

# Team Potency and Ethnic Diversity in Embodied Physical Action (EPA) Robot-Supported Dyadic Teams

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## Abstract

*In this study, we examined the impact of team potency and ethnic diversity on the individual performance and perceptions of viability among individuals in robot-supported teams that employ embodied physical action (EPA) robots. We conducted a between-subjects experiment with individuals in 30 teams. Results showed that team potency was a strong predictor of individual performance of robot operators, but the impact was moderated by team ethnic diversity. Team potency increased performance in ethnically diverse teams but had no impact on performance in ethnically homogeneous teams. Surprisingly, team potency also decreased viability in ethnically diverse teams. These results have several theoretical and practical implications for the literature on team potency in technology-supported teams.*

**Keywords:** team potency, team viability, diversity, technology-supported teams, robots, EPA robots, and human-robot teams

## Introduction

Teamwork with technology has become more prevalent throughout society. Technology-supported teams — teams that rely primarily on technology to perform their work — have now become the norm in many organizations (Robert 2013). In fact, it is often difficult to imagine teamwork without the use of any type of technology. In many cases, such work requires individuals within teams to employ a technology to accomplish their work on behalf of the team (Fuller et al. 2006a). The success of these teams is often predicated on the performance of their team members (Alnuaimi et al. 2010). Examining the factors that promote individual performance in these teams is critical to comprehending the factors that facilitate team performance (Robert 2013). Therefore, in this paper, we focus on individual rather than team performance.

Team potency has long been recognized as a critical facilitator of the performance of technology-supported teams (Fuller et al. 2006a), yet many questions regarding its impact remain unresolved. Guzzo, Yost, Campbell, and Shea (1993) were among the first authors to coin the term “team potency.” Team potency is the belief that individuals have in their team’s ability to be generally successful (Guzzo et al. 1993). Despite the importance of team potency, much remains to be learned about the nature and impact it has on the conditions under which it might be beneficial or problematic (Monteiro and Vieira 2016). The literature on team diversity suggests that the degree of diversity within the team might be one such condition to examine. Team diversity – the differences among team members on a particular attribute – is often vital to understanding the performance of individuals within teams (Van Dick et al. 2008). Nevertheless, we found no studies examining the potential moderating role of team diversity on the impact of team potency on team members’ individual performance.

Our lack of knowledge on this topic is problematic for several reasons. First, theoretically, it is not altogether clear whether team potency always enhances performance in teams. For example, research on social loafing has shown that individuals tend to put forth less effort when they believe their team as a whole can still perform well despite their effort reduction (Alnuaimi et al. 2010). Second, team diversity can also decrease individual performance within technology-supported teams by undermining the effort individuals put forth on behalf of their team (Giambatista and Bhappu 2010; Hütter and Diehl 2011). Given this, the importance of team potency on individual performance likely depends on team diversity. Therefore, we argue that team diversity has the potential to be an important moderator of the impact of team potency on individual performance in teams.

To determine whether team diversity influences the impact of team potency we examine teams employing robots. Robots are fast becoming a widely used technology within teams (Robert and You 2014). In most cases, robots are not fully autonomous but are instead operated by humans (Shah et al. 2011; Zawieska and Duffy 2014). In these teams, each individual participant uses a remote-control robot to perform individual team tasks. Examples of such human robot teams include military bomb disposal teams (Carpenter 2013) and urban search and rescue robots (Dole et al. 2013).

In this study, we examine teams employing embodied physical action (EPA) robots. EPA robots are robots which are capable of engaging humans through some type of physical embodiment (You and Robert forthcoming). This physical embodiment facilitates human interactions that are more visceral, which is known to engender strong emotional and psychological responses from humans (Dautenhahn 2007; Groom and Nass 2007). These interactions can lead individuals to humanize robots. The humanization of robots is “defined as the representation of robots as humans and/or to attribute human like qualities to robots” (Robert 2017). Humanization can lead individuals to interact with EPA robots in much the same way they do with other humans (Robert 2017). Thus, it is plausible that working with EPA robots in teams is likely to be qualitatively different from working in teams using traditional technologies such as collaborative software (Robert and You 2014, 2015). We believe this physical embodiment warrants an investigation on teams working with EPA robots.

Based on this assertion, there are several merits to study robot-supported teams. From a practical standpoint, robot operators offer a distinct context to examine the relationship between team potency and team diversity. A plethora of research has looked at the link between individual factors and the performance of robot operators (Robert and You 2014). Yet, the role of team factors like team potency and team diversity remains largely ignored. From an academic standpoint, the study of individuals employing technology within teams is a major inquiry for both information science and information systems scholars. Yet, the study of EPA robots and the individuals who employ them remains relatively unexamined in both research communities. This is disappointing because robots are expected to be involved in 30–45% of all jobs in the United States by 2025 (Sirkin et al. 2015). Scholars in both areas have the potential to provide theoretical insights on the topic.

Given these gaps in the literature and the importance of team potency, we seek to understand whether team ethnic diversity moderates the impact of team potency on the individual performance and perceptions of viability. Viability is defined as an individual’s willingness to remain a member of the team and is an important predictor of future performance (Bell and Marentette 2011). To empirically test this research model, we conducted an experimental study with 60 individuals in 30 teams using EPA robots, each team consisting of two EPA robots and two humans. Individual robot operators performed a task by using their remote-controlled EPA robot. To manipulate team potency, we gave 15 teams and 30 robot operators team

training while giving the others only individual training. In this study, we found that team ethnic diversity moderated the impact of team potency on robot operator performance. Team potency increased the individual performance of robot operators in ethnically diverse teams but had no effect on their performance in ethnically homogeneous teams. Team potency was associated with increases in viability in ethnically homogeneous teams but was actually associated with decreases in viability in ethnically diverse teams.

This study contributes to theory in several ways. One, we extend the current thinking on the impacts of team potency on the performance of individuals working in technology-supported teams. We accomplish this by identifying and examining an important contingency variable: team diversity. We provide new insights into when team potency is likely to facilitate or not facilitate the performance of individuals working in technology-supported teams. In doing so, we complement the current research on team potency in technology-supported teams – research that has paid little or no attention to the link between team potency and the performance of team members in technology-supported teams (Fuller et al. 2006a; Hardin et al. 2007; Lira et al. 2007, 2013). Yet, understanding individual members' performance often leads to new insights regarding team performance (Alnuaimi et al. 2010; Hütter and Diehl 2011).

