AI as an Emancipatory Technology: Smart Hand Tools for Skilled Trade Workers

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Abstract

For skilled trade workers who use tools to do their work, technological innovation has often resulted in subjugation at the hand of their employers. Advances in artificial intelligence (AI) introduce the possibility of a new dynamic. While most of the hype around AI has focused on its potential to automate tasks and eliminate jobs, the intersection of AI and data cooperatives could allow for the development of smart hand tools that support and empower, rather than subjugate or replace, skilled trade workers. This paper explores smart hand tools as an emancipatory technology (ET) through interviews with supervisors of skilled trade workers employed by a municipal government. This paper responds to the call for additional research on how AI will influence work and workers and suggests that technology can enable skilled trade workers with new levels of agency.

Keywords: AI, Smart Hand Tools, Skilled Trade Workers, Emancipatory Technology.

1. Introduction

The introduction of Artificial Intelligence (AI) is transforming the future of work. Many expect the introduction and proliferation of AI to "significantly disrupt" labor markets (Frank et al., 2019, p. 1). These market-facing transitions are taking place while the technology is being defined. As such, the definition of AI is a topic of scholarly debate (Littman et al., 2021). We chose to define AI as "oriented toward the use of large datasets, analyzed through computational methods, to engender predictions arising from that data or to attempt to replicate human intelligence" (Slota et al., 2023, p. 311). AI promises to add enhanced efficiency and productivity; simultaneously, the threat of tech-induced automation and job elimination looms large (US-EU Trade and Technology Council, 2022). Ample attention has been paid to the impact of AI on knowledge workers (e.g., office workers) and unskilled workers (e.g., warehouse workers), but there has been less focus to date on the skilled trade workforce (Kane, 2023). The OECD classifies workers in the skilled trades who use tools to perform their tasks as middle-skill workers whose professional credentials are defined by a two-year associate degree or industry-related certifications (Autor et al., 2003; Green, 2019).

Innovation has often resulted in the subjugation of workers by their employers (Montgomery, 1980). AI could exacerbate similar trends through enhanced workplace surveillance and/or monitoring of the workflow and work production. The intersection of AI and the skilled trades does not need to be all doom and gloom, however. Some scholars offer a new perspective and invite a reframing of AI and related emerging technologies as an opportunity to capitalize on technological advances in ways that support workers instead of diminishing their skills and abilities (Xu et al., 2018).

Recent work by Information Systems (IS) scholars explores the concept of emancipatory technology (ET) and gives an example of how blockchain enables a vulnerable group, women miners, by providing greater transparency of gemstone supply chains (George & Whitten, 2020). Young et al. (2021) provide a foundation for emancipation research in IS and introduce a typology that includes the concepts of agency, dialogue, inclusion, and rationality. We are encouraged by the work in IS and ET and are inspired to apply these frameworks to AI in support of those in the skilled trades. In this study we explore how AI may forge new paths so that skilled trade workers may directly influence how they add

URI: https://hdl.handle.net/10125/107164
978-0-9981331-7-1

value to the marketplace minus a common-and-control employment model.

An example of how ET could be relevant to the skilled trades is through the concept of smart hand tools. Smart hand tools are hand tools embedded with sensing capabilities that collect data, analyze the outcomes, and return feedback to the user (Zoran et al., 2014). Workers who use smart hand tools receive information so that they may adjust their workstyle, enhance their end product, improve safety, and bolster their training. Smart hand tools go beyond the sensing capabilities of the Internet of Things (IoT) and instead impact the environment in which they operate, including the workers' physical self. Smart hand tools also create a digital record of workers' outputs, enabling them to be honored for their contributions and no longer be subjected to the hierarchical control of an employer. Researchers in computer science, mechanical engineering, and the social sciences are embarking on an interdisciplinary effort, alongside industry and government collaborators, to explore the ethical applications of AI to smart hand tools (Lassiter et al., 2023; Hill et al., 2023; Hill et al., 2022).

