ensure reliability and dependability of our coding, we had three research assistants code the same two interviews independently. After appointing codes to text units, the percentage of agreement across the coders was 96.25% for the interdisciplinary translation question (Kappa = .56). The coders then met to discuss any discrepancies. Following this discussion, we realized we needed to clarify how to interpret the “none” code. It was determined that “none” would be broken up into three more specific codes pertaining to why there was no interdisciplinary translator. The specific “none” codes were as follows: 1) no reason given, 2) nothing needed to be translated, and 3) the team members already knew enough. After this discussion, there was 100% agreement between raters.

Interview Results

Table 1 lists the codes derived for the interdisciplinary translation interview question: 1) there was no one to fulfill the role of interdisciplinary translator 2) there was one person to fulfill the role of interdisciplinary translator and 3) there were two or more people who fulfilled the role

of interdisciplinary translator. The majority of the interviewees (65.22%) reported having one or two interdisciplinary translators during their collaboration. Eight interviewees out of 23 reported having no interdisciplinary translator (34.78%). Of the eight interviewees who reported having no translator, three of them offered no reason, two said they had no translator because nothing needed to be translated, and three said it was because the team members already knew enough. Six interviewees reported having one interdisciplinary translator (26.09%), and 9 reported having two or more interdisciplinary translators (39.13%).

Table 1: *Translation Interview Responses*

	No translator	One translator	Two or more translators	Total
Number of interview responses	8	6	9	23
Percentage	34.78%	26.09%	39.13%	100%

All three interviewees who reported having no interdisciplinary translator but did not say a reason said it would have been helpful to have someone fill that role. However, they also admitted it is a hard position to fill. For example, two interviewees responded:

“In fact, ...I would have to say, I got other multi-disciplinary area grants with five or six PIs across five or six departments, that’s a unicorn. I’ve never seen that person that stands in both worlds, maybe every now and then... I think they would be helpful but they had background in both areas.”

“I think that would, in this case, ...have required someone really brilliant... I think you could...happen upon a person that knows a bunch about everything... So that kind of collaboration would be perfect.”

Interviewees who reported having one interdisciplinary translator praised the role for being helpful to their team. Some quotes include:

“Our postdoc was huge in that way. Because he was kind of a boundary spanning guy that he could speak credibly to the computer science side and to ... [the] political science side. And it was really useful.”

“She can just use the language that both of us are comfortable with. So ... the graduate student has been incredibly helpful with that.”

Interviewees who reported having two or more interdisciplinary translators also praised the role for being helpful with collaboration and communication between team members, though some also admitted to the difficulty in fulfilling this role. Some notable quotes include:

A “translator background will be very helpful for the collaboration, right, as well as communication, because somehow you equip the language that the other side of the team talk about or speak, such that in the future, when we talk to each other, we kind of know what you're talking about. So that's also very important. I think this is a very important for not only the future communication, but also maybe some, like future collaboration projects.”

“I think right now we're the translators for our students trying to translate between the two sides and trying to complement each other while doing that. ... I really like this idea for a translator but it's so hard to find these people.”

Interview Discussion

Given the scarcity of research regarding the role of translators in interdisciplinary teams, we started with an inductive approach (Braun & Clark, 2006). We conducted 33 interviews with

NSF-funded PIs/co-PIs of whom 23 of them spoke about the role of an interdisciplinary translator in their research and whether they had someone to fulfill that role or not. Coding data yielded three primary responses: no translator, one translator, two or more translators.

Approximately two thirds of respondents reported having one or two interdisciplinary translators on their team. All of these respondents said that having an interdisciplinary translator was beneficial for their collaboration. Specifically, most respondents touched on language use and how the interdisciplinary translator was able to convert language from one discipline into language that those of another discipline can understand. Some interviewees said that this role was hard to fill because it is somewhat rare to find people who can speak the language of multiple disciplines.