Two, this study demonstrates the potential negative effects of team potency on the viability of ethnically diverse technology-supported teams. Over the years, scholars have amassed an impressive body of research documenting the positive effects of team potency across many different teams and tasks (Fuller et al. 2006a; Hardin et al. 2007; Lira et al. 2013). Much less attention has been paid to understanding when these benefits are not likely to materialize, or when they are likely to have negative outcomes (Monteiro and Vieira 2016). One exception, Lira et al. (2013), found that team potency had a stronger relationship with satisfaction and team identification in teams that relied on communication technology than in face-to-face teams. Our study goes further by showing when team potency can actually harm teams. Third, this study extends the literature on team potency in technology-supported teams to include the use of EPA robots. Whereas prior studies on team potency in technology-supported teams have focused exclusively on communication technologies (Fuller et al. 2006a; Hardin et al. 2007; Lira et al. 2007, 2013), the current research complements those studies by extending this research to EPA robots.

## **Background and Research Model**

### ***Team Potency***

Team potency refers to team member's collective belief about their team's general capability (Guzzo et al. 1993). The concept of team potency extends from Bandura's self-efficacy concept (Bandura 1986), which refers to one's belief of their capability to perform well in a particular task. Team potency and team efficacy, as a collective belief of efficacy of one's team, had been used interchangeably (Jung and Sosik 2003). However, team potency is theoretically different from team efficacy, in that team potency refers to team's capability in general no matter the task, while team efficacy and self-efficacy are task- and domain-specific (Collins and Parker 2010). Since team potency is a confidence regardless of a particular task, the concept is viewed as a prospective evaluation of team capability in the future, rather than a retrospective based on the previous experience (Akgün et al. 2007).

The shared belief includes confidence that the team will successfully accomplish team goals and motivation to perform well in tasks (Pearce et al. 2002). Team potency, as the shared belief of capabilities of their members, is a basis of better teamwork among team members such as trust and communication (Howell and Shea 2006; Schaubroeck et al. 2011). Team potency, thus, often relates to better effectiveness in teams (Gully et al. 2002; Hu and Liden 2011). Research in general shows that team potency is a predictor of productivity and satisfaction of team members in various settings (Campion et al. 1996; Gully et al. 2002). Team potency of software development teams was reported to increase the success of their product and shorten the duration of the development (Akgün et al. 2007). In addition, team potency has been found to increase the performance of virtual teams (Hardin et al. 2006).

### ***Team Ethnic Diversity***

Team ethnic diversity can be defined as the extent to which team members vary in their ethnic background. Ethnic diversity in teams can both increase and decrease team performance (Robert 2013; Windeler et al.

2015). Ethnic diversity provides teams with unique information that facilitates more creative solutions and leads to better decisions (Giambatista and Bhappu 2010; Shin et al. 2012). However, ethnically diverse teams often have weaker social–emotional bonds (Newell et al. 2008; Robert 2013), have more conflicts (Jehn and Bezrukova 2010; Lee and Farh 2004), and are less motivated to work together (Gully et al. 2002), all of which explain why ethnic diversity can sometimes lead to lower performance and lower satisfaction (Harrison et al. 2002; Robert 2013).

This study looked at ethnic diversity for several reasons. First, ethnic diversity has been identified as an important predictor of performance in many types of teams across many settings (Jackson and Joshi 2011 for review). Second, ethnic diversity has been used to explain performance in teams enabled by technology (Giambatista and Bhappu 2010; Robert 2013). Third, ethnic diversity is one of the most common types of diversity across many societies (Ely et al. 2012). Finally, it is becoming more common for teams using EPA robots to be ethnically diverse (Makatchev et al. 2013; Robert and You 2014).

In this study, we propose a research model, in which team ethnic diversity should moderate the impact of team potency on individual robot-operator performance (Figure 1). Ethnically diverse teams often have weaker social–emotional bonds (Newell et al. 2008; Robert 2013) and are less motivated to work together (Gully et al. 2002), all of which explains why ethnic diversity can sometimes lead to lower performance and lower satisfaction (Harrison et al. 2002; Robert 2013). However, homogeneous teams can develop unwarranted high levels of team confidence and believe that they are far more capable of accomplishing objectives than they really are (Kellett et al. 2000). Individuals tend to project positive attributes like competency onto others like them because it reinforces the positive perceptions they have about themselves (Whyte 1998).

On the other hand, team potency is likely to lead to better performance in ethnically diverse teams. Members of diverse teams often believe their teammates are not as capable as themselves because they are different. This often results in team members believing their team is not capable. This, in turn, leads these team members to put forth less effort in their team activities (Choi and Kim 1999). Consequently, performance in diverse teams falls short because of a lack of confidence (Ely et al. 2012). However, if diverse teams can find a way to overcome such issues, they should perform as well as or better than more homogeneous teams (Harrison et al., 2002). As such, it is very likely that when confidence is instilled in individuals in ethnically diverse teams they should be willing to exert more rather than less effort to accomplish their team objectives. Effort is a strong predictor of individual performance in teams (De Jong & Elfring, 2010; Fuller et al., 2006). Therefore, team potency should be associated with an increase in performance among individuals in ethnically diverse teams. Thus, we hypothesized that:

*H1: When ethnic diversity is high, team potency increases individual performance; however, when ethnic diversity is low, team potency decreases individual performance.*

Team viability is both an important and relevant concept in understanding teamwork (Balkundi and Harrison 2006). Team viability represents an individual's general intention to either remain a member of the team or consider re-joining the team in the future (Bell and Marentette 2011). Team viability is often associated with an individual's intention to continue to perform well on behalf of the team (Balkundi et al. 2009). Therefore, team viability can be viewed as both an indication of team members' assessment of their past experience with their team and their potential performance with the team in the future.

Team potency has been associated with increases in a team's socio-emotional outcomes like cohesiveness and with decreases in anxiety and stress (Gil, Rico, Alcover & Barrasa, 2005). This is because when members are more confident in their team's ability to succeed they often have a more positive experience with their team members (Gibson and Earley 2007). Positive team experiences should increase the likelihood that individuals want to remain a member of the team. Therefore, team potency should be positively related to team viability.

