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Industrial Robot Acceptance: Effects of Workforce Demographics and Establishing a Culture of Acceptance within Manufacturing Industry

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By

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ABSTRACT

Industrial applications have not been extensively researched regarding human-robot interaction. This project investigated industrial robot acceptance in the context of one manufacturing site. Acceptance was examined in relation to the workforce and conditions of acceptance were identified using mixed methodology. Quantitative (surveys) and qualitative (interviews) data was used to measure and analyze the existing state of technology acceptance and site culture. Based on this exploratory study, it was found the manufacturing facility has a weak culture but would be generally accepting of industrial robots if the technology were easy to use and useful. The identified boundary conditions to acceptance included training, job satisfaction and the opportunity to work in teams. It is hypothesized there was hesitation towards acceptance for age groups > 42 years and with less technology experience or exposure.

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CHAPTER 1: INTRODUCTION

The purpose of my thesis was to investigate industrial robot acceptance in a manufacturing facility. As industries adopt advanced technologies, the workforce and workplace must adapt to change which has not yet been measured or explored in detail. Many existing studies have not analyzed the relationship between industrial robot acceptance and workplace culture. This thesis was exploratory in nature and focused on industrial robot acceptance as it pertains to conditions of acceptance, culture and demographics. Due to its exploratory aims, this project focused on a single workplace site to draw a preliminary understanding of the factors that influence industrial robot acceptance. I investigated the boundary and facilitating conditions of industrial robot acceptance and was guided by two main topics of focus. First, this thesis evaluated those factors of acceptance in comparison to the site's workforce demographics and descriptors (e.g., age, experience). Second, my research explored avenues in which the manufacturing site could establish a culture that fosters technology adoption of industrial robots. This research did not include the actual adoption via robot introduction but used the employees' perception to make conjectures.

Industrial Robots

Industrial robots are considered to be a radical technology. By ISO8373, industrial robots are defined as automatically controllable, reprogrammable, multipurpose manipulators programmable in three or more axes, which may be fixed in place or mobile

(IFR.org). The industrial robot market accounted for greater than four billion dollars with a growth rate of four percent per year in 2005, and is now valued at over twenty-nine billion dollars in the US alone. (Kumar, Bekey, & Zheng, 2005, IFR.org). Most industrial applications are in material handling or welding, however industrial robots can also be assemblers, palletizers, or painters.

Typically industrial robots are contained to the workplace environment and have repeatable programmable tasks, which compared to personal robots, require less social interaction between a human operator and the robot. Although much of the work in the field of human-robot interaction (HRI) has been conducted within the scope of personal robots, HRI still plays an important role in industrial robotics because as such robots become more advanced, they are more likely to work collaboratively with people (Guizzo & Ackerman, 2012). Thus, it is crucial to understand HRI within an industrial application.

HRI has five main components, which include the robot, the human, the interaction between the robot and human, the environment in which the interaction takes place, and the specific tasks to be completed. Environment, or physical space, is of particular interest. This is because the environment is both a part of an organization's culture and it includes the physical space in which a robot would interact with a human. Culture has been found to be a boundary condition to robot acceptance specifically if the culture is stagnant or resistant to change (Straub, Keil, & Brenner, 1997). I define a boundary condition in this context as an obstacle or challenge to overcome. Similarly, a facilitating condition is one that promotes or furthers the acceptance or object itself. Research on personal robots emphasizes the interaction between human and robot since

there is high social interaction between the two. However, industrial robots typically have little social interaction; yet, the existence of the human and robot is in a physical space that can affect the acceptance of robots due to varying elements of workplace culture. There is no one prevailing, correct definition of culture. Culture, for the purposes of this research, encompassed the physical space, people, behaviors, and team environment of an organization (Robbins, 2013).

Industrial environments have not been observed or assessed in regards to robot acceptance. Early research has been focused on managerial influence on workplace culture and attitudes in a standard corporate setting to provide an advantage over competitors (Bellot, 2011). Many HRI frameworks also ignore task or environment while focusing on aspects of the robot, like design and usability (Hancock et.all, 2011). The Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology and Task-Technology Fit Model generally center on incremental technology acceptance. Incremental technology acceptance refers to a series of small developments for continuous improvement. Industrial robots on the other hand, are regarded as radical technologies; industrial robots are not an adaptation or a series of small developments (Smarr, Fisk, & Rogers, 2013). Industrial robots are implemented as a new technology and entirely new product. Thus, the existing technology acceptance models are applicable, but are likely not the best representations of industrial robot acceptance. Despite this, these models and frameworks provided a starting point for understanding this problem space by suggesting some variables that might be important for industrial robot acceptance. The following sections consider some variables that likely influence industrial robot acceptance and use.

Perceived Usefulness and Perceived Ease of Use

There are varying levels of robot acceptance to include perceived usefulness and perceived ease of use (Chen & Chan, 2011; Davis, 1989; Ezer, Fisk, & Rogers, 2009). These studies have found that there is an increased desire to accept and value technology that will enhance daily life. If the technology makes a task easier, enhances convenience or supports current everyday activities, it is deemed useful. Additionally, if the technology is easy to facilitate, users are more inclined to use the technology and have positive attitudes towards the technology. However, studies also found older adults generally have a lesser interest in adopting new technology and are less likely to use new technology than younger adults (Chen & Chan, 2011). One limitation of this research, within the context of this proposal, is that the technology that was investigated mainly operated within the home and related to domestic actions. Therefore, there is an absolute need for observation and research relating to robot acceptance within an industry. This thesis project explored the perception of industrial robots and acceptance from the workforce. The study was not to be limited to a specific age in order to confirm or refute existing frameworks about age and technology adoption. Technology might also affect culture, in addition to the fact that culture affects technology acceptance. Industries must remain competitive in today's technological environment which may infer that newer and radical technologies are unavoidable. A workforce may not have the option to adopt certain technologies.

Demographics of the Workplace

This project collected demographics and descriptors about various constructs, such as age, occupation level, job experience and general technology experience. There

are stereotypes about age-related performance and mental abilities regarding an aging population (i.e., called "ageism"). Stereotypes include being incompetent when compared to younger generations and more dependent on assistance like additional training or traditional work methods that do not include the use of technology. Older adults tend to suffer the effects of these stereotypes as studies found that older workers receive less support for learning and development (Lee, Czaja & Sharit, 2009). Additionally, with technology-based employment, it is the aging population that must engage in training to remain competitive. In relation to technology adoption and perceived usefulness, training and development is influenced by factors such as perceived benefits of participation and self-efficacy. The older adults whom believed that they were indeed capable of improving or learning new skills tend to be more likely to participate in training classes (Lee, Czaja & Sharit, 2009). Due to changes in work demands and shifting demographics, an active learning process is emphasized as optimal for older learners (Lee, Czaja & Sharit, 2009). Gathering information about workforce will allow this research to discover any demographic related themes that may exist within the manufacturing site.

One way to battle against ageism is to establish a supportive workplace culture. A responsive and welcoming culture can also impact robot acceptance because it has been said "a company's cultural characteristics can inhibit or defeat a reengineering effort before it begins" (Detert, Schroeder, & Mauriel, 2000, pp. 850). Technology adoption and radical innovations can, in theory, not succeed without a supportive culture. Culture includes the physical space, people and behaviors and the team environment. The physical work environment is said to "tell a story regarding… how the organization

supports employees" (Brower, 2014). An organization with a dedicated space to celebrate and build camaraderie supports positive organizational behavior amongst employees. This dedicated space can be communal, such as a location where meals are shared to include tables or cafes. Identified spaces can be indoor, outdoor or even multi-functional to take on a variety of events. Each physical space should be a focal point with an intention of use.

Physical spaces are occupied by people with behaviors. The main components of individual attitudes include cognitive, affective and behavioral. First, cognitive attitudes are defined as the description or belief in the way things are (Robbins, 2013). These attitudes are a person's evaluation about an object, being or situation. Second, affective attitudes include a person's emotions or feelings. Lastly, behavioral attitudes are one's actions of behaving in a certain way. There are also major job attitudes within culture.

Job attitudes include job satisfaction, job involvement, perceived organizational support and employee engagement. Job satisfaction is defined as the contentment an individual about their work or occupation. Job involvement is the employee's belief in the extent to which they influence their work environment. Involvement also includes how meaningful one feels their job is. Perceived organizational support refers to the support of the organization for the employees. Employee engagement is the involvement of the employees in the organization itself, whether this is new developments or state of the business. According to Detert and Schroeder, "Shared vision and shared goals among employees and management are critical for organizational success. Because of this, all employees should be involved in meaningful ways in the decision-making about the vision and goals they are asked to support" (Detert, Schroeder, & Mauriel, 2000).

The third component of culture is team environment. Team environment is directly related to people and behaviors, specifically major job attitudes. Team environment includes how employees perceive the characteristics of an organization's culture. Environments of an organization can include having attention to detail. It also includes being innovative and risk taking, outcome orientated, people orientated, team orientated, aggressive and stable.

Demographics of the workplace of interest include age, the physical work environment, physical spaces and the team environment. All components and variables played a role in robot acceptance. It was hypothesized, that if the culture and individuals within the culture are not supportive of change and radical technology, the reception would be limited. Therefore, it was important that the workplace demographics be taken into account when evaluating robot acceptance within this particular manufacturing facility.

Measuring Culture

There are multiple ways in which culture can be measured. Most studies measure culture quantitatively (e.g., surveys), qualitatively (e.g., interviews), or using mixed methods which is a combination of the two previously mentioned. Quantitative measurement contains the "numbers" collected through surveys. Qualitative analysis is oppositely, the "words" gathered through the use of interviews, focus groups, participant observation and document review, to name a few examples. Because there is no one true definition of culture, focus areas for culture quantification and research differ greatly. Mannion, Davies and Marshall (2003) posit that instead of choosing one best instrument for cultural assessment, "the choice of instrument should be determined by how organizational culture is conceptualized by the research team, the purpose of the

investigation, intended use of the results and availability of resources" (Bellot, 2011). Hofstede used open-ended questions, standardized surveys, questionnaires and personal interviews. His use of mixed model assessments is considered to be a precedent set for thorough culture evaluations (Hofstede, et.all, 1990).

Surveys are the most popular method to gather information with custom-designed measures (CR Magazine, n.d.). A high consensus amongst respondents is indicative of a strong and integrated culture while a lower consensus correlates to differentiation and a weaker culture. Differentiation could mean that there are many sub-cultures within the organization's culture. No agreement amongst participants points to no established culture and much fragmentation within the establishment. The optimal time for qualitative measurement is within the first two to six months of evaluation. Subsequently, quantitative research is executed post the qualitative portion and it should not exceed eleven to fourteen months.

Changing Culture

Resistance to change and creating a culture to support change are subjects of interest for many industries. Innovative companies must undergo more change in terms of technology than mature product market-producing companies to remain competitive in their industry. However, there has been little effort to discern what dimensions of organizational culture relate to the implementation of such innovative or change programs (Detert, Schroeder, & Mauriel, 2000). It is known that incorporating change can be positive if it leads to open discussion and debate. To overcome employees' resistance to change, a business must educate and communicate with the people. Participation is important as a company must build the support and commitment of its workforce. Organizations can select people who accept change but cost remains a

significant obstacle for industries (Brower, 2014). These costs include implementing training programs or hiring people open to change, but losing the knowledge of the aged workforce.

Innovative organizations tend to have similar cultures. These cultures promote experimentation, reward successes, encourage failures and celebrate mistakes. Innovative organizations align with technology by actively promoting training and development in order to keep the employees "most current". Companies that have greater technology availability tend to have more employee work-life supports. Greater job satisfaction and organizational citizenship behavior in turn leads to positive relationships (Robbins, 2013).

To promote a positive and cohesive culture, organizations can improve the physical space by making it more attractive to employees (Brower, 2014). Businesses can offer places for employees to meet and connect with one another. Some examples include meeting rooms or inviting spaces with food and drinks, like common areas or lunch rooms. Keeping the space fresh and changing will allow for creativity. The creativity should be fueled by people's ideas about how to use the space. There is also an optimal level of density. Positive behaviors and social conditions can result from physical surroundings that are "inspiring, stimulating and not too dense" (Brower, 2014).

Purpose of Proposed Study

Robot acceptance within an industry has not been investigated within the context of a manufacturing site and culture as it was presented in this research. Industries are becoming more technologically innovative with new products and the methods required in creating those new products. As industries evolve, the workforce must also be accepting of the radical changes, not only of the product being manufactured for

example, but with the use of such advanced technologies in daily tasks. This project is important because it researched how a manufacturing site can promote a culture of robot acceptance and identify probable facilitating and boundary conditions of acceptance.

Main components of a company include the workforce and the workplace, or organizational culture within it. Certain aspects within culture are found to be hurdles when it comes to industrial robot acceptance; however they have not been measured (Straub, Keil, & Brenner, 1997). The means in which a manufacturing facility can influence the culture to promote innovation, change and acceptance also required exploration. For older learners, providing feedback is extremely important throughout the educating process but to what lengths does an organization go to incorporate active training in the culture? Thus, the proposition of my thesis was to:

- Investigate acceptance of industrial robots in a manufacturing facility in regards to its workforce
- Identify the boundary and facilitating conditions of industrial robot acceptance
- Understand how a manufacturing site might establish a culture that fosters positive attitudes toward industrial robot adoption.