Approximately one third of respondents reported having no interdisciplinary translator, whether it be without stating a reason, nothing needed to be translated, or everyone on the team knew enough to not necessarily need a translator. Even though in some cases an interdisciplinary translator was reported to not be needed, no one said that it would have hurt to have someone fill the role. For those that did not state a reason for not having a translator, they claimed it would have been helpful in their collaboration process.

Interviewees who answered this translation question agreed that having an interdisciplinary translator either was or would be beneficial to their work in interdisciplinary teams. This finding is promising and invites more research to be done on the role of interdisciplinary translators as it was viewed as beneficial in this qualitative study. To further the results we received from the interviews, we also sent out a survey of which two questions focused on the role of interdisciplinary translators to the same population of EAGER grant awardees.

Chapter 4

Survey Hypotheses, Methodology, and Results

Hypotheses

We expect interdisciplinary translation to affect multiple outcomes because having an interdisciplinary translator should make it easier for those from diverse disciplines to work together. Specifically, we predict that interdisciplinary translation will be significantly related to interdisciplinary individual differences (research orientation, transdisciplinary behaviors) and teamwork (interdependence, collaboration type, knowledge convergence, collaboration outcomes).

Interdisciplinary Individual Differences

Interdisciplinary individual differences consists of two variables; research orientation and transdisciplinary behaviors.

Research orientation assesses researchers' values and attitudes towards multidisciplinary (Hall et al., 2008). Research orientation can be broken down into three factors; unidisciplinarity, multidisciplinary, and interdisciplinarity/transdisciplinarity. Researchers with a unidisciplinary research orientation tend to focus on their own work within their own discipline and prefer not to collaborate with other disciplines (Hall et al., 2008). Researchers with a multidisciplinary research orientation tend to keep a focus on their own discipline but will work collaboratively with others from different disciplines (Hall et al., 2008).

Researchers with an interdisciplinary/transdisciplinary research orientation also collaborate with different disciplines but demands a higher level of integration of those disciplines than a multidisciplinary orientation (Hall et al., 2008).

Transdisciplinary behaviors are behaviors researchers may engage in that involve other disciplines outside of their own (Frescoln & Arbuckle, 2015). For example, reading publications from other disciplines, going to conferences focusing on other disciplines, submitting grant proposals with colleagues from other disciplines, etc. (Frescoln & Arbuckle, 2015).

Hypothesis 1 predicts that higher interdisciplinary translation will be a) negatively correlated with unidisciplinary orientation, b) positively correlated with multidisciplinary orientation, and c) positively correlated with transdisciplinary orientation. We hypothesize that researchers who report having more interdisciplinary translation in their team will be negatively correlated with unidisciplinary orientation and positively correlated with multidisciplinary and transdisciplinary/interdisciplinary orientation. This is because those who report having an interdisciplinary translator have a tendency to be more interdisciplinary oriented and to have interdisciplinary preferences when it comes to working in teams.

Hypothesis 2 predicts that researchers who report higher translation in their teams will be positively correlated with higher transdisciplinary behaviors. We expect those that reported having interdisciplinary translators in their project to also report more transdisciplinary behaviors.

Teamwork

Hypothesis 3 predicts that researchers who report having an interdisciplinary translator will be positively correlated with PI/co-PI task interdependence. We expect that those who report

having an interdisciplinary translator(s) are working together more and depending on each other more, thus will have higher task interdependence.

Hypothesis 4 predicts that interdisciplinary translation is positively correlated with the extent of disciplinarity or collaboration type. The extent of disciplinarity or collaboration type refers to whether their research represents a multidisciplinary, interdisciplinary, or transdisciplinary focus. We defined multidisciplinary collaboration type as “working with your EAGER PI/co-PI(s) from your own discipline-specific perspective.” An interdisciplinary collaboration type was defined as “interacting with your EAGER PI/co-PI(s) dynamically and at a higher level of integration than multidisciplinary, however with contributions remaining anchored in your own disciplines.” A transdisciplinary collaboration type was defined as “working with your EAGER PI/co-PI(s) to extend discipline-specific theories so that new approaches were created to address a common problem.” We expect those who report having an interdisciplinary translator to also report higher levels of disciplinarity.

