Communicating Augmented Reality Devices Improving Technology Acceptance Among Electric Utility Field Workers

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COMMUNICATING AUGMENTED REALITY DEVICES IMPROVING TECHNOLOGY ACCEPTANCE AMONG ELECTRIC UTILITY FIELD WORKERS

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ABSTRACT
COMMUNICATING AUGMENTED REALITY DEVICES IMPROVING TECHNOLOGY ACCEPTANCE AMONG ELECTRIC UTILITY FIELD WORKERS

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Augmented Reality (AR) is very useful for many different fields and purposes such as entertainment, education, military, navigation, industrial, or electric utility. Electric utilities find use in AR due to the flexibility of location and the real-time information sharing with visuals to keep employees safe and efficient. This exploratory study investigated the use of infographic templates as a way to introduce this new technology to line workers in the electric utility field. Infographics were used as a way to prime workers to be more aware of the technology and its possible uses as well as usefulness. Through the use of Communication Accommodation Theory and the Technology Acceptance Model, the researcher found evidence indicating that presenting information in a clear and interesting way increased electric utility workers desire to adopt the new technology through perceived ease of use and perceived usefulness (Davis, Bagozzi & Warshaw, 1989).

Keywords: Augmented Reality, Electric Utility Field Workers, Infographics, Communication Accommodation Theory, Technology Acceptance Model.

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Introduction

Augmented Reality (AR) is often confused with Virtual Reality (VR) and is oftentimes assumed to be an entertainment only tool by the general public. However, since its inception, AR has been growing and perfected for use in a number of fields in order to enhance efficiency and to ensure a safe working environment. AR has been demonstrated, though research continues, as an effective tool for entertainment, education, military, navigation, industrial, and electric utility. The version of AR differs in each context through the various forms of headgear, displays, and projection. With each of these diverse uses and contexts, AR has great potential (Klinker, Stricker, & Reiners, 1999). Over the past two decades research has been conducted on the devices, both available and emerging. Many issues addressed in early research, in regard to AR, have now been identified and improved upon. However, there are still evolving issues of human factors and ergonomics with the technology and the devices (Klinker, Stricker, & Reiners, 1999).

Augmented Reality is the combination of real and virtual information done in an interactive way in real time. AR operates and is used in a 3D environment (Kipper & Rampolla, 2013). The technology permits an overlay of a digital image on the real world (Tilley, 2016). It allows the user to be aware of their surroundings while enhancing their vision or knowledge through visual additional displays (Aukstank, 2017; Schmalstieg & Höllerer, 2016). In some cases, the mobile smart devices such as tablets or smartphones use their cameras to create an interactive interface which combines the view of the consumer with the physical environment and overlays “texts, graphics, and other media

files that have been ‘geotagged’ to specific coordinates on the Earth’s surface,” (Morely & Tinnell, 2017). In addition, many AR browsers on different devices incorporate image tracking software in order to create an accurate target of digital overlays on top of print media, building facades, and other environmental structures (Morely & Tinnell, 2017).

As AR is becoming a huge part of various industries workers are being faced with using new technology in their daily jobs. The electric utility field is hoping to transition nationwide to AR devices as a standard tool for carrying out tasks (Simmins, Gray, & McCollough, 2015). Electric utilities believe that AR will help the safety and efficiency of workers (Enel, 2016). However, the demographic of electric utility workers may be resistant to new technology and need a clear communicative process to explain why AR is a useful choice for their profession (Chatlani, 2016). Tools such as infographics have been proven to be useful and effective when it comes to translating research into a palatable and comprehensible package (Agwa-Ejon & Batchelor, 2016).

In order to gain acceptance of this useful and efficient tool, employers must find a way to present AR as easy to use and useful. Both the communication accommodation theory and the technology acceptance model (Davis, 1989; Giles, Coupland & Coupland, 1991; Giles, 2016; Markus, 1990; Rogers, 2003) offer potential theoretical pathways towards successful implementation of these technologies. These theoretical frameworks will be used in order to create an effective infographic template to present AR to utility line workers and inform and help encourage the adoption of the new technology in the workplace.

Literature Review

The field of electric utilities has many uses for AR technology. Some possible uses of AR in the electric utility field according to the Electric Power Research Institute's (EPRI) project Field Force Data Visualization, are as follows:

- "viewing asset maintenance manuals
- performing storm damage assessment or inspections
- accessing asset information in the field
- facilitating switching communications integrating work-order information flows
- obtaining real-time system status validation
- visualizing faults in the field
- overlaying any data, like weather or operational data in the field
- viewing and analyzing power quality data in the field
- using the same technology in the control center as well as in the field devices," (Simmins, Gray, & McCollough, 2015).

Other uses, as described by other sources, explain how workers could visualize poles, guy wires, overhead secondary and service lines before they are built, (Hamsa, 2015). AR would also allow visualizing line sag and spacing to understand how it would look in the real world, as well as visualizing the sag with temperature elements or clearance requirements (Hamsa, 2015). Additional possibilities include collaboration with real-time video sharing and increased independence with digital manuals (Judson, 2017). Other uses of AR for utilities would allow workers to maintain substations, perform inventory transactions, track radiation exposure, and repair equipment (Vukojević, Johnson, & Simmins, 2016). Moreover, AR can even help with underground utilities combining data of water, electric and gas lines helping multiple utilities with one application (Meehan, 2017). In the next 5-10 years these uses described will likely be in action in the utility field. (Vukojević, Johnson, & Simmins, 2016).

Experts predict that AR technology will increase productivity and safety in the electric utility field. As a result, companies such as EPRI and the IEEE are working to improve user experience and encourage companies to move towards AR (Enel, 2016; IEEE, 2017).

Augmented Reality

There are many types of AR available within the entertainment, education, military, navigation, industrial-manufacturing, and electric utilities sectors. Specific types and uses of AR are noted in each domain beginning with current types of AR devices, the future of AR and the various domains where AR is used.

The general public became extremely acquainted with Mobile Augmented Reality (MAR) the summer of 2016 when *Pokémon Go* was released (Sage, 2016). The game's premise allows for the maps on the mobile devices and cameras to be accessed. When individuals point their camera at the road, the road is present on their screen with an additional figure of a Pokémon (see Figure 1). This interactive game took advantage of the current technology within mobile devices, as well as consumers' strong understanding of how to use these devices and their dependency on it (Sage, 2016). Pokémon Go was a very successful incorporation of AR in an affordable setting to the general public. This game displayed the accuracy, and sensitive target ability of the software, as well as the location geotagging, giving the world a taste of what is to come with AR.

AR is not just for mobile augmented reality (MAR) devices but can be used on a number of different platforms. Head Mounted Displays (HMDs) or Heads Up Displays (HUDs) are a common tool that developers choose to create their software and

applications for; when users need to have a hands-free experience (Aukstakalnis, 2017). Whether the user is driving, carrying packages or defending the country with weaponry, the hands-free information sharing, and real-time accurate displays are necessary for efficient, safe operation, and completion of tasks (Aukstakalnis, 2017; Schmalstieg & Höllerer, 2016). HMDs for AR must be See-Through Displays (STD) so that the user may be aware of their surroundings and not have their vision impaired by the information presented on the headset (Nakanishi, Ozeki, Akasaka, & Okada, 2007). When wanting to display information to a larger group rather than for an individual, AR projection tracking and mapping is a useful tool. AR projection tracking and mapping are used in various fields to achieve success through projecting images onto real-world objects, in a hologram style (Schmalstieg & Höllerer, 2016). This could be done in order to show what a room would look like once the interior design additions are added or be used in meetings to present the new design for a product (Schmalstieg & Höllerer, 2016).

Although AR is not a common term in every household, it is expected to become one, and very soon. AR is expected to take three-quarters of the projected $108 billion a year spent by 2021 (Economist, 2017). The statistics indicating that AR will soon be a $100 billion industry in 2020 are compelling (Tilley, 2016). The main group expected to participate in buying these products comes not from independent consumers but businesses and corporations. This predicted economic boom for the AR industry and demand for products requires multiple fields need to work together to produce successful AR devices (Dunston & Wang, 2005). AR is not just for entertainment but is of use in multiple fields (Economist, 2017). The projected spending and costs of AR take into consideration corporations, military, navigation and industry jobs that will be requiring

the use of AR to better enhance worker experiences, efficiency and safety. The following sections will review how a few of these key industries are incorporating AR.

Entertainment.

Augmented reality seems to some to be the stuff of science fiction novels, films, and TV shows. The *Star Wars* idea of wearing helmets with data uploaded on the side view, and target sensors to shoot at the "Death Star", or the ability to project Princess Leia from a small robot into the air in a 3D form, is now accessible to the general public (see Figure 2.) Tools that were once thought to be fictional, and only in movies are becoming made for the mass consumer, in addition to being more affordable.

The entertainment sectors such as films and media sources are incorporating AR as a part of their marketing plan (Star Wars, 2017). By creating interactive trailers on YouTube, or movie ads in magazines producers are engaging fans in new ways (Star Wars, 2017). For the new *Star Wars* movie, individuals could hold their iPad camera at a magazine page following directions are written in a magazine to find a "Death Star" floating on the magazine in front of them (see Figure 3; Star Wars, 2017). Having moving pictures and 3D elements to magazines mirror the fantasy writings of J.K. Rowling in her *Harry Potter* Series (Rowling, 1997). Perhaps moving newspaper pictures will not be limited to wizards in the next twenty years, but a part of our daily lives. Magazines are allowing tech-savvy readers to participate and enjoy additional visuals and interactions through AR (Eaton, 2013). By using devices such as tablets and smartphones individuals may interact and enjoy apps available often for free (Eaton, 2013). Static magazine covers on store shelves now can become videos with the use of apps on

smartphones. This clever marketing trick "enhances the sense of interactivity for the reader," (Eaton, 2013, p. 1). It also assists in keeping this print medium alive for the digital native generation.

Figure 1. Pokémon Go the worldwide phenomenon that introduced VR gaming to the general public. (Image: http://thearea.org/pokemon-go-means-enterprise-ar/)

Figure 2. Luke Skywalker's AR headset to assist with shooting down TIE fighters. Science fiction and film is often where we see technology ideas first. Headsets like these are currently being created for other fields. (Image: http://www.starwars.com/databank/luke-skywalker)

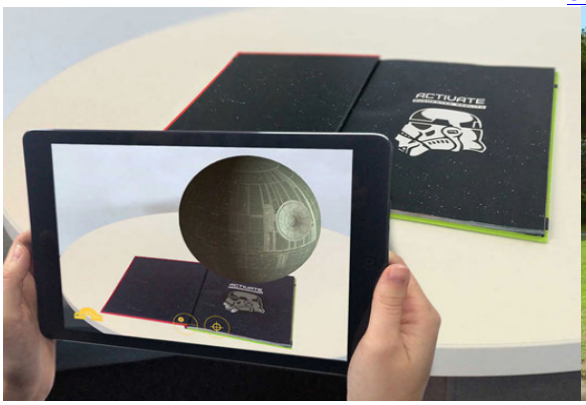

Figure 3. Star Wars ad in magazine that incorporates AR elements when using smart devices with built in cameras. (Image: http://www.starwars.com/news/star-wars-app-augmented-reality-instructions)

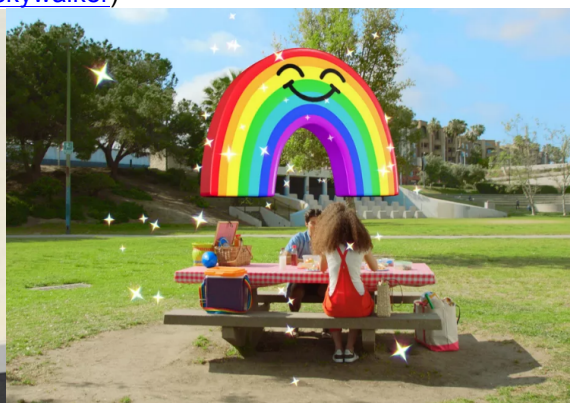

Figure 4. Snapchat filters that overlay images onto camera screen while taking pictures. Filters can change daily and be created by locations so that individuals can use filters for cities, restaurants or events (Newton, 2017). https://www.theverge.com/2017/4/18/15333130/snapchat-world-lenses-something-new-for-facebook-to-copy

Education.

In addition to the entertainment industry utilizing AR, the education field is attempting to find new ways of incorporating technology to enhance learning (Kipper & Rampolla, 2013; Sheehy, Ferguson, & Clough, 2013). In order to keep students up to date with the changing technology climate, as well as to keep their attention, more and more schools of all age groups are incorporating AR as a possible tool in the classroom (Sheehy, et al., 2013). Pre-K through higher education learning and even into the training world of business, AR is evolving to become a staple of education in all subjects (Morely & Tinnell, 2017). Particularly, AR is being used in the STEM (science, technology, engineering, and mathematics) fields and subjects due to its ability to allow for more laboratory time, experiments or use of manipulatives virtually (see Figures 5 & 6, Lasica, Katzis, Meletiou-Mavrotheris, & Dimopoulos, 2017). AR also helps to promote enhanced learning and achievement (Akçayır & Akçayır, 2017). AR encourages students to develop "critical thinking, problem-solving and communicating through interdependent collaborative exercises," (Dunleavy, Dede, & Mitchell, 2009, p. 20). Because of these advantages, some schools are hoping to begin using AR technology. Two of the major factors limiting school use of AR are the financial strain for class sets and the limit in applications that currently exist.

