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**APPLYING TECHNOLOGY ACCEPTANCE RESEARCH
TO INFORMATION SYSTEMS IMPLEMENTATION
IN THE FIRE SERVICE**

by

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March 2019

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**APPLYING TECHNOLOGY ACCEPTANCE RESEARCH TO INFORMATION
SYSTEMS IMPLEMENTATION IN THE FIRE SERVICE**

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Submitted in partial fulfillment of the
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ABSTRACT

The role of a firefighter has remained relatively static over the years, but the way a firefighter documents incidents and accesses logs, maps, and a range of forms is changing from paper-based practices to digital media systems. Unsuccessful technology acceptance can negatively affect efficiency and work production. A better understanding of the variables that are most relevant to influencing firefighters' acceptance of technology will help improve the success of the implementation of new ideas. The purpose of this thesis is to develop a model specific to the fire service and to gain a better understanding of the variables that influence technology acceptance in that field. How can technology acceptance research be applied to the fire service to better understand and influence the acceptance of information technology? A review of the literature reveals three relevant variables of technology acceptance in the fire service: self-efficacy, facilitating conditions, and social influence. These variables were tested using two thought experiments including one retrospective scenario and one prospective scenario. The thought experiments further refine the model by revealing that facilitating conditions had a positive relationship with self-efficacy. With a better understanding and leveraging of the variables that affect technology acceptance, fire administrators can improve the likelihood of acceptance.

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LIST OF ACRONYMS AND ABBREVIATIONS

CSE	computer self-efficacy
EHR	electronic healthcare records
ePCR	electronic patient care reporting
EMS	emergency medical service
ERP	enterprise resource planning
IS	information sciences
IDT	innovation diffusion theory
NFPA	National Fire Protection Association
PBC	perceived behavioral control
PEU	perceived ease of use
PU	perceived usefulness
RFID	radio-frequency identification
SCT	social cognitive theory
SLT	social learning theory
TAM	technology acceptance model
TAM 2	technology acceptance model 2
TAM 3	technology acceptance model 3
TPB	theory of planned behavior
TRA	theory of reasoned action
UTAUT	unified theory of acceptance and use of technology

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EXECUTIVE SUMMARY

The role of a firefighter has remained relatively static over the years, but the way a firefighter documents an incident and accesses logs, maps, and a range of forms is changing from existing paper-based practices to digital media and its related systems. Staffing, incident reporting, response mapping, resource allocation, supply tracking, and water system testing are all processes that are currently moving to digital media and its related systems. The purpose of this integration of information systems technology is to improve efficiency and quality of work.

Fire department members and administrators alike resist new technologies for multiple reasons, such as time and money. Members may see the new technology as more work due to the effort required to learn a new process. Administrators may be concerned about the cost of training, equipment, and downtime. While the drivers of behavior may vary depending on the perspective of the user, they remain important variables for predicting acceptance. Attitudes, beliefs, experiences, and perceptions about new technology are just some of the behavioral aspects that may play a role in the acceptance of new technology.

Researchers and practitioners from sociology, cognitive psychology, and information sciences have produced a significant amount of theoretical and empirical research related to the larger problem of explaining factors that influence product and service adoption.

While the literature from the aforementioned fields does provide important empirical and theoretical contributions that explain and predict the adoption of products and services and, in the information sciences, user acceptance of information technology, prior research related to technology acceptance has not fully considered the unique environment of the fire service. The fire service environment is unique in that it shares some specific traits such as fraternity, shift structure, and social networking with other work environments, the overall combination of which is not identical to any other field.

This type of environment warrants further research to identify which variables explain the variance in for technology acceptance in fire services.

A better understanding of the variables that are most relevant to influencing firefighters' acceptance of technology will help improve the success of the implementation of new ideas. The purpose of this thesis is to develop a model specific to the fire service and to gain a better understanding of the variables that influence technology acceptance in that field. A better understanding of the variables that influence technology acceptance may help improve the actual use of the systems and, subsequently, the efficiency and quality of work.