CHAPTER 2: METHODOLOGY

A mixed methodology was used to investigate the effects of an aging workforce on industrial robotic acceptance. Quantitative surveys and qualitative interviews were employed to determine the extent to which manufacturing sites can be limited, or facilitated, by its workplace culture. The site for which data collection took place for this project fabricates one category of manufactured goods and is continuously supporting the introduction of new products. The site is currently the only kind for the company in the world that manufactures this product. The facility has been in its current industry location since the 1980s. It is a non-union facility with approximately 220 manufacturing personnel that assemble and test the product, 10 members of manufacturing management and 10 support staff. Manufacturing employee demographics include the following: 1) more than 50% have tenure over 15 years 2) approximately 40% are over 50 years of age and 3) 75% to 25% male to female ratio. For this project, there were multiple focuses for the data collection, as shown in Table 2.1.

Table 2.1: Proposed Study

Goal	Constructs	Measures
1. Investigate Robot Acceptance	• Perceived usefulness • Perceived ease of use • Intentional use and acceptance	• Robot Opinions and Attitudes • Assistance Preference Checklist
2. Identify Conditions of Acceptance	• Boundary • Facilitating	• Management Interview (Q1, Q2) • Workplace Culture Survey (Q1, Q2, Q4-6, Q11, Q13, Q16) • Robot Opinions and Attitudes
3. Measure Culture	• People and Behaviors • Physical Spaces • Team Environment	• Management Interview (Q3-Q9) • Workplace Culture Survey
4. Collect Demographics and Descriptors	• Age • Occupation Level • Job Experience • Technology and Robot Experience	• Demographics Questionnaire • General Technology Experience • Robot Familiarity and Use

Part A: Survey (N=37) Study

Participants: Distribution of surveys to manufacturing personnel resulted in a response from 37 out of a population of approximately 220 manufacturing personnel. Although not all respondents reported gender or age, 91.43% were males. On average, the workforce had an associate's degree or had some college work in process. One

respondent did not report their gender and five did not report their age. The average age for the sample size was 41.37, *SD* = 11.42, *Median* = 42 years.

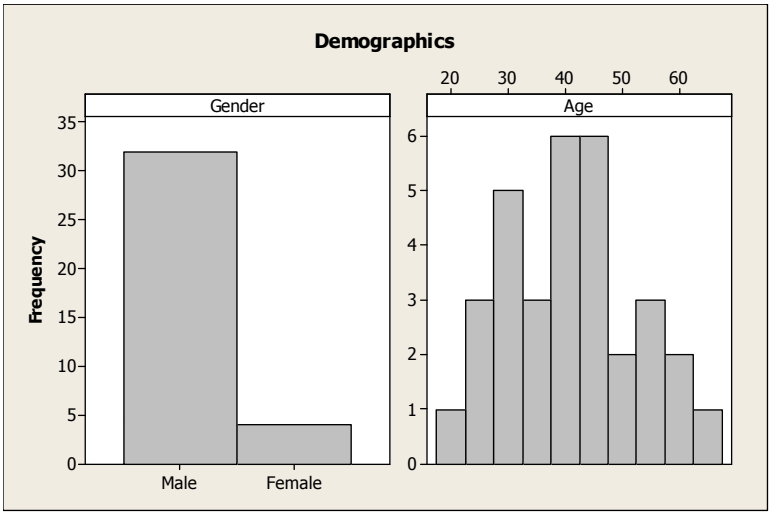


Figure 2.1: Demographics of Workforce

Surveys were administered in a conference room or private office during the employee's normal shift working hours. There were no supervisors present, and all data was kept confidential with no descriptions as to reveal the identity of the employee. Each survey completion lasted approximately 30 minutes.

Survey Procedure: We determined how the current workforce perceives technology and advanced technology adoption. To do this we distributed multiple surveys. The surveys focused on the following topics (Appendices A-E):

- Demographics Questionnaire
- General Technology Experience
- Robot Familiarity and Use
- Robot Opinions and Attitudes (Perceived Usefulness & Perceived Ease of Use)

- Assistance Preference Checklist

We also examined the role of culture; surveys administered to all employees determined whether there is one strong and integrated culture, a weaker culture, or no established culture based on employee viewpoints or beliefs as referred to by Rousseau and Cooke (1988). The Workplace Culture Survey, framed from the Development and Use of the Organizational Culture Profile by O'Reilly and colleagues (O'Reilly, Chatman, & Caldwell, 1991), focused on the employee's perception in the following areas:

- People and behaviors (i.e. job satisfaction, training)
- Team environment (i.e. organizational support)
- Physical space (i.e. common areas, lunch rooms)

The surveys collected robot usage and acceptance, culture information and demographic details (Reference: Demographics Questionnaire) about the workforce. They also assessed technology adoption in general.

Part B: Interview (N=8) Study

Participants: Interviews were only given to site management to examine if there were any misalignments in opinion between management and the workforce. Because management does not assemble or test the product, the surveys were not applicable for this sample. Therefore, qualitative questions were used to gain a better understanding of their perceptions on the site's culture. Eight interviews were conducted with manufacturing management. Of those eight, one member was female and two omitted their age. The average age of the six respondents was 43.67 years, SD = 7.76 years. The average years of service at the specific manufacturing facility ranged from seven to

twenty nine with M= 17.19 years. Four managers had an education level of a Master's Degree and four managers had a Bachelor's Degree.

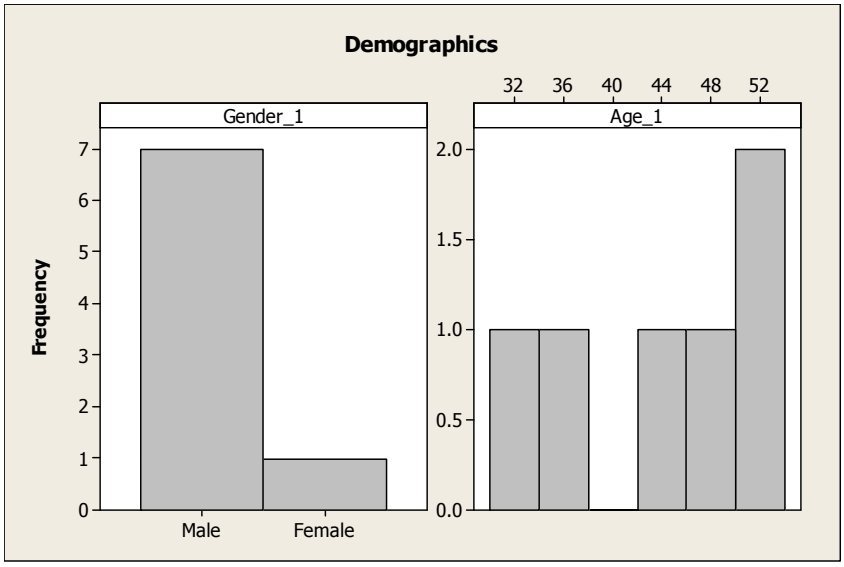


Figure 2.2: Demographics of Management

***Interview Procedure*:** Qualitative interviews were conducted to assess the perception of culture and technology adoption from site management. The Demographics Questionnaire was also administered for site management for descriptive purposes, as well as correlations between responses. This expanded upon the quantification of culture and the extent to which the environment can promote the acceptance of change from a management perspective. Next, interviews were administered in a conference room or private office with only the interviewer and the interviewee. The interviews were audio recorded and as expected, the sessions lasted approximately 30 minutes. Examples of interview questions from the Management Culture Interview include:

- How would you describe manufacturing employees' acceptance of change?
- What does the site do to promote employee engagement?

- How do you think the manufacturing personnel perceive management?
- How do you perceive the workforce regarding job satisfaction in the industry's current state?
- What opportunities does the site provide for the employees to work cross functionally or in teams?
- In your opinion, is there a shared vision across the site with specific goals?
- Describe how the site may or may not empower its employees to go above and beyond their daily roles and responsibilities.
- Do you see employees take initiative to work in teams or side projects, if so how?

Data Analysis

Part A Survey Study: Surveys in Part A were assessed using descriptive and correlational statistics. The surveys were analyzed with a variety of goals. First, demographics, technology experience, and robot experience were assessed for descriptive purposes. Reports of means, ranges, and standard deviations of these data provided information regarding the participants' overall descriptors, but also for determining descriptive differences between the older and younger employees.

Assistance Preference Checklist was assessed to gain an understanding of the type of help robots may provide to employees. The ordinal data was averaged, so that the means could be used in analysis. Means, medians and quartiles from this questionnaire were used to compare groups of actions to determine if the participant responses were different from the mid-point response.

Workplace culture was determined by a questionnaire based on O'Reilly and colleagues (1991). Our anticipated small sample size did not allow for factor analysis or

regression, thus our findings on culture is descriptive in nature. Participants were asked to rank 18 statements about culture (see Appendix F), from least true to most true. Each statement was given a rank-order number, so that the frequencies of statements considered most true or least true could be compared amongst the respondent group. Ranks from 1-9 were considered least true while ranks 10-18 were considered most true. A smaller subset of statements was chosen due to the scope of this project and focus on the relationship between the site's culture and industrial robot acceptance.

Robot opinions provided data on employee's perceptions of robot ease of use and usefulness (i.e., robot acceptance). Similarly ordinal data was assessed using frequency counts. Furthermore, acceptance was assessed to determine if it is correlated with age, technology or robot experience, or participant's perceptions of workplace culture.

Part B Interview Study: Interviews were analyzed according to a qualitative coding scheme to identify patterns and themes from the discussions. To do this, interviews were transcribed, then segmented into units of analysis (i.e., a segment may be determined as any utterance in which a though or opinion related to robot acceptance and culture is mentioned). Next, a coding scheme was developed to categorize each segment. A coding scheme is an organized categorization of the information in the interviews. The coding scheme was based on both the literature and the nature of the participant comments. In other words, an initial coding scheme was developed top-down, so that it depicts themes already known to be related to culture (i.e., physical space, employee behaviors, etc.) or robot acceptance (i.e., usefulness, ease of use, etc.). Then an iterative category generation strategy was used to complete the coding scheme. In this approach, several transcripts were randomly selected. The first segment was coded either on a

category already included in the coding scheme, or assigned a *new* category label that described the general idea of that segment (i.e., a bottom-up approach). Therefore, each segment was grouped naturally by its label(s).

CHAPTER 3: PART A SURVEY RESULTS

Technology and Robot Experience Findings

Based on the General Technology Experience questionnaire, participants did not report a frequent exposure to communication, computer, every day, health recreational, or transportation technologies (Ref: Figure 3.1: General Technology Experience). On average, the personnel reported occasional to frequent use of communication, computer and every day technology, occasional use of recreational technology and one time use of health or transportation technologies.

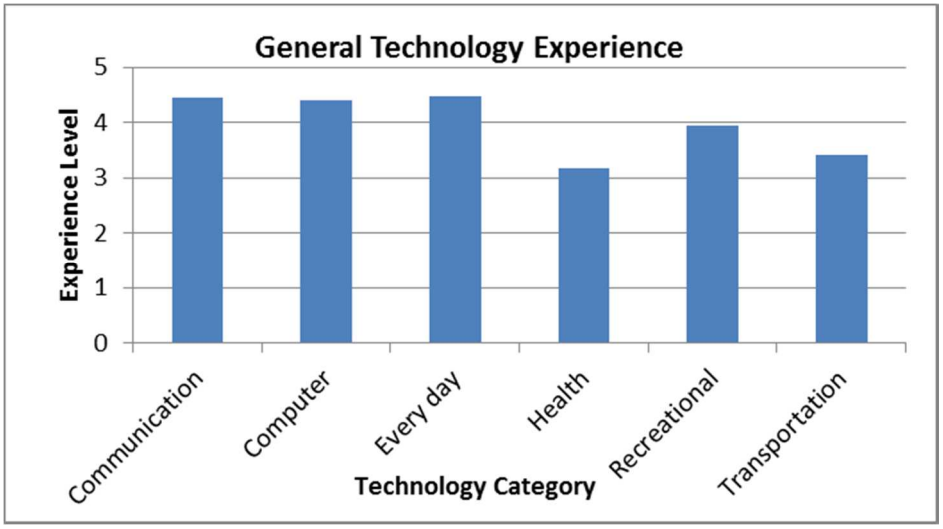


Figure 3.1: General Technology Experience

In addition to unfamiliarity with general technology, industrial robot familiarity was measured with the Robot Familiarity and Use Questionnaire. (Response scale: 1= Never heard about, seen, or used this robot, 2= Have only heard about or seen this robot, 3= Have used or operated this robot only occasionally, 4= Have use or operated this robot

frequently). The average response was a 1.96 (SD= 0.66). Based on this sample mean with 95% confidence, it is estimated the larger population at the site would result in a response range of 1.75 to 2.17. This approximation means that the workforce at this site may be unfamiliar with robotic technology as well. Although the majority of individuals were unfamiliar with various robot types, 67.57% respondents indicated that they would be open to using a robot.