Figure 5. "Virtual and Augmented Reality apps are starting to hit the market in force. Companies are getting involved realizing the potential that Augmented and Virtual Reality may have as education tools," (Ternovyi, 2016). (Image: https://infinityleap.com/22-augmented-reality-education-vr-classroom-apps/)

Figure 6. A new and interactive way to learn about anatomy. Accessible on multiple platforms, students can have interactive 3d models to pull apart, touch and learn from. (Image: https://3d4medical.com/)

Military.

When it comes to technology being ahead of the consumer market the military has always been on the cutting edge of the next big technology boom (see Figure 7). With the invention of the radio, mobile phones, computers, and Internet, the idea that VR and AR are being improved upon by the military seems natural (Schmalstieg & Höllerer, 2016; 2016; Vivian, 2013). The military improvements and research have focused on the acuteness of the eye gear and the accuracy of targets for combat purposes as well as reaction time (Argenta, Murphy et al., 2010; Kalawsky, Hill, Stedmon, Cook & Young, 2000; Schmalstieg & Höllerer, 2016). Research as early as 2000, discusses the

improvements and tests being done to take advantage of this emerging technology (Cook & Young, 2000). As more technology becomes available and perfected by the military AR will continue to improve the general consumer market (see Figures 8 & 9).

Figure 7. US Military funded smart helmet that can beam information to soldiers on the battlefield (Prigg, 2014). (Image: http://www.dailymail.co.uk/sciencetech/article-2640869/Google-glass-war-US-military-reveals-augmented-reality-soldiers.html; https://www.ara.com/national-security)

Figure 8. ARC4 allows commanders to send maps and other information directly to soldiers' field of vision. (Image: http://www.dailymail.co.uk/sciencetech/article-2640869/Google-glass-war-US-military-reveals-augmented-reality-soldiers.html; https://www.ara.com/national-security)

Figure 9. The system is connected to control units on the soldier's body. Information is sent wirelessly to the soldier and displayed over one of their eyes (Prigg, 2014). (Image: https://www.ara.com/national-security)

Navigation and travel.

The areas that AR can assist with are vast, and ever growing. As technology and affordability continue so will the pervasiveness of AR in all aspects of life. From aerospace usage, to railways, to boats, to driving a car, AR helps individuals navigate using maps and other means to get from point A to point B (Bertuccelli, Khawaja, & O'Neill, 2014; Hall, Lowe, & Hirsch, 2015; Hong, Andrew, & Kenny, 2015; Kourouthanassis, Boletsis, & Lekakos, 2015; Lehikoinen & Suomela, 2002; Liang, 2015; Morrison, Mulloni, Lemmelä, et al., 2011; Plavšić, Bubb, Duschl, et al., 2009; Schall, Rusch, Lee, et al., 2013; Schmalstieg & Höllerer, 2012; Tippey, Sivaraj, & Ferris, 2017). The main devices used are HUDs and MARs (Bertuccelli, et al., 2014; Plavšić, et al., 2009). These devices help provide better information to navigators and assist with situational awareness (see Figures 10-13; Hong, et al. 2015). Some of the HUDs show rear and side cameras of the vessel creating an information-rich environment (Hong, et al., 2015). The AR detection of hazardous objects and assistance in low visibility increases safety for the individual and others who may be present (Schall, Rusch, Lee, Dawson, Thomas, Aksan, Rizzo, 2013). These features are becoming more readily available and exposed to the general public. Many new makes of cars are being advertised for their safety and awareness due to having back up cameras with AR graphic lines over them to show distance and direction to parallel park or back out of a driveway (Engstrom, Markkula, Victor, & Merat, 2017; Schall, et al. 2013; Schmalstieg & Höllerer, 2012). The AR situational awareness can be used for small vehicles to large, including massive ships that use the cameras and AR parameter lines to dock or avoid other ships. Airplanes are able to use the AR cameras for landing safely on runways even

at night with the help of the visual aids AR provides (Kourouthanassis, et al., 2015; Plavšić, et al., 2009). These applications and uses of AR branch out to far more than just the navigation and travel realm but can be used in other fields as well.

Figure 10. HUD with Texas Instrument DLP technology assists with directions, safety and other information for the driver of the vehicle. (Image: http://www.ti.com/ww/en/dlp/automotive/hud.html?DCMP=HUD&HQS=dlpHUD)

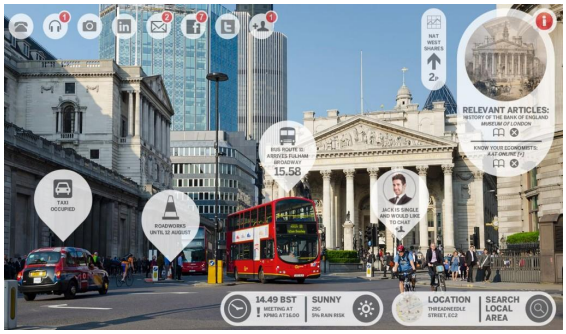

Figure 11. AR uses, the smart devices, geolocation, compass, GPS and vision sensors to track images and provide information useful to travelers. (Image: http://www.enukesoftware.com/blog/augmented-reality-augments-your-travel-business/)

Figure 12. AR assists pilots and other navigators with safely getting from point A to point B. It assists in providing information quickly and clearly. This means that errors will be less likely (Maroy, 2017). (Image: https://uploadvr.com/ar-aviation-safer-better/)

Figure 13. Rio de Janeiro, Brazil Tourist Guide with Augmented Reality. Assists with self-guided tours, providing information about landmarks through using personal mobile devices. (Image: https://www.youtube.com/watch?v=hvCfr-CpLcI)

Industrial and manufacturing processes.

An area that is greatly in need of AR technology to increase productivity and safety is the Industrial and Manufacturing field. Equipping factory and warehouse workers with hands-free devices, allows those employees more mobility, independence and efficiency. Industrial and manufacturing have many uses for AR technology. Each sect of the field has different needs that AR is able to satisfy. In industrial mechanics AR can hold information on every make and model of car and project overlays of parts needed or identify problems under the hood of vehicles (Anastassova, & Burkhardt, 2009; Kipper & Rampolla, 2013). In manufacturing, AR is used to design products and present prototypes (Faust, Roepke, Catecati, Araujo, Ferreira, & Albertazzi, 2012). This assists with creating new and better products, expediting the process from idea to creation, and allowing for better visuals when describing new ideas. In factories, individuals can wear the new Google Enterprise Edition glass in order to do hands-free work putting together motors for tractors (Levy, 2017). In work-places like these, the headwear of AR glasses blend in as safety goggles but are far more useful, as information can be displayed, or voice commands can control the images on the glasses (Levy, 2017).

Electric utilities.

The electric utility industry may also soon be using AR as a part of daily tasks. The uses for AR in electric utilities is expanding as more programs are created. Electric utilities are one of the foundations of our modern society. Without their work, our way of life would stop. Electricity is vital in our current social and economic climate. As recently occurred during the writing of this study, millions of Florida residents were without power from the hurricanes, the utility field workers nationwide went to address their

plight (Achenbach, Zezima, Berman & Wan, 2017). Without electricity, air conditioning, refrigeration, charging of mobile devices or computers, the running of Wi-Fi and many other daily needs were unable to occur. Businesses had to shut down, grocery stores were unable to keep food, and individuals who needed phones or Wi-Fi to communicate were unable to do so. The workers repairing the electric grid, maintaining the grid and putting in new lines all help to make our society function, will soon be using augmented reality devices (Achenbach, Zezima, Berman & Wan, 2017). Augmented reality devices hope to make their job easier and safer in the future. However, in order to do so, workers must accept this new technology as useful and easy to use. To aid in this endeavor this study will create infographics accommodating the information from research informing workers how AR may be useful for them in their work. The following discusses some of the current uses and challenges of AR for electric utilities.

Manuals and independence.

Electric utilities have jobs that require manual reading and have legacy hardware that must be repaired and worked on (Judson, 2017; Nakanishi, Ozeki, Akasaka, & Okada, 2007) With the changing age of the work-force, many younger workers are inexperienced with legacy hardware and the AR information would have access to digital manuals for repairs and the necessary tools for dealing with older equipment (Judson, 2017; Nakanishi, et al. 2007). As workers jobs can vary daily from performing storm assessments, to performing inspections. The access to information of integrated field force data that can be reached nationwide in real time is extremely valuable (Simmins,

Gray, & McCollough, 2015). The available access to the data in one place allows workers to save time and work more independently (Chi, Kang, & Wang, 2013).

Collaboration.

In addition to allowing workers to be more independent, AR can also be useful for collaboration and cooperation between workers (Judson, 2017; Schmalstieg & Höllerer, 2016). AR could allow for communication with an expert through video sharing and interactive computer interfaces. "With Augmented Reality, a worker can pull up to a job site, don a pair of AR glasses, and have at their fingertips every piece of information necessary to perform their task. In some instances, they can connect live to a remote technical service agent to help walk them through particularly difficult activities," (see Figures 14 & 15; Judson, 2017, p. 2). If a worker needed to confer with someone who was an expert, they could share what they were seeing and receive verbal directions or even visual cues overlaid on the equipment they are viewing (see Figures 16 & 17; Economist, 2017). In addition, the larger a project, such as in construction, the greater the need for close collaboration between the designers, the engineers, the builders, and the client," (Aukstakalnis, 2017). Building Information Modeling (BIM) allows for each person in the team to collaborate with assembling digitally their part of the project (Aukstakalnis, 2017) This interactive teamwork approach would create more efficiency and prevent accidents, saving companies money (Syberfeldt, Holm, Danielsson, Wang, & Brewster, 2016).

Figure 14. “With the number of diverse devices residing in a typical substation these days – some new and some very old – it is nearly impossible to have at hand all of the relevant maintenance and repair data in the form of hard-copy manuals and papers to get the job done,”(Judson, 2017). (Image: https://blogs.cisco.com/energy/augmented-reality-a-new-reality-for-utilities)

Figure 15. “These wearable computers are now giving industrial workers the ability to evaluate their surroundings and check if equipment is working properly or if an environment is safe,” (Lacey, 2015). (Image: https://www.greentechmedia.com/articles/read/heres-what-augmented-reality-for-utility-workers-might-look-like)

Figure 16.
Atheer Augmented interactive Reality (AiR technologies). (Image: http://atheerair.com/)

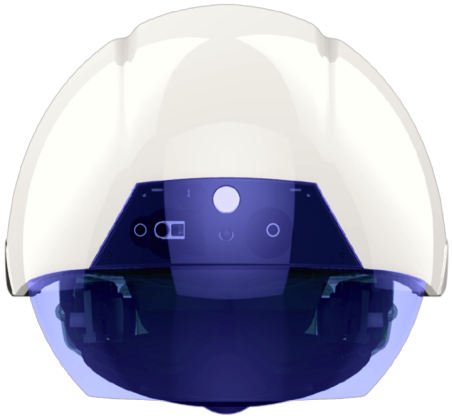

Figure 17. DAQRI Smart Helmet. (Image: https://daqri.com/products/smart-helmet/)

Safety.

Besides efficiency and saving money the safety of the workers is paramount (Beyond Standards, 2015; Gabbard, et al., 2003). With the AR collaborative BIM, everyone is on the same page, there is clear double-checking and any conflicts between systems can be smoothed out quickly so that no problems emerge during builds (Aukstakalnis, 2017). AR also assists in safely training employees to operate heavy equipment, manage construction activities, operate cranes or even plan underground infrastructure (Chi, et al. 2013; Golparvar-Fard, Pena-Mora, & Savarese, 2009; Schall, Mendez et al., 2009; Siu & Lu, 2010; Simmins, et al., 2015; Talmaki, Dong, & Kamat, 2010; Wang, 2007). These projects concern the safety of many individuals as well as surrounding structures (Schall, Mendez et al., 2009; Talmaki, et al., 2010). Using equipment or excavating safely without any hazardous situations is imperative. Other ways of ensuring safety are by training before workers go out in the field. The ability to train and simulate experiences in a controlled environment before going out in the field will reduce user error and accidents; saving companies time and money (Wang, 2007). The combination of on and off-field AR use for electric utility workers will help to create a safer work environment, increasing employee satisfaction, and reducing costs due to accidents or injury.

Affordability.

Not only is AR being tested to ensure efficiency and safety in many fields, but also it is becoming more and more affordable due to the availability of mobile devices, and accessibility of the Internet and cloud data storage (Chi, et al., 2013; Beyond

Standards, 2015; Simmins, et al., 2015). The new weight and size of AR devices are improving user experience and allow corporations to invest in sets for their workers (Chi, et al., 2013). Furthermore, AR devices are constantly improving, with lighter weights and less bulky size (Chi, et al., 2013). The mobile devices also make it possible for AR to be used with tablets or smartphones provided by the company or owned by the employees. Mobile AR devices effectively lower the cost by not having to have a console specific for AR, but a multiuse device such as a tablet. The safe, efficient and affordable uses of AR make it a realistic and sensible choice to carry out tasks in the utility field (Chi, et al., 2013).

