Computers in Human Behavior 145 (2023) 107763

Contents lists available at ScienceDirect

Computers in Human Behavior

journal homepage: www.elsevier.com/locate/comphumbeh

The forgotten teammate: Considering the labor perspective in human-autonomy teams

Sydney R. Begerowski [a], Katelyn N. Hedrick [a], Flanagan Waldherr [b], Laine Mears [b], Marissa L. Shuffler [a,*]

[a] Department of Psychology, Clemson University, United States
[b] Department of Automotive Engineering, Clemson University, United States

ARTICLE INFO

Handling Editor: Paul Kirschner

Keywords:
Human-autonomy teaming
Teamwork
Qualitative
Field work
Human worker

ABSTRACT

Advancements in technology, such as autonomous agents, have sparked a substantial increase in human-autonomy teaming (HAT) research. Despite this increase in research, there is one perspective that is often overlooked in the literature: the human worker. As such, our research extends the literature by presenting the worker's perspective and providing key contextual considerations for successful integration of HATs within field environments. To accomplish this, interviews, focus groups and site visits were conducted in both the construction and manufacturing industries. We aim to answer two questions: (1) what are the subjective worker experiences regarding HATs in the field? And (2) what is the influence of context on worker experiences in field HATs? We discuss three themes that emerged, followed by implications for research and practice.

1. Background

The ongoing, large-scale implementation of information technology in all areas is presently driving an "explosion" of research and development on autonomous agents (Wang et al., 2021). Industries across the world have begun implementing autonomous agents into their workforce at a rapid pace including the fields of medicine (Kasina et al., 2017; Williams et al., 2019), manufacturing (Evjemo et al., 2020; Inkulu et al., 2021), spaceflight (Gao & Chien, 2017; Hambuchen et al., 2021) and construction (Ardiny et al., 2015; Xu & de Soto, 2020). Importantly, as technology is becoming more advanced, the notion of agents is said to be transitioning from "tool to teammate" (e.g., Bradshaw et al., 2007; Rebensky et al., 2022; Rix, 2022). That is, rather than functioning as a resource to support teams, autonomous agents are expected to exhibit teamwork behaviors and varying levels of independence, thereby functioning as members of the team.

This proposed transition demonstrates a critical need to understand how autonomous agents can and will interface with human team members, and how fundamental concepts of human-human teaming will apply to Human-Autonomy Teams (HATs). With research on HATs growing at an exponential rate (Seeber et al., 2020), several human-human teaming constructs are being investigated within the contexts of HATs. This research examines constructs including coordination (e.g., Demir et al., 2018; Schneider et al., 2021), trust (e.g., Hancock et al., 2021; Schaefer et al., 2018), shared cognition (e.g., Andrews et al., 2022; Schelble et al., 2022), and communication (e.g., Baker et al., 2021; Johnson et al., 2021), among others. However, nearly all empirical HAT studies occur within lab settings. Recent reviews highlight the need for further field research on HATs to understand the effectiveness of HATs in applied settings, particularly in regard to workplace context (Larson & DeChurch, 2020; O'Neill et al., 2022).

Nonetheless, industries continue to adopt advanced technologies at unprecedented rates, particularly in labor-intensive industries (Autor et al., 2022). For instance, construction and manufacturing continue to advocate for HAT integration for a variety of reasons, such as combatting skill shortages (Taylor et al., 2016; Wellener et al., 2021), lowering fatality rates (Aghimien et al., 2020; Bhatt et al., 2020), increasing safety (Gunadi & Ryu, 2021; Njord et al., 2006), and improving cost savings (Ashima et al., 2021; Daneshgari & Moore, 2018). While HATs have the potential to ease these issues, fast levels of integration have led to more problems than solutions. In fact, research suggests that rapidly increasing automation has eroded human involvement in manufacturing

Abbreviations: HAT, Human-Autonomy Team.

* Corresponding author. Department of Psychology Faculty Fellow, Clemson School of Health Research Clemson University, 418 Brackett Hall Clemson, SC, 29634, United States.

E-mail address: mshuffl@clemson.edu (M.L. Shuffler).

https://doi.org/10.1016/j.chb.2023.107763
Received 5 October 2022; Received in revised form 3 March 2023; Accepted 25 March 2023
Available online 27 March 2023
0747-5632/

(Elprama et al., 2017; Sauppé & Mutlu, 2015), leading to outcomes including declined worker satisfaction (Welfare et al., 2019), engagement (Morris et al., 2017; Sverke & Hellgren, 2002) and output (Blumberg & Alber, 1982; Clampitt & Downs, 1993).

Given these concerns, it is evident that the state of the literature on HATs does not adequately account for field contexts, thus lacking a clear translation to the industry. While some research addresses strategies for integration (e.g., Schelble et al., 2020), many fail to consider the perspective of the individuals who will interact with an autonomous teammate the most - the worker. Consideration of the worker perspective offers a richer understanding of potential applications of HATs and strategies for effective integration.

Therefore, the present study responds to the call by O'Neill et al. (2022) to leverage qualitative field research methods when considering the human experience in HATs. Interviews, focus groups with subject matter experts, and site visits were conducted within two separate industries currently using autonomous agents in their workforce: construction and manufacturing. The manufacturing industry has typically demonstrated higher rates of HATs than the construction industry (Brosque & Fischer, 2022), so investigating both allows for a broader perspective on the role of human workers while also examining unique considerations of industries that are in different implementation stages. Specifically, we aim to extend the HAT literature by presenting the worker's perspective to expand upon current notions of HATs, demonstrating the value of qualitative approaches for elucidating key nuances underlying HAT effectiveness, and providing contextual considerations for successful HATs functioning within field environments. In doing so, we highlight the importance of the worker perspective within HATs, thereby encouraging methods for research and integration of HATs in a manner that preserves the relevance of human workers in the face of rapid technological development.

2. Literature review

2.1. Human-autonomy teaming

Teams represent a group of individuals working interdependently towards a common goal (Mathieu et al., 2001) that engage in various behaviors, leading to affective and cognitive emergent states (Bell et al., 2018). The simple inclusion of an autonomous agent in a team is not, however, enough to constitute a human-autonomy team. Synthesizing over three decades of research on human-autonomy teaming, O'Neill et al. (2022) put forward specific criteria that must be met to be considered a human-autonomy team. Failure to meet these criteria produces a reliance on the technology as a resource to enhance teamwork, rather than the agent functioning as a teammate. As such, it is imperative to understand these criteria to properly assess current HATs in the field.

Perceptions of autonomous agents as teammates are dependent on two factors: interdependence and agency (O'Neill et al., 2022). First, the agent must exhibit a degree of interdependence when working with other teammates and across tasks (Walliser et al., 2017). Second, the agent must have a degree of agency that demonstrates independence of actions (Wynne & Lyons, 2018). These criteria can be better understood when assessing the level of automation (LoA) of the agent. LoA conceptualizes both physical and cognitive abilities of an agent across a continuum, ranging from fully manual to fully automated (Fasth et al., 2011). LoA translates to descriptions of agent autonomy (O'Neill et al., 2022); for example, an agent low in autonomy would rely on a human operator to make all decisions and actions, with the agent unable to complete actions without receiving direction and approval. On the other end, an agent high in autonomy can make decisions and act on these decisions without the need for human input. Consequently, agents low in autonomy tend to function more as a tool whereas agents high in autonomy resemble a teammate due to the capability to manage interdependencies within the team and do so in an agentic manner. When these conditions are met, humans exude politeness towards agents, use notions of self and other, and even adjust to programmed personalities of the agent (Nass et al., 1995; O'Neill et al., 2022). In turn, this perception of a teammate begins to lead to more affective states that resemble key emergent states in human teams (e.g., trust, perceived efficacy and competence, cohesion).

2.2. Worker representation in HAT research

Despite growing use of HATs in the workplace, the role of worker preferences in field HATs research is significantly limited. Job preferences (i.e., factors of a job that impact worker well-being and satisfaction) have long been studied without respect to technology integration in the workplace (Jurgensen, 1978; Wanberg et al., 2020). In manufacturing, this often looks like understanding worker attitudes regarding plant design (Park, 2019) or job rotation (Botti et al., 2021). In construction, the emphasis is placed on preferences such as sources of information and working hours, among others (Burns & Conchie, 2013; Goodrum, 2003).

The introduction of technology also prompted significant research attention in terms of automation (Frank et al., 2019; Nam, 2019), merely assessing general outcomes of technology integration such as productivity (e.g., Autor et al., 2022) and safety (e.g., Gleirscher et al., 2020). Studies that do investigate worker preferences often investigate attitudes towards robotics for job replacement (e.g., Bhargava et al., 2021; Mokyr et al., 2015). Other topics can include preferences on advanced technologies for training (Kaasinen et al., 2020), decision-making (Cao et al., 2021), or even safety procedures (Nnaji et al., 2021). Understanding worker preferences regarding technology can inform proactive redesign of tasks to optimize worker success (Parker & Grote, 2022). However, articles regarding worker preferences often fail to capture the nuances regarding technology as a teammate. In fact, very few studies have addressed the notion of augmentation over automation, i.e., incorporating agents to enhance existing worker capabilities and tasks rather than complete replacement of workers with agents (Matarić, 2017). One exception we found was Welfare et al.'s (2019) study in which 50 construction workers were interviewed regarding their attitudes towards robots on the jobsite. While their findings emphasized the critical importance of augmenting work through human-agent interaction, none of the workers had experience in HATs; all questions were hypothetical in nature. While this is likely due to the relatively new paradigm shift of autonomous agents serving as teammates and recent adoption of HATs in the field, it is critical to understand worker perspectives from those who have worked in HATs. In order to fill this gap, we set out to answer the following research question:

RQ1. What are the subjective worker experiences and perceptions of human-autonomy teams, regardless of workplace context?