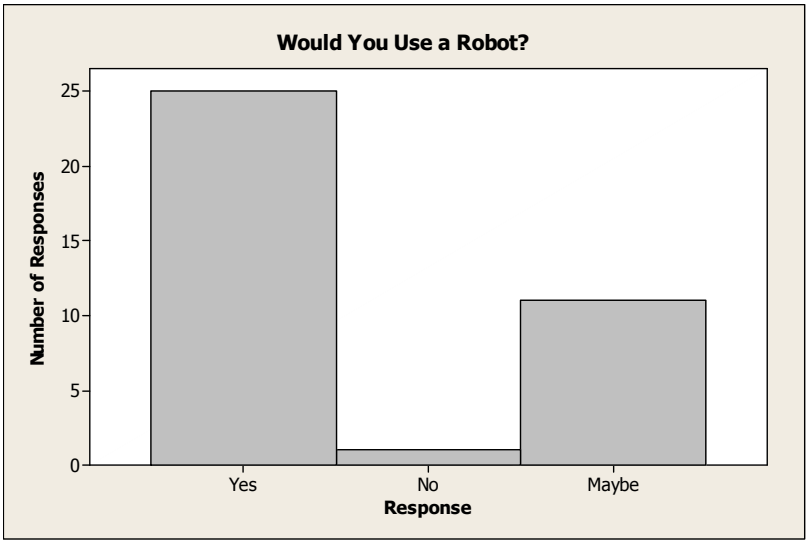


Figure 3.2: Robot Use

Robot Acceptance: Robot Opinions Survey and Assistance Preference Checklist Findings

Robot Opinions:

Robot acceptance was investigated with two primary measures: Robot Opinions Survey and the Assistance Preference Checklist. These surveys measured perceived usefulness, ease of use, intentional use, and preferences for use (Davis, 1989; Ezer, Fisk, & Rogers, 2009).

General opinions of robots (Ref. Robot Opinions and Attitudes Survey) response scale ranged from 1= extremely unlikely, to 7 = extremely likely. As shown in Figures

3.3 and 3.4: Perceived Usefulness and Perceived Ease of Use, the collective response to the twelve questions is skewed towards 'likely' responses. A majority of those surveyed stated that a robot would be useful, enhance effectiveness, increase productivity, make a job easier, improve the workplace and allow tasks to be completed quickly. In addition, a majority of the workforce also thought robots would be easy to use. This is shown with the same pattern that a majority of responses are in the 'likely' responses. Specifically, it is supposed that the interactions would be clear, it would be easy to become skillful and learning to operate the robot would not be a challenge. The employees in general believe they would likely have positive interactions with robots. This leads to the assumption that the respondent group would be open to robots in the workplace, as they are perceived to be useful and easy to use.

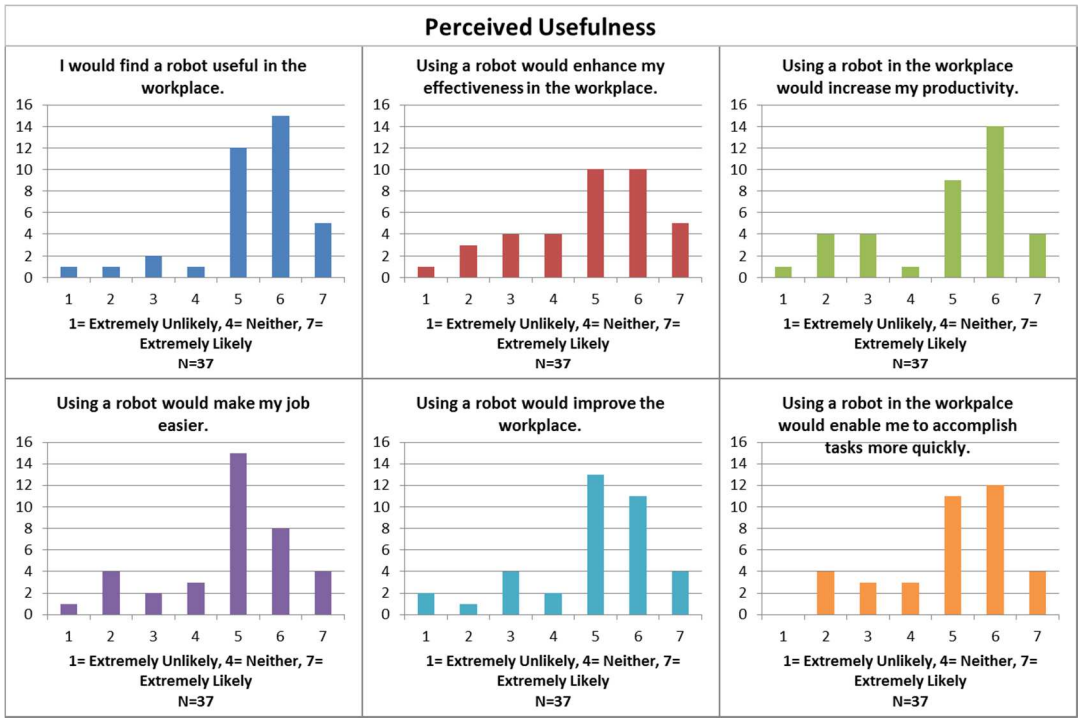


Figure 3.3: Perceived Usefulness

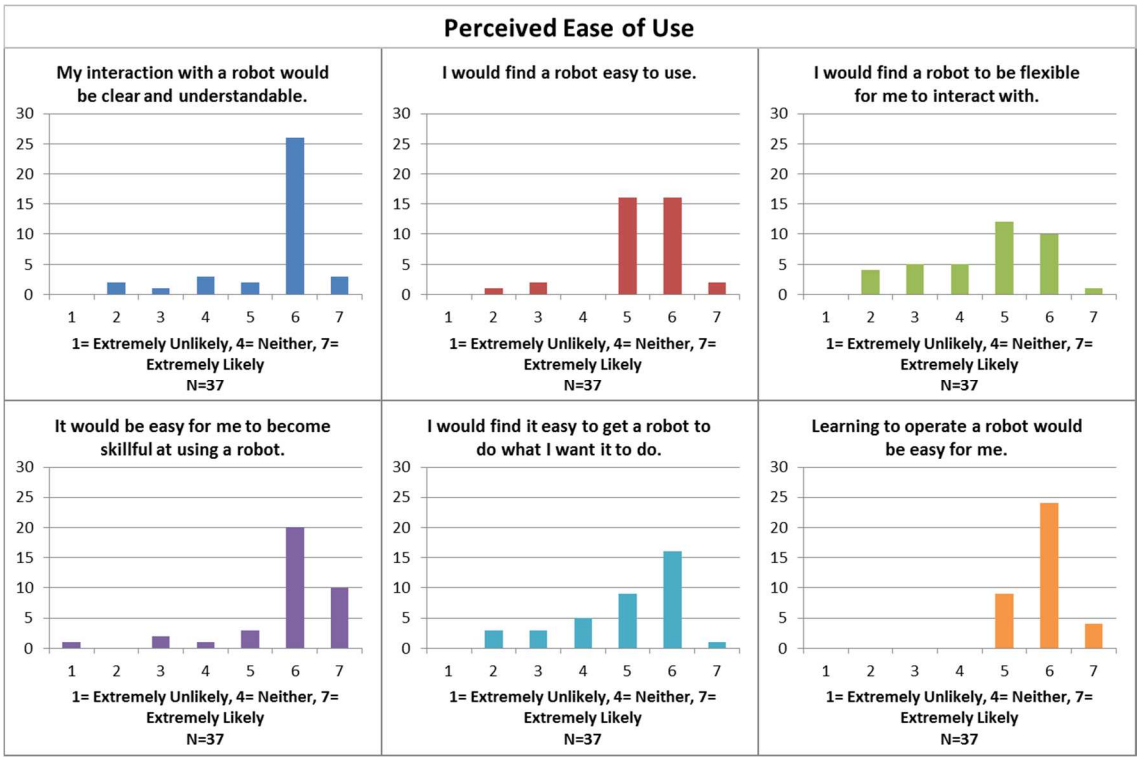
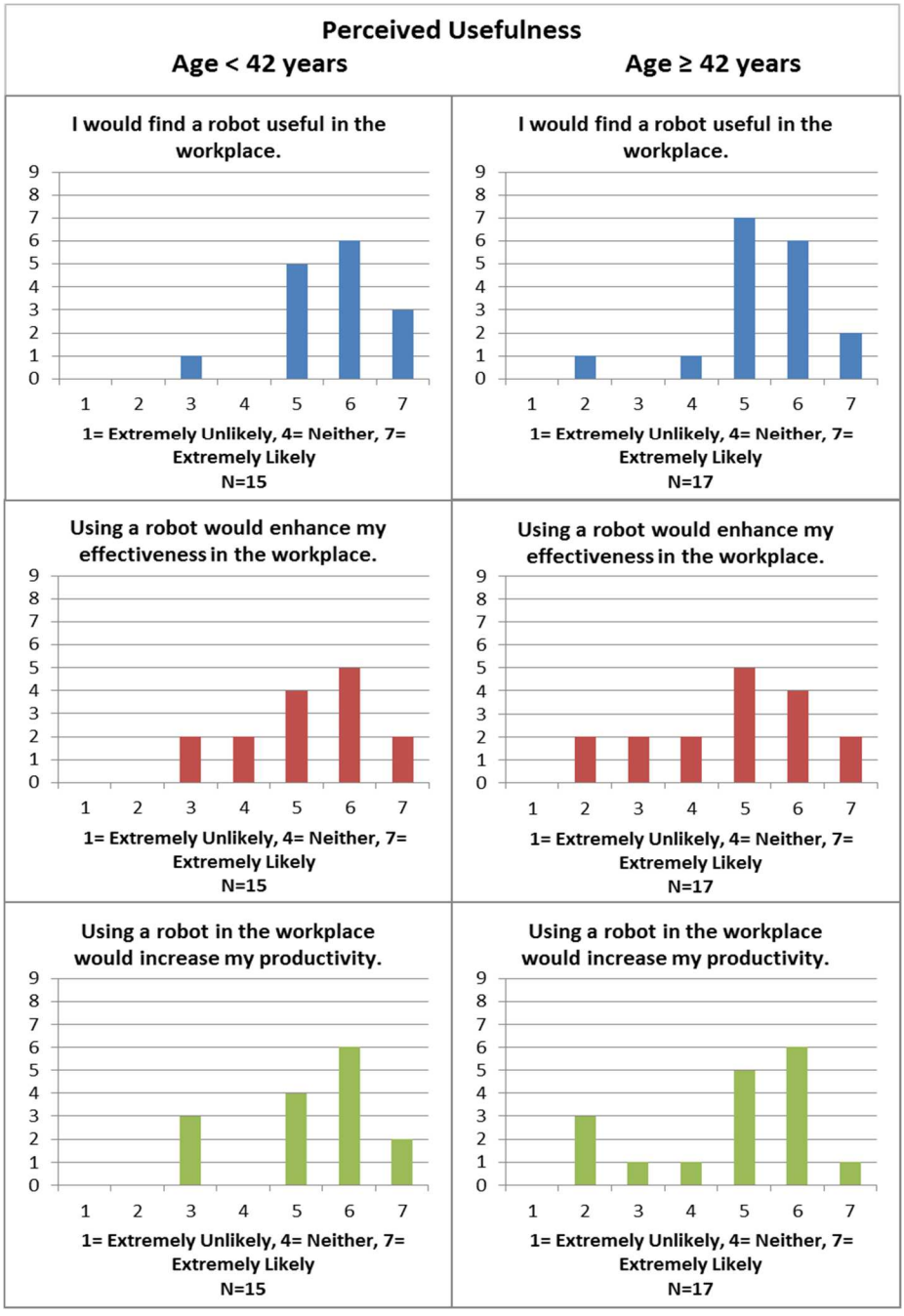


Figure 3.4: Perceived Ease of Use

Data was also sorted according to the employees' median age of 42 years. The median age was chosen because for this workforce, it reflects two age groups- a younger and an older (although not aged), approximate in sample size for ease of comparison. Both age groups would still be accepting if the robots were perceived easy to use and useful, however there are slight differences amongst 42 years of age and older. Those ≥ 42 years (N=17) had responses of "unlikely" at least once for every question relating to usefulness. Those < 42 years (N=15), had no responses in the extremely unlikely (i.e. response of 1) or quite unlikely (i.e. response of 2) as shown in Figure 3.5. Similarly, those ≥ 42 years, were less sure (i.e., responses "slightly likely"; "no preference"; and "unlikely") if it would be easy to become skillful at using a robot, if robot would be flexible to interact with or if the robot would be easy to use. However, it is interesting

that although less sure, those above the median age believed a robot would be flexible to interact with, more so than those < 42 years. The average weighted response was 4.8 for ≥ 42 years and 4.4 for < 42 years. There is also no or little difference amongst the age groups when asked if a robot would improve the workplace or if the robot learning to



operate a robot would be easy.($M_{\text{improve workplace, } < 42} = M_{\text{improve workplace } \geq 42} = 5$; $M_{\text{learning to operate, } < 42} = 6$, $M_{\text{learning to operate } \geq 42} = 5.82$).