Issues faced.

One of the main issues facing AR users in the electric utility field is that the harsh field conditions (Beyond Standards, 2015; Di Donato, Fiorentino, Uva, Gattullo, & Monno, 2015). The locations of jobs change daily and therefore have different challenges, dangers, and environments. Different locations may affect the projection abilities or the effectiveness of the computer, or the clarity of the eyewear. The elements such as cold or heat may affect the computer hardware (Beyond Standards, 2015). The different variables and environments require a need to ensure legibility of text, especially on projected materials (Di Donato, et al., 2015). Moreover, there are ergonomic and human factors concerns for users. Some concerns presented to deal with cognitive ergonomics such as presence for the individual (Redaelli, et al., 2008). Presence describes the awareness of time and others while using AR devices (Redaelli, et al., 2008). Other concerns regard the physical stressors such as neck pain, and eyestrain.

These possibilities for AR use in the electric utility field will be presented through the infographics in a simpler and more visually appealing way. Thus, informing, educating, and persuading workers to adopt the new technology in the workplace. The use of infographics to accommodate the previous literature reviewed on AR in electric utility will be further explained in the methods section.

AR's many uses and applications in various fields has made it a major commodity, and one that is expected to grow in the next several years. The wide range of use, allows AR to be improved upon and adjusted for different work environments and tasks. The technology is ever evolving and continues to become more affordable as it becomes more available. This study will be looking at how Augmented Reality can be used in the Electric Utility Field and how to communicate the research, usefulness, and ease of use to workers to encourage their adoption of the new technology.

Training and Development

Training and development research should also be considered when addressing how workers respond to changes in the workplace and having to learn a new tool (European Journal, 2012; Training Journal, 1999). Articles from the training and development realm discuss the transformative organizational change in its many forms (Minton-Eversole, 1991; Paine, 2014; Van Buren, 2000). In the case of technology-induced change, different articles have taken oral and written response, as well as ethnographic observations to examine how the change was perceived and characterized by the workers of the study. One study found that using storytelling to help explain the benefits of the change with technology was helpful for employees (Sweety, 2009). The storytelling

allowed for a new way to learn the information. The stories helped to "capture the interpretation and analysis of information by people, by revealing how the new technology has affected work-design, employee's functioning in new partnerships and workflows, and other people-centered needs such as the sense of agency," (Sweety, 2009 p. 1). Robert (2010) sought to measure the response of blue-collar manufacturing workers to new technology (2010). The exploratory study utilized a questionnaire which identified several themes of worker response: "disgruntlement, job-security concerns, accommodation, informal learning, resistance, discussion, and formal learning," (Robert, 2010). This study suggested improving the learning culture in the organization to improve technology acceptance. These studies are useful when considering working with the utility line workers and improving their acceptance of AR.

Theory and Concepts

Before delving into the context of electric utility workers, it is important to identify what theories and concepts were utilized in the current study. The researcher seeks to find an effective template with infographics to present an HMD of AR to electric utility line workers. In order to find ways of communicating the research, facts, and information to the workers in an accessible and simple way, communication accommodation theory (CAT), and technology acceptance model (TAM) are useful frameworks for communicating the research, facts, and information to the workers in an accessible and simple way (Davis, 1989; Giles, et. Al., 1991; Giles, 2016; Markus, 1990; Rogers, 2003).

Communication Accommodation Theory

Researchers in the STEM fields may find challenges presenting their findings to the general public (Bizony, 2009; Fahnestock, 1986; Giagante, 2012). Often the language used is academic jargon that requires a great deal of prior knowledge to comprehend (Popan, 2016). One way to bridge the divide of understanding is to accommodate the communication style to fit the audience (Bizony, 2009; Popan, 2016). Communication accommodation theory (CAT) has typically been used in the past to help in co-cultural, and organizational settings (Popan, 2016; Rogerson-Revell, 2010).

Much of the early research surrounding CAT looks at speech, dialect, and accent. The terms divergence and convergence are meant to describe non-accommodation and accommodation (Giles, 2016; Rogerson-Revell, 2010). Other areas that have been of interest to CAT scholars are in intergroup accommodation, social categories, and

identities (Giles, 2016). Intergroup contexts include different age groups, physical abilities, genders, and police-civilian interactions (Giles, 2016). Within intergroup communication convergence and divergence still apply (Rogerson-Revell, 2010). Often the communication studied is of existing problems and solutions proposed to enhance or remedy communication between intergroups (Giles, 2016).

CAT is used by many disciplines and is useful for many areas of study. Health communication, for example, finds use in this by understanding how to speak with patients as health professionals (Giles, 2016). Over accommodating by the nurses or doctors can come off as patronizing and demeaning. If they under-accommodate they tend to use challenging jargon and confusing medical terms that will seem pretentious and may cause confusion on the part of the patient (Giles, 2016). However, there is a possibility in CAT to simultaneously converge and diverge, such as diverging to keep authority and converging to ensure vocabulary is understandable (Giles, 2016).

In the current study, CAT will be useful for accommodating language from science and research to the jargon and terminology more associated by laypeople in the line worker utility field. Furthermore, the bilingual workforce will benefit from CAT through the co-cultural aspects of this theory to take into consideration meaning and strategies (Rogerson-Revell, 2010).

Science communication.

Several fields outside of communication have looked at the idea of accommodating scientific language to meet the general audience needs, using the methods of CAT, but terminology separate from the communication field (Bizony, 2009;

Fahnestock, 1986; Giagante, 2012; Rice & Giles, 2017). Many disciplines recognize the challenges that academic research present when attempting to communicate it to a different audience (Fahnestock, 1986; Rice & Giles, 2017). Even when translating studies to fit into magazine articles, information can be lost, or misinterpreted (Bizony, 2009; Fahnestock, 1986; Giagante, 2012). Science communication often hopes to better inform the public of research and topics that they would otherwise not be exposed to (Giagante, 2012; Nisbet & Scheufele, 2009; Rice & Giles, 2017). In order to do so, interdisciplinary writing and collaboration are found to be useful, when accommodating communication to the general public (Fahnestock, 1986; Rice & Giles, 2017). Journalists may not have a scientific background, and scientists may only have an academic style of writing, therefore collaboration between disciplines can allow for the generation of ideas, tactics and quality writing that presents science accurately and in a comprehensible way (Fahnestock, 1986). This study hopes to bridge engineering, technology, and utilities with the communication and journalistic field by helping accommodate the topic of augmented reality to utility workers.

How CAT will be used in this study.

Communication Accommodation Theory will be used in this study to look at how the organizational leaders could communicate the research and reasoning behind AR use in the electric utility field to their workers (Lewis, 2011). The hope is that by accommodating the research and reasoning to a clear and visually interesting message, workers will be more willing to adopt the new technology and be more informed about why they are using it.

A challenge will be to ensure that the information is not over accommodating and therefore insulting to the readers (Giles, 2016). As the creator of the infographics, the researcher will vary the accommodation of information slightly on infographics and receive feedback through the interview process. The formal communication practice during an organizational change of employers informing staff of the shift to AR technology would not be solely done through infographics, rather, infographics would be a supplemental tool to enhance employee understanding in addition to training and presentations (Lewis, 2011). The uncertainties in the role of the worker can be reduced through information dissemination (Lewis, 2011). Through increasing access to relevant information about the change, workers will feel more at ease, and employers can be more confident of a smooth change (Lewis, 2011). This study also hopes to add a future contribution to the areas of accommodating scientific communication to the general public.

Technology Acceptance Model

For many people change is a challenge, whether it is moving, starting a new job, or changing the way a task is completed every day (Disalvo, 2017). Technology implementation is one of these changes that may be met with resistance, especially when it is very new. The Technology Acceptance Model (TAM) provides insight as to why people accept or reject new technology (Davis, 1989; Davis, Bagozzi & Warshaw, 1989; Venkatesh & Davis, 2000). Much of the early research of TAM focused on early computers, and email in the workplace (Bagozzi, Davis, & Warshaw, 1992; Davis, 1989; Venkatesh & Davis, 2000). Specifically, earlier TAM studies asked participants if they

thought email would make their jobs easier, was useful at work, and would improve efficiency at work. The perceived usefulness and ease of use are the main factors regarding whether or not an individual will accept new technology, whether or not it is actually more efficient (Bagozzi, Davis, & Warshaw, 1992; Davis, Bagozzi & Warshaw, 1989). Those who thought email was a waste of time and it would not help them, rejected email; even though now it can be seen that email can be very effective at crafting messages and sending information in real time without waiting for the traditional post. Perceived usefulness is the "degree to which a person believes that using a particular system would enhance his or her job performance" (Davis, 1989, p. 320). Whereas perceived ease of use is "the degree to which a person believes that using a particular system would be free of effort," (Davis, 1989, p. 320). The cost-benefit and cognitive tradeoff of use are important in the adoption of the new technology (Davis, 1989). Numerous studies have shown how TAM explains why individuals choose to use technology or not because of the aforementioned usefulness and ease of use (Venkatesh & Davis, 2000).

The current research on CAT and TAM are traditionally focusing on areas much broader than AR in electric utilities. CAT has typically been looked at in organizational communication between hierarchical levels of employment or between different language communicators (Venkatesh & Davis, 2000). The older research on TAM looked primarily at the dissemination and acceptance of email in the workplace, or of cell phones. More recent research looks at many different examples of new technology, such as online student learning, online teaching, online banking and commerce, and perceptions of children and technology (Altanopoulou & Tselios, 2017; Azam, 2017;

Hui-Fei & Chi-Hua, 2017; Martens, Roll, & Elliott, 2017; Powell & Wimmer, 2017; Wingo, Ivankova, & Moss, 2017). These major technology disrupters to the workforce are a hot topic for TAM scholars, and in keeping the same tradition, this study is looking at the next potential major technological disrupter.

In the context of this study, line workers may be hesitant to adopt AR HMDs on the job as it would be a major change to their daily routine and practice. AR research has shown that it can make workers safer and more efficient for travel and several other fields, however, the research does not equate to acceptance from workers (Judson, 2017; Schmalstieg & Höllerer, 2016; Syberfeldt, et al., 2016)). Testing the equipment in addition to learning about it will assist in their adoption of the new technology. Workers wish to know if it improves performance, the quality of their work, and most importantly their safety (with no risk involved). In order to help communicate the new technology to workers, the infographic will need to include information that will help encourage workers to find AR to be useful and to show its ease of use. This work will add to the current body of TAM research and will also add to training and development research in terms of communicating a change in the workplace.

Additional Concepts

Although CAT and TAM are the main theories in which to frame the research, the concepts of Diffusion of Innovations (DOI) and Critical Mass Theory (CMT) are additionally valid (Canchu & Ha, 2010; Rogers, 2003). Both concepts identify that there are stages in which individuals go through in order to adopt new technology.

Diffusion of innovations.

Diffusion of Innovations (DOI) is a concept that aligns with TAM (Rogers, 2003). DOI "details the process by which a new innovation or product diffuses through a social system," (Vishwanath & Barnett, 2011, 2). The process of information shared between individuals about the innovation is extremely important in allowing the spread of technology (Vishwanath, & Barnette, 2011). Research of DOI looks at how new technology is spread throughout the community (Rogers, 2003; Slyke, Ilie, Lou, & Stafford, 2007). The current body of research focuses on topics such as DOI of environmentally friendly innovation, health care practices as innovation, the role of early adopters and the stages of DOI (Dearing & Cox, 2018; Dedehayir, Ortt, Riverola, & Miralles, 2017; Door, Cohen, Adler-Milstein, 2018; Rice, 2017; Sukanya, Noppol, Xu & Yu, 2017; Zhai, Ding, & Wang, 2018). With more and more innovations and disrupters such as Amazon, Uber and Airbnb, researchers have many areas for which DOI can be seen in action and studied (Dedehayir, et al., 2017).

There is a pro-innovation bias, that most research using DOI holds, where there is an assumption by researchers that the innovation should be “diffused and adopted by all members of society,” and diffused quickly (Dearing & Cox, 2018; Rogers, 2003; Vishwanath & Barnette, 2011). DOI also identifies the uncertainties of individuals with adopting a new and unknown innovation, because of the unknown outcomes (Dearing & Cox, 2018; Valente, 1994). In order to reduce this uncertainty, individuals seek information about the innovation from friend, peers, and colleagues (Dedehayir, et al., 2017; Valente, 1994).

Different stages take place regarding the innovation-decision process, such as an acquisition of knowledge, being persuaded, making a decision, implementing the innovation, and confirming the benefits and use of the innovation (Rogers, 2003; Slyke, et al., 2007; Zhai et al., 2018). This study considers the DOI important for identifying why utility workers may choose to adopt AR or not. The decision process of innovation is what many workers will experience when provided information about AR by employers. At which point they will begin to form attitudes towards AR and will decide whether to accept or reject AR as other stages of the diffusion takes place (Rogers, 2003; Slyke, et al., 2007).