The impact of team potency on team viability should be stronger because ethnically diverse teams have more challenges to overcome. In general, demographic diversity among team members has been shown to decrease socio-emotional outcomes like team viability (Webber and Donahue 2001). This is often explained by the difficulty team members in diverse teams have bonding with their teammates (Newell et al. 2008; Robert 2013). Individuals tend to have a much more positive attitude toward teammates who are similar rather than dissimilar to them (Van Dick et al. 2008). This positive attitude can lead to team members enjoying their interactions more with others who are like them (Harrison et al. 2002). Team potency should

be needed more in diverse teams to help individuals in these teams overcome their challenge. Therefore, team potency should be more important to helping diverse teams overcome these negative effects. When this occurs, the impact of team potency on team viability should be stronger. Therefore, we hypothesized that:

*H2: When ethnic diversity is high, team potency has a stronger impact on viability than when ethnic diversity is low.*

Taken together, it is likely that ethnic diversity plays a moderating role in technology-supported teams by altering the impact of team potency on the performance of team members and viability. A theoretical research model illustrates the cross-level moderation effects of team ethnic diversity on outcomes of teams (Figure 1).

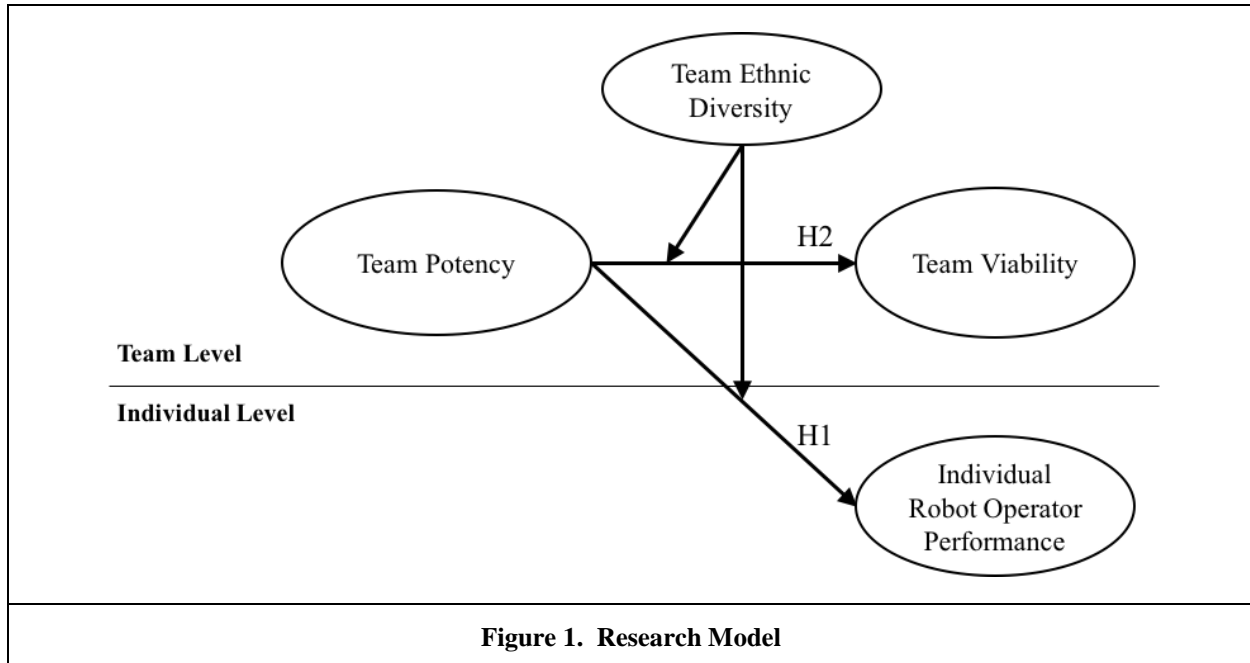


Figure 1. Research Model

## Method

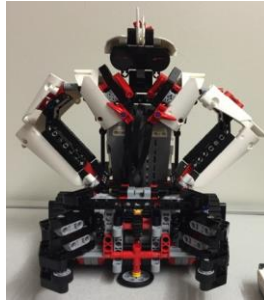
### *Participants and teams*

We recruited 60 participants from a Midwestern university in the United States. A team consisted of two participants, each employing their own EPA robot to accomplish a team task. Participants were randomly assigned to a team to avoid creating teams with members who knew each other prior to the experiment. Nonetheless, to ensure this, we asked participants after the study whether they knew their assigned teammate. One team among the 30 teams indicated that teammates had known each other before the experimental session. We excluded this team in our analysis, which resulted in 58 individuals in 29 teams.

The mean age was 23 years old (standard deviation [SD] = 4.33) and 22 were male (37.9%). Our sample consisted of 35 Asian (60.3%), 17 White (29.3%), five Black or African American (8.6%), and one American Indian/Alaska Native (1.7%). Among the 29 teams in total, seventeen teams (58.6%) were ethnically diverse.

### *Robots*

Each team member employed a LEGO Mindstorms EV3 to accomplish their part in the team task. These EPA robots were modified (See Figure 2) and programmed to grasp small objects and were controlled by an infrared remote controller. The EPA robots were capable of moving forward, backward, and side-to-side. The EPA robots said “okay” when grasping and releasing objects. The EPA robots were identical.