Hypothesis 5 predicts that translation is positively correlated with knowledge convergence. Knowledge convergence is the degree to which team members agree with each other on aspects of their project. We expect that teams who reported having an interdisciplinary translator will have a greater degree of agreement between team members.

Hypothesis 6 predicts that translation is positively correlated with collaboration outcomes. Collaboration outcomes included the impact of collaboration, satisfaction with collaboration, and trust and respect. We expect that those who report having interdisciplinary translators in their team will also report having higher collaboration outcomes like higher satisfaction and impact.

Hypothesis 7 predicts that translation is positively correlated with interdisciplinary research productivity (e.g., publications, conferences, grants). We expect those who report having an interdisciplinary translator to produce more interdisciplinary research.

Survey Recruitment and Sample

Each of the 149 EAGER PIs and co-PIs in the sample were asked to complete a survey via email on multidisciplinary collaboration in their EAGER team. Survey respondents were presented with a \$20 Amazon gift card for their participation. PIs and co-PIs were also contacted via phone to remind them to participate in the survey.

The end sample consisted of 38 responses, amounting to a 25.5% response rate. Out of the 38 responses, 33 responses included complete survey data. Five surveys were only partially completed and unidentified, and thus could not be linked to interviews or archival data. Responses were missing at random, as shown by a missing values analysis. Fourteen of the 38 survey respondents also participated in the interview.

The majority of survey respondents were White (60%), with 20% of respondents being Asian/Pacific Islanders, 2.9% were Black/African American, 2.9% were multiple races, and 14.3% selected “other.” Most respondents were males (51.4%), with one non-binary participant (2.9%). However, the survey respondents included more females (45.7%) compared to the interview sample (21%). Most respondents were between the ages of 40-49 (45.7%), but other categories included 30-39 years and 70 and older. The number of years from 2022 and when participants received their Ph.D. ranged from 6 to 53 with a mean of 20.52 (Median=17,

SD=11.24). The most frequently reported organizational tenure was between 11-15 years (23.5%) but ranged from between 1-5 years to more than 20 years.

The survey sample consisted of 27 different EAGER projects, 46.6% of the larger sample of 58 EAGER projects, 5 interviewees did not report any identifying information that could be used to link to archival data). Awards ranged from \$90,000 to \$315,997, with an average of \$234,413 (Median=234,251, SD=\$74,776). The number of years since the EAGER grant was awarded from 2022 ranged from 2.74 to 8.61, with an average of 5.65 years (SD=2.11). There was an overlap of six participants with other participants representing the same EAGER grant.

The average PI/co-PI team size represented by the participants was 2.73 members (SD=0.98) and ranged from 2 to 5. Most teams had a mixed gender composition (57.6%), with 30.3% of teams being male-only and 12.1% of teams being female-only. The majority of teams (63.64%) were from the same university, the maximum number of universities being represented being three.

Survey Measures

This research was part of a larger study and a broader survey. For the purposes of this study, we focus on two survey questions about the role of an interdisciplinary translator in their PI/co-PI EAGER team. The survey asked participants to respond to how strongly they agreed (strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree) with the following two statements:

“At least one member in my EAGER team was able to ‘translate’ across the represented disciplines so members from one discipline could understand concepts from the other discipline(s).”

“PI/co-PI(s) ‘spoke the language’ of more than one discipline in the EAGER grant team to help team members who were only familiar with one discipline understand the perspectives of the other discipline(s).”

Research orientation was measured via a 10-item research orientation scale including three factors; unidisciplinary, multidisciplinary, and interdisciplinary/transdisciplinary orientation (Hall, 2008). There were 3 items for unidisciplinary orientation, a sample item being: “I tend to be more productive working on my own research projects than working as a member of a collaborative research team.” (Hall, 2008). There were 2 items for multidisciplinary orientation, a sample item being: “Although I rely primarily on knowledge from my primary field of interest, I usually work interactively with colleagues from other disciplines to address a research problem.” (Hall, 2008). There were 5 items for interdisciplinary/transdisciplinary orientation, a sample item including, “In my collaborations with others, I integrate theories and models from different disciplines.” (Hall, 2008). All items were measured using a 5-point Likert scale ranging from strongly disagree (1) to strongly agree (5). Cronbach’s alpha for unidisciplinary, multidisciplinary, and interdisciplinary/transdisciplinary was .77, .76, and .80 respectively, demonstrating admissible internal consistency reliability.