Researchers are also exploring methods to ensure that data resulting from smart hand tool use is managed and analyzed in a way that supports workers and does not contribute to their further subjugation or surveillance. These methods include data cooperatives. Data cooperatives are digital structures by which workers can voluntarily contribute and manage their own data and receive insights from the collective data analysis (Pentland & Hardjono, 2022).

In this paper, we pose the following research question: How can AI-enabled smart hand tools serve as emancipatory technologies? We explore whether AI-enabled smart hand tools, developed to support skilled trade workers and complemented by data cooperatives, may be included in the classification of ET. We review the literature related to smart hand tools and data cooperatives, as well as the concepts of ET and agency. We then reference ongoing qualitative research on the development of smart hand tools enabled by AI and describe the findings from semi-structured interviews with skilled trade worker supervisors. This initiative yields insights into the challenges of those working in the skilled trades and considers if AI-enabled tools can help to address these issues. We connect the themes from literature with our research results and demonstrate that the integration of smart hand tools can transform worker roles. Participants provided examples of how AI could support workers in doing work more effectively and safely. Participants shared how AI could support training efforts and encourage new entrants to the skilled trades. Insights from the interviews are aligned with IS research on emancipatory technologies and participant responses speak directly to the concept of agency for skilled trade workers (George & Whitten, 2020; George et al., 2021; Young et al., 2021). Finally, we offer recommendations for future research.

2. Background

This paper connects the literatures on smart hand tools, data cooperatives, ET, and agency.

2.1 Smart Hand Tools

Smart hand tools are hand tools with embedded sensing, internet of things, and edge AI capabilities that can produce data and deliver feedback to the user (Zoran et al., 2014). Hand tools are equipped with sensors that collect data about how the tool is used; this data is shared with other tools and can be fed into a digital twin via the internet of things, and edge AI can be used to detect patterns in the data, such as identifying if the worker is an expert or a novice, giving a novice user guidance that may help them to build their expertise, and giving workers real-time feedback that may help them to avoid workplace accidents or repetitive stress injuries. Our chosen definition of AI is "oriented toward the use of large datasets, analyzed through computational methods, to engender predictions arising from that data or to attempt to replicate human intelligence" (Slota et al., 2023, p. 311) The data resulting from smart hand tools can offer insights into how workers can use tools to create a better work product and to increase their own safety, reduce workplace injuries and bolster training efforts (Lassiter et al., 2023; Hill et al., 2023; Hill et al., 2022).

Smart hand tools contribute to creating more equitable access to work in the skilled trades by providing information to lower-skilled workers on proper tool use. Smart hand tools can open new possibilities for non-traditional skilled trade workers including women and those who are physically differently abled. For example, data from smart hand tools about a tool's weight can inform how long a worker can use that tool and/or suggest when to take a break. Information from smart hand tools can offer additional access for those who may have traditionally not considered this line of work. The societal impact of equitable employment also supports economic interests by addressing skilled worker shortages by attracting new entrants to the field.

An interdisciplinary research team is currently designing both the physical sensing and analytical apparatuses for smart hand tools and the social science

frameworks needed to ensure mechanical and computer science engineers are not designing in a vacuum. To further this co-design effort, the research team has established community partnerships with a local government entity and support from a nonprofit organization focused on advancing research across sectors. These partnerships offer collaborative research opportunities to directly explore and integrate numerous stakeholder perspectives from employers, educators, trainees, and skilled trade workers.

2.2 Data Cooperatives

In the mid-1800s, industrial workers began pooling their resources to offset low wages and the high cost of goods to create cooperatives (Curl, 2010). Historically, when the labor movement has undergone such efforts, the result has been an increase in wages and new employment opportunities leading to economic resilience for the cohort and their communities (Deller et al., 2009; Moro et al., 1972). A cooperative is "an autonomous association of persons united voluntarily to meet their common economic, social, and cultural needs and aspirations through a jointly owned and democratically-controlled enterprise" (www.ica.coop). Cooperatives operate in banking, retail, healthcare, and other sectors, to provide social alternatives to traditional marketplace offerings (Rothschild, 2009).