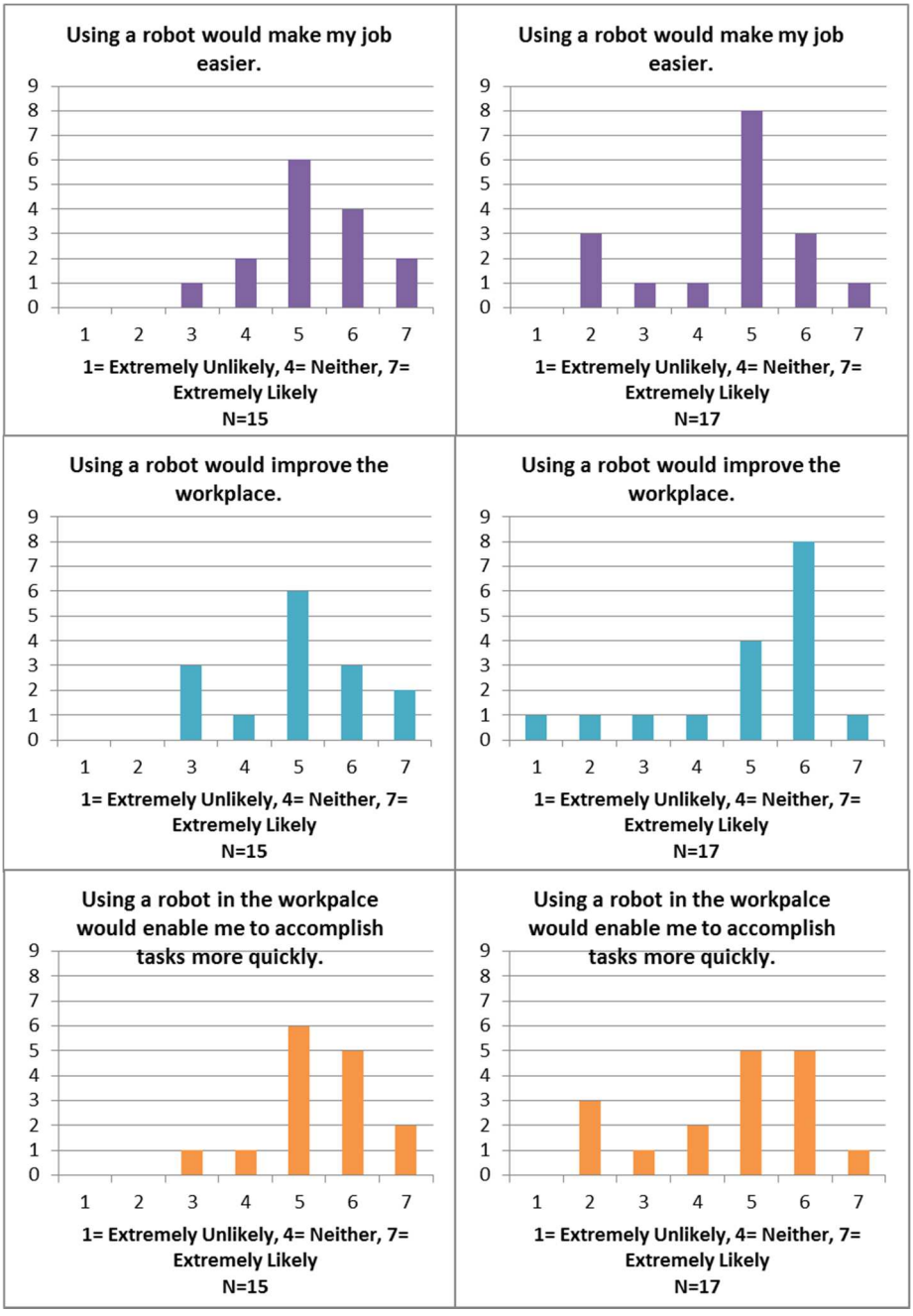
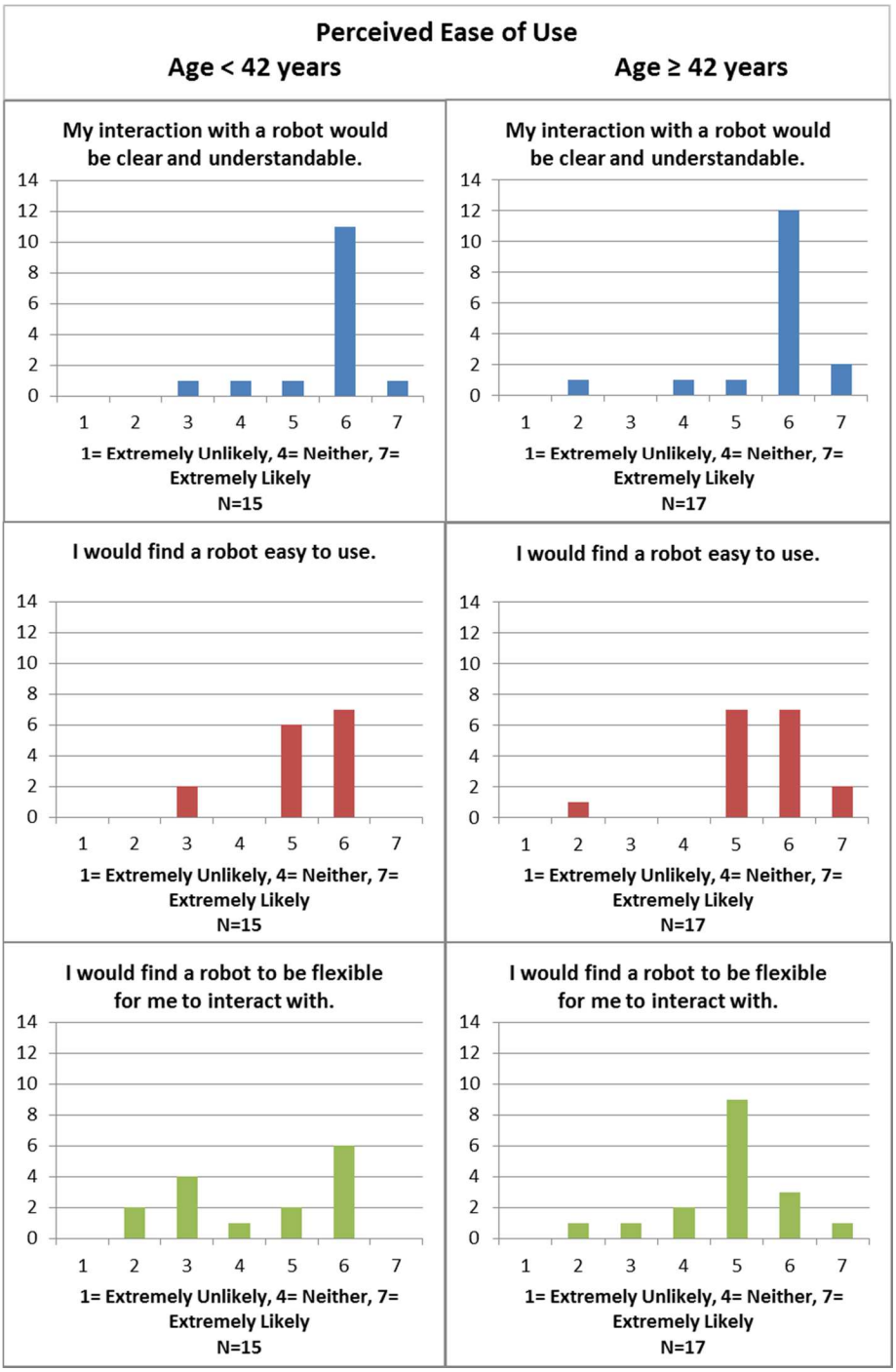


Figure 3.5: Perceived Usefulness Comparison


Perceived Ease of Use
Age < 42 years
Age ≥ 42 years
My interaction with a robot would be clear and understandable.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=15
My interaction with a robot would be clear and understandable.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=17
I would find a robot easy to use.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=15
I would find a robot easy to use.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=17
I would find a robot to be flexible for me to interact with.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=15
I would find a robot to be flexible for me to interact with.
1= Extremely Unlikely, 4= Neither, 7= Extremely Likely
N=17

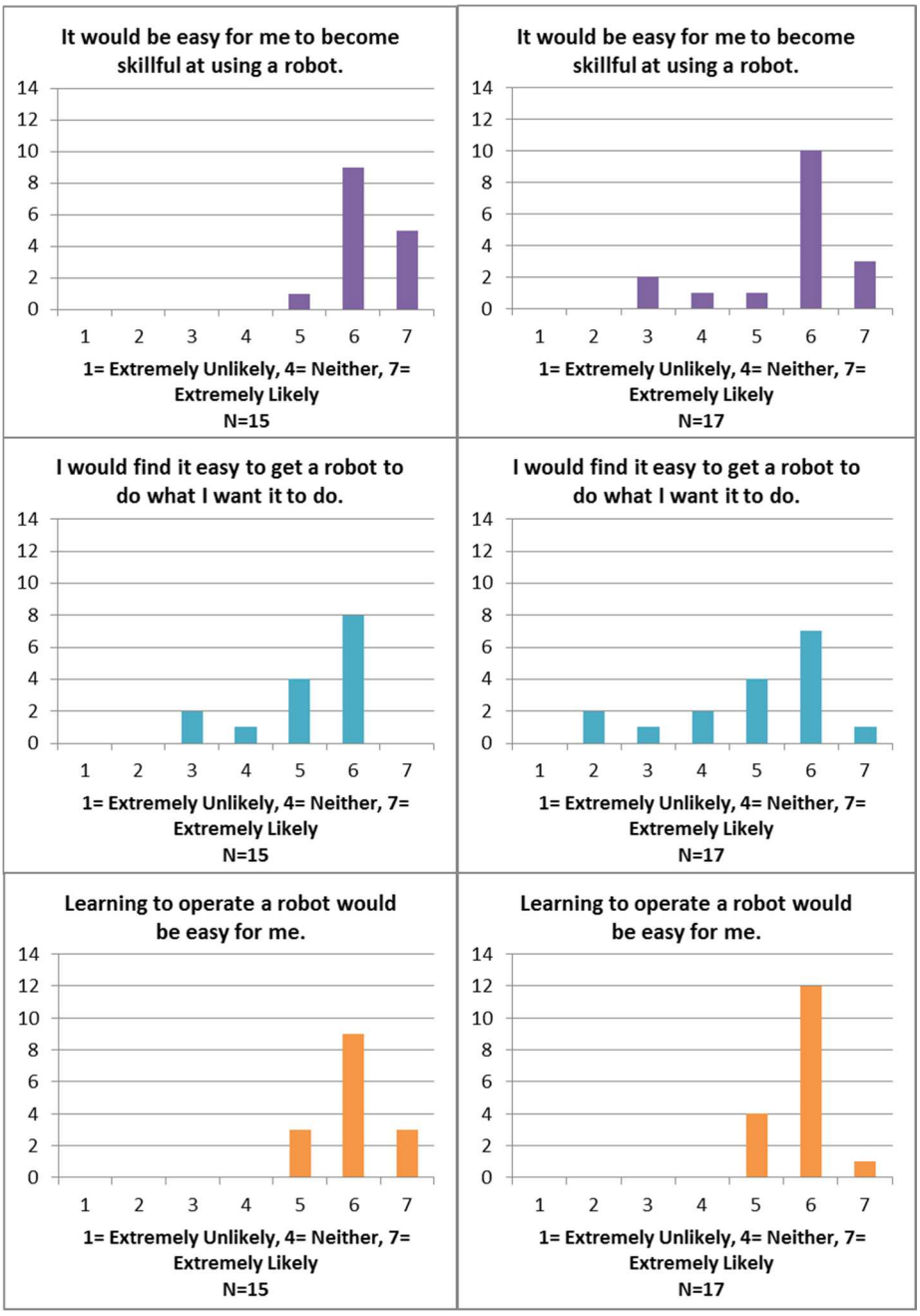


Figure 3.6: Perceived Ease of Use Comparison

Robot Opinions and Attitudes were also evaluated in relation to participants' technology experience. The data was divided into two groups, 20 employees with a technology experience average of < 4.0 indicating technology is used once or less and 17 employees with an average of ≥ 4.0, indicating more frequent use of technology. It was

found those with a greater experience level of ≥ 4.0 were more likely to have favorable opinions of robots amongst all 12 questions relating to perceived ease of use and perceived usefulness, as shown in Figure 3.6. Following the same pattern, question 13, "Would you use a robot?" returned a greater response for "Yes" of with those that have more technology experience. Table 3.1 shows there may be a relationship between less technology experience and hesitance towards robot use. A two sample t-test was calculated for the response of robot opinions based on technology experience. This resulted in a rejection of the null hypothesis ($p=0.002$, $\alpha=0.05$) concluding there is in fact a significant difference in response values between those with less technology experience (< 4.0) and those with more experience(≥ 4.0).