Transdisciplinary behavior was measured using a 6-item scale ranging from never (1) to weekly (5) (Frescoln & Arbuckle, 2015). A sample item included, “Read journals or publications outside your primary discipline?” Cronbach’s alpha for transdisciplinary behavior was .76.

Task interdependence was measured using a 5-point Likert Scale from strongly disagree (1) to strongly agree (5) for three items (Campion et al., 1993). A sample item adapted from Campion et al. (1993) included, “I cannot accomplish my tasks without information or materials from my PI/co-PI(s).” Cronbach’s alpha for task interdependence was .80.

Collaboration type was measured using a 5-point Likert scale with 1 being multidisciplinary, 3 being interdisciplinary, and 5 being transdisciplinary.

Knowledge convergence was measured using a 5-point Likert scale from completely unique thinking between PI/co-PI(s) (1) to completely similar thinking between PI/co-PI(s) (5) with a N/A option available for items that were not relevant to their EAGER grant for 10 items. Items were divided into 3-item vision, which assessed goals and outcomes, 4-item research content, which assessed theory, methodology, and analysis, and 3-item teamwork, which assessed how, who, and when work should be accomplished. A sample vision item included “What we plan to accomplish.” A sample research content item included, “How we conduct research specifically (e.g., detailed technical aspects of methods).” A sample teamwork item included “Who does what (member roles and responsibilities and how they intersect to work as a team.” Cronbach’s alpha for the 10-item knowledge convergence scale was .89.

Collaboration outcomes were measured using an adapted scale developed by Masse et al. (2008), which consists of three factors. The first 7-item factor assessed satisfaction with collaboration. For example, acceptance of new ideas, conflict resolution, communication, organization, capitalizing on researcher strengths, discipline involvement, and working styles. Cronbach’s alpha was .97. The second 6-item factor measured the impact of collaboration. This included overall productivity, research productivity, meeting productivity, product productivity, time burden, and quality research. Cronbach’s alpha was .85. The last 4-item factor measured

trust and respect. This included trust, respect, openness to criticism, and comfort showing gaps in knowledge. Cronbach's alpha was .93. These three factors were highly correlated, so we combined them into one measure. The overall Cronbach's alpha was .97.

Survey Results

Hypothesis 1a predicted that interdisciplinary translation would be negatively correlated with unidisciplinary research orientation. The association between having an interdisciplinary translator and having a unidisciplinary research orientation was significant and negative ($r(38) = -.44, p = .006$). This correlation supported the hypothesis, showing that PIs/co-PIs with a unidisciplinary orientation were less likely to report interdisciplinary translation in their teams.

Hypothesis 1b predicted that interdisciplinary translation would be positively correlated with multidisciplinary research orientation. The association between having an interdisciplinary translator and being of a multidisciplinary research orientation was marginal and trended positive ($r(38) = .29, p = .075$). Therefore, this hypothesis was not supported.

Hypothesis 1c predicted that interdisciplinary translation would be positively correlated with interdisciplinary research orientation. The association between having an interdisciplinary translator and being of an interdisciplinary/transdisciplinary research orientation was positive and significant ($r(38) = .39, p = .015$). Hypothesis 1c was supported.

Hypothesis 2 predicted that interdisciplinary translation would be positively correlated with transdisciplinary behaviors. The association between having an interdisciplinary translator and transdisciplinary behaviors was marginal but trended positive ($r(38) = .29, p = .079$). This finding did not support our hypothesis.