A data cooperative is a shared data repository that exists to benefit individuals through collective infrastructure and management and includes "the voluntary collaborative pooling by individuals of their personal data for the benefit of the members of the group or community" (Pentland & Hardjono, 2021, pp. 20-21). Individuals who participate in data cooperatives may benefit from data analysis insights and advice that can be used in negotiations to improve economic outcomes or social conditions (Bühler et al, 2023; Pentland & Hardjono, 2021). Mehta et al. (2021) summarize the benefits of a data cooperative in three concepts: control, bargaining power, and compensation. Control speaks to the notion that data cooperatives place power in the hands of members who determine its structure, intent, governance, and rights as a social good.

Data cooperatives present the possibility for workers to gain greater agency by accessing and managing the data generated from smart hand tool use. By contributing data generated by smart hand tools to the cooperative, skilled-trade workers avoid the need to understand how to manage their data and instead receive administrative support from those beholden to the group. Cooperative members may access insights from aggregated data that they may leverage to gain greater knowledge and control (Pentland & Hardjono, 2021). This is a departure from digital platforms where individuals relinquish data rights to technology companies (Fuchs, 2021; Salau et al., 2022).

2.3 Emancipatory Technologies (ET)

Scholars call for "wise interventions" to support skilled labor who are being impacted by technology (Tyson & Zysman, 2022, p. 257). While Tyson & Zysman refer to policy and institutional interventions, technology may also offer support. George & Whitten (2020) introduce the notion that blockchain qualifies as an emancipatory technology (ET) by presenting how blockchain enables women miners to follow the result of their work, gemstones, through the supply chain which offers greater transparency and clarity to the process ultimately resulting in greater authority and agency for this traditionally vulnerable group.

George et al. (2021) provides an overview of emancipatory technology in Information Systems (IS) with a focus on societal aspects such as technology used for "proliferating frames, exposing the truth, and pushing social change" (p. 6371). Young et al. (2021) offer an IS exploration of ET through a lens of critical theory and present a definition of emancipation as "the overcoming of constraints in such a way that individuals may control their destinies and generally go from a worse to a better state" (p. 6359).

From a review of 232 papers, of which 55 were thoroughly reviewed and analyzed, Young et al. (2021) offer four key components to describe ET: Agency, Dialogue, Inclusion, and Rationality. Although all four of these components are relevant to those working in the skilled trades, we focus on the concept of agency as the most applicable to smart hand tools related to workers' capacity to influence their situation. The authors describe agency as "the freedom to act" and the IS Phenomena as "systems subverting human users, computer-mediated control of workers, behavioral control, punishment from surveillance" (Young et al., 2021, p. 6363).

The IS consideration of ET and the component of agency as expressed by George et al. (2021) and Young et al. (2021) is well aligned with concerns about AI's predatory potential. We propose that technical solutions (such as smart hand tools, data cooperatives, and blockchain) that enable workers to generate, manage, and benefit from their data serve as liberating technologies instead of mechanisms of oppression, and therefore, may be classified as emancipatory. AI-enabled smart hand tools, supported by data cooperatives and blockchain, can offer the same level of trust, transparency, and validation, and

therefore, results in a greater level of agency for a group that has traditionally been subjected to the authority of their employer. Greater worker autonomy and agency, enabled by participation in data cooperatives, presents the potential for a fundamental shift in the employer-employee power dynamic (Kalluri, 2020). As those in the skilled trades navigate AI and technology's impact, perhaps the forces of communal benefit that inspired labor cooperatives of the industrial era can a support modern-day workers.