There is a significant volume of empirical work on the problem of technology acceptance from the domain of information systems that supports the efficacy of the relationships between perceived ease of use, perceived usefulness, and behavioral intention. Likewise, the same body of research from information systems strongly supports the relationship between behavioral intention and actual use. Based on the aforementioned, the development of the current model was built upon and extended the foundational behavioral intention models, such as the theory of reasoned action and related technology acceptance model (TAM), in developing a model to explain technology acceptance in the fire service. Working from these foundational models, the next step is to identify antecedents of the core variables that are supported in the fire service environment.

Self-efficacy captures the individual's assessment of their own ability, while perceived behavioral control encompasses the individual's perceptions about their control over the behavior. Self-efficacy asks the question, "Do I have the skills, knowledge, and ability to complete the task?" One important variable that influences external beliefs of technology acceptance in the fire service is social influence. Social influence refers to any variable that derives from what the individual believes others in the peer group think and/or how that will affect the individual's standing in the group. The role of facilitating conditions in technology acceptance has also been supported in multiple fields. One challenge in using facilitating conditions as a variable is that it generalizes several other similar but unique variables. However, since the goal of this model is to help fire service administrators better understand the variables that influence technology acceptance, it is

appropriate to include the variables for which likely have the most control. Administrators ultimately have the most control over the facilitating condition like training, access to resources, and technical support.

The research question for this thesis is, “How can technology acceptance research be applied to the fire service to better understand and influence the acceptance of information technology?” Through a literature review, proposed model, and thought experiment, the author was able to identify and test three important variables influencing technology acceptance in the fire service. The identified variables were computer self-efficacy, facilitating conditions, and social influence. The thought experiments provided support for all three variables as antecedents of acceptance.

The primary objective of this research is to help fire service administrators better understand the variables that influence technology acceptance. Davis stated, in his original work developing TAM, that his goal was to provide a tool for technology developers and implementers to help them predict successful acceptance of a new technology.¹ Like Davis, this author strives to provide fire chiefs and their technology teams with a model that helps them select, design, and implement technology tools that have a high likelihood of successful acceptance.

The model constructed from the literature was tested, using two thought experiments, while considering a proposed type of information technology. The first thought experiment took the form of a retrospective hypothetical scenario of technology implementation. The model was tested by analyzing the implementation with consideration of the proposed variables and relationships. One additional relationship was added to the model as a result of the initial scenario and a second prospective scenario of technology implementation was conducted with consideration of the proposed variables and relationships. The thought experiments provided support for all three variables as antecedents of acceptance.

¹ Fred D. Davis, *A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results* (Cambridge, MA: Massachusetts Institute of Technology, 1985), 7.

The success of fire service technology is dependent on the acceptance by the men and women who serve and protect our communities. By better understanding and leveraging the variables that affect technology acceptance, fire administrators can improve the likelihood of acceptance. This improvement will ultimately result in a more efficient and effective workforce which, in turn, improves overall public safety.

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I. INTRODUCTION

A. PROBLEM STATEMENT

The role of a firefighter has remained relatively static over the years, but the way a firefighter documents an incident and accesses logs, maps, and a range of forms is changing from existing paper-based practices to digital media and its related systems. Staffing, incident reporting, response mapping, resource allocation, supply tracking, and water system testing are all processes that are currently moving to digital media and related systems. The purpose of this integration of information systems technology is to improve efficiency and quality of work.¹

Unsuccessful technology acceptance can have an inverse effect.² In the private sector, unsuccessful acceptance means that the user does not purchase the technology. In the public sector, such as the fire service, administrators can mandate use of a new technology, but efficiency and quality of work may suffer because of user resistance.³ Users forced to utilize a technology may not employ such technology to its full capacity or may use it only to the minimum acceptable level.⁴ This shortfall may harm the quality of the work.

Fire department members and administrators alike resist new technologies for multiple reasons, such as loss of time and money.⁵ The effort required to learn a new process causes firefighters to see the new technology as more work; administrators may be

¹ M. McCord, *Handbook of Research on Electronic Surveys and Measurements*, 2007, 306, <https://doi.org/10.4018/978-1-59140-792-8.ch038>.