2.3. Approaches to empirical studies

The majority of empirical studies regarding HATs are conducted within lab settings (O'Neill et al., 2022), which are relatively short in nature and merely propose practical implications (Kozlowski, 2015). These studies tend to be simplistic in nature (e.g., building legos, fetching parts, object placement) which is helpful in examining theoretical relationships, particularly when assessing applicability of human-human teaming phenomena to HATs. Nonetheless, such approaches fail to account for dynamic environments and task complexities within field settings. These studies comprise a significant portion of the existing literature, though a few recent exceptions exist (e.g., McNeese et al., 2021; Musick et al., 2021), paving way for more rigorous experimental designs (e.g., dynamic team tasks and simulations).

Additionally, context (i.e., the extent to which situational characteristics influence behavioral phenomenon in the workplace; Johns, 2006) is likely to play a significant role in the success of HAT integration. The assessment of contextual factors allows for a broader understanding of team dynamics by factoring in both broad (e.g., occupation, location, time) and discrete (e.g., task autonomy, teammate accountability, resource availability) phenomena that influence teams (Salas et al., 2015). For instance, organizational climate (i.e., collective agreement regarding workplace procedures, practices, and kinds of behaviors that are encouraged; Reichers & Schneider, 1990) is known to impact team functioning. Organizational climate is just one of many contextual factors that will likely significantly influence the extent to which employees feel they should value and engage in human-autonomy teaming practices. Yet, the role of organizational context is often overlooked in lab-based studies as the goal of these studies is to control for such external factors. As such, we propose the second research question:

RQ2. What is the influence of work context on worker experiences and perceptions of HATs?

2.4. The present study

The above summarizes the need to understand worker perceptions of HATs, including expanding the literature on worker preferences to address HATs directly, conducting research beyond laboratory studies to identify real-world implications, and understanding contextual factors that provide nuances to HAT functioning that may otherwise go unnoticed in controlled environments. Given that laborers will be the individuals working with autonomous agents most frequently, including them in the research and integration process will indeed provide valuable insights.

Our research seeks to highlight the importance of including the worker perspective when addressing each of these limitations. We use qualitative approaches to uncover worker sentiments from those with direct experience in HATs. In doing so, we provide guidance for future research as well as practical implications that emphasize worker involvement in the knowledge production and dissemination process.

3. Methods

Qualitative data were collected as part of two ongoing research projects that broadly focus on understanding how team members successfully integrate autonomous agents into predominantly human-centric work teams. Examining data from two research projects allowed for comparisons within and across industries at different stages of human-autonomy teaming.

The collection of qualitative data responds to O'Neill and colleagues' (2022) call for future research using methodologies that allow for a holistic and integrative understanding of workers' perspectives in HATs. More specifically, an iterative process of semi-structured interviews, focus groups with subject matter experts (SMEs), and observational site visits were utilized to allow for triangulation of key research themes. Table 1 below summarizes the data collected across the construction and manufacturing industries.

3.1. Recruitment of participants

Companies represented in this study served as Advisory Board Members of larger research grants looking at human-autonomy teaming issues. Advisory board members were practitioners from either the construction or manufacturing industry who expressed interest in HATs or had experience in implementing HATs. Each company had a primary point of contact that the researchers worked with to identify specific employees for participation. Additional companies were recruited through snowball sampling (Atkinson & Flint, 2001) in order to reach companies beyond the advisory boards.

Table 1
Data collection instances across industry.

	Industry	
	Construction	Manufacturing
Companies involved	10	5
Semi-structured interviews	10	18
Focus groups	7	3
Site visits	5	4

To participate in this research, companies needed to demonstrate implementation and ongoing use of HATs in their operations. We assessed the role of autonomous agents onsite according to O'Neill and colleagues' (2022) framework that accounts for interdependence and agency in order to determine if a company met these criteria. This includes (1) the agent in the HAT exhibiting a degree of interdependence when working with other teammates and across tasks (Walliser et al., 2017) and (2) the agent having a degree of agency that demonstrates independence of actions (Wynne & Lyons, 2018).

Finally, we ensured that the HATs in questions were of at least three entities (i.e., beyond the dyad). Despite autonomous agents presumably taking on a teammate role, few studies assess relationships beyond the dyad (i.e., one human and one agent; Demir et al., 2017). The assumption that phenomena in dyadic relationships will generalize to teams (i.e., three or more entities) is problematic. Affective and cognitive states manifest differently when in teams given that dyads fail to account for social processes such as emotional contagion and situational awareness (Moreland, 2010). Thus, only companies implementing HATs with at least two humans and one autonomous agent were selected.

In total, ten companies participated from the construction industry and five companies from the manufacturing industry. Within each company, frontline workers, middle management, and executive leadership were invited to participate in our research study. While the majority of the data collected were from frontline workers, we also included the perspective of middle managers and executive leadership. Understanding different levels of stakeholders embedded within the organization can elucidate key contextual factors affecting team dynamics (Savage et al., 1991), which are often excluded from lab research. Ensuring we spoke with individuals positioned throughout the company allowed us to gain a more nuanced understanding of multiple factors affecting attitudes towards HATs in the field.

3.1.1. Description of HATs in the construction context

There were several examples of HATs used on job sites in construction teams. The following details two examples of such HATs used by our participants. While specific names of agents have been removed for anonymity, the goal is to provide more detailed information in order to create a frame of reference for the themes later discussed.

One instance of a HAT in construction was centered around the task of concrete drilling. This is a labor-intensive process in which workers drill precise holes into concrete for various purposes (e.g., hanging tooling apparatuses). The holes can be drilled into walls and ceiling foundations, which are often upwards of fifteen feet tall. Because of this, concrete drilling, especially when into the ceiling, is considered an ergonomic risk and has increasingly become a target of agent augmentation (Brosque et al., 2021). To combat this risk and improve productivity, some job sites used an autonomous agent capable of drilling holes into the ceiling while the human workers simultaneously tackled drilling holes in the walls. The agent was capable of (1) moving through the jobsite independently and (2) completing its portion of the shared task, demonstrating interdependence among the team. Thus, we classified this as a HAT in the construction field context.

A second construction HAT we observed used an autonomous agent to assist with surveying and layout procedures: a long-standing process in which a team works together to indicate where foundations, columns, walls, and other structures will be erected. This is a highly interdependent task that requires communication and coordination between office and field personnel in order to ensure markings are made correctly and several factors are accounted for (e.g., horizontal and vertical curves, traverse computations, chain corrections; Crawford, 1995). Because this task is highly demanding and subject to the skills of the worker, it is often a source of significant rework on construction sites and only reasonable on small scale projects (Park et al., 2022). Some construction sites augmented this task with the use of an agent. Human workers would share information regarding blueprints and specifications, then the agent began surveying the site and creating chalk lines. If any errors, inconsistencies, or concerns were detected by the agent, these were sent to both office and site personnel who then work together to resolve the issue. This repeated until the full jobsite has been surveyed and marked. Given the continued communication and coordination between agent and human throughout this iterative process, we classified the surveying team as a HAT.

3.1.2. Description of HATs in the manufacturing context

Similarly, several examples of HATs in manufacturing contexts were identified. The following details two such examples.

One example of HATs in manufacturing comes as a result of the proliferation of collaborative robotic systems. Recent advances in control methodologies have significantly reduced the risk of working with robots, permitting a variety of assembly tasks to be completed by teams of humans and industrial robots (Weckenborg et al., 2020). This allows the relative strengths of human workers and industrial robots to be leveraged, with benefits to final product quality and with respect to ergonomic concerns. A robot in a collaborative setting may, for example, lift a component into an overhead position where human teammates install fasteners and make electrical connections. The common goal of successful installation relies on each teammate's tasks, whose execution is informed by the actions of the others (e.g., a collaborative robot altering course or interrupting motion in response to movement of human workers), demonstrating interdependence and motivating classification as a HAT.

Another example of a HAT in manufacturing dealt with vehicle undercarriage tasks. We observed an assembly line that used conventional suspension for the car chassis (i.e., the frame of the car hangs from the ceiling while moving down the assembly line), which allows for access to nearly all parts of the vehicle. However, there is a high risk for laborers assigned to undercarriage tasks. To complete these tasks, workers stand underneath the vehicle and reach above their heads, resulting in strain from repetitive motions outside of safe ergonomic zones. The manufacturer chose to position agents directly underneath the chassis to independently complete the physically strenuous tasks while workers perform complementary assembly tasks in more accessible positions during the chassis marriage process. As such, we classified this as another example of a HAT in manufacturing contexts.

3.2. Process

Qualitative research was conducted in two phases: an exploratory phase and a more targeted, investigative phase based on initial data collection. The first phase consisted of six semi-structured interviews and one focus group discussion with SMEs to allow the researchers to gain a general understanding of (1) worker sentiments towards HATs and (2) the construction and manufacturing context. After the first phase of data was collected, two co-authors utilized an inductive approach for thematic analysis wherein themes were developed based on the initial set of interviews and focus groups. The themes were presented to three SMEs to allow for feedback and guidance. The initial set of themes focused on the differing perspectives among stakeholders, the importance of team ABCs (i.e., affective, behavioral, and cognitive states; Bell et al., 2018) in HATs, and the influence of the context. These themes were used to guide our data collection in phase two which consisted of twenty-two interviews, nine focus groups, and nine site visits. In this phase of data collection, we revised our interview and focus group protocols to include more targeted questions in order to refine our initial set of themes and ensure data saturation (i.e., no new data, themes, or coding; Guest et al., 2006). Fig. 1 below summarizes the data collected within each phase.

3.3. Semi-Structured Interviews

In total, 28 semi-structured interviews were conducted with industry leaders and workers. As there is a lack of research surrounding practitioners' perspectives on the augmentation of work, semi-structured interviews were utilized to provide researchers with additional flexibility during the interview process (Wilson, 2014). More specifically, researchers were allowed to discuss emerging themes within the interview and ask the interviewees probing questions to establish a rich understanding of key issues. This led to the authors uncovering additional information that would not have been discovered in a structured interview. Sample questions from phase one include "What are your expectations for agents in [industry][1]?", "In what areas or processes do you see human-agent teaming being most helpful?", and "What are the fundamental skills that a human worker needs to be able to work with autonomous agents in [industry]?" Sample questions from phase two of data collection include "What are the barriers and facilitators to introducing agents in [industry]?" and "How do team members go about learning an agent's strengths and weaknesses?"