2.4 Agency

Young et al. (2021) define the term agency as "the freedom to act" (p. 6363). Their definition of agency joins prior research in the social sciences. Bandura (2001) provides insight into human agency defined as "to influence intentionally one's functioning and life circumstances" (p. 164). Bandura (2006) argues that human agency has four core properties: intentionality, forethought, self-reactiveness, and self-reflectiveness, and describes three modes of agency: personal, proxy, and collective (Bandura, 2001). Trade unions are a particularly notable form of collective agency, particularly in the context of skilled trade workers (Briskin, 2011). However, Giddens (1986) distinguishes between agency and intentionality, arguing that unintentional acts still constitute agency. Fleischmann (2006, 2007, 2009) extends the concept of agency to technology, creating a distinction between humans (bioagency) and nonhumans (cyberagency). The concept of nonhuman agency builds upon previous literature on actor-network theory which illustrates that information technologies can possess agency (Callon & Law, 2005; Latour, 1987). Humans may delegate agency to organizations (trade unions) or to technology (smart hand tools, data cooperatives). While agency can be viewed as a power struggle among these actors, this relationship can be shifted through participatory design (Schuler & Namioka, 1993) or appropriating technology (Eglash et al., 2004).

3. Methods

In this study we offer the following research question: How can AI-enabled smart hand tools serve as emancipatory technologies? To answer this question, we use an iterative approach and begin with a search of the literature. Young et al. (2021), George & Whitten (2020), and George et al. (2021) provide a significant compass for this work as the articles showcase how IS scholars embrace the construct of emancipatory technologies and provides a framework that includes the concepts of agency, dialogue, inclusion, and rationality.

Guided by the literature, we revisited a qualitative research effort where we conducted semi-structured interviews with seven supervisors at a local municipality who manage skilled trade workers related to hand tool use, the concept of smart hand tools, and general attitudes toward technology. This qualitative research effort is part of a broader initiative by an interdisciplinary team of researchers who are designing smart hand tools employing user-centric and participatory design methods (Lassiter et al., 2023; Hill et al., 2022). We gained access to participants thanks to a formalized partnership between the city and the university, and we recruited participants via email with support from the city's Office of Innovation. We initiated contact with supervisors and asked participants to complete a brief survey to gather qualifying information. We then scheduled supervisor interviews online and conducted interviews via Zoom. All participation was voluntary, and respondents were not compensated. To analyze our research results, we continued an iterative approach and used thematic analysis. We slightly adjusted the research instrument based on participant insight.

3.1 Participants

We conducted interviews with municipal employees who supervise skilled trade workers across five divisions: Parks & Recreation, Water, Watershed Protection, Fleet Mobility, and the Airport. The formal names of the divisions have been edited to ensure anonymity. Each of the supervisors comes with substantial experience working in the skilled trades and offers a unique perspective both from their own experience and the experience of their workers. The participants have varying years of experience working with the city, from less than one year to 30 years.

Table 1. Participant descriptions

Identifier	Department	Years of City Employment
Supervisor 1	Parks & Recreation	7.5
Supervisor 2	Water	13.5
Supervisor 3	Watershed Protection	8
Supervisor 4	Fleet Mobility f	<1
Supervisor 5	Watershed Protection	20
Supervisor 6	Airport	28
Supervisor 7	Parks & Recreation	30

3.2 Data Collection

Once we received an email from the supervisor expressing interest in participating in the study, we replied with a link to a Qualtrics survey to collect basic information including Department and years of experience employed by the city. Participants could also schedule their online interviews through a link in the survey. We conducted seven semi-structured interviews with skilled-trade supervisors placed via Zoom's call-in feature. We did not use the video function of Zoom to conduct interviews. Each interview took place over an average of 45 – 60 minutes. We followed IRB protocols and recorded the interviews with the participants' consent. We began our interviews with questions about the supervisors' use of hand tools for the city and asked for examples where using hand tools went well and where there were opportunities for improvement. We then asked questions about training skilled trade workers on their teams related to smart hand tool use. We asked questions specifically about smart hand tools but did not include examples of specific commercially available tools or prototypes so as to not influence or bias participants' responses. Our discussion with participants on smart hand tools was generic and conceptual. Our questions were designed to request feedback on if and how technology could be integrated to hand tools to improve their function.