² McCord, 306.

³ Ibrahim M. Al-Jabri, "Adoption and Use of Information Technology in Mandatory Settings: Preliminary Insights from Saudi Arabia," *Proceedings for AMCIS*, 2010, 328, http://aisel.aisnet.org/amcis2010/328/?utm_source=aisel.aisnet.org%2Famcis2010%2F328&utm_medium=PDF&utm_campaign=PDFCoverPages.

⁴ Samar Mouakket, "Extending the Technology Acceptance Model to Investigate the Utilization of ERP Systems," *International Journal of Enterprise Information Systems* 6, no. 4 (October 2010): 38–54, <https://doi.org/10.4018/jeis.2010100103>.

⁵ David Cain, "Moving from Paper to Digital Logs," *Fire Rescue*, November 1, 2014, <http://www.firerescuemagazine.com/articles/print/volume-9/issue-11/technology/moving-from-paper-to-digital-logs.html>.

concerned about the cost of training and equipment as well as the downtime that accompanies both.⁶ Although the drivers of behavior may vary depending on the perspective of the user, they remain important variables for predicting acceptance. Attitudes, beliefs, experiences, and perceptions about new technology are just some of the behavioral aspects that may play a role in the acceptance of new technology.

Researchers and practitioners from sociology, cognitive psychology, and information sciences (IS) have produced a significant amount of theoretical and empirical research related to the larger problem of explaining factors that influence product and service adoption. Some examples include Rogers's 1962 innovation diffusion theory (IDT) from the field of sociology and Venkatesh and Bala's 2008 technology acceptance model 3 (TAM 3), which extended Davis's original technology acceptance model (TAM) in 1985 from the IS field.⁷

Although the literature from the aforementioned fields does provide important empirical and theoretical contributions that explain and predict the adoption of products and services and, as in IS, user acceptance of information technology, prior research related to technology acceptance has not fully considered the distinctive environment of the fire service.⁸ The fire service environment has some specific traits such as fraternity, shift structure, and social networking within the department, but the combination of characteristics is unlike that of any other field. This environment warrants further research to identify which variables explain the variance in technology acceptance in fire services.

To date, fire service organizations have not widely applied technology acceptance research to the profession.

⁶ Cain.

⁷ Everett M. Rogers, *Diffusion of Innovations*, 5th ed. (New York: Free Press, 2003); Viswanath Venkatesh and Hillol Bala, "Technology Acceptance Model 3 and a Research Agenda on Interventions," *Decision Sciences* 39, no. 2 (May 2008): 273–315, <https://doi.org/10.1111/j.1540-5915.2008.00192.x>; Fred D. Davis, Richard P. Bagozzi, and Paul R. Warshaw, "User Acceptance of Computer Technology: A Comparison of Two Theoretical Models," *Management Science* 35, no. 8 (1989): 982–1003, https://search.proquest.com/docview/61259435?rfr_id=info%3Axri%2Fsid%3Aprim.

⁸ Julian Weidinger, Sebastian Schlauderer, and Sven Overhage, "Is the Frontier Shifting into the Right Direction? A Qualitative Analysis of Acceptance Factors for Novel Firefighter Information Technologies," *Information Systems Frontiers* 20, no. 4 (August 1, 2018): 669–92, <https://doi.org/10.1007/s10796-017-9785-8>.

B. ACCEPTANCE VERSUS ADOPTION

The level of analysis of this study makes it critical to distinguish between technology adoption and technology acceptance. Sociology research generally focuses on the broader adoption process at the level of a society, which includes identifying, acquiring, and putting a new technology to use.⁹ Such research has characterized adoption as a function of innovation moving through a group of individuals.¹⁰ Psychology and IS research focuses on individual acceptance, which includes individual behaviors, attitudes, and beliefs about a given technology.¹¹ This study focuses on the individual level of acceptance.