**Figure 2. An EPA Robot Used in the Experiment**

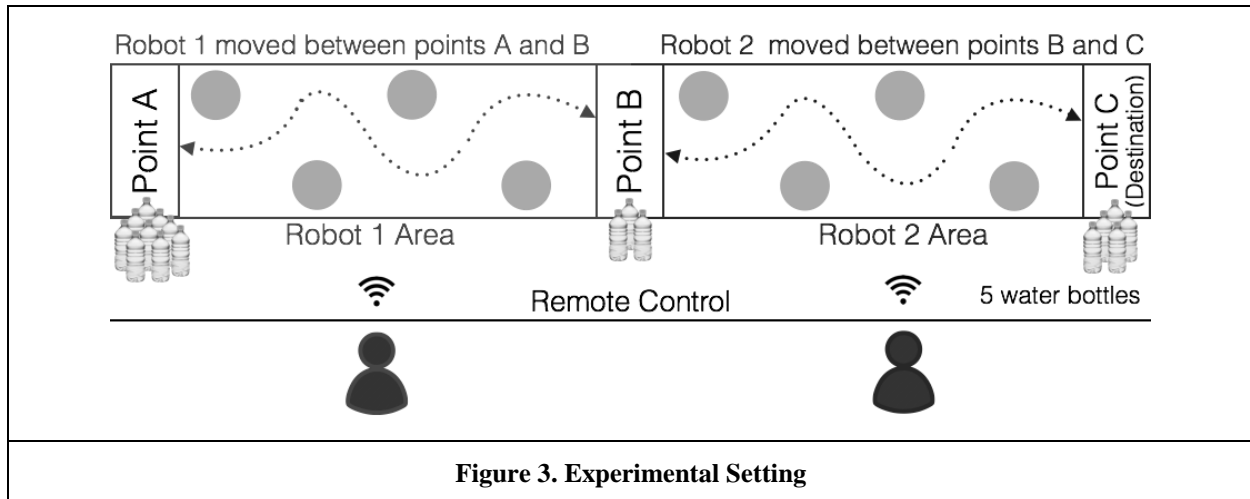
### ***Experimental Manipulation***

Team training was employed as a method of manipulating team potency into two levels: high team potency condition and low team potency condition. This manipulation was chosen based on the fact that team training increases team potency (Guzzo et al. 1993). Research on team training explains this phenomenon with the enhanced visibility among team members (Gibson 2001; Gully et al. 2002; Salas et al. 2007). When team members are training together, team members can observe each other's performance and better understand each individual's role (Cannon-Bowers et al. 1998). This explains why team members are more likely to feel confident after training together (Guzzo et al. 1993; Kirkman and Rosen 1999). The link between training and team potency has been found in medical teams (Gibson 2001; Wolf et al. 2010) and virtual work teams (Fuller et al. 2006b).

To manipulate team potency, teams in the high-team-potency condition had team training in which both individuals practiced how to control their EPA robot together in the same room. In this condition, two participants went through a two-minute free training for controlling the EPA robots and two practice runs of the experimental task without recording their performance in the same room. By doing so, team members were able to see how others were performing in the practice runs and had a better sense of how well their teammate would perform in the main task. However, for teams in the low-team-potency condition, two individuals in a team were sent to two separate rooms to practice how to control their EPA robot separately, without seeing the other's performance. The two team members went through the practice runs without recording performance separately in the separate rooms. The separation prevented them from seeing each other's performance during the practice, so that they did not have the visibility and knowledge team member's ability in the main task. The training in both conditions lasted about 10-12 minutes. The duration of the training in the two conditions were similar because participants in both conditions were performing the same training task. The only difference was whether they did the task together or separately.

### ***Experimental Task***

The experimental task required team members to employ their EPA robots to move five small water bottles from point A to point C as quickly as possible (see Figure 3 for the task course layout). The team task consisted of two parts that were sequentially connected. Part one required the first robot operator to move his or her water bottle from point A to point B. Part two required the second robot operator to move the water bottle at point B to point C. Both operators sequentially collaborated with each other to move five water bottles from point A to point C, through point B.



**Figure 3. Experimental Setting**

The task was taken from prior literature (Robert and You 2015; You and Robert 2016) and allowed us to achieve several objectives. First, we designed the task to represent the typical use of EPA robots in the context of teamwork. In many cases, operators employ EPA robots to move physical objects from one point to another. Construction teams employ remote-controlled EPA robots to take down and put up structures. Second, the task was designed to be a collaborative, interdependent team task. Individual operators were only allowed to move water bottles using their EPA robot and were not allowed to touch or move water bottles themselves. Therefore, one team member could not complete the task alone.

Teams were informed that the task was a team-based competition and that team performance would be determined by the time it took to move all five water bottles from point A to point C. They were also informed that the three best-performing teams would receive prize money: \$100 for the team with the fastest delivery time, \$40 for the second-place team, and \$20 for the third-place team. Regardless of performance, all operators received \$20 for participation.

### **Experimental Procedure**

Participants signed up for a session using an online anonymous sign-up sheet. Participants did not know their teammate in advance of coming to the behavioral laboratory. Participants were randomly assigned to a team, and teams were randomly assigned to one of two conditions: individual training or team training. Participants were also unaware of which treatment condition they were assigned.

Upon arrival, participants were greeted and asked to fill out a consent form. Next, they took a pre-questionnaire using a laptop. The pre-questionnaire included questions regarding their gender, nationality, and ethnicity. Then, participants were provided with written instructions about the experimental procedure and task. After reading the task instructions, the participants watched a 3-minute video that provided a step-by-step visual tutorial on the experimental task. Then, they were provided with instructions on how to employ their EPA robot using their remote control. After reading the instructions, they watched a 2-minute video tutorial on how to use the remote control.

Next, participants were guided to another room to practice the experimental task. Participants assigned to the low team potency condition trained alone in separate rooms and were allowed to play with their EPA robot individually for two minutes freely. Individuals assigned to the high team potency condition were allowed to have the two-minute training and practice together in the same room. Once participants finished their training based on their treatment condition, they were guided to another room, where they filled out the second questionnaire, which included questions on team potency.

After participants finished the second questionnaire, they were guided to another room to perform the task. We used stopwatches to measure the performance of each individual robot operator. Team member 1's performance was determined by averaging the time it took to move each water bottle from point A to point B. Similarly, the performance of team member 2 was determined by averaging the time it took to move each water bottle from point B to point C. The "Individual performance" portion of the "Measures" section

provides additional details regarding the measurement of individual performance. After the team completed the task, participants were guided to another room to fill out the final questionnaire, which included questions related to team viability. After participants completed the final questionnaire, they were debriefed, paid, and dismissed.

## Measures

### Control Variables

#### Demographic Diversity

We measured gender and nationality of individual operators along with their age. This was done because ethnic diversity is the construct of interest in this study and it was necessary to control for impacts of other diversity dimensions. Team gender diversity and team national diversity were calculated with Blau's heterogeneity index (Blau 1977). Blau's H index has been used in research of teamwork to capture the heterogeneity of teams in different dimensions including ethnicity (Robert 2013).

Blau's index H is described as:

$$H = 1 - \sum p_i^2$$

where  $p_i$  is the proportion of group members in each of the I categories. Based on the index, the values for diversity were either "0" when two team members were in the same category or "0.5" when they were in different categories.