Hypothesis 3 predicted that interdisciplinary translation would be positively correlated with PI/co-PI(s) task interdependence. The association between interdisciplinary translation and PI/co-PI(s) task interdependence was positive and significant ($r(37) = .49, p = .002$). This hypothesis was supported.

Hypothesis 4 predicted that interdisciplinary translation would be positively correlated with collaboration type. The association between interdisciplinary translation and collaboration type was found to be positive and significant ($r(38) = .45, p = .004$). This hypothesis was supported.

Hypothesis 5 predicted that there would be a positive correlation between interdisciplinary translation and knowledge convergence. The relationship that was found between interdisciplinary translation and knowledge convergence was positive and significant ($r(36) = .42, p = .012$). This finding supported our hypothesis.

Hypothesis 6 predicted that interdisciplinary translation would be positively correlated with collaboration outcomes. The relationship found between interdisciplinary translation and collaboration outcomes was positive and significant ($r(38) = .66, p < .001$). This positive correlation between translation and collaboration supported our hypothesis.

Table 2: Means, Standard Deviations, and Correlations Among All Group-Level Variables

Variable	<i>M</i>	<i>SD</i>	1	2	3	4	5	6	7	8	9
Unidisciplinary Research Orientation	2.31	.90	-.44**								
Multidisciplinary Research Orientation	3.75	1.00	-.55**	.29							
Interdisciplinary Research Orientation	3.81	.84	.73**	-.61**	.39*						
Transdisciplinary Behaviors	2.93	.71	.56**	.62**	-.44**	.29					
Task Interdependence	3.87	.82	.08	.11	.21	-.27	.49**				
Collaboration Type	3.21	1.14	.03	.31*	.57**	.42**	-.56**	.45**			
Knowledge Convergence	3.59	.78	.22	.01	.08	.05	.14	-.32	.42*		
Collaboration Outcomes	4.24	.76	.60**	.40*	.32	.28	.21	.12	-.38*	.66**	
Team Research Productivity	5.62	7.20	.22	.22	.13	.00	.61**	.24	.33	-.11	.23

Note. $N = 38$ for all except $N = 37$ for task interdependence, $N = 36$ for knowledge convergence, and $N = 149$ for all collaboration outcomes.

* $p < .05$. ** $p < .01$.

Survey Discussion

Six out of the eight survey related hypotheses were supported by the data. Having an interdisciplinary translator role in interdisciplinary team research was negatively correlated with unidisciplinary research orientation and positively correlated with interdisciplinary research orientation, PI/co-PI(s) task interdependence, collaboration type, knowledge convergence, and collaboration outcomes. Interdisciplinary translation was not significantly correlated with multidisciplinary orientation or transdisciplinary behaviors, though both showed a positive trend.

According to our results, if teams had interdisciplinary translators, they were less likely to be composed of members with a preference for unidisciplinary work and more likely to be composed of members with a preference for interdisciplinary research orientation. This makes sense because if members already had an interdisciplinary research orientation, they already had a preference for working with other disciplines which could make them better suited to work with or be the interdisciplinary translator themselves. Even though the result was not significant, it makes sense that interdisciplinary translation's relationship with multidisciplinary research orientation trended positive because a multidisciplinary research orientation still includes aspects from other disciplines and thus would give these members some experience with other disciplines. This could make them more likely to communicate with or fulfill the interdisciplinary translator role.

Having an interdisciplinary translator was also found to be positively correlated with PI/co-PI(s) task interdependence. This was expected because those who report higher PI/co-PI(s) task interdependence are working together more and need each other more to get each task done. This type of collaboration would go well with the interdisciplinary translator role because the more team members rely on each other, the more useful it would be to have someone who can facilitate better communication between disciplines.

Collaboration type was also positively correlated with having an interdisciplinary translator. This was expected because the higher levels of collaboration type meant that members were reporting that their collaboration was more transdisciplinary which requires a higher level of integration between disciplines. With a higher level of integration needed between disciplines, an interdisciplinary translator can be useful to aid in communication between the different disciplines.