3.4. Focus groups

Furthermore, ten focus groups with SMEs were also conducted to allow for discussion among academic researchers and laborers. SMEs were defined as individuals who have familiarity with the construction and/or manufacturing industry. The typical size of the focus group ranged from four to seven, with the exception of a sixteen person focus group with industry leading professionals. Sample questions from phase one include "In your opinion, do you believe that utilizing agents will positively impact how you complete your work?" and "In your opinion, do you believe you are prepared to work with agents?". Three sample questions from phase two are "What should designers consider when developing human-computer systems that involve rich interactions among people and technology?", "How do you go about onboarding an agent into teams? What role does leadership play?", and "How can we best train teams to integrate autonomous agents?".

3.5. Site visits

Nine site visits were conducted to allow researchers to understand the context of both the construction and manufacturing industries. The lead researcher attended each site visit with an additional observer to help capture the nuances of the construction and manufacturing contexts. Each site visit began with a tour led by an industry professional. Given that these industries are in different phases of implementation, the observations focused on different contextual factors. Observations within the construction industry focused on understanding team dynamics, the infrastructure available to support implementation of autonomous agents, and identifying labor-intensive tasks. On the other hand, observations within the manufacturing context focused on understanding the general layout of the plant (e.g., plant structure), the level of automation (i.e., extent to which the agent exhibits agency and degree of interdependence; O'Neill et al., 2022), and understanding existing interactions among humans and autonomous agents. The tours were followed by informal interviews in which researchers could ask questions such as "where do you see potential applications for integration of autonomous agents into processes for [industry]?" These site visits were essential to developing a holistic and integrative

[1] Industry referents were adapted based on the specific interview, focus group, and/or site visit to reflect participants' industry (i.e., manufacturing, construction).

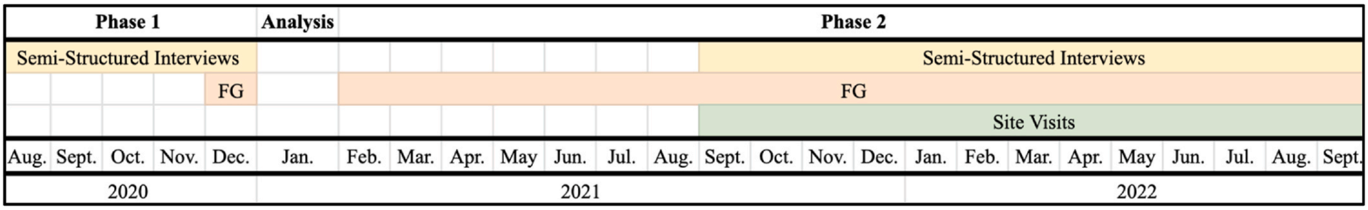

Fig. 1. Data Collection Phases. Note: FG signifies focus group.

understanding of the themes that emerged during the interview and focus group discussions.

4. Results

The qualitative analysis revealed three broad themes that will each be discussed in turn. Table 2 provides a summary of each theme and the key findings within them.

4.1. Theme 1: *Workers often feel their perspectives fall secondary to other factors, despite this threatening optimal use of HATs in industry*

The first theme we uncovered was centered around the extent to which workers felt valued and heard, particularly when it concerns use of HATs in relation to job demands. That is, workers expressed concern that their own experiences and opinions fall below other considerations when organizations begin to implement HATs in the field. This often led to increased reluctance to engage in HATing onsite, especially when the workers felt their knowledge could have impacted implementation of the agent. The following elaborates on (1) how worker reluctance to team with agents increases when use of agents results in more job demands and (2) the ways in which these feelings become amplified when technology and design firms (i.e., firms responsible for the development and dissemination of advanced technologies) do not account for worker experience.

Table 2
Overview of themes and key findings.

Theme	Key Findings
RQ1: What are the subjective worker experiences regardless of contexts?	
1. Workers often feel their perspectives fall secondary to other factors, despite this threatening optimal use of HATs in industry.	1.1. Workers were more reluctant to engage in HATing when they perceived an increase in demands due to inadequate opportunities to provide feedback on agent use.
	1.2. Workers communicated an increased burden specifically when technology and design firms prioritized market entry over market needs during agent development.
2. Workers recognize the potential of HATs to improve dynamic processes in the workplace, but often feel skeptical about current capabilities of agents in use.	2.1. Workers acknowledged the potential benefits of HATing to meet increasingly complex coordination processes in the field.
	2.2. Workers consistently named trust as a critical factor for successful human-autonomy teaming, and increasing knowledge of agents as a mechanism for improving trust.
RQ2: What is the influence of context on the worker experience?	
3. Workers feel that HATs are being increasingly used as a fail-safe against external contextual factors when this is not always the best approach.	3.1. The infrastructure of the workplace can significantly impact successful HAT integration and long-term worker perceptions towards HATing.
	3.2. Industry pressures such as the labor shortage function as an important contextual factor that can amplify worker sentiments towards HATs.

4.1.1. Sub-theme 1: Workers were more reluctant to engage in HATing when they perceived an increase in demands due to inadequate opportunities to provide feedback on agent use

Several discussions with participants were centered on job demands. While autonomous agents can reduce job demands in the long-term (Lloyd & Payne, 2022), demands seem to be higher following immediate implementation, particularly when workers were not consulted during the process of onboarding the agent. Workers tend to have the best understanding of tasks at hand as they are the individuals completing them day in and day out. As such, they can often provide critical feedback as to where HATing may be most effective. One worker noted that if they know "1. What [the agent] is doing 2. How [the agent] is doing it 3. Tolerance and limits of [agent]" ahead of time, they can help maximize use of the agent onsite based on prior experience.

However, this input from workers is rarely sought after, only leading to further reluctance from direct labor to adopt the agent teammate. For example, one worker recalled a frustrating experience in which forcing human-autonomy teaming took time away from primary tasks, a problem they knew would occur ahead of time. Since then, they communicated reluctance to work with agents when not asked for input:

> "If it's taking too much of my time or my team's to get the hang of it then I'm just not doing it. I don't have time to do something new when I can just get my job done."

As demonstrated above, workers often revert to how they completed their tasks prior to assistance from autonomous agents when they were not involved in initial implementation decisions or provided adequate support. Sentiments from mid-level managers were no different, with adopting existing processes as a main source of frustration. One viewed a subtraction approach as valuable, but rarely used: "We need to use 'subtraction'. Remove work or simplify processes instead of just adding an agent to the mix because you can."

In a focus group, these views were reiterated with participants stating things such as "I don't want to add another [agent] if I don't see the value for my team," and "Other things are competing with agents for people's attention. It can be hard to "pile on" more changes to the process just for [agent]."

The interplay of competing demands and process adaptation represent only a few factors that lead to perceived increased job demands when integrating autonomous teammates. While some changes in processes are inevitable, factoring in workers' perspectives prior to implementation can improve HAT functioning and mitigate potential reluctance from direct labor to engage in HATs.

4.1.2. Sub-theme 2: Workers communicated an increased burden specifically when technology and design firms prioritized market entry over market needs during agent development

Similar to above, several focus group participants expressed that current autonomous agents often failed to address existing issues in industry-specific processes, resulting in increased worker responsibilities rather than easing task demands (a common selling point of integrating agents). For example, one worker noted:

> "[Workers] don't have the time to learn the new technology especially when the project is not designed for it. The design team needs to understand - 'let's design it in a manner that will facilitate it.' A lot

of projects don't meet the criteria that would make [agent] a viable option."

That is, workers often communicated significant barriers to effective human-autonomy teaming that were largely attributed to insufficient consideration from technology and design firms. One potential explanation as to why the worker perspective gets overlooked is the concept of the first mover advantage (i.e., a competitive strategy in which a firm is the first to present a product to market; Lieberman & Montgomery, 1988). In other words, there is a competitive advantage for technology and design firms to be the first to release innovative technology. Tang et al. (2018) found that the first mover advantage leads to increased profitability and productivity within technology firms. Thus, technology and design firms may not focus on developing autonomous agents that add value to specific industries, but rather aim to contrive novel approaches to human-autonomy teaming that broadly appeal to several markets. Consequently, it is no surprise that one interviewee noted how technology has significantly outpaced the infrastructure available in the construction industry:

"When tech in construction really took off, it was all about new software and how to keep [agent] connected. But construction sites don't even have wifi so it's not much help on the actual jobsite."

Together, these quotes demonstrate the potential devastating consequence when failing to account for the workers' perspective in the design process: the autonomous agent is rendered useless. In the words of an interviewee, "the market just isn't addressing the needs." Thus, it becomes evident that communicating with workers and valuing their input helps ensure advancements in agent technology will improve HAT functioning while still achieving the innovation goals of technology and design firms.

4.1.3. Theme 1 concluding thoughts

Organizations risk suboptimal HAT performance when they fail to consider worker perspectives. Not only do workers have important knowledge regarding job demands that may be augmented via HATs, but they can also help drive technological innovation in a meaningful way. Failure to consider these perspectives often results in an increase in perceived work demands, leading to workers being reluctant to interact with agents in the future. In sum, the individuals that are most impacted by the implementation of autonomous agents are the direct laborers and amplifying their voices regarding use of HATs in the workplace will lead to easier transitions to human-autonomy teams in industry.

4.2. Theme 2: Workers recognize the potential of HATs to improve dynamic processes in the workplace, but often feel skeptical about current capabilities of agents in use

Manufacturing and construction are riddled with dynamic processes that can affect HAT functioning. For example, both industries are increasingly adopting mass customization approaches in products and processes (Nielsen et al., 2017; Qi et al., 2020). That is, every product (e.g., car, building structure) is highly unique with nearly every aspect specified by the consumer. Such dynamic processes will likely produce an increased reliance on HATs.