#### Individual Robot-specific Self-efficacy

We included additional control variables. First, we measured individual-level robot self-efficacy to capture the degree to which individual participants believed in their ability to complete the task using the EPA robot. Individual self-efficacy contributes to one's motivation and performance and often influences individual performance in teamwork (Monteiro and Vieira 2016). Research also shows that individual's ability and the belief in the ability are associated with individual and team performance (Gully et al. 2002). Therefore, it is important to control for the impacts of individual team members' belief in their specific ability of using EPA robots on their performance. The scale of individual robot self-efficacy consisted of seven items adapted from Compeau, Higgins, and Huff (1999) that were measured using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). One example of the items was "I can complete this task using this robot even if I have never used a robot like this before." Another example in the index was "I can complete this task using this robot even if there was no one around to tell me what to do as I go." The reliability of the scale (Cronbach's  $\alpha$ ) was 0.88.

#### Knowledge on Relevant Technologies

In addition, we measured each participant's general knowledge of technology to rule out alternative explanations of individual skills and experience of relevant technologies and LEGO products. This construct was captured by summing up three self-report questions about relevant technology fields to robots — computer programming, robotics, and artificial intelligence, all measured based on a 5-point Likert scale (1 = *none* to 5 = *professional*). Finally, we measured each participant's experience with LEGO products. This construct was measured by the sum of two items — LEGO products in general and Mindstorms — based on a 5-point Likert scale (1 = *never* to 5 = *all of the time*).

#### Team Ethnic Diversity

In this experiment, we defined ethnicity as the racial category participants self-reported. Team ethnic diversity was calculated using Blau's heterogeneity index (Blau 1977). This is consistent with the literature on work groups in which ethnicity was used to represent physical differences (Giambatista and Bhappu 2010; Harrison et al. 2002).



## **Team Potency**

We measured team potency to capture the degree to which participants believed in the team's general ability to perform well. The scale of general team potency consisted of seven items that were derived from Guzzo et al. (1993). They were measured using a 5-point Likert scale (1 = *strongly disagree* to 5 = *strongly agree*). The example items included "We believe we can succeed at most any endeavor to which we set our mind", "Even when things are tough, we will perform quite well", and "We are confident that we can perform effectively on many different tasks." The reliability of the scale (Cronbach's  $\alpha$ ) was 0.85. Team potency was a team-level construct obtained through individual participants by averaging scores of the two participants on each team. The intra-class coefficient (ICC) score was used to justify this aggregation. Typically scores over 0.1 provide justification for aggregation (Bliese 2000). The ICC score for team potency in our study was 0.49, justifying the aggregation.

## **Individual Performance**

We measured the performance of individual operators separately by calculating the average time per trip for an individual robot operator to finish delivering all five of his or her water bottles. The performance of robot operator 1 was the average duration of his or her five round trips of grabbing a water bottle at point A, dropping it at point B, and returning to point A. Similarly, the performance of robot operator 2 was the time it took to travel the path B-C-B.

We took several additional measures to avoid spillover effects between robot operators. Spillover effects are the additional wait time that the second robot operator incurs from waiting on the first robot operator to deliver a water bottle to point B. In order to remove this idle time from robot operator 2's performance, we used separate stopwatches for each operator. The stopwatch for the second robot operator was stopped when the EPA robot returned to point B and restarted when another bottle arrived to be moved to point C.

## **Viability**

Viability captures individuals' belief in the degree to which they are willing to remain and to continue to perform on the team (Bell and Marentette 2011). The scale consisted of three items adapted from Balkundi and Harrison (Balkundi and Harrison 2006) and measured using a 6-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*). The items included, for example, "This team including the robots would perform well together in the future" and "If we were assigned to another project, I am confident that this team including the robots would work well together." The reliability of the scale (Cronbach's  $\alpha$ ) was 0.95. The ICC score for team viability in our study was 0.43, justifying the aggregation.

## **Results**

### **Manipulation Check**

Results of a *t*-test showed that team potency was higher in the teams that underwent team training (i.e., high team potency condition,  $M = 4.01$ ,  $SD = 0.35$ ) than the teams that did not (i.e., low team potency condition of individual training,  $M = 3.69$ ,  $SD = 0.36$ ). The manipulation of team potency was successful in terms of making a significant difference in the perception of team potency between the conditions ( $t(27) = 2.41$ ,  $p < 0.05$ ).

### **Measurement Validity**

Convergent and discriminant validity of constructs included in the research model were evaluated by a factor analysis. There were no cross-loadings above 0.4 between two constructs (Table 1). Most items loaded at the level of 0.7 or above on their construct; the fifth item of individual robot self-efficacy did not. This item loaded at .68 and was included because of the face validity of the construct. In addition, we examined correlations among model constructs (Table 2). All constructs' average variance extracted (AVE) were above 0.50, which demonstrates convergent validity of constructs (Fornell and Larcker 1981). The correlations among constructs were smaller than the square root of the AVEs of each construct (Table 2), demonstrating discriminant validity.

Because our model consisted of team-level and individual-level constructs, we performed a multilevel analysis. This multilevel analysis was conducted using the SPSS 22 mixed model. The results are shown in tables 3 and 4. Model 1 is the main effect model of team potency and team ethnic diversity. Model 2 indicates the moderation between team potency and team ethnic diversity on the performance of robot operators (Table 3) and viability (Table 4).