Table 3.1: Robot Use and Technology Experience

Would you use a robot?		
Technology Experience < 4.0	Yes	60%
	No	5%
	Maybe	35%
Technology Experience ≥ 4.0	Yes	76%
	No	0%
	Maybe	24%

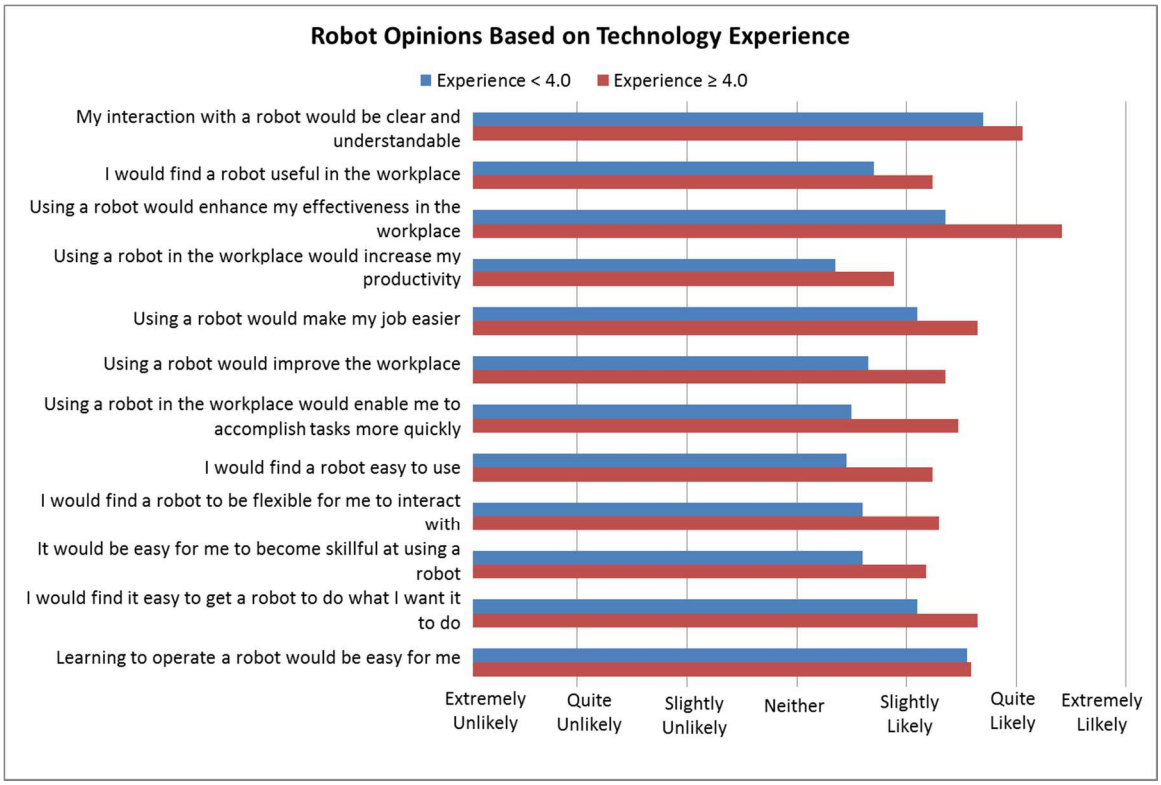


Figure 3.7: Robot Opinions Based on Technology Experience

Assistance Preference Checklist:

The Assistance Preference Checklist measured participants' preferences for human and robot assistance for 21 workplace tasks (Response scale: 1= Only a human, 2= Prefer a human, 3=No preference, 4= Prefer a robot, 5= Only a robot). In this checklist, participants indicated who (robot vs. human) they would prefer to assist them, if they needed help performing certain tasks. Interestingly, the participants' preferences were very task-dependent. Manual tasks that use technology such as calling for assistance (i.e. stockroom, support) or using the computer data-entry system (i.e. eDHR, password entry) resulted in a preference toward human assistance, with means lower than 3.0 (3.0 = no preference). However, the remainder of manual tasks such as using hand tools, unpacking parts, or re-labeling resulted in no preference (means ~ 3.0). Select

items, listed in Table 3.2, pertaining to specialized, tedious or non-ergonomic tasks like soldering, lifting heavy parts, installing or picking hardware, moving kit carts, sweeping, bending down to the floor or over reaching above head or climbing to reach parts resulted in a slight preference for robotic assistance, with means greater than 3.0.

Table 3.2: Assistance Preference Checklist

Preference Type	Range	Actions	Mean (M)
Human Assistance	M < 3.0	Calling a support specialist or PE	1.73
		Typing username and password	1.97
		Completing tasks in eDHR	2.03
		Calling the stockroom	2.11
No Preference	M ~ 3.0	Using hand tools	2.86
		Unwrapping parts	2.92
		Walking on flat ground	2.97
		Putting away tools	2.97
		Taping floor/re-labeling	3.00
		Aligning parts or components	3.16
Robot Assistance	M > 3.0	Installing nuts and bolts	3.27
		Disinfecting	3.30
		Holding parts during install	3.30
		Moving a kit cart	3.32
		Picking hardware or piece parts from bins	3.32
		Sweeping area	3.32
		Climbing five steps to get part	3.46
		Soldering (if applicable)	3.49
		Bending down to floor	3.51
		Reaching above head	3.65
		Lifting heavy parts	4.22

A visual representation of the assistance preference results (Ref: Assistance Preference Checklist Survey) is depicted in Figure 3.8. The actions are listed next to the respective box-plot indicating the range, lower and upper quartiles and median of responses. The response for 3.0= No preference is highlighted in bold to emphasize the preference to the left or right of the centerline. Left of the line contains responses of a 1 or 2 identifying human preference and right of the line shows responses of a 4 or 5

identifying robot preference. The actions from the survey are grouped into manufacturing related categories, color-coded for ease of comparison. For example, the two tasks in the Reach category, presented in purple, resulted in robot preference.

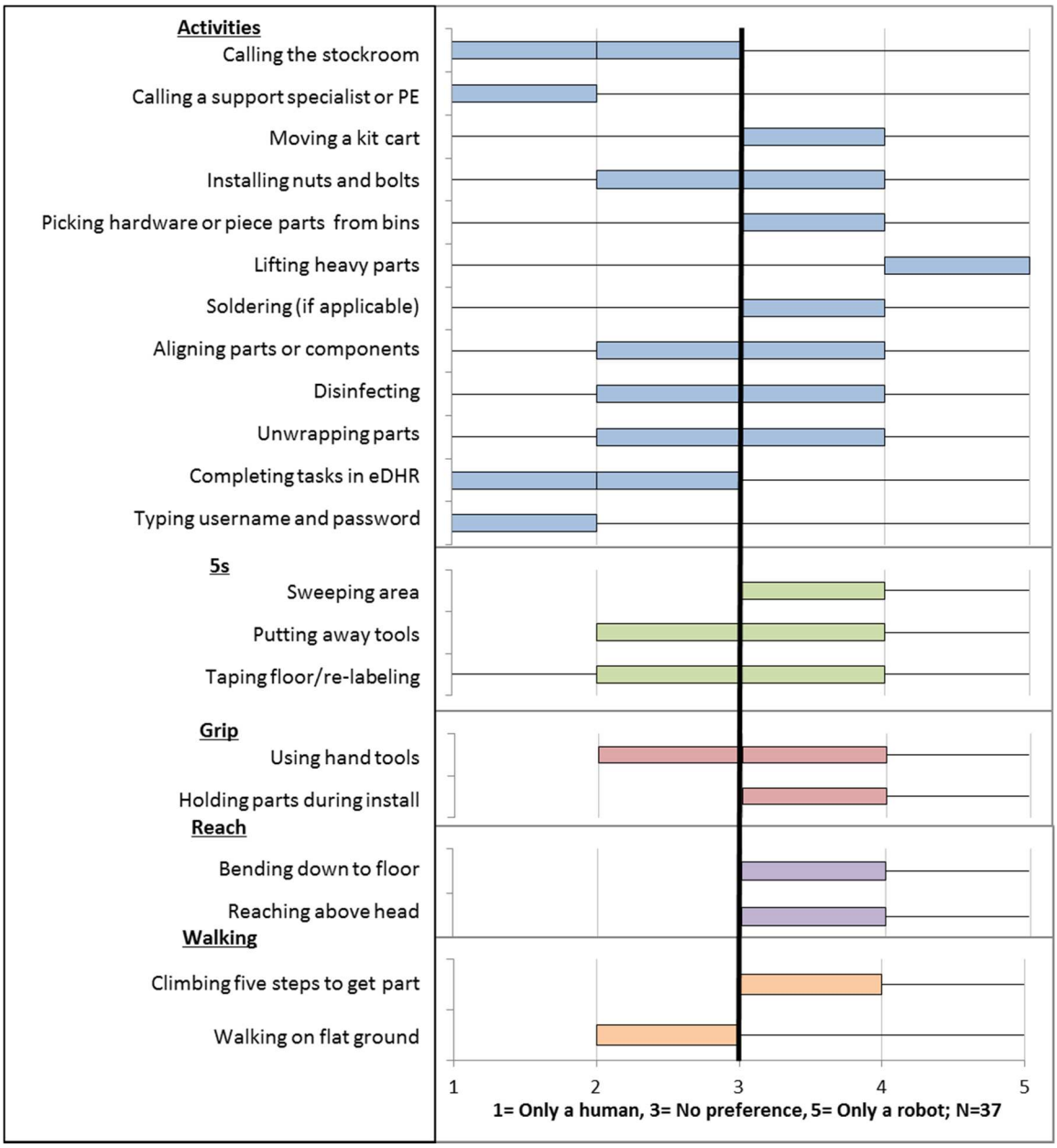


Figure 3.8: Assistance Preference Checklist Boxplot

Workplace Culture Survey Findings

Additional boundary and facilitating conditions were identified from the Workplace Culture Survey. Employees were asked to rank eighteen statements from an order of least true to most true. The statements and their rank order were analyzed for agreement amongst responses and order of rank highlighting potential themes or topics within the culture. For this survey, one employee omitted questions thirteen and fourteen, one employee omitted question two and one employee chose not to partake. Items ranked one through nine were least true, while ten through eighteen were most true. From the survey, training, job security, and qualities of innovative companies were topics that could be boundary conditions to acceptance due to lack of manufacturing consensus or importance. One facilitating condition is the existing workplace demands. The following sections address each of these boundary/facilitating conditions.

Training:

Statements four, five and six from the Workplace Culture Survey pertain to the employee benefitting from more training to meet current work demands, desire for more training and importance of providing training, respectively. Benefitting from and the desire for more training were not the highest in any ranking however, approximately 64% and 60% rated the statements as most true (in positions ten to eighteen). Seen in Figure 3.9 and 3.10, training ranks as desired amongst respondents as the number of occurrences increases as the rank order increases towards most true. This indicates the employees believe training is a very important topic.

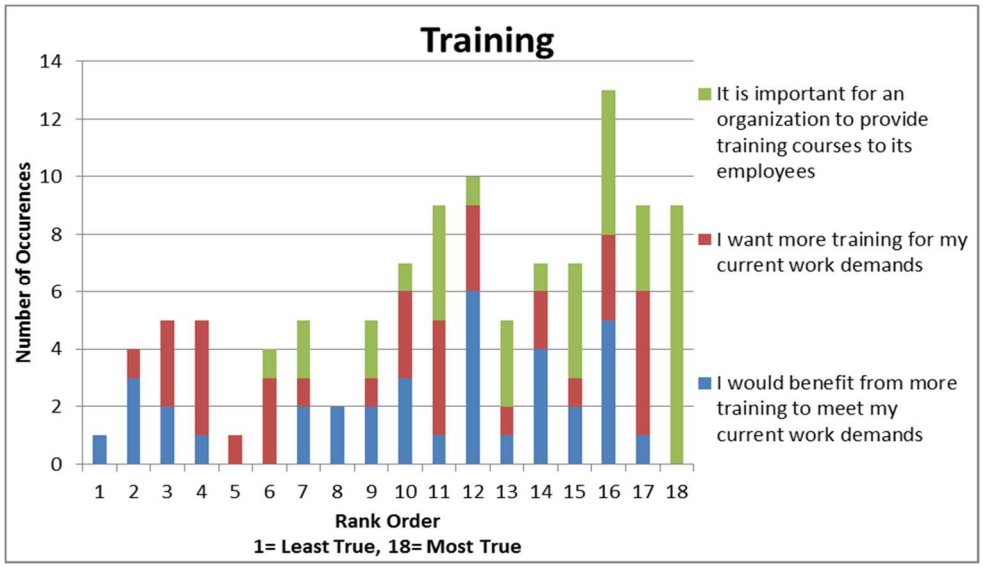


Figure 3.9: Training Statements

Actually, 13.89% wanted more training to meet current work demands ranking this need as second to most true. 86.11% also rated the importance of training courses for employees as most true (in positions ten to eighteen). All training related statements indicate the industrial workforce could benefit from training, wants more training for current work demands and thinks it is most important for an organization to provide training courses to its employees.

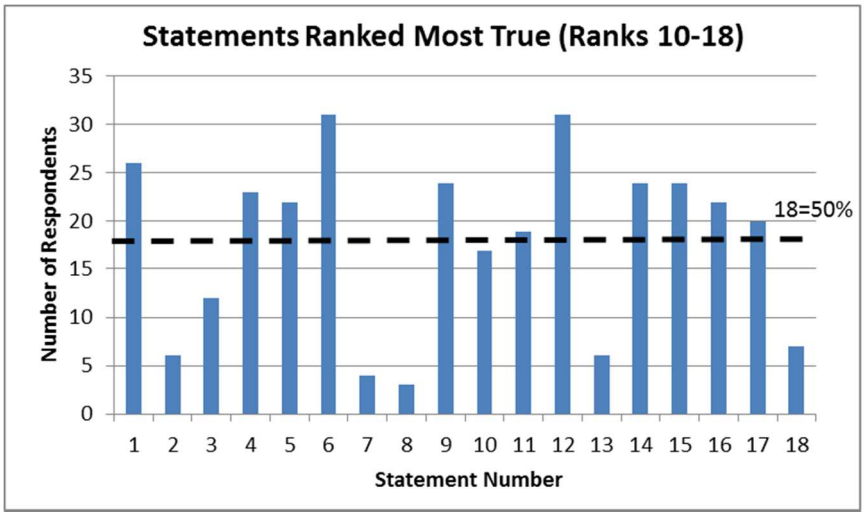


Figure 3.10: Statements Ranked Most True

Job Security:

Job security was identified as a second boundary condition. There was no consensus amongst the manufacturing employees regarding job security. The lack of agreement is seen when asked to rank the statement "I have good job security". 47.22% ranked the statement in a lesser true position while 52.78% ranked the statement in a more true position. Also, 52.78% state their current position is not the perfect job for them. With almost a fifty-fifty split amongst those surveyed, I did not find evidence of agreement.