Critical mass theory.

An additional theoretical framework that is important to consider during this study is critical mass theory (Canchu & Ha, 2010). CMT is useful when looking at the adoption of technologies and the role information plays in the adoption (Markus, 1990; Slyke, Ilie, Lou, & Stafford, 2007). Early studies of this theory looked at the adoption of computers, email, and more recently instant messaging in the workplace (Markus, 1990; Lin & Ha, 2010; Slyke, Ilie, Lou, & Stafford, 2007). Critical Mass looks to identify "the key factors that determine whether or not an interactive medium introduced to a community will achieve universal access," (Markus, 1990, p. 194). The length of time before an interactive media reaches critical mass is shortening more and more (Lin & Ha, 2010). That means that the adoption of the new iPhone, for example, will catch on more quickly than when the first smartphone was released. The early adopters and influencers have a very strong sway to convince the adoption of the technology, possibly due to

social media (Lin & Ha, 2010). It is much clearer now when everyone's friends and family have gotten a new technology because they post about it, so the perceived critical mass is often very apparent to other users.

Both DOI and CMT are important when understanding how workers will be convinced to adopt new technologies in the workplace. The decision process of innovation is what many workers will experience when provided information about AR by employers. At which point they will begin to form attitudes towards AR and will decide whether to accept or reject AR as other stages of the diffusion takes place (Rogers, 2003; Slyke, Ilie, Lou, & Stafford, 2007). Furthermore, as AR becomes more used, workers may be more willing to adopt it as they see other workplaces, and colleagues in the field adopt AR as a standard tool (Lin & Ha, 2010). In addition, if major utility companies adopt AR, other smaller or independently owned companies will follow suit.

Infographics

In order to gain technology acceptance of AR as well as accommodate scientific writing to the demographic of interest, infographics will be utilized in this study. The visuals and limited text will allow for a creative and useful way to present challenging information. Infographics are able to present a great deal of information into a quick, visually aesthetic format is often done through the use of infographics (Ajmi, 2016; Krauss, 2012; Lankow, Ritchie, & Crooks, 2012; Smiciklas, 2012). Infographics, is the term used for information graphic, can be simple or complicated, presenting graphs, charts, icons, images, and information (Krauss, 2012; Lankow, Ritchie, & Crooks, 2012).

Infographics help to “concisely communicate messages to an audience,” (Smiciklas, 2012, 3). Our brains can process images faster than text. Infographics communicate research in a visually simpler way to audiences (George-Palilonis, 2006; Krauss, 2012; Lankow, Ritchie, & Crooks, 2012). Infographics are an effective way to communicate statistics or research findings. In the case of augmented reality, the infographics can pinpoint and present data that is important to that specific audience of line workers.

Aid in Language

Infographics also assist when language is a struggle because they make use of both words and visuals. Infographics find a balance between "linguistic and non-linguistic systems coverage,” (Krauss, 2012, 11). Infographics also help to decode jargon specific to the topic and remember the audience's needs. (Smiciklas, 2012). Engineering and technology jargon surrounding augmented reality can be daunting for those unfamiliar with the field, so translating accurately or even defining terms can be a useful too.

Support Learning

Infographics have been shown to support robust learning (Lyra, Isotani, Reis, Marques, Pedro, Jaques, Bitencourt, & Ibert, 2016). Studies have indicated that infographics help the retention of information and the comprehension of materials (Agwa-Ejon & Batchelor, 2016; Lyra, et al., 2016). Therefore, using infographics as a tool in addition to other training processes, line workers may remember specific terms, and ideas surrounding AR. Moreover, infographics aid in acceptance of new information

and aide in employee knowledge (Agwa-Ejon & Batchelor, 2016). Infographics help to show the use of a technology as well as available data (Agwa-Ejon & Batchelor, 2016). Infographics also help explain information such as “training workforces, that might face language barriers or have varying levels of education,” (Smiciklas, 2012, p. 38). Furthermore, infographics attract more attention than other text or visuals due to the brain's desire notice things that are different. An infographic stands out in text and traditional formats (Heller & Landers, 2014; Yikun & Zhao, 2015). Finally, infographics are able to then guide faster decision-making and tactical implementation due to the concise and clear information (Smiciklas, 2012), which ensures that workers find the ease of use and usefulness of AR for their work in electric utilities.

Limitations

Infographics also have some drawbacks particularly in the area of effectiveness. Success depends upon the formatting, information, and visuals used (Pittman, 2017). Infographics are useful if they target audiences with relevant content, they cannot be a one size fits all (Heller & Landers, 2014; Pittman, 2017; Yikun & Zhao, 2015). In the case of this study, the infographics are specifically crafted for the line workers, and so will be targeted at them with specific information and terminology. Infographics do have limitations and should be looked at as a "communication stepping stone" (Smiciklas, 2012, p. 52). Some critics of infographics feel that they are dumbing down readers and make complex things appear too simple, or do not show the whole aspect of a topic by minimizing it down too much (Smiciklas, 2015). Much of the concerns for infographics appeared during their first push in print media in the 1980’s. However, in recent years

infographics have gained more support from scholars as an effective and useful tool (George-Palionis, 2006; Heller & Landers, 2014).

Through using the infographics to present information on Augmented Reality, the research hopes to simplify the complex and potentially intimidating aspects that can accompany anynew technology to show its usefulness and ease of use to electric utility workers. Through creating a template of an infographic, the research hopes to improve technology acceptance for future technology as well as AR.

Research Questions

The more experienced and older demographic of the utility field tends to be resistant to new technologies (Dogruel, Joeckel, & Bowman, 2015; Gurchiek, 2016). To assuage their concerns, workers may hope to gain more information on the topic of augmented reality (AR) in electric utilities before working with the new AR devices (Dogruel, Joeckel, & Bowman, 2015). Some research has been done on the efficiency and safety of the AR devices for utility workers, however, this is not easily accessible to the general public (Marklin, Kroll, Bauman, & Simmins, 2018). Finding a way to accommodate the communication of the researchers to the language of the laypeople is imperative to help encourage the adoption of the new technology. Through presenting information to the line workers informing them of the usefulness and ease of use of AR, they may be more receptive to adopting AR as a part of their daily routine. To that end, the following research questions will be explored:

RQ1 What individual communicative elements within each infographic are best received by electric utility field line workers to introduce augmented reality?

RQ2 How does the information presented to workers on the infographic convince them of:

- **A.** AR's ease of use?
- **B.** AR's usefulness in electric utility field work?

RQ3 With the limited knowledge presented, how do workers interpret utilizing the new technology in the workplace via the infographics shown?

There have been similar CAT and TAM studies on new technology in the workplace and views as well as accommodating scientific research into accessible language. However, no research has currently looked at this audience and topic. Moreover, this interdisciplinary approach of communications with emerging technology is not often done in academic research.

Methodology

This study interviewed eight participants who work full time as line workers in the electric utility field. A Midwest electric utility company agreed to have their employees interviewed on company time at the central office location of the company. A communication spokesperson was present during the interviews to ensure confidentiality and safety of the employee. The participants who were present raged in age from 18-65, were males and ranged in work experience from apprentice to having been employed 40 years (M = 18.13, SD = 12.11).

Participants and Procedure

Electric utilities are undergoing a major upheaval in their workforce. The workers in this field are an aging demographic, with one in five workers are at retirement age (Wright, 2010). The average age of electric line workers is 50 years old (Williams, 2017). As a large percentage of utility workers are retiring a new young and diverse group will be replacing them (USDE, 2006). The workforce will be more tech savvy, bilingual, and diverse, but may not have the education preferred and lack the years of experience the current body of workers have (BLS, 2017a; BLS, 2017b; Chatlani, 2016; Electric Perspectives, 2007, USDE, 2006).

Changing age.

Since the current average age of electric utility field workers is retirement age, a major portion of these workers have retired or will be retiring in the coming years (BLS, 2017a; BLS, 2017b; Electric Perspectives, 2007; Wright, 2010). It is expected that the

utility field will hire primarily millennials to replace the retiring population (Chatlani, 2016). In order to attract their new workforce, companies are sharing how they want to change the general format to sustainable grids, microgrids, and incorporate more technology for workers, such as augmented reality headsets (Chatlani, 2016; Electric Perspectives, 2007). The changes and future of electric utilities will rely heavily on those with strong experience, and interest in new and changing technologies such as AR (Chatlani, 2016).

Unfortunately for the utility industry, most of the individuals who go to school for electrical engineering or computer engineering tend to work in IT (Chatlani, 2016). The utility professions do not tend to have the same appeal to the millennial generation. As a result of this worker shortage, companies are attempting to train individuals with line worker skills with some of the engineering skills necessary to do a particular task (Chatlani, 2016; IBEW, 2005; USDE, 2006). The extreme need for more workers and demand for particular roles is a struggle the utility field has been dealing with for the past decade (IBEW, 2005).

For the workers that are experienced and have worked there for many years, the resistance to change is very strong (Gurchiek, 2016). Workers are often used to using particular tools or doing things a certain way and are not easily convinced to change how they are carrying out tasks. This resistance to change, and often time technology is a challenge that employers will face when introducing AR to their workers.

Education and language.

The expected incoming workers over the next decade will become a heavy bilingual workforce (Chatlani, 2016). Primarily Spanish speaking, these individuals will make up a large portion of the electric utility field (Chatlani, 2016). The change in language demographics will require that employers and management need to be cognizant of making the training bilingual and accessible. This decision should also take into account the text of the AR technology joining their workplace. If the AR devices do not also transmit information in Spanish, then that program or specific device may not be the best choice for employers. There is currently AR technology available that can pick up voice commands and present text in multiple languages (Aukstakalnis, 2017; Schmalstieg & Höllerer, 2016). Moreover, explaining the technology to workers may need more visuals, which are universal, allowing for the transmitting of information to be successful. Visuals can be extremely helpful not just for bilingual individuals but also for anyone attempting to grasp a new concept (Lankow, Ritchie, & Crooks, 2012). As a result, the infographics will be extremely useful when presenting AR to this particular audience.

Understanding of technology.

The generation currently leading utilities, averaging age 50, is familiar with legacy hardware that has existed for a better part of the century (Williams, 2017). Many tools and pieces of equipment have remained the same or nearly the same for decades. However, utilities are attempting to make the grid more sustainable and are modernizing much of the technology to be used. Entire sections of posts and wire are being replaced to

be more storm worthy, safer, and carry a higher voltage. However, as utilities replace and improve, new technology is becoming a staple of carrying out the tasks. Change and new technology is often a challenge for older workers (Dogruel, Joeckel, & Bowman, 2015; Gurchiek, 2016). Technology acceptance of older individuals often depends on the social demographics and the previous use of technology experience (Dogruel, Joeckel, & Bowman, 2015). Despite having workers who may not wish to adopt new technology, the newer generation entering the workforce is expected to be more flexible and comfortable taking on the changing and evolving technology and tools (Chatlani, 2016).

Utility line workers understanding of AR may be from pop culture such as the NFL's virtual first-down line, back up cameras in vehicles, or landing screens for aviators (Fong, Caswell, & Barton, 2017. These common and well-known examples of AR may be a useful example or introduction to what AR is in order to get workers comfortable with the concepts and possibilities AR has to offer. Furthermore, as AR becomes a part of entertainment such as snapchat, Pokémon go, or other common applications, they may have already experienced AR in a comfortable low-stress environment, possibly increasing their comfort level with the technology.

All of the demographic factors of the electric utility line workers were taken into consideration in this study when crafting and accommodating the communication in the infographics and interviewing the individuals. Participants age, education, language and previous technology experience all add to create a unique population. It should be noted that due to the sample size of this study demographics is a limitation, but these variables should be studied in a larger endeavor.

Methodology

This study was conducted using a mixed method approach to data collection. This methodological approach provided in-depth details for creating an effective presentation of information to individuals that are clear and concise. The interview process illuminated the thought process behind those who are affected most by the new devices, electric utility field workers. This study is not generalizable to the whole community of electric utility workers due to the limited sample size of 8 workers (Brennan, 2017). However, it provides the insight necessary for the Midwest electric utility company, whose employees are part of the current study, to have a solid communication flow between employers to employee. Furthermore, the qualitative semi-structured interviews provided insight into workers perceived ease of use and perceived usefulness of AR based off of the infographics presented, and their limited background knowledge (Brennan, 2017). Finally, the interviews allowed the researcher to learn about potential conditions where workers would be willing to utilize the AR technology on the job, and to learn the worker's reasoning for why or why not. This in-depth and varied responses from workers were important to building on the bodies of research for Technology Acceptance Model (Davis, Bagozzi & Warshaw, 1989), and Diffusion of Innovations (Rogers, 2003).

Interviews

For this study, employees from a Midwest electric utility company were interviewed about their preferences on four different infographics. There is currently a standing relationship with the workers of a Midwest electric utility company and the

university where this study is being conducted. In order to recruit individuals from Midwest electric utility company, a convenience sampling or volunteer sampling was utilized (Keyton, 2015; Weis, 1995). These types of sampling were useful due to time constraints, as well as a limit in funding. Participants were not compensated for their time by the researcher, however, they were interviewed while on payroll company time. The employer's willingness to allow employees to use company time and to provide the location was vital to the completion of this project.