Several workers focused on applications of HATs when it comes to these complex and dynamic demands. Data revealed an understanding of the potential of HATs to meet such demands, followed by skepticism around the current abilities of agents. More specifically, workers tended to name different concerns for affective states, behavioral processes, and cognitive understandings of current HAT functioning when asked about use of HATs to meet complex demands. As such, we use the ABC paradigm of team functioning (i.e., affective states, behavioral processes, and cognitive states; Bell et al., 2018) to further explore worker sentiments towards HATs in the field. In doing so, we demonstrate how workers are open to novel levels of human-agent collaboration to tackle dynamic processes at work. However, ensuring adequate affective and cognitive states emergence is critical to HAT functioning.

4.2.1. Sub-theme 1: Workers acknowledged the potential benefits of HATing to meet increasingly complex coordination processes in the field

Our findings show that the increasingly complex demands in manufacturing and construction lead to higher cognitive and physical demands on workers. However, these tasks are often too dynamic to be completed by autonomous agents alone, requiring levels of coordination and interaction between humans and agents on unprecedented scales. Several workers raised concerns about the complicated and dynamic nature of their work. For example, one worker noted: "job sites are dynamic and change daily which makes it incredibly difficult just to navigate a project … [agent] has to adapt to these dynamic conditions."

For instance, a site visit to an automotive manufacturer demonstrated the extensive impacts these complex demands have on workers. This manufacturer allows consumers to personalize their vehicle across a variety of amenities (e.g., trim, colors, seating configurations). There are over 10,000 possible seating configurations - which does not account for other elements of the vehicle that can be customized. These demands are far too complex to rely on agents alone, but too cognitively and physically demanding to place on workers. As a result, there was consensus across several organizational levels, ranging from executive leadership to direct labor, that there is a pressing need to identify best practices for effective coordination between humans and autonomous agents to meet these demands. One focus group member echoed this sentiment: "This is where coordination and planning is critical, when it's all custom. This is when a human and agent truly need to work together and basically take turns doing tasks."

It is evident that workers recognize the potential for HATs to meet demands more efficiently, assuming that the agent will have the behavioral capabilities to do so. As such, we highlight how autonomous agents need to exhibit both teamwork and taskwork behaviors to realize optimal levels of coordination. Whereas taskwork reflects behaviors regarding what the team does, teamwork behaviors address how the team members interact (Crawford & Lepine, 2013). Teamwork behaviors encompass strategy formulation (i.e., developing courses of action), goal specification (i.e., identifying and prioritizing tasks), team monitoring and backup behaviors (i.e., assessing progress and providing or receiving support), among others (Crawford & Lepine, 2013; Fernandez et al., 2008). One focus group emphasized the need for monitoring and backup behaviors in particular, as the human and agent will need to support each other to effectively meet increasingly complex and dynamic production demands.

4.2.2. Sub-theme 2: Workers consistently named trust as a critical factor for successful human-autonomy teaming, and increasing knowledge of agents as a mechanism for improving trust

In order to effectively coordinate, humans must trust the agents they work with. The notion of trust emerged as the most commonly discussed and heavily emphasized affective state valued by workers. Both focus group and interview data echoed this sentiment. For example, one worker noted the importance of trust particularly in the face of complex job demands: "both trust and affection are very important but heavily based on the task, which can be complicated." Moreover, there was often a trust but verify mindset present among workers. One interviewee expressed this when posing a rhetorical question: "do we fully trust the behavior [of the agent]? I mean we think they follow what humans want … how do we track that?" That is, trust emerged as a critical affective state to improve HAT functioning. However, workers can be skeptical of agent capabilities which can limit interaction with agents in the field and pose a threat to HAT performance. To put it in the words of an interviewee: "No trust means no work so it's very important. If the human does not trust the agent, then there will be no collaboration between them."

In order to achieve high levels of trust and lower skepticism, data collected suggests that human workers and autonomous agents will need to understand their own roles, each other's roles, and how these fit together. That is, human-autonomy teams also need to develop team cognition (i.e., the manner in which knowledge important to team functioning is mentally organized, represented, and distributed within the team; Klimoski & Mohammed, 1994). Workers heavily emphasized this need to understand the function of the agent and its responsibilities. For example, when asked what workers and agents need to be on the same page about, one interviewee said: "what is the output of the agent and who is using the output? It's important for the human workers to know." Similar sentiments were expressed in additional interviews as well as focus groups.

When applying team cognition to HATs in particular, not only do human teammates need to understand capabilities and roles of the agent, but the agent should also understand that of the human (Demir et al., 2020). Some focus groups explored this notion, identifying what the agent is responsible for knowing. Participants discussed the cognitive dependencies needed for an autonomous agent to successfully collaborate in dynamic work environments, identifying capabilities such as "situational awareness," "the ability to recognize the type and behavior of counterparts," and "understanding the tasks and activities for each day even when that is updated multiple times a day." As such, workers not only recognize the importance of trusting their agent teammate but also have strong ideas on how to improve trust relationships.

Our findings are consistent with current literature, which highlights the importance of the interaction between cognitive and affective states in human-autonomy teams (see Glikson & Woolley, 2020 for a comprehensive review). Trust becomes especially important when considering the extensive levels of coordination needed to meet increasingly complex job demands, such as those introduced through mass customization. The ideas presented by workers to improve trust and HAT functioning also demonstrate a need for team cognition within human-autonomy teams. In sum, workers highly value the trustworthiness of their agent counterpart, and failure to foster high levels of trust can lead to skepticism or even refusal to interact with the agent. As one mid-level manager said, "the worker won't even engage with the agent unless there is trust."

4.2.3. *Theme 2 concluding thoughts*

A common goal of utilizing HATs in labor-intensive industries is to achieve more dynamic processes and meet complex work demands (Nielsen et al., 2017; Qi et al., 2020). Workers did in fact recognize the potential for HATs to achieve these goals but cited low trust and limited understanding of agent capabilities as barriers to achieving said objectives. A critical consideration in this approach is that the agent teammate augments, and does not automate, the responsibilities of the human worker. That is, leveraging the strengths and weaknesses of both the human worker (i.e., limited physical and cognitive abilities, flexible) and the autonomous agent (i.e., higher physical and cognitive thresholds, less flexibility) results in a team with complimentary abilities, leading to opportunities for extensive coordination and collaboration.

To this end, our results corroborate previous research demonstrating that coordination cannot occur without team cognition and affective states (Bell et al., 2018). This is of particular importance when trying to optimize HAT performance in dynamic environments. Without trust, understanding, and coordination between humans and autonomous agents, achieving increasingly complex production goals, such as vehicles with over 10,000 seating configurations alone, would not be possible. As such, improving workers' trust in agents by increasing understanding of the agent's capabilities to both complete tasks at hand and adjust to dynamic environments is critical to achieving optimal levels of HAT performance.

4.3. *Theme 3: Workers feel that HATs are being increasingly used as a fail-safe against external contextual factors when this is not always the best approach*

The third theme we present demonstrates the influence of the work context on worker experiences and perceptions of HATs. Previous research on teams has demonstrated the influence of contextual factors on team performance, especially in demanding, high-risk environments such as healthcare (e.g., Schmutz et al., 2019; Wolf et al., 2023), military (e.g., Goodwin et al., 2018; Shuffler et al., 2012), and spaceflight (e.g., Burke et al., 2019; Landon et al., 2018). However, the majority of research on HATs has been conducted in lab-based settings (O'Neill et al., 2022), resulting in a need for research exploring the impact of contextual variables on HAT functioning in the field. We gathered data from multiple stakeholders to understand key contextual factors affecting HAT dynamics as well as external industry pressures impacting worker perspectives on HATs.

Furthermore, our research includes data from two labor-intensive industries at different stages of HAT integration, allowing for a deeper understanding of the industry-wide influences on contextual variables. We present two key industry-wide contextual variables that workers heavily emphasize within the construction and manufacturing industries: the need to consider the infrastructure readily available to support HATs and the role of the labor market on implementing HATs.

4.3.1. *Subtheme 1: The infrastructure of the workplace can significantly impact successful HAT integration and long-term worker perceptions towards HATing*

Workers, among other stakeholders, often discussed the need for adequate infrastructure to support HATs and how this differs by industry. Namely, participants emphasized that manufacturing facilities often have the resources needed for HATs readily available while construction does not. In one interview, a senior-level construction manager communicated the stark difference:

> "First we have to solve the data connectivity problem then deal with location awareness so we can effectively leverage IoT solutions to really be able to have edge computing at the jobsite. Manufacturing facilities don't have this problem because the building is already there with an infrastructure to support agents."

Ironically, construction lacks its own infrastructure - the purpose of construction is to build infrastructure for others. Job sites often lack both the physical and technological framework needed for human-autonomy teaming. During a focus group, another construction manager expressed frustration regarding the failure to consider infrastructure prior to implementing HATs. The participant discussed the promising use of an agent to support drilling; however, the agent would not be removable from the jobsite in question once the infrastructure is built, rendering it useless. Specifically, one worker noted: "you can get [agent] there. But then what happens? You need to make sure it can fit in a 3' door frame. Once the building is built, we need to get [agent] out."

On the other hand, manufacturing occurs in factory settings that already consist of the physical and technical requirements needed to support HATs. Rather than having to build infrastructure to support agent teammates, manufacturers can strategically implement agents based on the surrounding infrastructure to maximize benefits from HATs. The example of HATs completing undercarriage tasks previously discussed demonstrates how manufacturers are able to leverage existing infrastructure to optimize HAT functionality. Implementation was strategically based on not only strenuous tasks but also the surrounding environment. The company was able to use existing platforms to maximize the ergonomic benefit of the agents, easing job demands and improving worker experience.