|        | <b>Team Potency (TP)</b> | <b>Individual Robot-specific Self-efficacy (IRSE)</b> | <b>General Knowledge of Technology (GKT)</b> | <b>Previous LEGO Experience (PLE)</b> | <b>Viability (VI)</b> |
|--------|--------------------------|---|--|---------------------------------------|-----------------------|
| TP 1   | <b>0.77</b>              | 0.10  | 0.15   | 0.02                                  | 0.01                  |
| TP 2   | <b>0.80</b>              | 0.02  | 0.08   | 0.02                                  | 0.03                  |
| TP 3   | <b>0.81</b>              | 0.01  | 0.11   | 0.27                                  | 0.07                  |
| TP 4   | <b>0.86</b>              | 0.00  | 0.04   | 0.01                                  | 0.07                  |
| TP 5   | <b>0.90</b>              | 0.03  | 0.03   | 0.06                                  | 0.21                  |
| TP 6   | <b>0.79</b>              | 0.10  | 0.11   | 0.07                                  | 0.16                  |
| TP 7   | <b>0.86</b>              | 0.06  | 0.01   | 0.03                                  | 0.32                  |
| IRSE 1 | 0.05                     | <b>0.87</b>   | 0.22   | 0.01                                  | 0.05                  |
| IRSE 2 | 0.01                     | <b>0.78</b>   | 0.13   | 0.12                                  | 0.06                  |
| IRSE 3 | 0.04                     | <b>0.84</b>   | 0.20   | 0.05                                  | 0.01                  |
| IRSE 4 | 0.00                     | <b>0.75</b>   | 0.02   | 0.27                                  | 0.11                  |
| IRSE 5 | 0.09                     | <b>0.68</b>   | 0.40   | 0.04                                  | 0.23                  |
| IRSE 6 | 0.04                     | <b>0.81</b>   | 0.05   | 0.14                                  | 0.00                  |
| IRSE 7 | 0.15                     | <b>0.77</b>   | 0.04   | 0.08                                  | 0.15                  |
| GKT 1  | 0.00                     | 0.12  | <b>0.88</b>                                  | 0.11                                  | 0.01                  |
| GKT 1  | 0.14                     | 0.23  | <b>0.90</b>                                  | 0.11                                  | 0.00                  |
| GKT 1  | 0.16                     | 0.18  | <b>0.88</b>                                  | 0.04                                  | 0.00                  |
| PLE 1  | 0.05                     | 0.17  | 0.16   | <b>0.76</b>                           | 0.14                  |
| PLE 2  | 0.03                     | 0.01  | 0.17   | <b>0.84</b>                           | 0.21                  |
| VI 1   | 0.13                     | 0.03  | 0.04   | 0.10                                  | <b>0.89</b>           |
| VI 2   | 0.12                     | 0.04  | 0.00   | 0.13                                  | <b>0.92</b>           |
| VI 3   | 0.14                     | 0.06  | 0.05   | 0.17                                  | <b>0.86</b>           |

Note: Values in bold indicate items loading at the 0.7 or above on each of their constructs. Extraction method was Principal Component Analysis using Varimax with Kaiser Normalization as a rotation method.

**Table 1. Factor Loadings**

|  | <b>Mean</b> | <b>SD</b> | <b>TP</b>   | <b>IRSE</b> | <b>GKT</b>  | <b>PLE</b>  | <b>VI</b>   | <b>IP</b> |
|--|-------------|-----------|-------------|-------------|-------------|-------------|-------------|-----------|
| Team Potency (TP)                              | 3.86        | 0.38      | <b>0.83</b> |             |             |             |             |           |
| Individual Robot-specific Self-efficacy (IRSE) | 3.96        | 0.70      | -0.09       | <b>0.79</b> |             |             |             |           |
| General Knowledge of Technology (GKT)          | 7.14        | 2.94      | -0.23       | 0.35**      | <b>0.89</b> |             |             |           |
| Previous LEGO Experience (PLE)                 | 3.67        | 1.10      | 0.02        | -0.13       | 0.03        | <b>0.80</b> |             |           |
| Team Viability (VI)                            | 4.66        | 0.81      | 0.06        | 0.02        | -0.01       | -0.07       | <b>0.89</b> |           |
| Individual Performance (IP)                    | 50.19       | 12.11     | -0.04       | -0.06       | -0.12       | -0.25       | 0.18        | <b>NA</b> |

\*\*p < 0.01; N = 59; Values on the diagonals represent the square root of the AVE for each factor.

**Table 2. Descriptive Statistics and Correlations among Constructs**

**Test of Hypotheses**

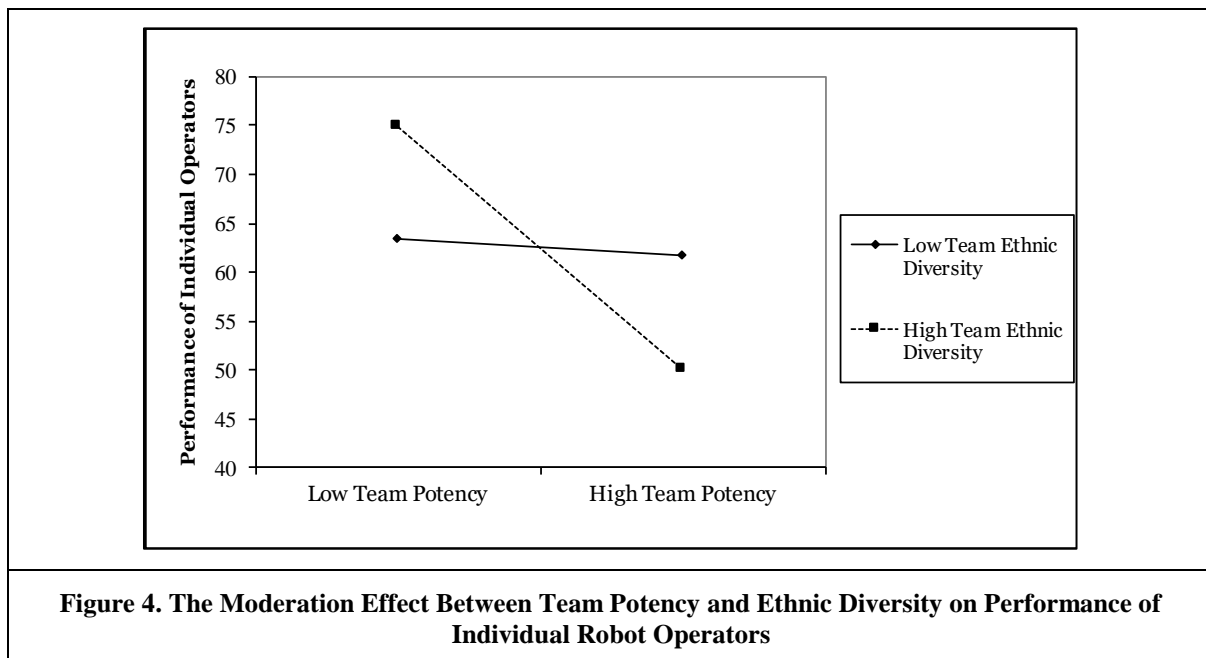
Hypothesis 1, which posited that team ethnic diversity moderates the impact of team potency on the performance of individual robot operators, was supported ( $\beta = -5.84, p < 0.05$ ). Results of Model 2 in Table 2 explained 76.42% of the individual performance of robot operators. As seen in Figure 4, team potency

increases the individual performance of robot operators when teams are ethnically diverse but makes no difference in individual performance when teams are ethnically homogeneous. The performance in this study was measured by recording time to complete the task; shorter time indicates better performance.