The first nine questions of our interview focused on worker experience and general hand tool use. We then provided a brief definition of a smart hand tool as "hand tools with embedded sensors and intelligence that will be able to provide feedback to the user." We then proceeded with questions on smart hand tool design such as "What kinds of tools do you think could be usefully converted into smart hand tools?" and "Are there any particular situations where a smart hand tool would be particularly useful?" We also inquired about the participants' beliefs about data usage and data collection.

3.3 Data Analysis

We used thematic analysis to review interview responses in search of themes that support the concept of smart hand tools as emancipatory technology in line with the concept of increasing agency for skilled trade workers (Braun & Clarke, 2006). The research team consisted of two social science scholars who independently manually line-by-line coded a subset of the interview transcripts and then came together to review the process and resulting codes. The researchers then identified and organized the interviews key themes and then applied these themes and individually manually coded the remainder of the interview transcripts. The research team checked transcripts for accuracy and discussed the application of the themes. The team created a document where all interview responses were organized by theme. Interviews were transcribed using rev.com and stored on a secure online repository. Researchers reviewed qualitative research results using an inductive approach to explore if results from participant interviews aligned with the ET framework and the concept of worker agency.

4. Results

Our analysis of interviews with skilled-trade worker supervisors (labeled Supervisor 1 – 7) revealed five core areas of insight that align with the concept of ET: Attitudes and Beliefs Towards Technology, Technology's Influence on Effectiveness, Emphasis on Safety, and Technology and Training.

4.1 Attitudes and Beliefs Towards Technology

Supervisors expressed enthusiasm for technology and AI. One supervisor exclaimed, "I think everything we do should be data-driven" (Supervisor 2). Participants generated their own ideas about how to design technology to support workers, "If you had some biotic eyes or whatever to tell the tool where to go to. I mean that'd be pretty cool, too" (Supervisor 3). Related to the discussion on if technology could support, not replace, skilled trade workers, one participant responded affirmatively, "I'm sure there's always innovations, as we see stuff. We're always looking for ways to incorporate new tools if we can" (Supervisor 5). Another supervisor echoed this sentiment:

> *You have to embrace what's new… if you're already on shutdown before you've ever given it an opportunity, it's not gonna benefit you… I think the acceptance is very important.* (Supervisor 6)

Supervisors explained some of the challenges that skilled workers experience and offered ideas on how technology, specifically AI, could help workers by providing them with direct feedback on tool use. "If a machine tool could say, 'Hey, incorrect accessory, please try another' or… give the operator a warning of those type of things, I think would be extremely helpful" (Supervisor 6). "Just providing some sort of feedback to an individual utilizing the tool that it's not

necessarily being utilized to the best of its ability might be beneficial" (Supervisor 5).

These supervisors' expressed enthusiasm for smart hand tools offers the perspective that workers may embrace, instead of balk at, AI-enabled technologies.

4.2 Technology's Influence on Effectiveness

Information generated by smart tool use may support workers in doing their jobs more effectively and allow them to certify the accuracy of the final work product. One participant suggested, "It would be great if there was a more efficient way to have the work done on the back end to check the accuracy of what you're producing" (Supervisor 6). Another supervisor specifically pointed to how data, and presumably analytics, could contribute to a better end product, "Any kind of accumulation of data is gonna be good to make the jobs efficient" (Supervisor 5).

Included in the concept of doing a job successfully (or effectively) was delivering information to the user about the status of their tools, specifically related to the tool's durability and longevity. One supervisor stated, "I'd be interested to see what tool is most damaged, what tool are we buying the most often, what tool are we using the most often? What tool is the most useful?" (Supervisor 2). Supervisor 7 also supported this notion:

> *Any data that we can collect regarding tools that were misused, tools that burnt out, tools that were too old... The tools that we have, they're so heavily used that they don't give us warning that they're about to expire.* (Supervisor 7)

Another participant spoke to the idea of AI supporting workers in identifying correct tools and suggested a possible intervention where a "smart socket" could augment existing tools:

> *...my guys never have the right size socket that they need or the right size open-end wrench… if you had an actual very versatile smart socket that could change size to be the exact size you need anytime you needed it, that would be super slick.* (Supervisor 2)

Supporting tool choice while maintaining tool integrity may also lead to improved safety outcomes.