Knowledge convergence was also found to be positively correlated with interdisciplinary translators. This was expected because knowledge convergence was how similarly team members thought and had a shared understanding of different aspects of the collaboration. The more of a shared understanding team members had, the more likely it was that they had someone who was able to effectively communicate between disciplines.

Translation was also positively correlated with collaboration outcomes. This means that teams that utilize a translator can have better outcomes such as satisfaction, productivity, and trust and respect. These are all positive outcomes that would be beneficial to have in any team collaboration.

Though having an interdisciplinary translator was not significantly correlated with transdisciplinary behavior, it had a marginal relationship which trended positive. This makes sense as well because members who exhibit transdisciplinary behavior are exposing themselves to information from outside of their own fields, they are going to conferences hosted by other disciplines and reading outside of their field's publications. These behaviors would also go well with working with an interdisciplinary translator or acting as the interdisciplinary translator themselves in their teams.

Chapter 5

Archival Hypothesis, Methodology and Results

Hypothesis

We expect that having an interdisciplinary translator(s) will help the team produce more conference papers, publications, and grants because interdisciplinary translators offer a way to lower the barriers associated with interdisciplinary teams (Ashby, 2022). Communication can be difficult in interdisciplinary teams as members come from different backgrounds and thus are unfamiliar and uncomfortable with different jargon and language use. By providing someone to aid in this communication between disciplines, team members will have an easier time working with one another and be more likely to want to work in interdisciplinary teams again. It is as simple as having a good experience will make members more likely to repeat that experience (Eubanks, 2023). If members have a better experience and are more likely to repeat that experience, the end result is higher quality interdisciplinary collaborations resulting in more research productivity. Hypothesis 7 predicted that interdisciplinary translation will be positively correlated with research productivity during and after the NSF EAGER grant.

Method

Using publicly available information, we collected and cataloged PI and co-PI research productivity during and after their EAGER award. Research productivity was measured as the total of publicly available conference papers, publications, and grants the PIs and co-PIs produced with each other during and after their EAGER grant through the end of 2021.

The sample included 33 survey respondents who produced grants, publications, and/or conference papers.

Results

Hypothesis 7 predicted that interdisciplinary translation will be positively correlated with research productivity during and after the NSF EAGER grant. The relationship found between the two trended positive but was not significant ($r(33) = .23, p = .200$). The hypothesis was not supported. However, if we had used a larger sample size, the relationship might have reached significance.

Chapter 6

Conclusion

Research will always include grand challenges and wicked problems, as we want to find solutions to these issues. Because these challenges are so large-scale and interconnected, we must rely on interdisciplinary teams to try to solve them. No one person, unidisciplinary team, or entity can solve these issues on their own (Ferraro et al., 2015). Having interdisciplinary teams working on grand challenges and wicked problems is essential. It allows a diverse knowledge pool to work together to combine ideas and knowledge to hopefully, eventually create a solution. Because interdisciplinary teams are essential in solving these grand challenges and wicked problems, we must look for ways to improve the effectiveness of these teams.

Working in teams where members come from different backgrounds and disciplines can be incredibly challenging. Communication is a major roadblock for this kind of collaboration (Ashby, 2022). When people come together from different disciplines, they often know and use different terminology and jargon relevant to their specific field (Ashby, 2022). This creates a divide between members that could potentially lead to flawed communication (Ashby, 2022). This flawed communication could result in a lack of otherwise attainable solutions.

A way to improve the effectiveness of these interdisciplinary teams, especially as it relates to communication, is to include an interdisciplinary translator (Knoedler, 2019). An interdisciplinary translator is someone who is able to convert technical language and jargon from one discipline, using the surrounding contexts, into language and ideas that are understandable

and include another discipline (Knoedler, 2019). The present study focuses on this role of an interdisciplinary translator and how it affects interdisciplinary teams.

We used a mixed-methods approach to combine interview, survey, and archival data from NSF-funded interdisciplinary research teams. The purpose of the mixed-methods approach is to compensate for weaknesses of one method with the strengths of another. This approach also allows for greater triangulation and generalizability.