It is essential for leaders to consider the available infrastructure as a contextual factor that can impact HAT functioning. As previously discussed, the worker perspective is invaluable in understanding how an autonomous agent can be integrated into a job site. This includes determining which tasks may be best for agent augmentation as well as the feasibility of use dependent on jobsite context, such as physical infrastructure. An agent may demonstrate all the capabilities needed to augment a task but if it is not operational due to lack of infrastructure (e.g., limited power supply, too large for space), it is rendered useless and can lead to negative downstream effects for workers. Like in the door frame example, negative perceptions can occur when integration fails due to poorly planned infrastructure support, worsening any prior sentiments towards agents. Initial experiences with autonomous agents has been proven to be essential for developing trust, and once trust is lost it can be difficult for autonomous agents to gain an individual's trust back (Desai et al., 2013).

4.3.2. Subtheme 2: Industry pressures such as the labor shortage function as an important contextual factor that can amplify worker sentiments towards HATs

With 437 thousand current job openings in construction (U.S. Bureau of Labor Statistics, 2022) and 3.5 million manufacturing jobs projected to be unfilled in 2025 (Subcommittee On Advanced Manufacturing Committee on Technology, 2018), it is evident that physically intensive industries are experiencing widespread labor shortages. Workers are not immune to the effects of such a shortage, as it often leads to additional job demands and more intensive work schedules (Kim et al., 2020). This was demonstrated in our findings as well, with elements of the labor shortage embedded in nearly every interview, focus group, and site visit we conducted. Participants echoed these sentiments as well as raised additional concerns regarding how technology may be used to offset such effects. As discussed in earlier themes, workers can perceive integrating autonomous agents as adding additional job demands for workers. Synthesizing across all observations, it became evident that human-autonomy teams are a viable option to combat these effects of the shortage but should not be treated as the sole solution. One interviewee explicitly communicated this note of caution:

> "Everyone acknowledges that there is a shortage of skilled workers, but agents are not the only option to address this problem."

That is, companies should not default to human-autonomy teams as a way to mitigate workforce shortages. It can result in increased job demands by burdening the worker to learn new skills when already facing stress due to the labor shortage. For example, when asked about how autonomous agents might mitigate effects of the labor shortage, we received comments such as "we don't have the time to learn new technology when already dealing with these problems" and "[agent] is creating a burden for us more skilled workers who can work without it."

During a site visit to an automotive manufacturing plant, an industry professional gave an example where implementing HATs to combat a skilled shortage failed and led to more work. A few years prior, the organization implemented several collaborative agents to work alongside humans in an effort to increase productivity as well as offset low staffing levels. However, the particular processes at this point in vehicle assembly were nuanced and complex. The autonomous teammates were incapable of meeting these demands, leading to lower productivity through both direct (e.g., inability of agents to maintain speed and accuracy demands) and indirect (e.g., human workers combatting newly introduced errors) effects. The agents have since been removed and remain in storage while the task continues to be human operated.

This example demonstrates the costly mistake of failing to account for contextual factors (e.g., industry pressures, labor shortages) when seeking to integrate HATs in the field. Workers that are already experiencing increased demands due to such factors may be more reluctant to collaborate with an agent. Integrating agents can require further worker adaptation and learning, and the constant adjustments can create undue burden on workers. Failure to consider how these demands and external pressures interact can amplify negative perceptions or hesitancies that already exist (e.g., skepticism surrounding agent abilities, as demonstrated above).

4.3.3. Theme 3 concluding thoughts

Contextual factors can significantly impact team functioning, and our findings suggest this holds true for HATs in field environments as well. Namely, consideration of contextual factors can amplify worker perceptions of HATs and impact HAT functioning. By observing HATs from industries in vastly different stages of implementation, we demonstrate how infrastructure and labor markets play a critical role in influencing worker perceptions of HATs. Both cyber and physical infrastructure is imperative to effective HAT functioning, and failure to obtain adequate infrastructure for specific agents will result in more reluctance and frustration from workers. Similarly, organizations should seek to understand how external pressures impact workers, and be intentional in use of HATs to support workers. Failure to do so can result in additional demands and increased negative perceptions of HATs, threatening long-term viability of HAT functioning.

5. Discussion

The human-autonomy teaming literature is growing at a substantial pace, yet few studies use qualitative approaches (e.g., field studies) to understand the influence of context on successful integration of HATs (O'Neill et al., 2022). Through a series of interviews, focus groups, and site visits, we extend this literature by examining one perspective frequently forgotten: the human worker. By utilizing qualitative field methodology, we provided answers for two research questions: (1) What are the subjective worker experiences and perceptions of human-autonomy teams, regardless of workplace context? And (2) What is the influence of work context on worker experiences and perceptions of HATs?

With regards to the first research question, we identify two core themes important to consider when understanding the workers experiences and perspectives regarding HATs. The first is that workers often feel their perspectives fall secondary to other factors, despite this threatening optimal use of HATs in industry. Our research revealed that as a result of this, the implementation of HATs is met with increased frustration and reluctance among direct laborers. Additionally, failure to consider their perspective can have adverse effects, often leading to increased job demands due to misunderstanding or misapplication of agent technology. Second, workers recognize the potential of HATs to improve dynamic processes in the workplace, but often feel skeptical about current capabilities of agents in use. It is critical to foster trust and shared understanding within human-autonomy teams if organizations want to achieve increasingly complex coordination demands.

In addressing the second research question, we demonstrate how workers feel that HATs are being increasingly used as a fail-safe against external contextual factors when this is not always the best approach. Contextual factors, such as infrastructure and labor shortages, can and do significantly impact workers' perceptions of HATs and consequently HAT functioning. In sum, each theme speaks to the importance of including workers in both the research and implementation process of human-autonomy teams in industry settings.

5.1. Theoretical implications

Our research holds a number of theoretical implications. First, we demonstrated how workers' perspectives were not valued as strongly as other factors, which resulted in further reluctance to engage in human-autonomy teaming. We posit that this highlights the importance of including workers earlier on in the research process when assessing HAT functioning. One method to achieve this is to adopt a transdisciplinary approach to research. In fact, this echoes a recent call for more transdisciplinary approaches to human-autonomy teaming research (Fiore et al., 2021). Broadly speaking, transdisciplinary (TD) research seeks to transcend beyond simple integration of multiple disciplines (Stokols et al., 2008). Perhaps most important, TD research calls for integration of both scientists and practitioners in solving complex, real world problems to ensure impactful research findings and successful knowledge dissemination (Hadorn et al., 2010).

Additionally, our second theme highlighted the importance of affective states, behavioral processes, and cognitive states (ABCs) in HATs relative to this context. While affective states have garnered much attention (e.g., trust; Glikson & Woolley, 2020; Hancock et al., 2021), behavioral processes (e.g., coordination) and cognitive states (e.g., team cognition) remain understudied in HATs (O'Neill et al., 2022), particularly in field settings. Therefore, we posit that leveraging qualitative approaches, alongside existing quantitative research, can better inform future human-autonomy teaming research.

Finally, we identified key contextual factors that further impact worker subjective experiences in human-autonomy teams. Site visits were critical in grasping the impacts of these factors, especially the role of infrastructure. To this end, we demonstrate a need for further qualitative research, particularly in regard to field observations and studies, to identify broad categories of contextual factors affecting human-autonomy teaming. In doing so, existing theoretical frameworks may need to be adapted to account for contextual variables and capture nuances that affect existing relationships among variables (Shuffler et al., 2015). This is likely to have major implications in HAT literature as our research suggests that successful human-autonomy teaming is dependent on contextual factors that can be revealed through qualitative approaches (e.g., interviewing workers, observing environments for potential HAT integration).

5.2. Practical implications

Our findings also have a number of practical implications. Regarding worker experiences, we suggest that organizations seeking to adopt HATs in the field take worker's experiences and preferences into account in order to foster willingness to collaborate and improve HAT functioning. Specifically, we suggest organizations conduct a thorough needs assessment prior to implementing HATs. A needs assessment is focused on collecting evidence to identify needs across the organization (Altschuld & Kumar, 2010). Organizations that include workers in this process often see higher worker satisfaction and engagement (Sageer et al., 2012). As such, a needs assessment can function as a mechanism for systematically gathering worker feedback regarding HAT integration. In turn, workers' voices are amplified and concerns regarding integration are mitigated, leading to higher levels of openness towards HATs in the field.

Second, organizations should support workers in HATs by communicating all relevant knowledge regarding an agent (i.e., enhance team cognition) and foster trust in the agent (i.e., develop relevant affective states). This is feasible through trust calibration: a training paradigm centered around reducing expectations in the agent's reliability and capability to perform while also emphasizing persistence in interaction (de Visser et al., 2020). That is, the training explicitly communicates how often the agent might make an error (i.e., reliability expectation) and what the agent is and is not capable of (i.e., capability expectation) while encouraging interaction even when the agent makes a mistake. This approach has been successful in improving overall HAT team performance (Demir et al., 2021; Johnson et al., 2021).

Finally, consideration of contextual factors is imperative to improving worker experiences in HATs. While HATing offers promising outcomes for organizations on many fronts, it is imperative that factors such as infrastructure and labor accessibility, among others, are considered prior to implementation. Failure to do so can result in increased demands for workers and deter future collaborations with agents. One approach commonly used to ensure comprehensive oversight of large-scale goals such as HAT integration is advisory committees. For example, a technology and innovation committee put together by one organization in this study contained industry leaders, technology advisors, middle level management, and workers. This committee proved effective in identifying goals and concerns around human-autonomy teaming from both within and outside the organization, allowing for synthesis of objectives and development of an integrative path forward for implementation. Other fields (e.g., healthcare, public safety) have further highlighted the usefulness of advisory committees in adopting transdisciplinary research practices, leading to significant real-world solutions for their industries (Koskinas et al., 2022; Patten et al., 2019). We posit that the use of such committees and advisory boards are imperative for human-autonomy teaming in field contexts.