4.3 Emphasis on Safety

There was also a professed seriousness about the nature of skilled-trade work and the risks that workers take to perform their jobs. "If you're not paying attention, you know can miss something that can cause you to lose your life out in the field when we're performing some of these services" (Supervisor 7). There was a consistent theme throughout participants' responses about the importance of safety. One supervisor generated an idea about the role that AI could play in creating safer work environments by identifying the source of an accident, "(If) a tool… could relate back to if it was a close call that would've maybe resulted in an injury or something… that would be beneficial. To use that (data)... to find the causal factors of an incident" (Supervisor 1). Safety was a concept expressed related to training workers, especially less those with less experienced, on the risks of using tools:

> *Well, training on specific tools, especially tools that they're not familiar with… a lot of tools are dangerous…. So, the tools themselves, they need to be identified, hey these are tools for these kinds of jobs and for these are the kind of jobs you might think that you could use them but really, they're not intended for those jobs.* (Supervisor 3)

In addition to safety, the notion of reducing workplace injury was also a common theme:

> *And so, I think being able to tell them, 'When you use this old tool, you are putting this much strain or sprain on your muscles where with this new tool or this new method to do this, you're taking a lot of that strain off.'* (Supervisor 4)

Reducing tool-associated danger and injuries are important aspects of smart hand tool design.

4.4 Technology and Training

Supervisors also explain how AI-enabled technology, specifically video and Virtual Reality (VR), may support training to better prepare new entrants to the skilled trades. "There's a level of the combination of being able to give people hands-on training… I feel like people today learn really well with a visual video with somehow a hands-on virtual experience at the same time" (Supervisor 2). AI may be able to help adjust existing training protocols to fit the unique needs of more novice workers. "Well as our biggest challenge right now is that we're just having a

hard time getting experienced people and to where guys that we're hiring don't have a lot of experience to where they don't even know the tools" (Supervisor 2). One respondent discussed how AI-enabled tools and data could support a level of customized training to support diverse learning styles:

> *So, we all have written procedures… But sometimes you have to step outside of those guidelines because every individual learns different. Some people are visual, some people you have to take in a classroom setting, some people wanna be hands-on when they're trained. I could see some benefits in… training of some sort for the managers, the employee, the staff person to understand that this was the goal, and this is what the data is showing us to meet that goal. And any corrective actions from the data to better help us, again, be more efficient.* (Supervisor 6)

Another supervisor discussed how technology, and specifically AI, could support instances of how skilled trade workers learn and apply their knowledge. The respondent acknowledges that formal training materials are not always used and/or referenced:

> *<laugh> We don't really like to look at the instruction sheet or manual that comes with the tool. We know how to use them and it's usually trial by error that we use something and learn it that way. So, I guess that that'd be an improvement there as far as the operation manual and the instruction manual could be more appealing or inviting to (the) individual instead of just thinking we know how to use it.* (Supervisor 3)

These insights provide important direction for future AI-enabled training for skilled trade workers.

4.5 Technology to Increase Equity and Access

Supervisors describe the need for assistance for workers with specific physical limitations and pontificate as to how AI may be able to enhance accessibility and the impact on the broader work environment including other staff members. "So, some way to help enhance the senses somehow or any way to help improve eyesight… anything that would help me be able to magnify things… or provide extra light on something" (Supervisor 2). Supervisor 6 spoke to the concept of agency and how technology could support a worker in voicing their concerns and taking specific action to accommodate their physical needs:

> *If something's too heavy… I've been frontline and sometimes you're just like, man, I don't wanna say nothing makes it sound like I'm complaining… It keeps you, well, let me just be quiet and not say anything. Well, that's not a good thing long term for yourself (or) for the environment, the people around you. Smart technology, I could see where it has some very good benefits.* (Supervisor 6)

Despite positivity about technology, skilled trade worker supervisors still expressed a healthy skepticism. "Sometimes technology isn't as smart as it seems to be and can fail at times. That's why I don't trust it" (Supervisor 1). This was also met with a tone of acceptance and a willingness to work through the challenges, "But there are gonna be flaws, there're gonna be errors. Now when that happened, what is the corrective measure so that it's not a continuance of a hazard? You know what I mean? So, I think from that perspective" (Supervisor 6).