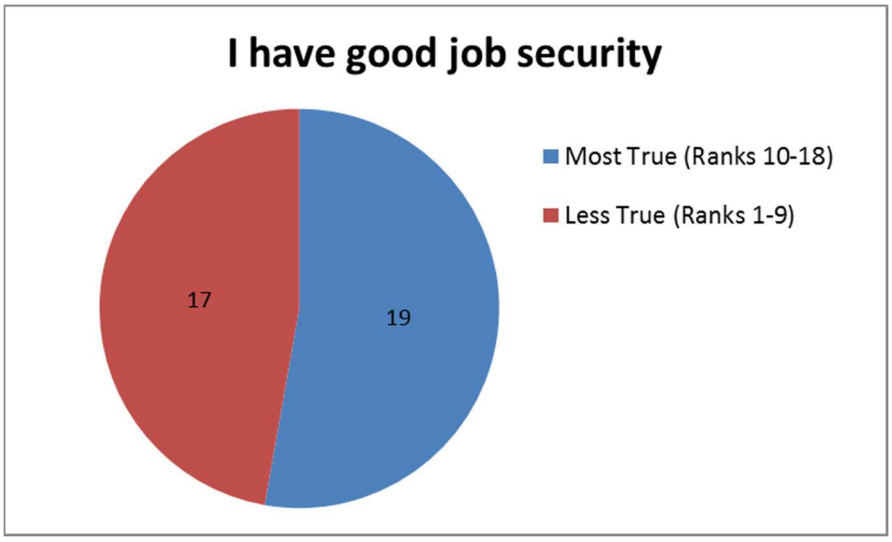


Figure 3.11: Job Security

Innovativeness:

A third boundary condition to acceptance related to characteristics and attractive physical spaces of innovative companies. Innovative organizations encourage failures, celebrate mistakes and promote training (Robbins, 2013). When asked if the site was innovative, 16.67% rated the statement was the second most true and 61.11% ranked the statement as generally most true (in positions ten to eighteen). However, 77.78% do not agree with the statement, "My workplace encourages failure and learning from mistakes". A main trait of an innovative organization was not found from the site culture survey. The lack of agreement between the two statements regarding innovation and culture insinuates that a boundary condition may exist. This boundary condition would be the alignment of the company with truly being innovative, adopting all characteristics as research suggests. To be truly advanced, the site must develop the culture and adopt qualities that are shared amongst innovative organizations, such as promoting experimentation, rewarding success and celebrating mistakes. The physical spaces were

also found to be unattractive. Rated as the some of the least true statements, the physical spaces such as the cafeteria and break areas are not ideal and unappealing for the workforce. An organization with a dedicated space to build fellowship supports positive organizational behavior amongst employees; this dedicated and updated space was not found to exist at the site.

Work Demands:

One facilitating condition identified was the current work demands. Approximately 55% and 72% of those surveyed believe they are able to meet their current work demands and did not think the workplace expects too much from its employees. Furthermore, 66.67% are satisfied with their career path. Thirty one of the thirty six respondents consider their job meaningful to themselves and those around them. Thus, if a new robot technology were to be introduced, it is theorized that the workforce would have adequate means to spend time with the new technology without adding extra stressors to their daily workplace.

Constructs of Culture:

In addition to identifying existing boundary and facilitating conditions, three constructs of culture were measured developing to a hypothesis about the existing culture at the site. Based on the employees sampled, the manufacturing site has a weak culture.

Only two statements from the Workplace Culture Survey had greater than 50% agreement by the employees in the top four rank orders for least true. There was little agreement for the statements rated most true; the highest number of employees that agreed on statement rank ranges from four to nine. However, if broadening the field of view into two halves of least true and most true, there is agreement that hovers around the

60-70 percentiles. Thus, there appears to be a culture but it is not integrated nor aligned amongst the manufacturing personnel.

CHAPTER 4: PART B INTERVIEW RESULTS

Interviews of eight managers revealed potential boundary and facilitating conditions to acceptance of change and site culture. Site management was misaligned with the shared vision and goals of the facility, communication and opportunities for a strong team environment. There was relative agreement regarding overall job satisfaction. The following sections address these conditions and constructs from the management point of view.

Acceptance of Change:

To battle against resistance to change, an organization has to educate and communicate with the people; it must build the support of its workforce (Brower, 2014). Communication and support are key factors for a workforce to accept change, especially of such radical technologies like industrial robots. When discussing how the site specifically introduces or promotes change, only four managers emphasized communication as being critical for reaching out to employees and establishing an open atmosphere. Of those four, two managers do not believe the site communicates well. "*I don't… think we do a good job of providing a ton of communication and a ton of information of why a decision is made or why a change is happening*" said one manager. Another stated, "*I think because we choose to only communicate to the broader employee population once a quarter, a lot of people are left in the dark about the nature of change and what's going on.*" Five managers also mentioned "resistance" or "hurdles" when asked if manufacturing employees are accepting of change. One even believed that "*The*

newer, less experienced… tend to be more open to… trying new things." Three of the managers did consider the workforce "generally accepting" with a 7/10 towards good acceptance of "low to no hurdles".

Although communication may hinder the acceptance of change, there does appear to be agreement regarding support for employees. When asked if the interaction between management and manufacturing personnel is supportive, seven managers openly said, "Yes" while one stated "*I think it's we over here*". The manager referred to "we" as a cohesive management-employee relationship as opposed to two separate identities. Thus, managers believed they provide employees with the needed support throughout the workplace. The support would theoretically help to battle against employee resistance to change.

For employees to be fully supportive, including introduction of change, the site management and employees must also have a common vision. The theme of a shared vision and goals across a site are essential for success. Every employee "should be involved in meaningful ways… about the vision and goals they are asked to support" (Detert, Schroeder, & Mauriel, 2000). There was a slight consensus, at best, regarding a vision and goals between the site management. Two managers indicated there was no shared vision or that there could be indicators but no explicit goals. "*I don't think if you asked 100 people, could be management, could be production associate, would be able to give you some tangible goals…*" Of the six remaining replies pertaining to the site's goals, five managers mentioned quality, four mentioned safety, and six highlighted cost or financial metrics.

Constructs of Culture:

People and their behaviors, including job satisfaction, largely shape the workforce. Seven out of eight managers believed the workforce was pleased with their jobs using key words such as happy, fairly or overall satisfied. Five managers actually attributed the satisfaction to the pay, wage, benefits and hours at the facility. Comments such as "*well treated from the standpoint of pay*" and "*highest paid in the area and in the state for what they do*" resonate as themes throughout the interviews.

Team environment is also a main component of culture. This portion of the study suggest that from site management's point of view, there were multiple opportunities to work in teams; however, employees at the site may not have been motivated as there was a lack of initiative to do so. A common trend throughout the interviews included team opportunities for lean activity, special projects and EHS (Environment, Health and Safety) to benefit the business or company. Five managers did recognize a potential for improvement, which alludes to self-awareness from management. "*I would say we have some [opportunities to work in teams], but… we probably should have more,*" said one manager. Others stated, "*I don't think there's as much initiative as it used to be*", "*No… I don't see initiative to work in teams*" or "*I see it [initiative to work on teams or go above and beyond], not as much as I'd like to see it I guess*".

CHAPTER 5: DISCUSSION

Summary of Findings

This study is important because it investigated industrial robot acceptance in relation to workplace culture. Although the project was largely exploratory, it identified several preliminary factors that may influence robot acceptance. Certain trends emerged from the questionnaire and interview data as descriptors such as age and experience were used to gauge robot opinions and constructs of the site's culture were explored. Age may not play a significant factor in industrial robot acceptance and a lack of technology experience may cause hesitation regarding robot acceptance. Top themes as boundary conditions within the identified weak site culture pertain to the importance of training, chance to work in teams and attractiveness of space.

The manufacturing personnel will be accepting of industrial robots and advanced technology if it is perceived to be useful and it is easy to use. Survey responses that gaged these factors resulted in 'likely' responses when asked various questions pertaining to robot opinions about use and interactions. Grouping the robot opinions by the median age did not result in strong differences in viewpoint. However, if grouping the data by technology experience, those with more exposure seemed to more open to the use or introduction of a robot in the workplace. Despite the general acceptance among the workforce, the preferences for human vs robot assistance did vary by task. Specialized and physical tasks, such as soldering, lifting heavy parts or reaching over head resulted in robot preference. This preference for robotic assistance supports the notion of perceived

usefulness of the robot. If the employee is unable or limited by their physical capabilities, the robot would allow them to fulfill the demands of their job more easily. In addition, tasks that require dexterity or fine motor skills such as installing nuts and bolts or communicating to another individual did not result in robot preference.

Training as the first culture related theme has the potential to be a boundary condition to robot and technology acceptance. This is evident from the employees ranking statements about training as some of the truest statements. In conjunction with the thought that training is very important, there was evidence that the existing workforce did not believe training was currently adequate. Therefore, if a new technology were to be introduced, there would need to be an emphasis on training to achieve the acceptance. The Robot Opinions survey showed the employees would be open and accepting if the technology is easy to use and useful. Yet, if there are no sufficient teachings for the employees to see the benefit, it is hypothesized that the workforce will object to the advanced technology. Also, because the workforce desires more training for current demands, the site may have a longer roadmap to successful implementation from a culture standpoint. If introducing a complex technology like a robot, existing training should be mitigated before extra training is required. Minimizing this conflict would ensure a smoother transition and more agreement amongst employees for a theme (training) ranked as high importance.

The site's weaker culture also expanded into the manufacturing employee and management interaction. Management was in relative agreement on the topic of job satisfaction due to the competitive wages and benefits; however there was no consensus amongst the manufacturing employees regarding job security. Because there is little

agreement, the implementation of a radical technology may actually skew the opinions regarding job security causing increased dissatisfaction. A lack of understanding of the technological benefit could add negative feelings due to the thoughts of "human replacement" instead of teamwork, like human-robot interaction. Additionally, there were differences in regards to shared vision and goals and the opportunity or availability to work on teams. There is even discrepancy between management in regards to the site's shared vision and goals which has translated down to the workforce. When asked to rank the statement, "I share the same values as my organization", 16 manufacturing employees listed it in a rank order of 1 to 9 (less true) while 20 placed the statement in a rank order of 10 to 18 (more true). There is little indication regarding the agreement of the vision throughout the facility.

The team environment at the manufacturing site was not very strong as indicated by the Workplace Culture Survey. The contrast in responses from the workforce and management also highlight a misalignment between the manufacturing personnel and senior managers. From the perspective of the manufacturing personnel, it is only slightly true that the site allow opportunities for employees to work on teams. Furthermore, the encouragement of teamwork was never a top ranked statement by employees. Yet, all eight managers stated that there are multiple opportunities to work in teams.

Physical spaces can also be upgraded or enhanced to establish that dedicated space for camaraderie. The spaces can also be developed to be more inviting and fresh allowing for creativity. According to this project, this improvement may allow for a more unified and supportive site culture to increase employee feelings of organizational support (Brower, 2014).

Based on this exploratory project, the following statements about the manufacturing site are speculated to be true:

- The site has a weak culture that can be accepting of industrial robots and advanced technology if it is perceived useful and easy to use
- Manufacturing employees prefer robotic assistance with specialized, tedious and non-ergonomic tasks
- More frequent use or exposure to technology may correlate to greater chance for robot acceptance
- Important sub-culture topics such as training, job satisfaction and opportunities to work in team can hinder the acceptance of change
- The facility can adopt characteristics of innovative companies such as open communication and attractive physical spaces to improve feelings of employee support

Discussion

The type of assistance preferred by industrial employees is human assistance when using general technology. For actions that are quite simple, such as re-labeling or putting away tools, the lack of preference does not indicate whether the employees would be accepting of or object to robotics performing in this category. Yet for tasks that may require additional training or are un-appealing, robotic assistance is preferred. Because industrial robot applications do address highly specific tasks (i.e. soldering, placement, painting, cleaning or lifting), it is theorized the subset of the population would be accepting of the introduction of robots or advanced technologies to complete these tasks. It is also theorized the sample surveyed will prefer robot assistance if the action is

perceived to be useful. In this instance, the industrial robot would be useful because it would replace the need for the human to partake in tedious, specialized or non-ergonomic activities. The actions are also primarily physical in nature. This observation about the industrial workforce supports the notion of increased acceptance if the technology enhances tasks or convenience (Chen & Chan, 2011; Davis, 1989; Ezer, Fisk, & Rogers, 2009). This theory of perceived usefulness as a facilitating condition based on the workforce sample is supported by the responses to multiple surveys (Ref: Robot Familiarity and Use, Robot Opinions and Attitudes, Assistance Preference Checklist).

If the technology was to be useful for the industrial workforce and assumed to be accepted, this exploratory study has found that employees > 42 years may not indicate a lesser interest of adoption as found by Chen and Chan (2011). The average sampled age of 41.37 years represents the industrial workforce at this site and as previously mentioned survey results of those > 42 years still point to overall acceptance. Because Chen and Chan's (2011) research was limited to domestic environments, this project confirms there is a need for research in this field. Despite the small sample size for this project, it is theorized some descriptors, like age, may not be boundary conditions in regards to advanced technology acceptance in the home versus workplace.

The emphasis placed on training by the workforce at this site indicates the need for an "active learning process" in regards to the introduction of industrial robots. Industrial robots will change work demands for both younger and older workers. Studies by Lee, Czaja & Charit, 2009 remain applicable to industrial robot acceptance. Those > 42 years that were more hesitant regarding acceptance may believe they will be capable of learning new skills and participating in training classes (Lee, Czaja & Sharit, 2009).