5.2. Limitations

It is important to consider our findings through the lens of several limitations. First, this research was conducted within construction and manufacturing industries, but may not be generalizable to other labor-intensive industries implementing human-autonomy teams (e.g., agriculture and mining). Future research is needed to examine the application of these findings to other industries. Additionally, as we utilized advisory board members who have already succeeded in adopting HATs and snowball sampling techniques to recruit our participants, the workers we interviewed may have been more accepting of HATs than the general construction and manufacturing worker due to supportive organizational climates. As such, these results may not be generalizable to every organization within the construction and manufacturing industries. However, employees still discussed reservations and prominent issues throughout the data collection process, reducing our fear that data were impacted. Future research should recruit companies with varying degrees of leadership support for HATs to better understand the downstream effects on workers' perceptions. Finally, researchers removed details of specific autonomous agents referenced during data collection to protect the confidentiality of both workers and organizations. This limited our ability to compare and contrast between current autonomous agents within the construction and manufacturing context. Overall, results of the thematic analysis extend the HAT literature by (1) expanding upon current notions of HATs by highlighting the worker's perspective, (2) highlighting the value of qualitative field studies to elucidate nuances of HATing, and (3) presenting contextual considerations when integrating HATs into field environments.

5.3. Conclusions

In sum, our study sought not only to understand (1) the subjective worker experiences and perceptions of HATs and (2) the influence of work context on worker perceptions, but to exemplify how integrating the human perspective in future research can address several limitations within the current HAT literature. By synthesizing themes across interviews, focus groups, and site visits in construction and manufacturing environments, our data show that workers often feel unheard and undervalued when considering applications of HATs in the workplace. Failure to consider their perspectives or external factors affecting workers can be harmful and result in increased work demands. In doing so, this leads to increased negative perceptions, with workers communicating reluctance or even refusal to engage in HATing often out of frustration. By placing an increased focus on understanding workers' experiences in the field, we have demonstrated that hesitations may be mitigated by soliciting feedback from workers. Workers, as the individuals working most closely with agents, often see the potential for HATs. Integrating their opinions into the decision-making process will lead to improved HAT functioning in the workplace. As one trade worker stated, "what interests me is augmenting human work in partnership."

Author credits

Begerowski & Hedrick: Conceptualization, Methodology, Investigation, Writing - Original Draft, Writing - Review & Editing. Waldherr:

Investigation, Writing - Original Draft, Writing - Review & Editing. Mears: Funding acquisition, Writing - Review & Editing. Shuffler: Funding acquisition, Methodology, Investigation, Writing - Review & Editing, Supervision.

Ethical approval

Ethical review and approval was obtained by the Industrial Review Board of Clemson University in accordance with the local legislation and institutional requirements.

funding acknolwedgements

This research was funded by the National Science Foundation through the projects: #1829008, #1928527, and #2036873.

Data availability

The data that has been used is confidential.

References

Aghimien, D. O., Aigbavboa, C. O., Oke, A. E., & Thwala, W. D. (2020). Mapping out research focus for robotics and automation research in construction-related studies: A bibliometric approach. *Journal of Engineering, Design and Technology, 18*(5), 1063–1079. https://doi.org/10.1108/JEDT-09-2019-0237

Altschuld, J., & Kumar, D. (2010). *Needs assessment: An overview*. SAGE Publications, Inc. https://doi.org/10.4135/9781452256795

Andrews, R. W., Lilly, J. M., Srivastava, D., & Feigh, K. M. (2022). The role of shared mental models in human-AI teams: A theoretical review. *Theoretical Issues in Ergonomics Science*, 1–47. https://doi.org/10.1080/1463922X.2022.2061080

Ardiny, H., Witwicki, S., & Mondada, F. (2015). Construction automation with autonomous mobile robots: A review. In *2015 3rd RSI international conference on robotics and mechatronics (ICROM)* (pp. 418–424). IEEE.

Ashima, R., Haleem, A., Bahl, S., Javaid, M., Mahla, S. K., & Singh, S. (2021). Automation and manufacturing of smart materials in Additive Manufacturing technologies using Internet of Things towards the adoption of Industry 4.0. *Materials Today Proceedings, 45*, 5081–5088. https://doi.org/10.1016/j.matpr.2021.01.583

Atkinson, R., & Flint, J. (2001). Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social Research Update, 33*(1), 1–4. https://doi.org/10.1111/j.1442-2018.2010.00541.x

Autor, D., Mindell, D., & Reynolds, E. (2022). *The work of the future: Building better jobs in an age of intelligent machines*. Penguin Random House. IBSN: 9780262046367.

Baker, A. L., Fitzhugh, S. M., Huang, L., Forster, D. E., Scharine, A., Neubauer, C., … Cooke, N. J. (2021). Approaches for assessing communication in human-autonomy teams. *Human-Intelligent Systems Integration, 3*(2), 99–128. https://doi.org/10.1007/s42454-021-00026-2

Bell, S. T., Brown, S. G., Colaneri, A., & Outland, N. (2018). Team composition and the ABCs of teamwork. *American Psychologist, 73*(4), 349–362. https://doi.org/10.1037/amp0000305

Bhargava, A., Bester, M., & Bolton, L. (2021). Employees' perceptions of the implementation of robotics, artificial intelligence, and automation (RAIA) on job satisfaction, job security, and employability. *Journal of Technology in Behavioral Science, 6*(1), 106–113. https://doi.org/10.1007/s41347-020-00153-8

Bhatt, P. M., Malhan, R. K., Shembekar, A. V., Yoon, Y. J., & Gupta, S. K. (2020). Expanding capabilities of additive manufacturing through use of robotics technologies: A survey. *Additive Manufacturing, 31*, 1–12. https://doi.org/10.1016/j.addma.2019.100933

Blumberg, M., & Alber, A. (1982). The human element: Its impact on the productivity of advanced batch manufacturing systems. *Journal of Manufacturing Systems, 1*(1), 43–52. https://doi.org/10.1016/S0278-6125(82)80066-6

Botti, L., Calzavara, M., & Mora, C. (2021). Modelling job rotation in manufacturing systems with aged workers. *International Journal of Production Research, 59*(8), 2522–2536. https://doi.org/10.1080/00207543.2020.1735659

Bradshaw, J., Fong, T., Goodrish, M. A., Groom, V., & Kaber, D. (2007). *Robot: Tool or teammate? Moderated by: Alan schultz*. IEEE International Conference on Human-Robot Interaction. Accepted as panel to ACM/.

Brosque, C., & Fischer, M. (2022). A robot evaluation framework comparing on-site robots with traditional construction methods. *Construction Robotics*, (6), 1–20. https://doi.org/10.1007/s41693-022-00073-4

Brosque, C., Skeie, G., & Fischer, M. (2021). Comparative analysis of manual and robotic concrete drilling for installation hangers. *Journal of Construction Engineering and Management, 147*(3), Article 05021001. https://doi.org/10.1061/(asce)co.1943-7862.0002002

Burke, C. S., Georganta, E., & Marlow, S. (2019). A bottom up perspective to understanding the dynamics of team roles in mission critical teams. *Frontiers in Psychology, 10*, 1322. https://doi.org/10.3389/fpsyg.2019.01322

Burns, C., & Conchie, S. (2013). Risk information source preferences in construction workers. *Employee Relations, 36*(1), 70–81. https://doi.org/10.1108/ER-06-2013-0060

Cao, G., Duan, Y., Edwards, J. S., & Dwivedi, Y. K. (2021). Understanding managers' attitudes and behavioral intentions towards using artificial intelligence for organizational decision-making. *Technovation, 106*, Article 102312. https://doi.org/10.1016/j.technovation.2021.102312

Clampitt, P. G., & Downs, C. W. (1993). Employee perceptions of the relationship between communication and productivity: A field study. *Journal of Business Communication, 30*(1), 5–28. https://doi.org/10.1177/002194369303000101

Crawford, W. G. (1995). Construction surveying and layout. *Safety Now, 3*(2).

Crawford, E. R., & Lepine, J. A. (2013). A configural theory of team processes: Accounting for the structure of taskwork and teamwork. *Academy of Management Review, 38*(1), 32–48. https://doi.org/10.5465/amr.2011.0206

Daneshgari, P., & Moore, H. (2018). Winds of change: Industrialization of construction. Insights magazine. *Independent Electrical Contractors, January, 2*(2018).

Demir, M., Cooke, N. J., & Amazeen, P. G. (2018). A conceptual model of team dynamical behaviors and performance in human-autonomy teaming. *Cognitive Systems Research, 52*, 497–507. https://doi.org/10.1016/j.cogsys.2018.07.029

Demir, M., McNeese, N. J., & Cooke, N. J. (2017). Team situation awareness within the context of human-autonomy teaming. *Cognitive Systems Research, 46*, 3–12. https://doi.org/10.1016/j.cogsys.2016.11.003

Demir, M., McNeese, N. J., & Cooke, N. J. (2020). Understanding human-robot teams in light of all-human teams: Aspects of team interaction and shared cognition. *International Journal of Human-Computer Studies, 140*, Article 102436. https://doi.org/10.1016/j.ijhcs.2020.102436

Demir, M., McNeese, N. J., Gorman, J. C., Cooke, N. J., Myers, C. W., & Grimm, D. A. (2021). Exploration of teammate trust and interaction dynamics in human-autonomy teaming. *IEEE Transactions on Human-Machine Systems, 51*(6), 696–705.

Desai, M., Kaniarasu, P., Medvedev, M., Steinfeld, A., & Yanco, H. (2013). Impact of robot failures and feedback on real-time trust. In *2013 8th ACM/IEEE international conference on human-robot interaction (HRI)* (pp. 251–258). IEEE. https://doi.org/10.1109/HRI.2013.6483596.

Elprama, S. A., Jewell, C. I. C., Jacobs, A., Makrini, I. E.l., & Vanderborght, B. (2017). Attitudes of factory workers towards industrial and collaborative robots. *Proceedings of the Companion of the 2017 ACM/IEEE International Conference on Human-Robot Interaction, 113*. https://doi.org/10.1145/3029798.3038309. –114.