Participant responses from skilled trade supervisors revealed a willingness to consider how technology, AI, and smart hand tools could support those working in the skilled trades. Supervisors expressed how the introduction of AI-enabled tools could help workers be more effective in their jobs, increase safety, reduce accidents, and enhance training. In the next section, we will connect these results to the existing literature.

5. Discussion

In this study we explore how AI-enabled smart hand tools and data cooperatives can support skilled trade workers and therefore be included in the topic of ET. We build upon a previous framing of emancipatory research that presents four concepts: agency, dialogue, inclusion, and rationality (Young et al., 2021). We focus on the concept of agency to explore the notion of skilled trade workers gaining greater autonomy in their jobs and with their final work product. The Young et al. definition of agency, which focuses on the concept of freedom, marries well with the description of the term from social psychology, which focuses on intentional influence (Bandura, 2001).

Results from our interviews with skilled-trade worker supervisors support these definitions. For example, Supervisor 6's comments that smart

technology could have some benefits support Fleischmann's (2006, 2007, 2009) extension of agency from humans to technology as the participant expresses how smart technology can aid workers in claiming their own voice and power.

Other IS work on ET showcases how technology supports vulnerable audiences by providing transparency and clarity (George & Whitten, 2020). These themes emerged from our qualitative research related to how AI could guide workers in making the proper tool choice for specific jobs or even how to use certain tools. Even though effectiveness was a theme that emerged from the interviews, workers' decisions related to tools go far beyond convenience. Physical safety was prevalent throughout our discussions with the supervisors, such as when Supervisor 7 warned about the dangers of work in their department.

Despite the historical precedent of innovation displacing workers, respondents voiced support for technology to assist those in the skilled trades (Montgomery, 1980), such as Supervisor 2's call to be data-driven and Supervisor 5's pro-innovation sentiment. Many supervisors enthusiastically offered ideas for how AI could augment tools and even suggested new product ideas that could support workers in the field such as Supervisor 3's call for biotic eyes.

Our research found parallels with IS literature that describes how technical interventions, such as blockchain and video, support vulnerable audiences (George & Whitten, 2020; George et al., 2021). Blockchain did not come up in our participants' comments. however, they did mention video as an important element for enhancing training. The topic of AI supporting diverse learning styles was also mentioned by our participants.

Young et al. (2021) describes emancipation as "the overcoming of constraints" (p. 6359). Participants spoke about how AI could help them see better and could reduce physical wear and tear on their bodies, reduce injuries, avoid accidence, and otherwise enhance their work experience. These statements are all supportive that smart hand tools belong in the classification of ET. In addition to supporting existing workers, our results showed evidence of how data could make the skilled trades more appealing and enable non-traditional workers, including women, to approach the field by providing information about the weight of certain tools.

This study suggests there is support both from the literature and from our qualitative research that smart hand tools, and by association data cooperatives, qualify as ET and contribute to worker agency and autonomy. Participants described how AI and smart hand tools support workers in doing their jobs more effectively and more safely while also assisting their professional development through training. In addition, because smart hand tools serve as catalyst for skilled trade workers to generate a digital record of their work, the resulting data product becomes an important element for skilled labor to participate in data cooperatives.

The appropriate applications of AI invite skilled workers to participate in the digital economy thereby increasing their agency. AI opens new opportunities for skilled trade workers to explore new ways to work and benefit from that work. Figure 1.0 shows how skilled trade workers generate data through smart hand tool use and the role of data cooperatives.