C. PURPOSE STATEMENT

A deeper understanding of the variables influencing firefighters' acceptance of technology will help increase the success in implementing new ideas and may improve the use of the systems and, subsequently, the efficiency and quality of work. This thesis aims to develop a model specific to the fire service and to gain a better understanding of the variables that influence technology acceptance in fire services. Analysis of the relevant literature identifies variables that influence technology acceptance within the fire service and helps to develop an idealized model that better explains the process.

D. RESEARCH QUESTION

How can technology acceptance research be applied to the fire service to better understand and influence the acceptance of information technology?

⁹ Judy Biljon and Karen Renaud, "A Qualitative Study of the Applicability of Technology Acceptance Models to Senior Mobile Phone Users," in *Multimodal Human Computer Interaction and Pervasive Services*, ed. Il-Yeong Song et al. (Berlin: Springer, 2008), 228–29, https://doi.org/10.1007/978-3-540-87991-6_28.

¹⁰ Rogers, *Diffusion of Innovations*.

¹¹ Biljon and Renaud, "A Qualitative Study," 228–29.

E. RESEARCH DESIGN

The research project intends to provide important insights for fire service professionals about the variables that influence technology acceptance as synthesized from the current literature. This literature review focuses on technology acceptance research and includes models and theories from cognitive psychology and IS and how each of these models/theories identifies variables that influence acceptance. The review, categorized by theme, contains all variables that are applicable to the fire service. The models and theories examined include IDT, social learning theory, theory of reasoned action (TRA), theory of planned behavior (TPB), TAM, TAM 2, TAM 3, and unified theory of acceptance and use of technology (UTAUT).

The previously mentioned models and theories are studied and their variables extracted. The variables examined included behavioral intention, perceived ease of use (PEU), perceived usefulness (PU), social influence, perceived behavioral control, self-efficacy, attitude, and extrinsic motivation. The variables were analyzed individually for relevance to the fire service by examining their use in comparable environments and in consideration of empirical research that identifies the strength of particular relationships. For example, technology acceptance that is moderated by the fraternal nature of the fire service may have applicable research from acceptance studies within military environments that explain the levels of variance in the intention to accept a particular technology. Prior empirical work in similar domains that supports certain variables were then adapted to create a model for technology acceptance in fire services.

We test the model constructed from the literature, using a thought experiment, while considering a proposed type of information technology. A thought experiment is a tool of the mind used to explore ideas in the absence of empirical data.¹² Thought experiments build on the foundation of previously established and accepted work.¹³ These

¹² James Robert Brown and Yiftach Fehige, "Thought Experiments," in *The Stanford Encyclopedia of Philosophy*, ed. Edward N. Zalta, Summer 2017 (Stanford, CA: Stanford University, 2017), <https://plato.stanford.edu/entries/thought-experiment/>.

¹³ L. D. Introna and E. A. Whitley, "Imagine: Thought Experiments in Information Systems Research," in *Information Systems and Qualitative Research*, IFIP — The International Federation for Information Processing (Springer, Boston, MA, 1997), 492, https://doi.org/10.1007/978-0-387-35309-8_24.

experiments allow practitioners to conduct experiments that would otherwise be impractical.¹⁴ The purpose of administering the thought experiment is to test the proposed model while examining it through the lens of the author's professional experience in the fire service. The thought experiment is then used to analyze the model, considering face validity for efficacy and completeness, and then a revised model is proposed. The first thought experiment took the form of a retrospective hypothetical scenario of technology implementation. The model was tested by analyzing the implementation with consideration of the proposed variables and relationships. One additional relationship was added to the model as a result of the initial scenario. A second prospective scenario of technology implementation was conducted with consideration of the proposed variables and relationships of the resultant model. Conclusions and recommendations for use with the new model conclude this research.

¹⁴ Introna and Whitley, 482.