Evjemo, L. D., Gjerstad, T., Grøtli, E. I., & Sziebig, G. (2020). Trends in smart manufacturing: Role of humans and industrial robots in smart factories. *Current Robotics Reports, 1*(2), 35–41. https://doi.org/10.1007/s43154-020-00006-5

Fasth, A., Mattsson, S., Fassberg, T., Stahre, J., Hoog, S., Sterner, M., & Andersson, T. (2011). *Development of production cells with regard to physical and cognitive automation: A decade of evolution. 2011 IEEE international symposium on assembly and manufacturing (ISAM)*. https://doi.org/10.1109/ISAM.2011.5942316

Fernandez, R., Kozlowski, S. W., Shapiro, M. J., & Salas, E. (2008). Toward a definition of teamwork in emergency medicine. *Academic Emergency Medicine, 15*(11), 1104–1112. https://doi.org/10.1111/j.1553-2712.2008.00250.x

Fiore, S. M., Bracken, B., Demir, M., Freeman, J., & Lewis, M. (2021). Transdisciplinary team research to develop theory of mind in human-AI teams panelists. *Proceedings of the Human Factors and Ergonomics Society - Annual Meeting, 65*(1), 605–1609. https://doi.org/10.1177/1071181321651351

Frank, M. R., Autor, D., Bessen, J. E., Brynjolfsson, E., Cebrian, M., Deming, D. J., … Rahwan, I. (2019). Toward understanding the impact of artificial intelligence on labor. *Proceedings of the National Academy of Sciences, 116*(14), 6531–6539. https://doi.org/10.1073/pnas.1900949116

Gao, Y., & Chien, S. (2017). Review on space robotics: Toward top-level science through space exploration. *Science Robotics, 2*(7), 1–19. https://doi.org/10.1126/scirobotics.aan5074

Gleirscher, M., Johnson, N., Karachristou, P., Calinescu, R., Law, J., & Clark, J. (2020). *Challenges in the safety-security co-assurance of collaborative industrial robots*. Cornell University. Retrieved from: https://arxiv.org/pdf/2007.11099.pdf.

Glikson, E., & Woolley, A. W. (2020). Human trust in artificial intelligence: Review of empirical research. *The Academy of Management Annals, 14*(2), 627–660. https://doi.org/10.5465/annals.2018.0057

Goodrum, P. M. (2003). Worker satisfaction and job preferences in the US construction industry. In *Construction research congress: Wind of change: Integration and innovation* (pp. 1–8).

Goodwin, G. F., Blacksmith, N., & Coats, M. R. (2018). The science of teams in the military: Contributions from over 60 years of research. *American Psychologist, 73*(4), 322. https://doi.org/10.1037/amp0000259

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field Methods, 18*(1), 59–82. https://doi.org/10.1177/1525822x05279903

Gunadi, C., & Ryu, H. (2021). Does the rise of robotic technology make people healthier? *Health Economics, 30*(9), 2047–2062. https://doi.org/10.1002/hec.4361

Hadorn, G. H., Pohl, C., & Bammer, G. (2010). Solving problems through transdisciplinary research. *The Oxford Handbook of Interdisciplinarity*, 431–452.

Hambuchen, K., Marquez, J., & Fong, T. (2021). A review of NASA human-robot interaction in space. *Current Robotics Report, 2*, 265–272. https://doi.org/10.1007/s43154-021-00062-5

Hancock, P. A., Kessler, T. T., Kaplan, A. D., Brill, J. C., & Szalma, J. L. (2021). Evolving trust in robots: Specification through sequential and comparative meta-analyses. *Human Factors, 63*(7), 1196–1229. https://doi.org/10.1177/0018720820922080

Inkulu, A. K., Bahubalendruni, M. R., Dara, A., & Sankaranarayana Samy, K. (2021). Challenges and opportunities in human robot collaboration context of Industry 4.0-a