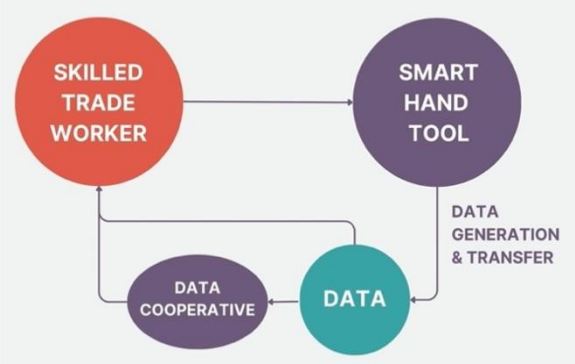

Figure 1. Skilled trade workers and data

This paper has limitations that can be addressed through further research. First, our research project is an early-stage, multi-faceted study with a multi-disciplinary team focused on engaging skilled trade workers in the design and appropriate implementation of smart hand tools. While ethical considerations are a primary driver of this effort, our research is not specifically designed to explore the fundamentals of ET or data cooperatives. Therefore, the interview instrument did not include any questions specifically focusing on the potential for smart hand tools to serve as an ET nor did it focus on the concept of data cooperatives. Instead, participant responses, combined with IS literature on ET, inspired this new direction. The emergent findings presented here are promising and compelling, and so it would be useful for future studies to more explicitly focus on AI as ET.

Second, the paper reports findings from interviews with supervisors of skilled trade workers, rather than with skilled trade workers themselves. It is important to note that many of these supervisors are themselves skilled trade workers, and their current role provides them with a valuable perspective that intermediates between skilled trade workers and bureaucrats. However, it would be useful to conduct similar interviews with skilled trade workers.

Third, the paper reports findings from only seven supervisors within a single city government. While this sample provides a valuable starting point for this research, it would be useful to interview a larger number of participants across a larger number of governments and even organization types.

AI as ET suggests a novel approach to overcome technology's threat of automation and the resulting displacement of humans in the workforce. This could have a significant social and civic impact. Our hope is that these efforts will inspire skilled trade workers to take collective action to join the digital economy and ultimately enjoy greater levels of agency.

6. Conclusion

As technology's impact on our daily lives and our economy continues to increase, so does the imperative to ensure that emerging technology does not further subjugate workers. Smart hand tools and data cooperatives are important mechanisms to continue the exploration of how AI can be a force multiplier for good. Instead of replacing skilled trade workers, AI can enable the future workforce to enhance their work, their work product, and even their own personal safety. Additionally, smart hand tools allow workers to generate their own data as a new source of economic value. All these mentioned factors contribute to AI as an extension of ET. Therefore, we suggest that our results demonstrate sufficient evidence that AI-supported smart hand tools are examples of ET.

The notion of AI as ET is an exciting new chapter and one that we believe is worthy of further investigation. We believe that this study serves as a beginning of continued research on ET to support the role of skilled trade workers as autonomous agents in the digital economy and how the resulting data from smart hand tools may be managed and optimized by workers for workers. Our qualitative research was not designed to gather insight from skilled trade workers on ET. Instead, our research focused solely on the development of smart hand tools. Researchers, inspired by the IS literature on ET, unearthed the notion that these technologies could be ET based on participant responses.

Additional research developed to specifically to investigate ET for skilled trade workers as well as associated stakeholders, such as employers, unions, and private and social sector partners, is necessary and needed. There is a unique and time-sensitive opportunity to co-design AI as ET with those who are traditionally left out of the technology evolution. We are enthused about developing future research on the idea of smart hand tools and data cooperatives as ET for skilled trade workers. In other words, our study reveals that there is sufficient evidence for AI-enabled technologies as ET. Further investigation would contribute to the field of IS as well as other scholarly disciplines in addition to serving the ultimate stakeholder - skilled trade workers.

7. Acknowledgements

We would like to thank all our research participants for generously sharing their time and expertise. This work was supported by funding from Good Systems, a research grand challenge at the University of Texas at Austin; Microsoft Research; and The MITRE Corporation.

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