The difference in opinion about the team environment at the site can be a distinct factor towards robot acceptance. If management believes there are plenty of team options, the introduction of an industrial robot may not be presented with this consideration in mind. There is potential for the workforce to not consider the robot a "team member", but the opposite and an advanced technology that is replacing human work. However, the workforce may support the additional interaction with a robot because it is comparable to teamwork and working together. Due to the smaller sample size and exploratory aims of this project, more research should be done to observe the interactions between human and robot within industry. Further research should draw conclusions relating back to the theory of acceptance and team environment as a suspect boundary condition.

Caveats and Future Directions

This exploratory project contributed to the confirmation or necessity to research conditions of acceptance. However, this study's small sample size does not confirm nor deny existing theories regarding acceptance. This project establishes potential conditions important in industrial robot acceptance that should be explored in the future within the context of multiple site-studies with larger respondent groups. These boundary and facilitating conditions act as a baseline for generalities regarding industrial robot acceptance. For topics such as preference for human or robot assistance with simple tasks, research with larger samples can form added conjectures.

Due to the method limitations and scope of the research, little statistical analysis could be performed, especially to form conclusions from the Workplace Culture Survey. Generalities and agreement was largely based upon rank-order and bulk groupings as a result of lack of consensus from the respondents. There may also be misinterpretations due to limited statistical analysis and increased focus on plausible themes or trends.

Biases were not identified with this exploratory study; potential biases may exist due to only subjective data being collected coupled with the fact that actual interaction with robots did not occur. There were also limitations regarding the time frame for research and data collection. Due to the time frame, there was an inability to request participation from all employees resulting in the smaller sample size. Therefore as this research provides a starting point for industrial robot acceptance in the spectrum of HRI, there is a need for future studies and developments.

Additional research can focus on age as a demographic factor for industrial robot acceptance and expand upon the boundary and facilitating conditions of acceptance in relation to culture. Technology experience was used to make preliminary conjectures, however age as a second factor for technology experience may propose additional themes or trends to acceptance. Hypotheses regarding manufacturing facilities can center on training, vision and goals or teamwork with efforts to confirm or refute assumptions from this exploratory project. The general hypotheses for industrial robot acceptance will also not be limited to a specific facility as many sites can be studied. Specifics regarding culture may vary across manufacturing sites; therefore the emphasis on boundary and facilitating conditions with demographics as an influence is a future direction for this type of research. Further research may also consider clarifying the surveys or adjusting questions. For example, innovation was a topic that resulted in conflicting responses; however the topic of innovation in can be open to interpretation. Innovation can be in regards to the tools or equipment or how innovative the company is as an entity; this clarification was not made in this study. Therefore, the following themes and topics should be considered for prospective studies:

- The correlation of descriptors such as age and technology experience with robot opinions and acceptance
- Existence of culture, training, job satisfaction and teamwork as conditions to robot acceptance

CHAPTER 6: CLOSING

In conclusion, this study helped to connect existing frameworks regarding robot acceptance in the home with potential themes about robot acceptance in industry. Future research is required to expand upon the baseline theories presented about advanced technology acceptance's relation to demographics and conditions of culture. Themes include conditions such as adequate training, teamwork and shared vision amongst demographics such as age groups technology experience.

REFERENCES

Bellot PhD, RN, MHSA, Jennifer, "Defining and Assessing Organizational Culture" (2011) *School of Nursing Faculty Papers & Presentations.* Paper 34.

Brower, T. (2014). Bring work to life by bringing life to work: A guide for leaders and organizations. Bibliomotion.

Chen, K. & Chan, A. H.S. (2011). A review of technology acceptance by older adults. Gerontechnology, 10(1), 1-12.

Complementary use of Qualitative and Quantitative Cultural Assessment Methods. Charlene A Yauch, Harold J. Steudel

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

Detert, J., Schroeder, R., & Mauriel, J. (2000). A Framework for Linking Culture and Improvement Initiatives in Organizations. The Academy of Management Review, 25(4), 850-863.

Ezer, N., Fisk, A. D., & Rogers, W. A. (2009). Attitudinal and intentional acceptance of domestic robots by younger and older adults. Lecture Notes in Computer Science: Universal Access in Human-Computer Interaction, Intelligent and Ubiquitous Interaction, 39-48.

Gershon, R, R.M. DrPH, MHS, MT, Stone, P. W. PhD, RN, MPH, Bakken, S, DNSc, RN, Larson, E, PhD, RN, CIC. (2004). Measurement of Organizational Culture and Climate in Healthcare. JONA, 34(1).

Guizzo, E., & Ackerman, E. (2012). How rethink robotics built its new baxter robot worker. IEEE Spectrum. Received from http://spectrum.ieee.org/robotics/industrial-robots/rethink-robotics-baxter-robot-factory-worker.

Hancock, P., Billings, D., Schaefer, K., Chen, J., Visser, E., Parasuraman, R. (2011). Meta-Analysis of Factors Affecting Trust in Human-Robot Interaction. Human Factors: The Journal of the Human Factors and Ergonomics Society 2011 53:517.

Hofstede, G., Neuijen, B., Ohayv, D., Sanders, G. (1990). Measuring Organizational Cultures: A Qualitative and Quantitative Study across Twenty Cases. Administrative Science Quarterly, 35: 286-316.

ISO Standard 8373:1994, Manipulating Industrial Robots – Vocabulary. (2007). American National Standards Institute.

Koten, A. Organizational Culture DNA. The Alder Koten Institute. http://www.alderkoten.com/institute/2013/10/breaking-dna-organizational-culture/

Kumar, V., Bekey, G., & Zheng, Y. (2005). Industrial, Personal, And Service Robots. Robotics: State of the Art and Future Challenges, 55-62. Retrieved April 22, 2015, from http://wtec.org/robotics/report/05-Industrial.pdf

Lee, C. C., Czaja, S. J., & Sharit, J. (2009). TRAINING OLDER WORKERS FOR TECHNOLOGY-BASED EMPLOYMENT. *Educational Gerontology*, *35*(1), 15–31.

O'Reilly, C., Chatman, J., Caldwell, D. (1991). PEOPLE AND ORGANIZAITONAL CULTURE: A PROFILE COMPARISON APPROACH TO ASSESSING

PERSON-ORGANIZATION FIT. *Academy of Management Journal*, 34(3), 487-516.

Quantifying Corporate Culture | CR Magazine. (n.d.). Retrieved March 1, 2015, from http://www.thecro.com/content/quantifying-corporate-culture

Robbins, S. (2013). *Essentials of organizational behavior* (12th ed.). Upper Saddle River, NJ: Pearson/Prentice Hall.

Rousseau, D., Cooke, Robert. Organizational Culture: Not Just Another Name for Climate. *Human Synergistics*. Retrieved from http://peak.ca/pdf/services/organizational-development/culture-change/Culture-and-Climate.pdf

Sharit, J., Czaja, S. J., Hernandez, M. A., & Nair, S. N. (2009). The employability of older workers as teleworkers: An appraisal of issues and an empirical study. Human Factors and Ergonomics in Manufacturing, 19, 457-477.

Slater, K. (2011). *Great Culture. Great Workplace.* Milwaukee: Kahler Slater, Inc.

Smarr, C.-A., Fisk, A. D., & Rogers, W. A. (2013). *Towards a qualitative framework of acceptance of personal robots* (HFA-TR-1304). Atlanta, GA: Georgia Institute of Technology, School of Psychology, Human Factors and Aging Laboratory.

Straub, D., Keil, M., & Brenner, W. (1997). Testing the technology acceptance model across cultures: A three country study. Information & management, 33(1), 1-11.

Tharp, B. (2009, April 1). Defining "Culture" and "Organizational Culture": From Anthropology to the Office. Haworth, 1-5.

Top News. (n.d.). Retrieved May 9, 2015, from http://www.ifr.org

APPENDIX A: DEMOGRAPHICS QUESTIONNAIRE

Participant ID_____

Please answer the following questions. All of your answers will be treated confidentially. Any published document regarding these answers will not identify individuals with their answers. **If there is a question you do not wish to answer, please just leave it blank and go on to the next question.** Thank you in advance

Demographics Questionnaire

Gender: Male ☐1 **Female** ☐2 **Age: _____**

Years of service (with present company): _____

Years of service (total): _____

1. **What is your highest level of education?**

☐1 No formal education
☐2 Less than high school graduate
☐3 High school graduate/GED
☐4 Vocational training
☐5 Some or in-progress college/Associate's degree
☐6 Bachelor's degree (BA, BS)
☐7 Master's degree (or other post-graduate training)
☐8 Doctoral degree (PhD, MD, EdD, DDS, JD, etc.)

2. **Current marital status (check one)**

☐1 Single
☐2 Married
☐3 Separated
☐4 Divorced
☐5 Widowed
☐6 Other (please specify) _____

3. How would you describe your primary racial group?

☐1 No Primary Group
☐2 White Caucasian
☐3 Black/African American
☐4 Asian
☐5 American Indian/Alaska Native
☐6 Native Hawaiian/Pacific Islander
☐7 Multi-racial
☐7 Hispanic or Latino
☐9 Other (please specify) _____

4. Is English your primary language?

☐1 Yes
☐2 No

7 a. If "No", What is your primary language? _____

5. What is your primary occupational status? (Check <u>one</u>)

☐1 Hourly- Contracted
☐2 Hourly
☐3 Non-Exempt
☐4 Exempt
☐5 Exempt- Management
☐6 Exempt- Executive
☐7 Other (please specify) _____

APPENDIX B: TECHNOLOGY EXPERIENCE SURVEY

Technology Experience Profile

1. Within the last year, please indicate how much you have used any of the technologies listed below.

		Not sure what it is$_1$	Not used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
Communication Technology						
a.	Answering Machine/ Voicemail (e.g., record and retrieve messages)					
b.	Automated Telephone Menu System (e.g., pay bills, refill prescriptions)					
c.	Fax (e.g., receive and send printed documents)					
d.	Mobile Phone (e.g., make and receive calls)					
e.	Text Messaging (e.g., BBM, iMessage, SMS)					
f.	Video Conferencing (e.g., Skype, Facetime)					

		Not sure what it is$_1$	Not used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
Computer Technology						
g.	Desktop/Laptop Computer					
h.	Email (e.g., Gmail, Yahoo)					
i.	Photo/Video Software (e.g., editing, organizing; iPhoto, Picture Manager, Photoshop)					
j.	Productivity Software (e.g., Excel, PowerPoint, Quicken, TurboTax, Word)					
k.	Social Networking (e.g., Facebook, MySpace)					
l.	Tablet Computer (e.g., iPad, Touchpad, Zoom)					
Everyday Technology						
m.	Automatic Teller Machine (ATM)					
n.	Photocopier (e.g., Lexmark, Xerox)					
o.	Home Security System (e.g., Ackerman Security System, ADT)					
p.	In-Store Kiosk (e.g., grocery self-checkout, price checker)					
q.	Microwave Oven					
r.	Programmable Device (e.g., coffee maker, thermostat)					

		Not sure what it is$_1$	Not used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
Health Technology						
s.	Blood Pressure Monitor (e.g., measure blood pressure)					
t.	Digital Thermometer (e.g., measure temperature)					
u.	Health Management Software (e.g., diet, exercise, keep track of weight)					
v.	Heart Rate Monitor (e.g., measure heart rate, pulse)					
w.	Medication Reminder Device (e.g., schedule electronic alerts)					
x.	Pedometer (e.g., measure walking distance)					
Recreational Technology						
y.	Digital Music Player (e.g., iPod, MP3 player, Zune)					
z.	Digital Photography (e.g., camcorder, camera)					
aa.	Electronic Book Reader (e.g., Kindle, Nook)					
bb.	Gaming Console (e.g., Playstation, Wii, XBox)					
cc.	Online Coupons/ Shopping (e.g., Amazon, Groupon, retail stores)					
dd.	Recording and Playback Device (e.g., Blu-Ray, CD, DVD, DVR, VCR)					

		Not sure what it is$_1$	Not used$_2$	Used once$_3$	Used occasionally$_4$	Used frequently$_5$
Transportation Technology						
ee.	Airline Kiosk (e.g., check in, print boarding pass)					
ff.	Bus Tracker (e.g., check location of buses, estimate time of arrival)					
gg.	Map Software (e.g., get directions, plan routes; Google Maps, MapQuest)					
hh.	Navigation System (e.g., GPS, OnStar)					
ii.	Online Travel Reservation (e.g., airline website, Expedia, Travelocity)					
jj.	Parking Payment System (e.g., exiting lot, paying for space)					

APPENDIX C: ROBOT OPINIONS AND ATTITUDES QUESTIONNAIRE

ROBOT OPINIONS AND ATTITUDES QUESTIONNAIRE

Imagine that you have the opportunity to use or operate a robot. Please place an X in the response box that best represents your general opinion (we understand that there may be exceptions).

1. My interaction with a robot would be clear and understandable.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

2. I would find a robot useful in the workplace.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

3. Using a robot would enhance my effectiveness in the workplace.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

4. Using a robot in the workplace would increase my productivity.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

5. Using a robot would make my job easier.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

6. Using a robot would improve the workplace.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

7.