In order to build rapport, the researcher had been introduced to the team at a monthly ergonomics meeting (Weis, 1995). At this meeting, the purpose of the study was discussed and the process for the study was explained to those who were to be involved. The researcher also observed the electric utility workers on the job alongside the employee's supervisor and will make note of the tasks they often carry out (Emerson, Fretz, & Shaw, 1995). The researcher was a safe distance away from the work and wearing location appropriate safety clothing. The six-hour field study, as observer-participant, allowed for the researcher to learn terminology, and to be taught processes by which workers perform tasks (Brennan, 2017). After which the researcher used the observation notes acquired during the collection of field observation of line workers to create infographics for how augmented reality headgear may be of use to these individuals in their particular daily tasks. The observation notes were useful for the researcher to reference in the interview, as well as for the creation of the infographics (Emerson, Fretz, & Shaw, 1995). The infographics held the same information about why AR devices would be a benefit to these workers. The infographics differed in the arrangement and presentation of the information.

The researcher then interviewed eight employees from the Midwest electric utility company. The eight employees volunteered their time as a convenience sample. During this interview, the employees were asked some questions to establish their understanding of AR, and their thoughts about new technology on the job. After which, the employees discussed their thoughts aloud with their impressions of the infographics that present information on how AR will help them with their job.

The order of infographics presented differed for each employee so to take into consideration the confounding variable of order. The employees identified their favorite aspects of the four infographics, choosing wording, image choice, placement and other elements that they find interesting or useful. In order to help visualize which aspects of the infographics are the most effective in the eyes of the participant, the participants noted out loud their specific thoughts on the different infographics which the researcher then noted on paper and recorded by an audio recorder. In the interview, the logic for preferences of infographic elements was explained by the participants to the researcher. After discussing the aspects of the infographics, they found useful or interesting, the researcher inquired about their perceived ease of use or usefulness of AR for their job, based off of what they learned in infographics. Workers were also asked about their willingness to adopt the technology as a daily tool in the workplace, based on their limited knowledge and understanding of AR.

Interviews were one hour in duration per participant and were videotaped for later review for analysis and transcription (Weis, 1995). The employees interviewed signed a release form for being recorded during the interview. The one-hour interview ensured that there was enough time for the participants to share the information requested

(Keyton, 2015; Weis, 1995). During the interview, the researcher collected data noting what viewpoints have been shared, confirmed or challenged (Keyton, 2015). This semi-structured interview utilized pre-established questions, which were asked in a flexible order due to the participants' willingness to elaborate (Brennan, 2017; Weiss, 1995). Follow-up questions were also asked in order to identify more details on the topic and clarify any uncertainty (Brennen, 2017). In addition, an interview schedule determines the series of questions to help prompt thoughtful discussion between the researcher and participant (Weis, 1995). The interviews provided insight into what the best presentation of information will be to clearly display and convey information to the working individuals of utility line workers.

There were some general concerns with doing the interview, including that the participants might have catered their responses for **s**ocial desirability (Keyton, 2015). When trying to appear knowledgeable they may have feared judgment by the researcher with response to their answers. Furthermore, the participants may have tried to answer in ways they thought would please the researcher or employer (Weis, 1995). By coming to the monthly meeting, observing on the job and talking at the beginning of the interview, it was hoped that the researcher established rapport with the participants. This comfort seemed to help the participants feel at ease when sharing their thoughts and opinions.

The analysis of the interviews was done through an inductive approach of transcribing the interviews and then making 'notes on notes' upon those transcripts in a process also referred to as jotting (Emerson, Fretz, & Shaw, 1995; Kleinman, Copp, & Henderson, 1997; Maykut & Morehouse, 1994). Jotting is a useful qualitative, method for sense making (Emerson, Fretz, & Shaw, 1995). Jotting can be helpful in identifying

themes and similarities, as well as experiences that may not align with the others discussed. The inductive method allows the categories to emerge rather than predetermining them (Maykut & Morehouse, 1994). In order to identify the categories, the 'notes on notes' technique and constant comparative method will be used. In these methods the researcher writes analytic memos (Grubrium & Holstein, 2002; Kleinman, Copp, & Henderson, 1997; Maykut & Morehouse, 1994). 'Notes on notes' is described as a "running analytic commentary on the continent of field notes. Writing such notes is a way to capture one's thoughts, insights, and analytic leads as a study proceeds. Every interview, just like ever venture into the field, should lead to the writing of similar notes (Gubrium & Holstein, 2002, p. 217).

Notes were also collected during the interview itself, as "interviews can be opportunities to gather data through observation as well as through talk," (Gubrium & Holstein, 1997, p. 217). Making notes on the body language and the attitudes portrayed during the interviews was helpful when reviewing the transcripts to understand implied meaning and participants feelings surrounding the topic of augmented reality, new technology and organizational change.

Keeping the research questions in mind the researcher attempted to find answers for each of the research questions with the individual interviewees, and then found a common narrative. For the purpose of anonymity, the interviewees will be referred to with pseudonyms. The names used in this report are not the names of any of the participants. But for assistance in discussing the insight the faux names will be used in place of the real ones.

Furthermore, the researcher highlighted and noted specific quotes that clearly demonstrated evidence for the usefulness and ease of use. These quotes are used in the results section to provide first-hand accounts. The information from the interviews and identification of valuable infographic elements culminate in creating an infographic template for the Midwest electric utility company to use so that they can provide handouts or print posters to present information to their employees. By preparing these steps, it ensured a smooth process of gathering and interpreting data.

Survey

As an additional method to the interviews, the researcher also had participants fill out a pre and post-TAM survey on paper which was suggested by the creators of the Technology Acceptance Model (Davis, 1989). The researcher adjusted and added several questions to the traditional template. The answers were denoted through a 5-point Likert-type scale. The pre and post surveys collected helped to provide numerical data in addition to the qualitative interview data. The surveys were short and could be completed in less than five minutes. The surveys were completed by the participants that were interviewed on the infographics; no additional external surveys were sent out. This limited sampling was useful and decided upon due to time constraints, as well as a limit in funding. Participants were not compensated for their time by the researcher but were on the clock for their employer; their volunteering was vital to the completion of the study. The information collected assisted with confirming the data shared in the interviews.

The demographics of the participants ranged in age from 18-65. The participants were all male. While there are female line workers, there were none available for interviews at the time the study was conducted. The participants also ranged in their level of responsibilities from apprentice to supervisor. All participants identified as a line mechanic or line worker. Their experience and age were all factors in their perception of the infographic information sheets and so did not identify with a particular socio-economic status, race or sexuality. Despite the age and varied experience, all the workers are from the same Midwest utility and worked using the same tools and equipment. Therefore, their experiences with adjusting to new technology, and tools on the job were similar, as were their responses to change in the workplace.

Results

Research Question Results

Experience with new tools.

The interviews began asking about their role at the company and their previous experience with new tools in the workplace. Each worker, other than the apprentice, had experienced a change in tools such as the shift to more battery powered tools rather than manual. “Over the years there has been a lot of tools some very good, very helpful, some not so good,” (Kyle, personal communication, February 19, 2018). Other changes were when a new fall device for climbing poles was introduced as well as a new tool for identifying phases, a Phasing ID tool. For each of these changes, the purpose was safety, followed by assisting with efficiency and ergonomics. With these changes, there was a process in order to make sure it works well and to get the staff on board. “They’d have us come in ahead of time and look at it, sometimes there are committees, and demos are given. Get feedback from workers, and base recommendations off of those feedbacks,” (Tyler, personal communication, February 19, 2018). Committees, demos, feedback, and training all occur as a part of the process for ensuring acceptance of the new technology. “Whether it is forced on us for regulations, or by choice, eventually we just have to come around to using it,” (Tyler, personal communication, February 19, 2018). The acceptance due to the technology being an obligation is still not necessarily the acceptance that employers are hoping for. By encouraging acceptance as a willing decision rather than a forced decision workers experiences will be more positive as will future experiences for both the employee and employer dealing with new technology in the workplace.

Introducing the new technology was never easy even with all the respective channels. Greg explained that as someone doing the introduction of a new tool "it was tough at first, you are introducing new equipment to a bunch of old dogs who don't want to learn new things. So, it was kinda challenging, but I did roll it out, and it really has made our job a lot safer," (Greg, personal communication, February 19, 2018). Greg experienced both sides as the person receiving a new technology as well as the one presenting it. He felt the pushback from those resistant to change but identifies that it was a helpful piece of equipment and improved safety for all workers.

Preferred infographic styles.

The primary purpose of the interviews was to get feedback on four different infographics that presented images, data, and facts about AR in relation to electric utilities. When eliciting the feedback workers were helpful in providing their preferences, what they found helpful and additional suggestions that were not included on the infographics. The feedback and preferences were noted to help answer the research questions of the study.

In terms of the styles of infographics, as questioned by **RQ1** What individual communicative elements within each infographic is best received by electric utility field line workers to introduce augmented reality?, it seemed that the preferences were divided depending on the age of the participant. Different age groups seemed to have a preference for style layout and presentation of information. Ages 18-25 preferred the less structured organization with more use of icons, and different fonts to separate different facts. With a slightly different perspective, the 26-35-year olds preferred a mix of details, short bullets,

and use of icons. And quite different than the 18-25-year olds the 36-year olds and above preferred simple organization, real images, and few details. The 36+ participants preferred the traditional classroom style of the poster rather than the more standard icon-based infographic template. When explaining their reasoning behind what they liked or found useful participants were quite frank and concise stating things like, “I like this one,” “oh ya, that’s cool” and the emotive “ya, that should be taken out back and burned,” (Adam, personal communication, February 19, 2018). All the age groups agreed that defining Augmented Reality and providing clear examples of how it applies to their job were important. Furthermore, the font size was not a large enough size for any of the participants to comfortably read quickly. The feedback was helpful to note which specific facts, wordings, and examples are most valuable to the workers for encouraging technology acceptance.

Despite there being a clear age breakdown with this group, the age ranges may differ from company to company with different demographics. Previous experience may also change preference over the variable of age. For example, if a 50-year old plays Pokémon Go or uses Snapchat, common examples of AR, they might be more willing to adopt and therefore less resistant to start with despite being in an age group that is typically more resistant. Previous experience in combination with reading the infographic may affect perceived ease of use thus factoring into the answer to **RQ2**. The experience of the individual or exposure to the tool or the styles of infographics may influence their response.

RQ1 and **RQ2** examined the elements of the infographics that were seen as useful, here the answers of color, format, font, information, and organization were all

shared by participants. As they voiced their opinions and preferences it became clear that there were some overarching themes of preference and usefulness within the infographics. Despite the commonality of some ideal elements, the preferences did differ slightly due to age demographics. The main themes that emerged and that led to the creation of the final ideal template were to have a clear definition of augmented reality, to provide several clear examples of how it assists in specific daily tasks for workers, and to highlight the user-friendly aspects of the technology. “I think having a full definition is important, cus I really had no idea what this was before I came in today, the one with the longer definition seemed to help me understand what was going on better,”(Dylan, personal communication, February 19, 2018). Furthermore, creating a typical poster size infographic with a larger font, and linear organization seemed to help display the information in an easy to understand way. One participant explained the need for different font, size and organization when he stated, “I can’t read this, us old dogs need big font, big size, big posters, I don’t need all this junk, I mean what the heck am I supposed to read first if its’ not in a straight line, I need it clearly organized,”(Tyler, personal communication, February 19, 2018). Tyler’s feelings were not alone, as many had personal thoughts on how to logically navigate infographics, and what size seems to work best for getting their attention and for their eyesight.

Concerns for augmented reality.

RQ3 attempted to figure out how workers interpreted using AR in the workplace after seeing the infographics. Based on the interviews, participants thought that the infographics were useful in teaching the new technology. The facts provided made

workers feel that the technology would be useful to their job. Todd explained, “well I guess, that if I could see underground and have that plus the diggers hotline that would be a huge help,” (Todd, personal communication, February19, 2018). They were still speculative on how easy it would be to use, as well as the challenge to trust new technology. “It takes a long time to trust a new system [a new tool],” (Tyler, personal communication, February 19, 2018). The trust was a common theme because as some of them mentioned their lives are on the line. “If it’s not accurate we may not go home safely,” (Greg, personal communication, February 19, 2018). If there are any minor inaccuracies or malfunctions the lives of the workers are at stake. Therefore, trust is something that needs to be communicated more to ensure technology adoption. “It is hard to take something virtual like this and try to trust it when everything you do is based on trust,” (Joe, personal communication, February 19, 2018). And they brought up a good point that the technology is “only as good as the information in it” (Todd, personal communication, February 19, 2018). As a result, the workers are not only relying on the accuracy of the tool but of the information that was programmed into it. Answering RQ3, the workers stated that the infographics presented AR as a potential use for efficiency, but were still concerned about the accuracy of safety, despite the safety being noted on the infographics.