state of the art review. *Industrial Robot: The International Journal of Robotics Research and Application, 49*(2), 226–239. https://doi.org/10.1108/IR-04-2021-0077
Johns, G. (2006). The essential impact of context on organizational behavior. *Academy of Management Review, 31*(2), 386–408. https://doi.org/10.5465/amr.2006.20208687
Johnson, C. J., Demir, M., McNeese, N. J., Gorman, J. C., Wolff, A. T., & Cooke, N. J. (2021). *The impact of training on human–autonomy team communications and trust calibration*. https://doi.org/10.1177/00187208211047323. Human factors.
Jurgensen, C. E. (1978). Job preferences (What makes a job good or bad?). *Journal of Applied Psychology, 63*, 267–276. https://doi.org/10.1037/0021-9010.63.3.267
Kaasinen, E., Schmalfuß, F., Özturk, C., Aromaa, S., Boubekeur, M., Heilala, J., … Walter, T. (2020). Empowering and engaging industrial workers with Operator 4.0 solutions. *Computers & Industrial Engineering, 139*, Article 105678. https://doi.org/10.1016/j.cie.2019.01.052
Kasina, H., Bahubalendruni, M. R., & Botcha, R. (2017). Robots in medicine: Past, present and future. *International Journal of Manufacturing, Materials, and Mechanical Engineering, 7*(4), 44–64. https://doi.org/10.4018/IJMMME.2017100104
Kim, S., Chang, S., & Castro-Lacouture, D. (2020). Dynamic modeling for analyzing impacts of skilled labor shortage on construction project management. *Journal of Management in Engineering, 36*(1), Article 04019035.
Klimoski, R., & Mohammed, S. (1994). Team mental model: Construct or metaphor? *Journal of Management, 20*(2), 403–437. https://doi.org/10.1016/0149-2063(94)90021-3
Koskinas, E., Gilfoyle, M., & Salsberg, J. (2022). Exploring how patients, carers and members of the public are recruited to advisory boards, groups and panels as partners in public and patient involved health research: A scoping review protocol. *BMJ Open, 12*(4), Article e059048. https://doi.org/10.1136/bmjopen-2021-059048
Kozlowski, S. W. (2015). Advancing research on team process dynamics: Theoretical, methodological, and measurement considerations. *Organizational Psychology Review, 5*(4), 270–299. https://doi.org/10.1177/2041386614533586
Landon, L. B., Slack, K. J., & Barrett, J. D. (2018). Teamwork and collaboration in long-duration space missions: Going to extremes. *American Psychologist, 73*(4), 563. https://doi.org/10.1037/amp0000260
Larson, L., & DeChurch, L. A. (2020). Leading teams in the digital age: Four perspectives on technology and what they mean for leading teams. *The Leadership Quarterly, 31*(1), 1–18. https://doi.org/10.1016/j.leaqua.2019.101377
Lieberman, M. B., & Montgomery, D. B. (1988). First-mover advantages. *Strategic Management Journal, 9*(1), 41–58.
Lloyd, C., & Payne, J. (2022). Digital skills in context: Working with robots in lower-skilled jobs. *Economic and Industrial Democracy*. , Article 0143831X221111416. https://doi.org/10.1177/0143831X221111416
Matarić, M. J. (2017). Socially assistive robotics: Human augmentation versus automation. *Science Robotics, 2*(4), Article eaam5410.
Mathieu, J. E., Marks, M. A., & Zaccaro, S. J. (2001). Multi-team systems. In N. Anderson, D. Ones, H. K. Sinangil, & C. Viswesvaran (Eds.), *Handbook of industrial, work, & organizational psychology* (pp. 289–313). London: Sage.
McNeese, N. J., Demir, M., Cooke, N. J., & She, M. (2021). Team situation awareness and conflict: A study of human–machine teaming. *Journal of Cognitive Engineering and Decision Making, 15*(2–3), 83–96. https://doi.org/10.1177/15553434211017354
Mokyr, J., Vickers, C., & Ziebarth, N. L. (2015). The history of technological anxiety and the future of economic growth: Is this time different? *The Journal of Economic Perspectives, 29*(3), 31–50. https://doi.org/10.1257/jep.29.3.31
Moreland, R. L. (2010). Are dyads really groups? *Small Group Research, 41*(2), 251–267. https://doi.org/10.1177/1046496409358618
Morris, K. C., Schlenoff, C., & Srinivasan, V. (2017). Guest editorial a remarkable resurgence of Artificial Intelligence and its impact on automation and autonomy. *IEEE Transactions on Automation Science and Engineering, 14*(2), 407–409. https://doi.org/10.1109/TASE.2016.2640778
Musick, G., O'Neill, T. A., Schelble, B. G., McNeese, N. J., & Henke, J. B. (2021). What happens when humans believe their teammate is an AI? An investigation into humans teaming with autonomy. *Computers in Human Behavior, 122*, 1–14. https://doi.org/10.1016/j.chb.2021.106852
Nam, T. (2019). Citizen attitudes about job replacement by robotic automation. *Futures, 109*, 39–49. https://doi.org/10.1016/j.futures.2019.04.005
Nass, C., Moon, Y., Fogg, B. J., Reeves, B., & Dryer, D. C. (1995). Can computer personalities be human personalities? *International Journal of Human-Computer Studies, 43*(2), 223–239. https://doi.org/10.1006/ijhc.1995.1042
Nielsen, K., Brunoe, T. D., Jensen, K. N., & Andersen, A. L. (2017). Utilization of mass customization in construction and building industry. In J. Bellemare, S. Carrier, K. Nielsen, & F. Piller (Eds.), *Managing complexity. Springer proceedings in business and economics*. Cham: Springer. https://doi.org/10.1007/978-3-319-29058-4_9.
Njord, J., Peters, J., Freitas, M., Warner, B., & Knowlton, L. (2006). *Safety applications of intelligent transportation systems in Europe and Japan*. Retrieved from https://rosap.ntl.bts.gov/view/dot/3670.
Nnaji, C., Awolusi, I., Park, J., & Albert, A. (2021). Wearable sensing devices: Towards the development of a personalized system for construction safety and health risk mitigation. *Sensors, 21*(3), 682. https://doi.org/10.3390/s21030682
O'Neill, T. A., McNeese, N. J., Barron, A. H., & Schelble, B. G. (2022). Human-autonomy teaming: A review and analysis of the empirical literature. *Human Factors, 64*(5), 904–938. https://doi.org/10.1177/0018720820960865
Park, S. (2019). Socializing at work: Evidence from a field experiment with manufacturing workers. *American Economic Journal: Applied Economics, 11*(3), 424–455. https://doi.org/10.1257/app.20160650
Parker, S. K., & Grote, G. (2022). More than 'more than ever': Revisiting a work design and sociotechnical perspective on digital technologies. *Applied Psychology, 71*(4), 1215–1223. https://doi.org/10.1111/apps.12425
Park, E. S., Seo, H. C., & Lee, A. Y. (2022). Development of a multi-layer marking toolkit for layout-printing automation at construction sites. *Sensors, 22*(13), 4822. https://doi.org/10.3390/s22134822
Patten, C. A., Albertie, M. L., Chamie, C. A., Brockman, T. A., Gorfine, M., Nicholas, R., … Balls-Berry, J. E. (2019). Addressing community health needs through community engagement research advisory boards. *Journal of Clinical and Translational Science, 3*(2–3), 125–128. https://doi.org/10.1017/cts.2019.366
Qi, Y., Mao, Z., Zhang, M., & Guo, H. (2020). Manufacturing practices and servitization: The role of mass customization and product innovation capabilities. *International Journal of Production Economics, 228*, Article 107747. https://doi.org/10.1016/j.ijpe.2020.107747
Rebensky, S., Carmody, K., Ficke, C., Carroll, M., & Bennett, W. (2022). Teammates instead of tools: The impacts of level of autonomy on mission performance and human-agent teaming dynamics in multi-agent distributed teams. *Frontiers in Robotics and AI, 9*, 1–15. https://doi.org/10.3389/frobt.2022.782134
Reichers, A. E., & Schneider, B. (1990). Climate and culture: An evolution of constructs. *Organizational climate and culture, 1*, 5–39.
Rix, J. (2022). From tools to teammates: Conceptualizing humans' perception of machines as teammates with a systematic literature review. In *Proceedings of the 55th Hawaii international conference on system sciences*. https://hdl.handle.net/10125/79378.
Sageer, A., Rafat, S., & Agarwal, P. (2012). Identification of variables affecting employee satisfaction and their impact on the organization. *IOSR Journal of Business and Management, 5*(1), 32–39.
Salas, E., Shuffler, M. L., Thayer, A. L., Bedwell, W. L., & Lazzara, E. H. (2015). Understanding and improving teamwork in organizations: A scientifically based practical guide. *Human Resource Management, 54*(4), 599–622. https://doi.org/10.1002/hrm.21628
Sauppé, A., & Mutlu, B. (2015). The social impact of a robot co-worker in industrial settings. *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems*, 3613–3622. https://doi.org/10.1145/2702123.2702181
Savage, G. T., Nix, T. W., Whitehead, C. J., & Blair, J. D. (1991). Strategies for assessing and managing organizational stakeholders. *Academy of Management Perspectives, 5*(2), 61–75.
Schaefer, K. E., Hill, S. G., & Jentsch, F. G. (2018). Trust in human-autonomy teaming: A review of trust research from the us army research laboratory robotics collaborative technology alliance. In *International conference on applied human factors and ergonomics* (pp. 102–114). Cham: Springer. https://doi.org/10.1007/978-3-319-94346-6_10.
Schelble, B. G., Flathmann, C., & McNeese, N. (2020). Towards meaningfully integrating human-autonomy teaming in applied settings. In *Proceedings of the 8th international conference on human-agent interaction* (pp. 149–156). https://doi.org/10.1145/3406499.3415077
Schelble, B. G., Flathmann, C., McNeese, N. J., Freeman, G., & Mallick, R. (2022). Let's think together! Assessing shared mental models, performance, and trust in human-agent teams. *Proceedings of the ACM on Human-Computer Interaction, 6*, 1–29.
Schmutz, J. B., Meier, L. L., & Manser, T. (2019). How effective is teamwork really? The relationship between teamwork and performance in healthcare teams: A systematic review and meta-analysis. *BMJ Open, 9*(9), Article e028280. https://doi.org/10.1136/bmjopen-2018-028280
Schneider, M., Miller, M., Jacques, D., Peterson, G., & Ford, T. (2021). Exploring the impact of coordination in human–agent teams. *Journal of Cognitive Engineering and Decision Making, 15*(2–3), 97–115. https://doi.org/10.1177/1555343421101057
Seeber, I., Bittner, E., Briggs, R. O., De Vreede, T., De Vreede, G. J., Elkins, A., … Söllner, M. (2020). Machines as teammates: A research agenda on ai in team collaboration. *Information Management, 57*(2), 1–22. https://doi.org/10.1016/j.im.2019.103174
Shuffler, M. L., Jiménez-Rodríguez, M., & Kramer, W. S. (2015). The science of multiteam systems: A review and future research agenda. *Small Group Research, 46*(6), 659–699. https://doi.org/10.1177/1046496415603455
Shuffler, M. L., Pavlas, D., & Salas, E. (2012). Teams in the military: A review and emerging challenges. In J. H. Laurence, & M. D. Matthews (Eds.), *The Oxford handbook of military psychology* (pp. 282–310). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780195399325.013.0106.
Stokols, D., Hall, K. L., Taylor, B. K., & Moser, R. P. (2008). The science of team science: Overview of the field and introduction to the supplement. *American Journal of Preventive Medicine, 35*(2), S77–S89. https://doi.org/10.1016/j.amepre.2008.05.002
Subcommittee On Advanced Manufacturing Committee on Technology. (2018). *Strategy for American leadership in advanced manufacturing*. National Science & Technology Council.
Sverke, M., & Hellgren, J. (2002). The nature of job insecurity: Understanding employment uncertainty on the brink of a new millennium. *Applied Psychology, 51*(1), 23–42. https://doi.org/10.1111/1464-0597.0077z
Tang, C. P., Huang, T. C. K., & Wang, S. T. (2018). The impact of Internet of things implementation on firm performance. *Telematics and Informatics, 35*(7), 2038–2053. https://doi.org/10.1016/j.tele.2018.07.007
Taylor, T. R. B., Karimi, H., Goodrum, P. M., & Albattah, M. (2016). *Is there a demographic craft labor cliff that will affect project performance*. Construction Industry Institute, The University of Texas-Austin.
U.S. Bureau of Labor Statistics. (2022). *Construction: Naics 23*. U.S. Department of Labor. Retrieved from https://www.bls.gov/iag/tgs/iag23.htm.
de Visser, E. J., Peeters, M. M., Jung, M. F., Kohn, S., Shaw, T. H., Pak, R., & Neerincx, M. A. (2020). Towards a theory of longitudinal trust calibration in human–robot teams. *International Journal of Social Robotics, 12*(2), 459–478.
Walliser, J. C., Mead, P. R., & Shaw, T. H. (2017). The perception of teamwork with an autonomous agent enhances affect and performance outcomes. *Proceedings of the*

Human Factors and Ergonomics Society - Annual Meeting, 61(1), 231–235. https://doi.org/10.1177/1541931213601541
Wanberg, C. R., Ali, A. A., & Csillag, B. (2020). Job seeking: The process and experience of looking for a job. *Annual Review of Organizational Psychology and Organizational Behavior, 7*, 315–337. https://doi.org/10.1146/annurev-orgpsych-012119-044939
Wang, L., Liu, Z., Liu, A., & Tao, F. (2021). Artificial intelligence in product lifecycle management. *International Journal of Advanced Manufacturing Technology, 114*(3), 771–796. https://doi.org/10.1007/s00170-021-06882-1
Weckenborg, C., Kieckhäfer, K., Müller, C., Grunewald, M., & Spengler, T. S. (2020). Balancing of assembly lines with collaborative robots. *Bus Res, 13*, 93–132. https://doi.org/10.1007/s40685-019-0101-y
Welfare, K. S., Hallowell, M. R., Shah, J. A., & Riek, L. D. (2019). *Consider the human work experience when integrating robotics in the workplace. 2019 14th ACM/IEEE International Conference on Human-Robot Interaction*. https://doi.org/10.1109/HRI.2019.8673139
Wellener, P., Reyes, V., Ashton, H., & Moutray, C. (2021). *Creating pathways for tomorrow's workforce today: Beyond reskilling in manufacturing.* Deloitte Insights.
Williams, A., Sebastian, B., & Ben-Tzvi, P. (2019). Review and analysis of search, extraction, evacuation, and medical field treatment robots. *Journal of Intelligent and Robotic Systems, 96*(3), 401–418. https://doi.org/10.1007/s10846-019-00991-6
Wilson, C. (2014). Semi-structured interviews. In M. Kaufmann (Ed.), *Interview techniques for ux practitioners: A user-centered design method* (pp. 23–41). Newnes.
Wynne, K. T., & Lyons, J. B. (2018). An integrative model of autonomous agent teammate-likeness. *Theoretical Issues in Ergonomics Science, 19*(3), 353–374. https://doi.org/10.1080/1463922X.2016.1260181
Xu, X., & de Soto, B. G. (2020). On-site autonomous construction robots: A review of research areas, technologies, and suggestions for advancement. *Proceedings of the International Symposium on Automation and Robotics in Construction, 37*, 385–392. https://doi.org/10.22260/ISARC2020/0055
Wolf, A., Hedrick, K.N., Begerowski, S.R., Wiper, D.W., III, Carter, D.R., & Shuffler, M.L. (2023). Making every meeting count: A qualitative investigation of multiteam meeting events & their role in supporting coordinated cancer care delivery. JCO Oncology Practice, 19, e53-e66. doi: 10.1200/OP.22.00388.