| Independent Variable                    | Individual Robot Operator Performance |         |         |
|---|---------------------------------------|---------|---------|
|   | Model 1                               | Model 2 | Model 3 |
| <b>Control Variables</b>                |                                       |         |         |
| Age                                     | -0.05                                 | -0.04   | 0.00    |
| Team Gender Diversity                   | -1.36                                 | -2.26   | -2.10   |
| Team Nationality Diversity              | 1.23                                  | 1.41    | 3.32    |
| Individual Robot-specific Self-efficacy | -1.26                                 | -1.15   | -0.83   |
| General Knowledge of Technology         | -0.46                                 | -0.50   | -0.60   |
| Previous LEGO Experience                | -1.36                                 | -1.31   | -1.45   |
| <b>Main Effects</b>                     |                                       |         |         |
| Team Potency                            |                                       | -2.11   | -6.64*  |
| Team Ethnic Diversity                   |                                       | -0.39   | -0.07   |
| <b>Interaction Effect</b>               |                                       |         |         |
| Team Potency × Team Ethnic Diversity    |                                       |         | -5.84*  |
| -2 Restricted Log Likelihood            | 411.97                                | 404.11  | 396.74  |
| <i>df Change</i>                        | 6                                     | 2       | 1       |
| R <sub>1</sub> <sup>2</sup>             | 11.11                                 | 11.56   | 76.42   |
| Change in R <sub>1</sub> <sup>2</sup>   |                                       | 0.45    | 64.86   |

\*:  $p < 0.05$ ; Team Gender Diversity, Team National Diversity, Team Potency, and Team Ethnic Diversity are standardized.

**Table 3. Results of Multilevel Analysis for Performance of Individual Robot Operators**



Hypothesis 2 posited that team ethnic diversity moderates the impact of team potency on viability. Team viability was measured at the team level, which required the use of ordinary least squares regression analysis at the team level, including control variables based on our model. The results provided evidence of a moderation effect ( $\beta = -0.29, p = 0.05$ ) but in the opposite direction of our hypothesis (Table 4). That is, team potency decreased rather than increased viability in ethnically diverse teams.

| Independent Variable  | Viability |         |         |
|---|-----------|---------|---------|
|   | Model 1   | Model 2 | Model 3 |
| <b>Control Variables</b>  |           |         |         |
| Team Age  | 0.00      | 0.00    | 0.02    |
| Team Gender Diversity   | -0.03     | -0.01   | -0.02   |
| Team Nationality Diversity  | -0.18     | -0.17   | -0.15   |
| Team Robot-specific Self-efficacy   | 0.10      | 0.09    | 0.06    |
| Team Knowledge of Technology  | -0.05     | -0.05   | -0.10   |
| Team Previous LEGO Experience   | -0.11     | -0.13   | -0.12   |
| <b>Main Effects</b>   |           |         |         |
| Team Potency  |           | 0.04    | -0.20   |
| Team Ethnic Diversity   |           | -0.04   | -0.06   |
| <b>Interaction Effect</b>   |           |         |         |
| Team Potency $\times$ Team Ethnic Diversity   |           |         | -0.29   |
| $R^2$   | 0.14      | 0.14    | 0.30    |
| Change in $R^2$   |           | 0.01    | 0.12    |
| F   | 0.57      | 0.67    | 4.35    |
| *: $p < 0.05$ ; Team Gender Diversity, Team National Diversity, Team Potency, and Team Ethnic Diversity are standardized. |           |         |         |

**Table 4. Results for Viability**

## Discussion

In this research, we sought to understand whether team ethnic diversity can moderate the impact of team potency on the performance and perceptions of viability team members. Results from our laboratory experiment provide two overarching findings. One, team potency increased individual performance in ethnically diverse teams but had no effect on the performance of individuals in ethnically homogeneous teams. Team potency decreased robot operators' perceptions of viability in ethnically diverse teams but increased it in ethnically homogeneous teams. Below, we discuss the implications of these findings.

### Implications for Research

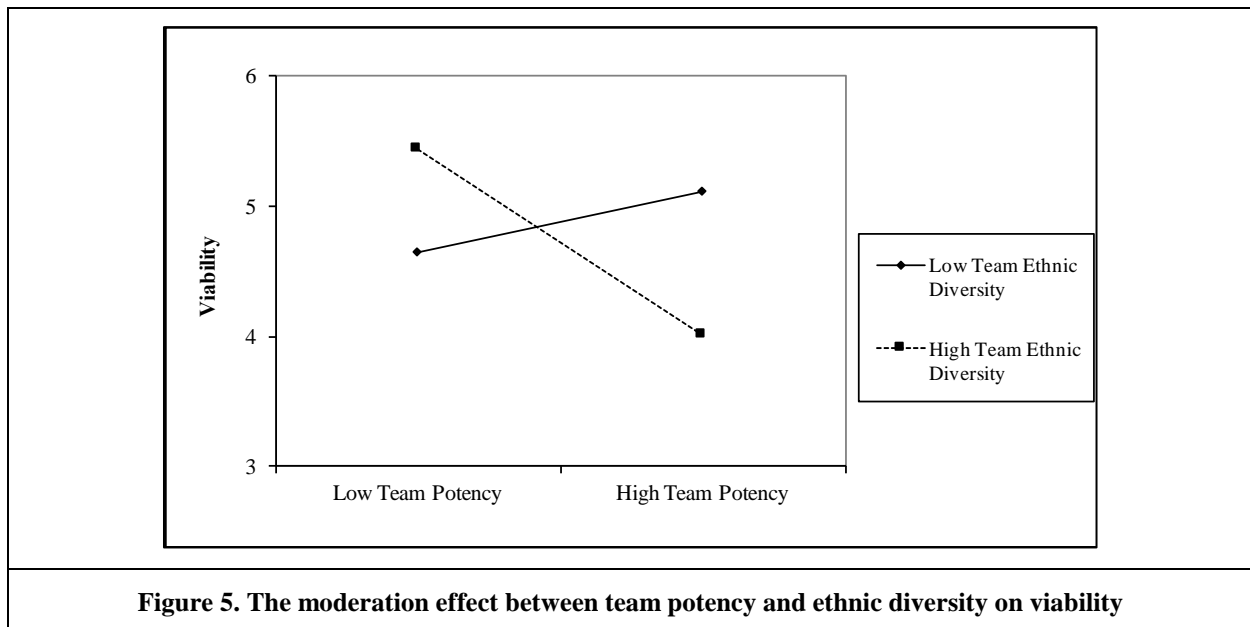
This study has several implications for research. First, this study contributes to the theory on team potency by specifically identifying and examining team diversity as an important contingency variable. Incorporating team diversity in the nomological network of team potency is an important contribution because, as our results show, the effect of team potency on individual performance varies greatly by the level of team diversity. Team potency facilitated the performance of individuals in ethnically diverse teams but had little impact on the performance of individuals in homogeneous teams. This may imply that the effects of team potency on individual performance are directly tied to the diversity of the team.