Another fear of workers was that too much reliance on technology would lead to a softening of mental sharpness or memory retention. Dylan (2018) shared how technology makes us dependent and diminishes our thinking process, he explained, “my son yeah, he goes to baseball, but he uses his phone thing every time, the map, and he doesn’t know where he is going. I say, ‘how long does it take to get there’ he says, ‘I don’t know put it

in your phone, ‘I say ‘How long does it take, you go there every day!’” (personal communication, February 19, 2018). Dylan described his son trying to drive to baseball practice, and not knowing where it is or how long it takes to get there at all because he follows GPS and has not memorized any roads or landmarks. This mentality is crossing over to other tools on the job. They need a contingency plan if batteries fail they need to know how to use the regular tools, if cellphones go down they need to have walkie-talkies. The fear that some of them voiced is that if the young workers are used to only the new technology they will not learn the traditional way and will be stuck if the technology goes down (Adam, personal communication, February 19, 2018; Dylan, personal communication, February 19, 2018). Dylan elaborated, “when you got battery powered crimpers, it’s great, but hey if the batteries die or have problems you gotta bust out the old school crimpers and know how to use them,” (personal communication, February 19, 2018). Having experience with both the traditional tools and new provides a contingency plan in case of failing technology. If young workers only learn the new tools, they may not have a fall back if batteries die, or phones go down.

The willingness of the participants to try out the AR technology increased after viewing the infographics, which depicts some positive response for **RQ3**. Some of them made the connection that “at first it was just like, change, and you don’t want that, cus I didn’t know what it was, I was skeptical, [but] time and learning more about it,” helped workers to come to accept it more (Adam, personal communication, February 19, 2018). Adam’s observation shed light on how workers were more willing to warm up to the idea of AR after learning more about it. His experience is not unique but seemed to be a similar reaction to the other workers interviewed. They explained how they go through

stages of resistance and acceptance whenever a new technology, tool or equipment is introduced to their crew. Todd felt similarly to Adam sharing that, "Well I don't really get these new tech things, I have a flip phone and all, I'm not what you would call tech savvy, but from what I see here I think I could manage. It would take some getting used to, but if it's voice activated like you say then hey I can do that," (Personal communication, February 19, 2018). Todd was brought into the idea of using AR due to the notes on the infographic describing AR as being user friendly

Other major concerns voiced by many of the participants were how AR would respond under weather conditions: cold, rain, snow, or too much sun, making it difficult to see graphics, (Randy, personal communication, February 19, 2018; Todd, personal communication, February 19, 2018). "I mean what happens if it's foggy, or cold out and your breath is fogging up the screen? How do you see the screen when the sun is shining, I mean I can't see my phone when it does that, how is this head set gonna do that?" (Randy, personal communication, February 19, 2018). The weather conditions could inhibit the accuracy, and the speed of the device causing lag, visual impairments or distractions, which would be a large concern for safety. AR's biggest challenge according to research is dealing with the changeable elements and locations that field workers like utilities and construction encounter (Marklin, Kroll, Bauman, & Simmins, 2018). Although the researcher did not have the exact answers to these questions for the workers interviewed, a note has been added to the final infographic stating that there is current research being done to ensure the tool works in all environmental settings. The hope is that with continued research on the ergonomics and these environment-related issues, the

Midwest Utility will not have to have those concerns when a roll out of AR headsets occurs in the future.

Potential future for augmented reality.

Suggestions made by the workers of where AR would be useful in their job are of great use to the researcher. Some suggestions that were not included on the infographics were how AR could be used to see the underground wires, gas lines, septic systems and so forth (Tyler, personal communication, February 19, 2018). The AR would be able to visualize the location of underground wires, but diggers hotline would still be used. Another suggestion was about using the cameras on the HUDs to take pictures or video and send it to troubleshooters and first responders (Tyler, personal communication, February 19, 2018). For incidents such as a car-pole accident, where a car crashes into an electric pole, there would be images to send immediately so those who are arriving know what tools and materials are needed (Greg, personal communication, February 19, 2018; Tyler, personal communication, February 19, 2018). It would streamline the process and ensure efficiency. An additional suggestion was about identification and locating of transformer boxes (Greg, personal communication, February 19, 2018). Many people cover their transformers either on purpose or accidentally with logs, snow or other items making it very challenging for workers to locate it. If there was GPS locating and the AR could help them visualize where it is near it would again assist with efficiency.

The TAM surveys and one-on-one interviews provided useful data to note the shift in acceptance of AR for line workers jobs in terms of usefulness and ease of use from before and after looking at the infographics. The impacts of the infographics were

more clearly demonstrated in the interview process, where participants pointed out what elements of different infographics on AR were more applicable to their work, and so helping them understand how it will assist them in their daily work tasks. Moreover, the amount of time reviewing the infographics resulted in an increase in the understanding of Augmented Reality and improved their desire or willingness to use AR devices, despite the group's general resistance to change and new technology in the workplace. The interview also provided ideas for future research such as age determining the preference of infographic style, the role of masculinity in technology acceptance in the trade industries, as well as how there are particular influencers who guide the group to accept technology more and therefore should be the infographic target audience.

TAM Survey

The survey had 13 questions that all relate to the TAM. The questions on the survey cover general knowledge of what AR is, how AR would be useful for their job, and their opinions on ease of use. The number “1” on the Likert scale indicated strongly disagree and number “5” indicated strongly agree. During the pre-test, the majority of the participants selected “3” for the majority of the questions, in which 3 denoted neutral, and the researcher said they could also select 3 if they did not know how to answer because of a lack of understanding in AR. None of the participants knew what AR was prior to reading the infographics, and only one had heard of it prior to coming in for the interview. As expected, after looking at the infographics and discussing their thoughts with the researcher, the post-tests show a substantial shift towards understanding and accepting of AR technology in their work (see Tables 1-3).

The tables of data for the pre and posttest show that there was a major shift from lack-of-understanding to understanding and becoming accepting of AR (see Tables 1-3). Although not everyone was convinced in AR as being very easy to use, the group found value in the specific tasks it could do which they shared more specifically in the interview section. After reading and viewing the infographics, the staff, which was very resistant to new technology and change found possible uses for it, and many seemed excited about its use in the future as will be explained in the interview section.

The tables identify some of the statistics of changes (see Tables 1-3). There was an overall average change of 20% between the pre-test and the post-test. The 20% was an increase to a more positive view of AR overall. The largest increases from before to after was a 40% change for "I know what augmented reality is", a 25% increase in "using AR in my job would enable time to accomplish tasks more quickly", 28% "using AR in my job would make it easier to do my job" and 30% I would find AR useful in my job (see Tables 1-3). The usefulness of AR seemed to be interpreted by the infographics, however the ease of use was not as dramatic a change. The only question that was an outlier on this was the question worded "I would find it easy to get Augmented Reality to do what I want it to do," 7 out of the 8 participants remained neutral on this topic causing only a 5% increase positively. This question would likely improve with experience and time using AR. The infographics did say user-friendly, and voice-activated, but it did not say much about the reliability and the simplicity of use. This sort of technology acceptance may come best from trying out the tools first hand rather than reading on it. As Rogers (2003) discussed in his explanation of Diffusion of Innovations, hands-on demos and training is key to ensuring a smooth adoption of a new device or technology.

The improvement is definitely positive and shows that there is hope for priming the workers to be more receptive to new technology when going into a committee meeting or, a training session where AR would be introduced. Just having the general knowledge and background may make workers more accepting and willing to adopt the technology rather than dismissing and shutting it out. Some improvement is needed for improving worker perception of ease of use, this may need to be improved not only with the infographic but in conjunction with demos and hands on training.

Table 1

Pretest Survey on Technology Acceptance for Augmented Reality (N=8)

Item	*M*	*Mdn*	*SD*	Min	Max
I know what Augmented Reality is.	2.25	2.50	0.89	1	3
I have used Augmented reality before.	2.25	3.00	1.04	1	3
Enable me to accomplish tasks more quickly	2.88	3.00	0.35	2	3
Increase my productivity	3.25	3.00	0.46	3	4
Enhance my effectiveness on the job	3.00	3.00	0.00	3	3
Make it easier to do my job	3.00	3.00	0.00	3	3
I would find Augmented Reality useful in my job.	2.88	3.00	0.35	2	3
Learning to operate Augmented Reality would be easy for me.	3.25	3.00	0.46	3	4
I would find it easy to get Augmented Reality to do what I want it to do.	3.00	3.00	0.00	3	3
My interaction with Augmented Reality would be clear and understandable.	3.00	3.00	0.00	3	3
I would find Augmented Reality to be flexible to interact with.	2.75	3.00	0.46	2	3
It would be easy for me to become skillful at using Augmented Reality.	3.00	3.00	0.00	3	3
I would find Augmented Reality easy to use.	2.75	3.00	0.46	2	3

Table 2

Posttest Survey on Technology Acceptance for Augmented Reality (N=8)

Item	*M*	*Mdn*	*SD*	Min	Max
I know what Augmented Reality is.	4.25	5.00	1.39	1	5
I have used Augmented reality before.	2.88	3.50	1.64	1	5
Enable me to accomplish tasks more quickly	4.13	4.00	0.83	3	5
Increase my productivity	4.00	4.00	0.76	3	5
Enhance my effectiveness on the job	4.25	4.00	0.71	3	5
Make it easier to do my job	4.38	4.00	0.52	4	5
I would find Augmented Reality useful in my job.	4.38	4.50	0.74	3	5
Learning to operate Augmented Reality would be easy for me.	3.75	4.00	1.04	2	5
I would find it easy to get Augmented Reality to do what I want it to do.	3.25	3.00	0.71	3	5
My interaction with Augmented Reality would be clear and understandable.	3.63	3.50	0.74	3	5
I would find Augmented Reality to be flexible to interact with.	3.75	3.50	0.98	3	5
It would be easy for me to become skillful at using Augmented Reality.	3.75	4.00	1.04	2	5
I would find Augmented Reality easy to use.	3.63	4.00	0.92	2	5

Table 3

Change between the Pretest and the Posttest Survey on Technology Acceptance for Augmented Reality (N=8)

Item	Average Change	% Change
I know what Augmented Reality is.	2.00	40.00%
I have used Augmented reality before.	0.63	12.50%
Enable me to accomplish tasks more quickly	1.25	25.00%
Increase my productivity	0.75	15.00%
Enhance my effectiveness on the job	1.25	25.00%
Make it easier to do my job	1.38	27.00%
I would find Augmented Reality useful in my job.	1.50	30.00%
Learning to operate Augmented Reality would be easy for me.	0.50	10.00%
I would find it easy to get Augmented Reality to do what I want it to do.	0.25	5.00%
My interaction with Augmented Reality would be clear and understandable.	0.63	12.50%
I would find Augmented Reality to be flexible to interact with.	1.00	20.00%
It would be easy for me to become skillful at using Augmented Reality.	0.75	15.00%
I would find Augmented Reality easy to use.	0.88	17.50%
Totals	0.98	19.62%

Discussion

Implications of Results

The results of the interviews and survey of this study will be important for many industries as Augmented Reality and other emerging technologies enter the workforces. Technologies such as automated vehicles, artificial intelligence, and the internet of things are all becoming integrated into fields from manufacturing and industry to the arts and creative professions (Marklin, Kroll, Bauman, Simmins, 2018). Finding ways of encouraging adoption of the useful new technology can be done through communication accommodation and using the technology acceptance model as a framework (Davis, 1989; Giles, Coupland & Coupland, 1991; Giles, 2016; Markus, 1990; Rogers, 2003). Although this study was with a small group at a Midwest utility, the ideas of communicating to workers can be used widely by companies of all sizes.

Resistance to new tools in the workplace is a challenge that will be seen particularly with augmented reality. As AR enters multiple workforces in the industries of entertainment, education, military, navigation, manufacturing, and utilities, it will be met with a pushback (Economist, 2017; Marklin, Kroll, Bauman & Simmins, 2018). Fear of change, lack of trust in the technology, perceived difficulty to use and uselessness are reasons that people don't want to adopt the trending new tool. However, research has shown that augmented reality is undergoing research and testing to move towards a user-friendly, ergonomically safe and comfortable trajectory, wherein five to ten years it will be ready to use with little-to-no issues (Schmalstieg & Höllerer, 2016). Although much of the previous research questioned if AR works: in terms of the logistics of the tool for

clarity, lag, frame rates, and accuracy; this study now looks at how we can get people on board to use the technology. AR is here, it is working, and it is growing fast, finding ways to incorporate it into the workplace to improve safety and efficiency are being noted by many organizations, but the training and development need to be considered to ensure success.

This study will contribute to the academic field through its work in CAT and TAM as well as looking at the use of infographics. Although this does not provide anything new on the topic of communication accomodation theory, it does present the benefits of doing interdisciplinary studies. This study combined scientific communication with trades worker's laymen's terms. This study builds off of and reinforces the previous research conducted on CAT that looks at convergence and divergence, to show how this can be done through the use of infographics. This study is also a benefit to the technology acceptance model because it brings this academic tool to the attention of those in the field, businesses, and organizations who may not have otherwise known about it. Encouraging academic theory use by non-academics is a practical use, but also creates a wider audience for the research of TAM. Furthermore, by encouraging communication tools in training and development improvements can be made in different industries, such as the electric utility field.