Using a robot in the workplace would enable me to accomplish tasks more quickly.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

8. I would find a robot easy to use.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

9. I would find a robot to be flexible for me to interact with.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

10. It would be easy for me to become skillful at using a robot.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

11. I would find it easy to get a robot to do what I want it to do.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

12. Learning to operate a robot would be easy for me.

☐1	☐2	☐3	☐4	☐5	☐6	☐7
Extremely Unlikely	Quite Unlikely	Slightly Unlikely	Neither	Slightly Likely	Quite Likely	Extremely Likely

13. Would you use a robot?

☐1	☐2	☐3
Yes	No	Maybe

APPENDIX D: ASSISTANCE PREFERENCE CHECKLIST

Assistance Preference Checklist

We are interested in learning about preferences for assistance in performing daily workplace tasks. In particular, we are looking for opinions about human assistance and robot assistance. When completing this questionnaire, please consider your **current abilities** in completing each task.

For each of the following tasks, please provide your opinion about whether you would prefer:

- Human assistance
- Robot assistance

Assume that the robot could perform the task to the level of a human. Please circle the most appropriate response for your general preference (we understand that there may be exceptions).

	***If I currently want assistance*, I would prefer help from…**				
	Only a human	**Prefer a human**	**No Preference**	**Prefer a robot**	**Only a robot**
Activities					
Calling the stockroom	**1**	**2**	**3**	**4**	**5**
Calling a support specialist or PE	**1**	**2**	**3**	**4**	**5**
Moving a kit cart	**1**	**2**	**3**	**4**	**5**
Installing nuts and bolts	**1**	**2**	**3**	**4**	**5**
Picking hardware or piece parts from bins	**1**	**2**	**3**	**4**	**5**
Lifting heavy parts	**1**	**2**	**3**	**4**	**5**
Soldering (if applicable)	**1**	**2**	**3**	**4**	**5**
Aligning parts or components	**1**	**2**	**3**	**4**	**5**
Disinfecting	**1**	**2**	**3**	**4**	**5**
Unwrapping parts	**1**	**2**	**3**	**4**	**5**
Completing tasks in eDHR	**1**	**2**	**3**	**4**	**5**
Typing username and password	**1**	**2**	**3**	**4**	**5**
5s (sort, set, shine, standardize, sustain)					
Sweeping area	**1**	**2**	**3**	**4**	**5**
Putting away tools	**1**	**2**	**3**	**4**	**5**
Taping floor/re-labeling	**1**	**2**	**3**	**4**	**5**
Grip					
Using hand tools	**1**	**2**	**3**	**4**	**5**
Holding parts during install	**1**	**2**	**3**	**4**	**5**
Reach					
Bending down to floor	**1**	**2**	**3**	**4**	**5**
Reaching above head	**1**	**2**	**3**	**4**	**5**
Walking					
Climbing five steps to get part	**1**	**2**	**3**	**4**	**5**

Walking on flat ground	**1**	**2**	**3**	**4**	**5**

APPENDIX E: ROBOT FAMILIARITY AND USE QUESTIONNAIRE

ROBOT FAMILIARITY AND USE QUESTIONNAIRE

For the following robots, please indicate your familiarity in terms of hearing about them, using them, or operating them. Please circle only one option.
Occasionally= once or twice in past 6 months, Frequently= more than twice in past 6 months

Robots	Never heard about, seen, or used this robot[1]	Have only heard about or seen this robot[2]	Have used or operated this robot only occasionally[3]	Have used or operated this robot frequently[4]
1. Autonomous Car	1	2	3	4
2. Programmable Robots	1	2	3	4
3. Manufacturing robot (e.g., robotic arm in factory)	1	2	3	4
4. Low Payload Robot (e.g. soldering, arc welding)	1	2	3	4
5. Material Handling Robot	1	2	3	4
6. Collaborative Robot (e.g. Baxter)	1	2	3	4
7. Foundry Robots (e.g. metal casting)	1	2	3	4
8. Robot security guard	1	2	3	4

9. Parallel Robots (e.g. picking and packing)	1	2	3	4
10. Paint Robots	**1**	**2**	**3**	**4**
11. Customer Assistance Robots	**1**	**2**	**3**	**4**

APPENDIX F: WORKPLACE CULTURE SURVEY

Workplace Culture Survey

Sort the following statements least true to most true. Please keep in mind that you are sorting these items according to your own preferences and the culture of the organization. Organization refers to your current workplace and employer.

Statements:

1. I am able to meet my current work demands.
2. My workplace expects too much from its employees.
3. I work harder when compared to my fellow employees.
4. I would benefit from more training to meet my current work demands.
5. I want more training for my current work demands.
6. It is important for an organization to provide training courses to its employees.
7. The physical spaces in the workplace, such as the micro mart cafeteria, are very appealing.
8. The break areas in the workplace are ideal and the best they can be.
9. I am satisfied with my current career path within manufacturing.
10. My current job is a perfect job for me.
11. I have good job security.
12. My job is meaningful to me and those around me.
13. My workplace encourages failure and learning from mistakes.
14. My workplace encourages teamwork.
15. My workplace and job allows me to work on a team.
16. The organization that I work for is innovative, always developing new technologies.
17. I share the same values as my organization.
18. My organization is focused on the outcome, not the people.

Scale	Statement (1, 2, 3…)
Least True	
Most True	

APPENDIX G: INTERVIEW SCRIPT

italics = action items or reminders (not said to the participant)

Protocol Materials

Computer
Digital audio recorders (2)
Extra batteries (AAA's)
Consent (2)
Debriefing
Questionnaires (bring extra copies & large print versions)
Microphone
Water
Pens (3)
Participant's cell phone number

General Interviewer Prompts (i.e., said only when needed)

- *If participant focuses too much on one thing (e.g., size, speed, safety), capture their point then say: "Thank you for your comments about _____, what are your thoughts about [re-ask question]?"*
- *If participant focuses on their own (or someone they know) needs, instead of the persona then say: "thank you for your comments. Now considering Mr(s)____ abilities, what are your thoughts about [re-ask question]?*
- *If participant is having difficulty answering the question, then say: "Please, take a moment and think about it. Then give me your best guess."*
- *Prompt: Tell me more about that.*
- *Prompt: Can you tell me what you mean by ___<repeat participant's wording>__*

- *Prompt: At the end of this interview, you can ask anything you want about the project.*

Greet Participant

- *Escort participant to testing room*

Informed consent

- *Administer Informed Consent*

Set up for interview

- To make sure the audio recorder captures everything, we would like to use a microphone. May I clip this microphone to the lapel of your shirt?
    - *Clip microphone 2-3 inches from person's mouth (if possible). Make sure microphone is tilted away from the person's shirt.*

General Introduction

Thank you for participating in our study.

Welcome. My name is Melissa and I work in Bays 1 and 2 as a Manufacturing Engineer. I am currently in graduate school and this project is for my thesis. Today we are going to talk about workplace culture.

Topic and goal

The goal of this research is to better understand what employees think about robots in the workplace and how to promote a culture of technology acceptance. Your information will help us to conduct research on the culture portion of this topic and, ultimately, to develop ways of positive acceptance in a manufacturing environment.

There are 2 parts to this session:

- First, we will discuss workplace culture in terms of people and behaviors and team environment.
- Second, I will ask you to fill out a demographics questionnaire.

There is no rush for any of these questions. Our session will take approximately 30 minutes. There is no right or wrong answers. We are interested in your thoughts and opinions. Please feel free to express your opinion, whether it is positive or negative. Some of these questions may seem repetitive, so it is okay if your answers overlap.

Icebreaker

Let's start with a just a few general questions.

<START RECORDER>

- What do you think it means when I say "workplace culture"?

Workplace culture for the purposes of this project encompasses three main topics- people and behaviors, team environment and physical spaces. For this interview, we will be focusing on people and behaviors and team environment.

People and behaviors include a person's attitudes about an object or situation, emotions, intentions, job satisfaction, perceived organizational support and employee engagement.

Team environment is how employees perceive the characteristics of an organization's culture. Characteristics can include an organization's attention to detail, innovation, risk taking, people-orientated, team orientated and stability.

- Are there any questions on those topics before we begin?

Part 1: People and Behaviors

Q1: How would you describe manufacturing employees' acceptance of change? For example, are there any hurdles or hesitations or complete openness at the site?

Q2: What does the site do to introduce or promote change that will or is occurring throughout the site?

Q3: What does the site do to promote employee engagement?

a. Do you believe this has had a positive impact on the culture?

Q4: How do you think the manufacturing personnel perceive management?

a. Do you feel the interaction is supportive?

b. What other actions do you think would increase the feelings of employee support?

Q5: How do you perceive the workforce regarding job satisfaction in the industry's current state?

Part 2: Team Environment

Q6: What opportunities does the site provide for the employees to work cross functionally or in teams?

Q7: In your opinion, is there a shared vision across the site with specific goals?

a. What is that shared vision?

b. What are the goals?

c. How is the shared vision communicated to all employees?

Q8:Describe how the site may or may not empower its employees to go above and beyond their daily roles and responsibilities.

a. What opportunities exist for this action?

Q9:Do you see employees take initiative to work in teams or side projects, if so how?

Closing Comments

Thank you for participating in this interview. This concludes the interview portion and before you leave, I have a short demographics questionnaire for you to fill out.. Thank you again for all of your comments and insights!

<STOP RECORDER>

Hand interviewee the demographics questionnaire and pen.
Collect questionnaire and pen.

APPENDIX H: ADDITIONAL TABLES AND FIGURES

Table H.1: Demographics- Gender and Age

	Age					
Gender	**21-30**	**31-40**	**41-50**	**51-60**	**60+**	**Unknown**
Male	6	6	11	5	1	3
Female	2	0	1	0	0	1
Unknown	0	0	0	0	0	1

Table H.2: Demographics- Occupation and Age

	Age					
Occupation	**21-30**	**31-40**	**41-50**	**51-60**	**60+**	**Unknown**
Hourly-Contracted	0	0	0	0	1	0
Hourly	2	3	3	1	0	1
Non-Exempt	4	2	9	4	0	4
Exempt	2	1	0	0	0	0

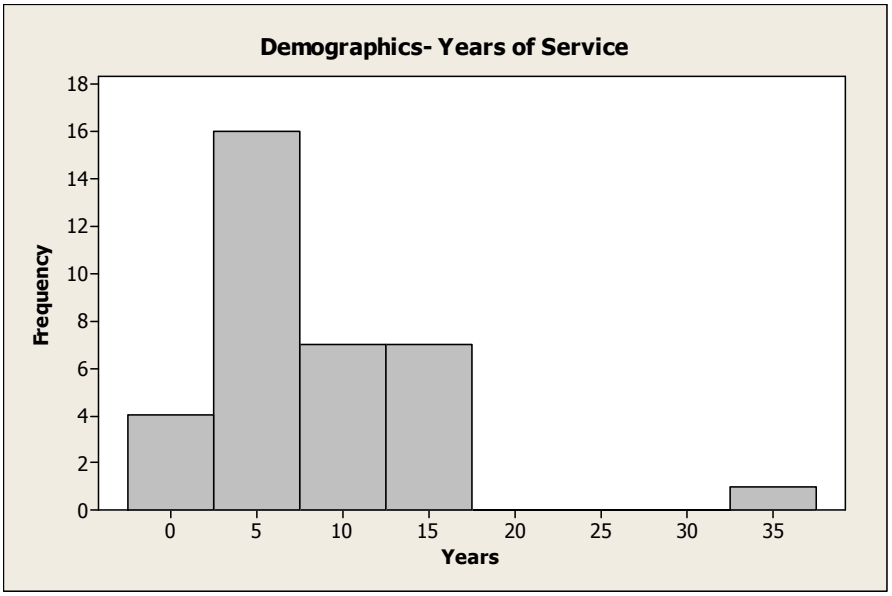


Figure H.1: Years of Service

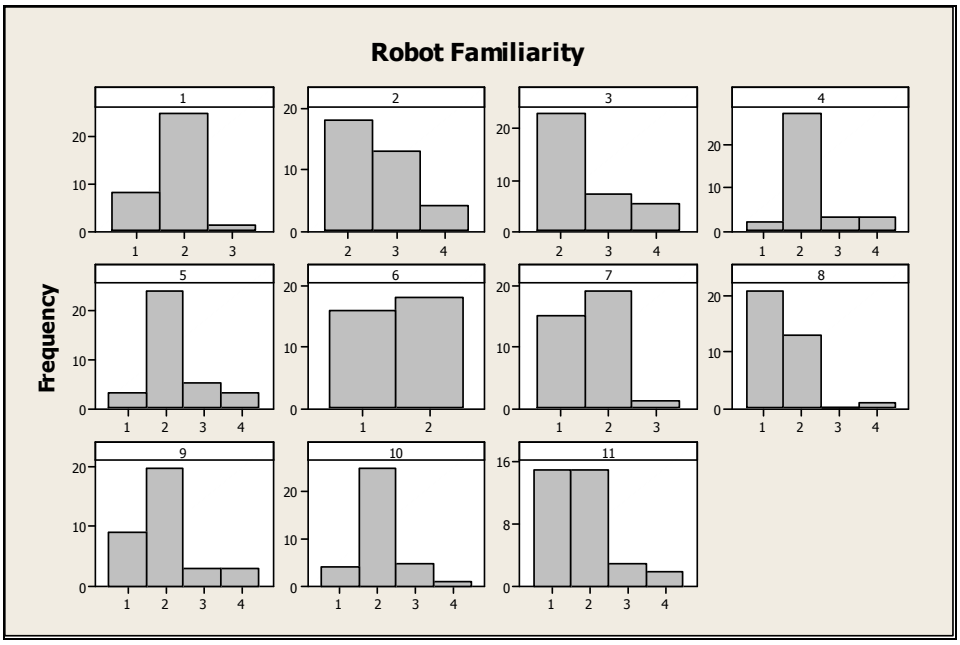


Figure H.2: Robot Familiarity