We should also note that we did not find that team potency led to negative effects in ethnically homogeneous teams. One explanation is that homogeneous teams did not need to believe in their team to perform well. Their performance may have been driven by the need to maintain a distinctive team identity with their similar teammate. The need to maintain a distinctive team identity can be a source of motivation itself that

encourages individuals to put forth greater effort on behalf of their team (Robert 2013). As such, team potency would have little effect on performance in these teams. Future research is needed to further explore the potential relationship between factors like distinctive team identity and team potency.

Second, contrary to our expectations, team potency was associated with decreases in the perceptions of viability and not increases. Individuals in ethnically diverse teams were less likely to want to remain a member of their team when team potency was high. This finding is contrary to what we expected and much of the prior literature. Several studies have found that team potency was positively related to satisfaction a similar outcome (Lester et al. 2002; Lira et al. 2007).

From a theoretical perspective, the very same contingency variable — team diversity — that enhances individual performance also seems responsible for creating the conditions that lead to the negative effects of team potency on viability. From a practical perspective, there may be tradeoffs between facilitating more viability versus promoting performance. Team potency may come at a cost to the relationships between diverse others. This becomes apparent when individuals in ethnically diverse teams with low team potency had the highest level of viability (see Figure 5). These represent the individuals in the ethnically diverse teams who did not have the training. Apparently, the interaction needed to promote team potency during team training may have led to decreases in viability.



Third, interpretation of the findings should take into account group size. In this study, teams consisted of two individuals using two EPA robots. Research suggests that larger teams composed of three or more individuals can have different processes and dynamics (Arthur Jr et al. 2007; Littlepage and Silbiger 1992). For example, in larger teams it is possible to have a majority and minority which can change team interactions. This could potentially lead more complex issues with team ethnic diversity (Newell et al. 2009; Robert 2013; Windeler et al. 2015). Therefore, examining the influence of team size offers a promising area for future research (see You and Robert, accepted for research agenda on teamwork with robots).

Finally, this study contributes to the literature on robot-supported teams by examining the employment of EPA robots. Unlike previous studies that focus on communication technology, we focused instead on the use of EPA robots because there are many situations where robot operators work in team settings (Jones and Hinds 2002; Yanco and Drury 2004; You and Robert forthcoming). Findings from team potency increased by training suggest that in EPA robot-supported teams, team members' perceived ability to work with EPA robots plays an important role in predicting the success of the teams.

Our findings open a new area of research on teams working with robots. In this study, we employed remote-controlled EPA robots in hopes that our findings offer immediate theoretical and practical implications to types of teamwork with EPA robots that are currently common (see Robert and You 2015; You and Robert

2016 for other examples of this work). However, robots are becoming more interactive, intelligent, and capable of autonomously working alongside human workers (Fiore et al. 2011; You and Robert 2016). Future research should examine human-robot interactions with more autonomous robots. Beyond this, examining the influence of the design of the robot is another promising research area. The design of the robot has found to be an important factor in determining the quality of interactions between humans and robots (Bartneck et al. 2009; Robert and You 2014). Given that robots' physical embodiment invokes strong emotional and psychological responses (Dautenhahn 2007; Lee et al. 2006), studying the different physical characteristics of robots will allow us to understand better how to promote better interactions with robots and ultimately leverage their use for greater success. Recently it has been suggested that there could be a dark side to promoting emotional attachment to robots (Robert 2017). Specifically, Robert (2017) suggested that there may be long term problems associated with humans developing strong emotional bonds due to the humanization of robots. Future research might explore when such conditions may or may not exist in teams working with robots. In sum, we believe it is vital for IS researchers to begin to consider the use of robots as a new team technology. We believe that IS scholars can contribute theoretically to this new research area.

### ***Implications for Practice***

This study has implications for practice. Teams and their managers should understand that promoting team potency does not always lead to better performance. Our results show that although team potency increased individual performance in ethnically diverse teams, it had no positive effects on performance in ethnically homogeneous teams. This informs managers of teams using EPA robots to be aware of any hubris or overconfidence, especially when operators are from different backgrounds. In such cases, teams using EPA robots in dangerous situations with high-stakes might be wary of heightening team potency (Groom and Nass 2007). For instance, many teams using robots are employing robots in extreme situations, such as special weapons and tactics (SWAT) teams and explosive ordnance disposal (EOD) teams (Carpenter 2013; Dole et al. 2013; Jones and Hinds 2002). Because individual performance can be directly related to human life and safety, overconfidence through heightened team potency should be avoided to maintain high performance of individual operators.

Finally, team training can be vital for EPA robot-supported teams. In this study, team training was offered as a mechanism to invoke higher levels of team potency for EPA robot-supported teams. Team training provided an opportunity for team members to know about other member's ability and adapt to each other during the performance. Many EPA robot-supported teams in these days employ multiple robots, which leads to higher demands in adaptation and coordination among team members. Moreover, such adaptation and coordination can also be required with robots, not only with human teammates (Jones and Hinds 2002; Torrey et al. 2006). Therefore, organizations adopting EPA robot-supported teams should provide opportunities for individual operators to try out their robots together and build a clear understanding of each other's ability.

### ***Limitations and Future Research***

This study has several limitations. First, we employed an experimental study in a controlled environment. Although, our goal was to increase the internal validity of our study we acknowledge the limitations with external validity. Future research can be conducted in a field environment to complement our research. Second, teams in this study consisted of two people and two EPA robots. Teams using EPA robots in reality vary in size. Future research should examine the relationship between team potency and performance of operators in teams of different sizes. Third, this study looked at one type of diversity — ethnicity. However, there are different types of diversity such as gender, age, and education level. The moderating impacts of diversity may differ by the type of diversity. Future research can be conducted to examine this issue by varying the type of team diversity.

### ***Conclusion***

Although team potency has been shown to be a strong predictor of teamwork, we know very little about the contingency variables that influence its impact. This study reports that team diversity is such a variable. Our study was conducted with individuals working with EPA robots. Given the growing number of teams using robots, our results are important for both research and practice.

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