This study shared similar results to a training and development study that looked at how storytelling helped to communicate the benefits of adopting technology with workers. The perceived usefulness was communicated through storytelling, communicating workflow and how it helped worker's needs (Sweety, 2009). The

infographics in this study worked, as the storytelling method did in Sweety's (2009) study, improving technology acceptance through training.

Using infographics to assist in organizational change and technology acceptance reinforced the teachings of Laurie Lewis (2011) in her text *Organizational Change: Creating Change Through Strategic Communication.* Lewis describes how for organizational change, there needs to be tools utilized in order to help enhance employee understanding, thus reducing uncertainty of the change. Through increasing the information about AR with the tool of infographics, the workers demonstrated more ease and acceptance as seen through their surveys, (see Tables 1-3).

Furthermore, using the TAM pre and post survey was a useful tool into seeing a change in perception of AR. This measurable tool was also used in multiple TAM studies including recent studies with utilizing online banking and using an online forum for conducting classes, both these studies and this study reinforce the usefulness of the survey to gain an understanding of the participants feelings surrounding the change in technology (Altanopoulou & Tselios, 2017; Azam, 2017; Martens, Roll, & Elliott, 2017; Wingo, Ivankova, & Moss, 2017).

In addition to confirming the usefulness of the TAM, this study preesnted how diffusion of innovations is reliant upon early adopters or influencers (Vishwanatha, & Barnette, 2011; Lin & Ha, 2010). In order to reduce uncertainty and become more willing to use AR, the workers discussed how they would talk with peers and colleagues to get their feedback on the technology (Dedehayir, et al., 2017; Valente, 1994). Although DOI was not the main focus of the study, the principles and process of DOI was hinted at by the responses of the participants during their interviews. The stages of gaining

knowledge, being persuaded and making a decision were expressed in how tools were adopted such as the battery powered wire crimpers (Rogers, 2003. Workers also expressed that the feelings of their colleagues would impact their perception of AR and might get them and others on board to try the technology (Lin & ha, 2010).

In the electric utility field, this study will be useful as a practical means for training and development. The creation of the infographic can be used by utilities not just in the Midwest but can be altered to fit the other utility groups. Their work is necessary to the functioning of society, their safety and efficiency are the means of having electricity and not. So much of our everyday lives are affected by the work utilities conducts and there is constant maintenance, upkeep, modernizations, and repair. Augmented reality devices hope to make their job easier and safer in the future. And so, by looking at how to communicate and introduce AR through infographics this study can assist in the transition to a more modern toolkit and workforce. The study proves that if we communicate in the language of the workers and present how AR can be useful and easy to use they are more willing to try the technology. Therefore, the training of workers needs to use a combination of approaches, one of which would be passively introducing them to a new tool through infographics. Incorporating communication theories into other fields is necessary to improve training and development for workers. This interdisciplinary study sheds a light on how communication theories can be used in many different contexts.

As a result of these observations and suggestions, the researcher made an ideal template that the utility company can use in the future to help present AR to workers in a passive way, posting it in the break room or having it on their TVs that display in the

lobby. Even if workers skimmed it, they will come away with the general idea of what AR was and some ways it might be helpful to them in their daily work. As the tables showed, there was a 20% increase in viewing AR as useful to their task after seeing the infographics (see Tables 1-3). The ideal template needed the insight of workers, because the researcher's age, gender, and profession would have affected the way the different information and images used. Getting feedback from the workers ensured that the infographics included information that the workers will find helpful. Finding what the specific audience wants and needs is vital to ensuring that the information is properly accommodated to the audiences' needs.

Interviews

The change of new tech in the workplace is challenging for this population, because, according to the workers, much of the work they have done has remained the same since World War II (Tyler, personal communication, February 19, 2018). The technique of "putting dead trees in the ground and putting shiny wire on top" has essentially remained as it was with a few minor adjustments (Greg, personal communication, February 19, 2018). In addition to not changing the techniques, when new tools are introduced many would prefer not to use it or feel that it is not respected as much. Even tools that help with safety, efficiency, and ergonomics are seen as lacking in masculinity because they make things easier. It is seen as manlier to do it the old, difficult and challenging way. "Sometimes we'd have the young new guys use the old cutters, show 'em how us men did it," (Adam, personal communication, February 19, 2018). There is a perception, sometimes, according to the participants, that you aren't as

hardcore, or legitimate if you use the newly battery powered wire cutters instead of crunching the wires yourself with the super heavy and hard to maneuver tools. Despite the stigma of using the new tools, they all admit that they do make their job easier. The masculinity as well as tradition within this field makes new technology, and the change towards a more tech involved work as undesirable. According to their interviews, the workers say they are not necessarily scared of the change or the risk-taking, in this case, they like things the way they have done them. It is a rite of passage for new line workers, and a marker of an established worker.

Limitations

Despite the applicability of the infographic and the ideas of CAT and TAM, this study has limitations due to the specific infographic not being generalizable to the larger population. The number of individuals interviewed was limited to eight, due to time constraints. Although useful and valuable information was presented in these methods, larger more diverse groups would be beneficial to creating reliable data for preferences on infographics. Moreover, the volunteer sampling limited the research to individuals all within the same organization, which can be limiting but also can help to focus the needs of that specific group for the creation of a catered infographic.

Another limitation is that the Midwest electric utility company wanted to have a supervisor and a communications staff member from the organization in the room for the interviews. This was agreed to as, it was the only way to gain access to the workers for interviews. However, the presence of the supervisor and communications individual may

have created some ethical concerns. The individuals interviewed may not have felt comfortable to speak freely and openly about their thoughts, feelings and previous experiences, for fear of reaction, or judgment from their supervisor or the other organization member. The communications staff member was there to censor if needed any comments that could make the company appear negative in the light of this paper. However, no censorship was needed outwardly, perhaps the workers self-censored their comments. The additional individuals in the room also may have hindered how much participants were willing to share, and therefore may have added to their very short responses. If this study were to occur again, a compromise should be made with the organization so that the participants feel able to speak more freely.

Finally, the interest in what specific aspects speak best to line workers was not clear due to the variables of personal preferences, and age. The participants shared feelings on color, organization, and information that may be valuable to them as an individual or possibly applicable to others in their field, however it is difficult to make a generalization with the sample size of individuals used. Therefore, the insight gained from the ideal template for an infographic may be specific only to this particular group of individuals, and not as generalizable as previously hoped.

Future Research

The interview also provided ideas for future research such as age determining the preference of infographic style, the role of masculinity in technology acceptance in the trade industries, as well as how there are particular influencers who guide the group to accept technology more and those may be the ones who the infographics should be

targeted to. These findings are preliminary research for a possible larger scale survey and interview group in order to gain more generalizable data. The practical use of data collected in this study is to add to existing bodies of research surrounding technology acceptance, communication accommodation theory and the benefits of infographics for presenting challenging information. This study continues the tradition of researching the perceptions of emerging technology on workers. This study aligned with the current body of research that describes how technology acceptance is improved when usefulness and ease of use are communicated (Davis, 1989). The interviews and the TAM survey confirmed that perceived usefulness and ease of use does change the perspective on adopting a new technology. They also displayed how more information can cause individuals to be more willing to try or adopt new tools. The main surprise and information that differed in this study was the style of infographics that are effective, the more popular styles were not found as useful to workers as the more traditional educational poster style. If this study is done on a larger scale, a section outlining preferences and useful styles of infographics for different age groups should be included in the literature review as a possible impact of how effective infographics are for their audience.

Age of staff.

For future research, it would be beneficial to assemble focus groups with workers who were grouped by work experience and age. This way infographics catered to the older more experienced generation could be created, and the infographics for the younger more tech accepting generation could also be made. It could be argued that the only ones

who would need the technology acceptance would be the more resistant, more experienced generation of workers. Therefore, infographics may not need to be focused or aimed at the younger generation of workers. Another thought for future research is when will the technology be rolled out and when is the older generation retiring? Therefore, planning ahead for the generation that will most likely be affected should be the aim of the researcher.

Masculinity and tools.

A recurring theme in the interviews was that there was a feeling of masculinity being equivalent to the old way of doing things; that technology is emasculating. This perspective of masculinity as being traditional passed down, a rite of passage and connected with physical strength, endurance and pain is a narrative in many organizations and societally as a culture. Because the topic came up with more than half the participants, it requires some thought as to how the traditional sense of masculinity can be used to the advantage of new tech and reinvent what it means to be masculine. Many of the workers also expressed being in pain and being sore, from the older more traditional equipment, but had some nostalgia about the old days of how simple the technology was. Although safety is a top priority for the workers, the conflicting masculinity and therefore resistance to new technology is something future research should look into and see if there is some way to integrate this into the infographics in order to grab the attention and convince staff to new technology adoption.

Fear of failure.

During observations there were some notes made to the researcher about the fear of failure, this topic did not come up during interviews, but it was shared informally to the researcher off the recorder. Explained to the researcher during the observations of workers in the field, some mentioned that they were concerned that they wouldn't be able to learn how to use it, that they were scared of messing up, not just for safety but for fear of failing. This topic may not have come up in the interview because of the formal setting, or because there were a communication representative and supervisor present during the interviews. The extra people may have caused some participants to not share their emotional concerns, such as fear of change, new technology, and failure.

Previous experience with new technology.

On the survey, all of the participants listed that they had never used AR before, however, after seeing the infographics many realized they had seen, experience or used AR. They all recognized that the yellow first down line in football was AR, and then would add comments about the Winter Olympics, or other large events shown on TV. They connected that their backup camera in their car was AR, and began to understand what the experience is like, and how it can be useful. Individuals can still use their mirrors to back up their car, but the AR backup cam and lines are an additional tool to assist and ensure people park more safely. One of the participants asked, "is it like that app you can hold up your phone and see the stars in the sky even during the day?" (Todd, personal communication, February 19, 2018). This app was something that Todd had experienced and did not realize that it was a graphics overlay on the real world, but when

connecting the previous experience to the term and seeing how that technology could apply specifically to utilities, Todd became much more excited about the idea of AR in the workplace. Considering how previous experience assists in technology acceptance has been looked at before, but perhaps should be delved into deeper in future research.

Influencers in the workplace.

Another area where more research is needed is the use of influencers. Influencers are discussed in the Diffusion of Innovations, as a catalyst that encourages adoption (Rogers, 2003). The interviews eluded that the use influencers were important for helping to create a diffusion of innovations and improved technology acceptance. “I think that there are some people who are respected that are liked more, that if there is somebody who sees the future and possibilities of this they get it out of their coworkers it might be more accepted rather than the company pushing it or someone they don’t know pushing it,” (Tyler, personal communication, February 19, 2018). The participants explained that there is some staff who are respected, and their opinion is valued by many. Therefore, if the influencers are willing to adopt the new technology, many will be far more likely to follow suit. In some cases, the influencers are supervisors and they are a part of the general line mechanic team. The communication between the influencers and their colleagues on the inclusion of new tools in daily tasks, the introduction of new tools in training and the process of technology acceptance within electric utilities may be an area where more time should be invested in research.

Conclusion

Adding new technology or tools to a daily routine is never easy. Change is always hard, as we are creatures of habit. In order to convince people to change and adopt new technology, they must first be convinced that it will be useful to their job, and it will be easy to use. By presenting these facts and arguments, the individual may be more likely to accept, adopt and continue to use the new technology. This study showed that accommodating scientific communication in a style that works best for electric utility lines workers aided their comprehension of the new technology and therefore improved their technology acceptance. In addition, the infographics informed workers of what the technology was, how it was used, how easy it might be to use, specific tasks they could use it for, and where they might have seen AR before. Although the formats and presentation were different, the information presented over the four infographics remained similar. The infographics helped in improving the technology acceptance of augmented reality with the workers, clearly shown through their pre and post-Technology Acceptance Model surveys. The workers agreed that easing them into the idea of using Augmented Reality in their daily tasks, through providing a definition, images, description of ease of use and usefulness of the AR tool would be beneficial. Through doing so, the hope is that technology acceptance will improve, and the resistance will decrease. This study is just a small look at how infographics can be used as a way to prime and introduce workers to new technology thus increasing technology acceptance, through perceived usefulness and perceived ease of use. This study also demonstrates how we need to accommodate scientific language into layman's terms, which can be

done through the use of infographics that both educate and translate topics as well as communication accommodation theory.

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Appendix

Interview Questions

Copies of the main questions asked in the interviews.