Our interview data showed that almost two thirds of respondents reported having one or two interdisciplinary translators. All interviewees credited the role as being helpful in their collaboration, specifically many mentioned it was useful for communication. Interviewees found the interdisciplinary translator(s) useful in converting language from one discipline into another. One third of interviewees reported having no translator for various reasons, though still said that it would have been beneficial had someone fulfilled that role.

Survey results yielded support for six out of our eight survey-related hypotheses. Interdisciplinary translation was negatively correlated with unidisciplinary research orientation and positively correlated with interdisciplinary research orientation, PI/co-PI(s) task interdependence, collaboration type, knowledge convergence, and collaboration outcomes. Interdisciplinary translation was not significantly correlated with multidisciplinary orientation or transdisciplinary behaviors, though both trended positive.

Our last hypothesis focused on archival data and was not supported. There was not a significant relationship found between interdisciplinary translation and research productivity. However, the relationship did trend positive and might have been significant if done on a larger sample size.

While we did use a mixed-methods approach to try to maximize strengths of different methods, a major limitation of this study was the sample size. Of the 149 NSF-grant recipients, only 33 participated in an interview, and of those 33, only 23 responded to the question pertaining to interdisciplinary translation. Of the 149 NSF-grant recipients, only 38 participated in the survey. Finally, our archival data focused on respondents of the interview and survey, thus the sample size was also 33. These are very small sample sizes.

Small samples size in mind, it was incredibly promising that we found significant correlations. It would be interesting to see this study done using a larger samples size and see how that affects the strength of the correlation. Due to our promising findings, research should continue to be conducted on this role of an interdisciplinary translator.

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Grace Miller

Education

The Pennsylvania State University

- Master of Science in Human Resources and Employment Relations
- Bachelor of Science in Psychology, *Business Op, Minor: Spanish*
College of the Liberal Arts, Paterno Fellows Program, Dean's List
Schreyer Honors College

University Park, PA
Expected: May 2024

Expected: May 2023

Work History

The Corner Room, a restaurant

Server

- Practice customer service and communication skills daily in a high stress environment
- Practice multitasking skills while adapting to different types of customers

State College, PA
June 2020 – Present

Research

Effective Assessment of Group Engagement and Re-Engagement (EAGER) Lab September 2021 – Present

- Under lab director Dr. Susan Mohammed, Professor of Psychology
- Coded archival data from 20 teams of researchers on whether they worked together post NSF grant
- Coded many interviews to reorganize them into pre-existing categories or add a new category based on the content of the interview response
- Goal of learning if interdisciplinary teams continue to work together post grant incentive
- Mohammed, S., Tirrell, B., Davis, C., Zhang, T., & Basore, C., Liao, X., & Miller, G. (2023, April). To stay or not to stay: Multidisciplinary collaboration *after* NSF Funding. Poster to be presented to the annual meeting of the Association for Clinical and Translational Science (ACTS), Washington DC.

Laugh Lab

August 2020 – May 2021

- Under lab director Dr. Reginald Adams, Associate Director of Graduate Studies and Professor of Psychology
- Coded comedy themes observed in comedy specials
- Goal of learning whether the themes of comedy special jokes were mainly positive or negative

Leadership Roles

Teaching Assistant for Rehabilitation and Human Services 300

August 2022 – December 2022

- Assist students with any questions or support they might need
- Aid professor in administrative tasks

Forensic Science Club THON Family Relations Chair

October 2019 – Present

- Lead a group of college students in supporting two families with a child with cancer
- Remained in constant supportive communication with the two cancer patient families

Honors

- National Security Analysis & Intelligence Summer Seminar, *nationally selected to participate in a government program* 2020
- Gold Key Award, *awarded for a positive impact on the community* 2019
- The English Department Award for Excellence, *awarded for excellence in student's English career* 2019

Skills

- Hardworking, quick learner, organized
- Computers: Windows 7 including Word, Excel, PowerPoint, and Final Cut Pro