1. What is your role at the electric utility company?
2. Describe a daily task you do.
3. What does a typical day of work look like?
4. Have you ever had to add new tools into your daily routine?
    a. What was that like?
    b. How did your supervisor communicate the change to you?
    c. Did you feel that the transition was smooth?
        i. Why or why not?
5. Have you heard of augmented reality?
    a. (If they say no, define augmented reality shortly with limited details)
    b. (If they say yes,) What do you know about augmented reality?
6. How willing would you be right now (without having seen the infographic) to add augmented reality headsets into your daily routine?
    a. Why is that?
7. Here is the first infographic, I'd like you to speak aloud and tell me what you notice first,
    a. What do you find interesting?
    b. Why does that jump out at you?
    c. Does that information surprise you?
        i. Why?
    d. What else are you thinking?
8. Here is another infographic, I'd like you to do the same as you did with the other one. The information will be similar, but it will be presented in a different way. I'd like you to make a note of what you like or don't like about this infographic versus the previous one.
    a. Why does that stand out to you?
    b. Why do you like that?
    c. How does that make you feel?
    d. Does that information seem useful?
    e. Follow up as necessary.
9. *Repeat questions 7 and 8 for the third and fourth infographic.
10. Place this post it note next to the elements of any of the four infographics that you find interesting or useful.
    a. Why did you choose that element to be useful and interesting?
    b. What information did it include that you liked?
    c. If you could improve this infographic even more, what sort of information or images would you want added?

11. (After the infographics). Now that you have seen these, and learned some information about augmented reality, how willing would you be right now to add augmented reality headsets into your daily routine?
    a. Why is that?
    b. What would help you make your decision?
12. How easy do you think it would be to used, based off of what you learned today or your prior knowledge?
    a. Follow up.
13. Do you think AR can be useful in electric utilities?
    a. What sort of tasks would you like to know if it can help with?
14. If everyone at work began using the AR devices, would that change your mind about using AR?
15. What do you think your coworker's reactions would be if you were told to begin using this device?
16. What sort of training would you find helpful for learning about AR?

Pre and Post TAM Survey

Circle the correct numeric response to each question

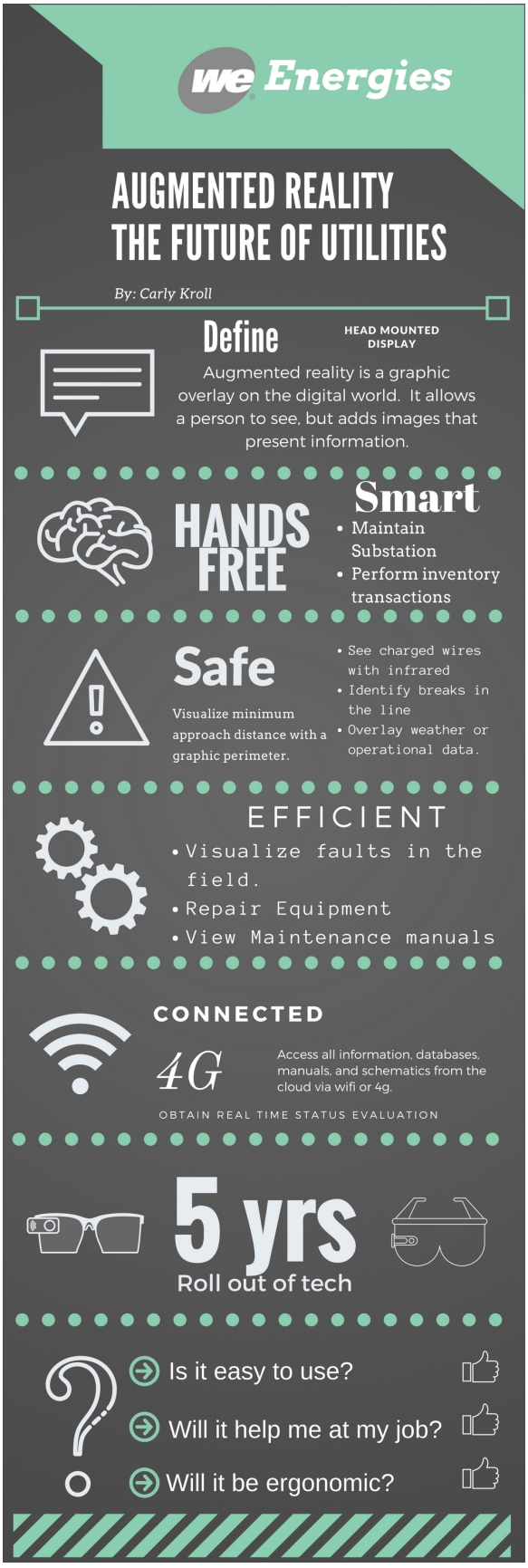
1-Strongly Disagree 2-Disagree 3-Neutral 4-Agree 5-Strongly Agree

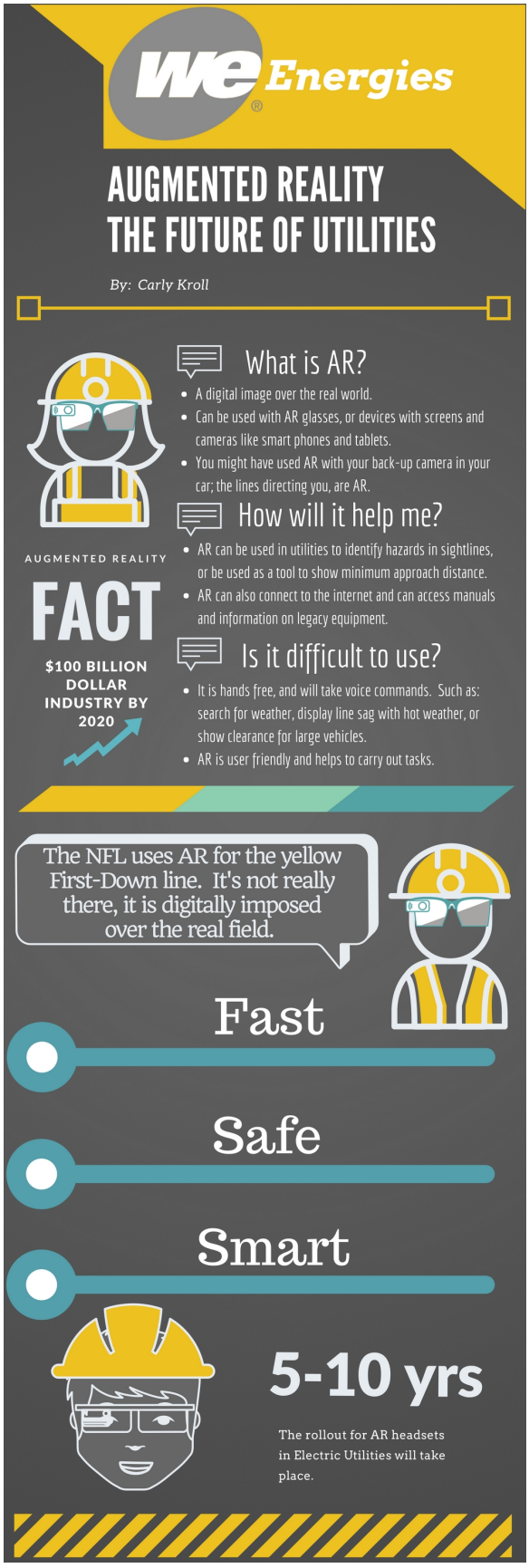
	Question							
#	**General Knowledge:**							
1	I know what Augmented Reality is.		1	2	3	4	5	
2	I have used Augmented reality before.		1	2	3	4	5	
	Using Augmented Reality in my job would:							
3	Enable me to accomplish tasks more quickly		1	2	3	4	5	
4	Increase my productivity		1	2	3	4	5	
5	Enhance my effectiveness on the job		1	2	3	4	5	
6	Make it easier to do my job		1	2	3	4	5	
7	I would find Augmented Reality useful in my job.		1	2	3	4	5	
	In my opinion:							
8	Learning to operate Augmented Reality would be easy for me.		1	2	3	4	5	
9	I would find it easy to get Augmented Reality to do what I want it to do.		1	2	3	4	5	
10	My interaction with Augmented Reality would be clear and understandable.		1	2	3	4	5	
11	I would find Augmented Reality to be flexible to interact with.		1	2	3	4	5	

12	It would be easy for me to become skillful at using Augmented Reality.		1	2	3	4	5	
13	I would find Augmented Reality easy to use.		1	2	3	4	5	

For the Researcher only: PRE POST

Four Infographics used for Interviews





Augmented Reality

Future tools for the electric utility industry

Augmented Reality: (AR) is a graphic overlay on the real world. Electric Utilities plans to use head mounted devices.

Safe

- Identifies obstacles and dangers.
- Hands free technology.
- Able to identify charged wires and objects.
- Can find breaks in the lines.

Fast

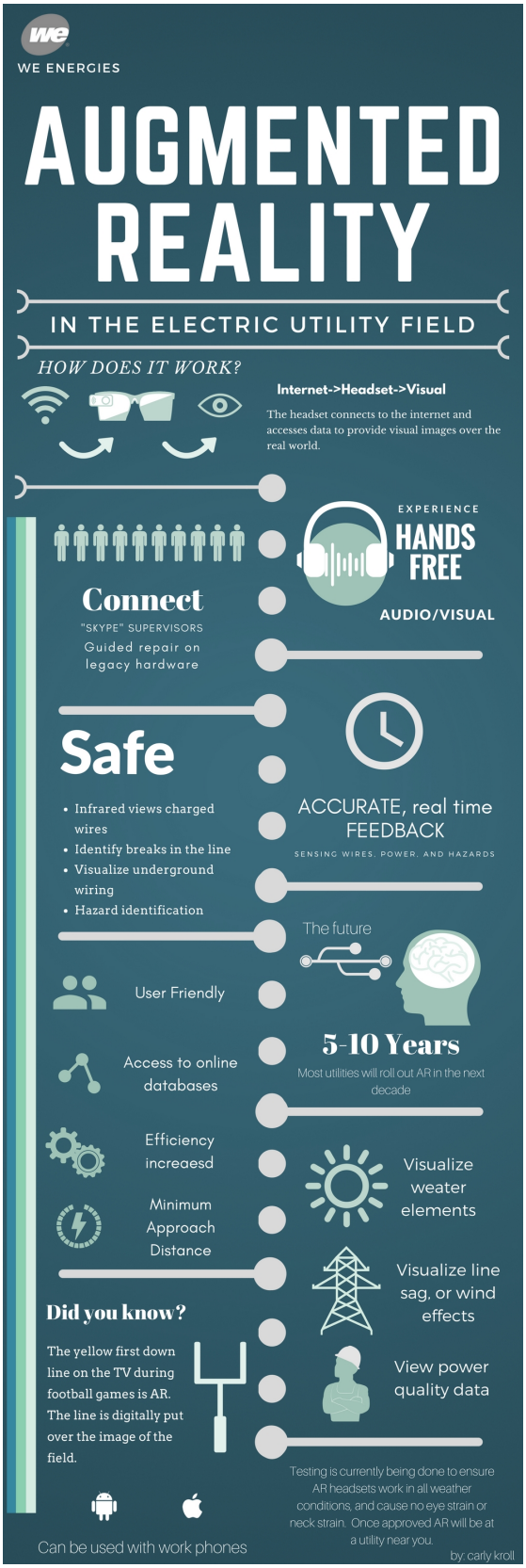
- Allows workers to keep their eyes on task.
- Can provide real time information.
- Access to internet database, can recall manuals and other information.
- Simple to use technology for the wearer.

Smart

- Able to relay information through video and sound.
- Can contact experts in the field.
- Can be programmed for many tasks.

The Future Is Here

AR is expected to be a daily tool in the next 5 years.
Current research is being done to improve user comfort.


WE ENERGIES
AUGMENTED REALITY
IN THE ELECTRIC UTILITY FIELD
HOW DOES IT WORK?
Internet->Headset->Visual
The headset connects to the internet and accesses data to provide visual images over the real world.
EXPERIENCE
HANDS FREE
AUDIO/VISUAL
Connect
"SKYPE" SUPERVISORS
Guided repair on legacy hardware
Safe
• Infrared views charged wires
• Identify breaks in the line
• Visualize underground wiring
• Hazard identification
ACCURATE, real time FEEDBACK
SENSING WIRES, POWER, AND HAZARDS
The future
User Friendly
Access to online databases
5-10 Years
Most utilities will roll out AR in the next decade
Efficiency increaesd
Minimum Approach Distance
Visualize weater elements
Visualize line sag, or wind effects
View power quality data
Did you know?
The yellow first down line on the TV during football games is AR. The line is digitally put over the image of the field.
Testing is currently being done to ensure AR headsets work in all weather conditions, and cause no eye strain or neck strain. Once approved AR will be at a utility near you.
Can be used with work phones
by: carly kroll

Ideal Infographic Template

Augmented Reality

Future tools for the electric utility industry

Augmented Reality: (AR) Augmented reality is a digital graphics overlay on the real world. It allows a person to see, but adds images that present information.

Safe

- Identifies obstacles and dangers such as charged wires and objects or minimum approach distance.
- Hands-free technology.
- Can find breaks in the lines.

Fast

- Allows workers to keep their eyes on the task.
- Can provide real-time information like phasing.
- Access to internet database can recall manuals and other information.
- Simple to use technology for the wearer.

Smart

- Able to relay information through video and sound.
- Can contact experts in the field to get feedback on situations or advice on legacy hardware.
- Can be programmed for many tasks such as viewing underground wires and lines.

The Future Is Here

- AR is expected to be a daily tool in the next 5 years.
- You currently use AR when using a backup camera in your car.
- Current research is being done to improve user comfort & accuracy in all weather conditions.