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II. LITERATURE REVIEW

Researchers from multiple disciplines have developed several explanatory and predictive theories and related models to better understand what influences an individual's decision to accept new technology. This literature review contains a broad description of explanatory and predictive theories and models that focus on the broader problem of individual-level adoption and technology acceptance. The perusal also considers the application of the aforementioned theories and models in fire services. A significant gap exists in the literature as it relates to technology acceptance in the fire service.

A. SOCIOLOGY

Research within the field of sociology has primarily focused on the movement of information through the social network. This level of research is valuable because it helps us understand how individuals within social networks accept technology. A high-level understanding of innovation and acceptance within a group of individuals lays the foundation for understanding how and why individuals accept technology.

1. Innovation Diffusion Theory

Multiple researchers have contributed to IDT. Rogers summarized IDT as “the process by which an innovation is communicated through certain channels over time among the members of a social system.”¹⁵ Innovation, communication channels, time, and social systems all influence IDT.¹⁶ Innovations are any new concepts, processes, or objects that an individual is exposed to¹⁷; communication channels are the routes by which individuals pass information to other members of the group¹⁸; and social systems are the relationships and networks between individuals within a group. Rogers proposed that

¹⁵ Rogers, *Diffusion of Innovations*. 35.

¹⁶ Rogers, 35.

¹⁷ Alaa M. Momani and Mamoun Jamous, *The Evolution of Technology Acceptance Theories* (SSRN Scholarly Paper, Rochester, NY: Social Science Research Network, April 7, 2017), <https://papers.ssrn.com/abstract=2971454>.

¹⁸ Rogers, *Diffusion of Innovations*.

awareness, interest, evaluation, and trial, represented the steps before final adoption.¹⁹ Rogers first classified and quantified individuals as innovators, early adopters, early majority, late majority, or laggards.²⁰ Frank Bass later aggregated the latter four groups as “imitators.”²¹ Rogers identified five attributes of the 2.4% of the population classified as “innovators.”²² These attributes, illustrated in Figure 1, are relative advantage, compatibility, complexity, trialability, and observability.²³ Since the latter became the basis of the antecedents and variables in the more contemporary adoption and acceptance models, they bear closer examination.

Relative advantage refers to the perception that the innovation is better than its predecessor.²⁴ Rogers noted that relative advantage could be either an economic or social advantage.²⁵ For example, home computers becoming affordable enough for most families to purchase demonstrates an economic advantage. Rogers describes a social advantage as the adoption of an innovation to improve perceived social status.²⁶ An example of this would be an individual who chooses to upgrade their cell phone with each iteration, regardless of the cost.

Rogers defined *compatibility* as an individual’s perceptions about whether the innovation matches one’s values, experiences, and needs.²⁷ Values may be religious, sociocultural, or personal in nature. Experiences guide expectations of compatibility as individuals compare the innovation to previously introduced ideas. For example, the adoption rate of a new version of software is directly related to its similarity to the previous

¹⁹ Rogers, 164.

²⁰ Rogers, 247.

²¹ Frank M. Bass, “A New Product Growth for Model Consumer Durables,” *Management Science* 15, no. 5 (January 1, 1969): 215–27, <https://doi.org/10.1287/mnsc.15.5.215>.

²² Rogers, *Diffusion of Innovations*.

²³ Rogers.

²⁴ Rogers.

²⁵ Rogers.

²⁶ Rogers.

²⁷ Rogers.

version. Finally, compatibility with needs simply refers to the user's perceptions about the level to which the innovation meets their needs.

Complexity is the variable that describes perceptions of how difficult the innovation is to understand and use.²⁸ Rogers predicted an inverse relationship between complexity and adoption rates. An example of this is the adoption rates of telephones versus short wave radios. Both provide two-way communication, but the telephones have been more widely adopted due to their simplicity.

Trialability is the opportunity for the user to try out the innovation before committing to purchase or adoption.²⁹ Rogers noted that early adopters held more value in trialability than later adopters. However, laggards, who by nature are slow to try out new ideas, moved from trial to adoption more quickly than early adopters did because they simply spent less time in the trialability phase.

Observability refers to the user's ability to see the results of the innovation.³⁰ Rogers held that users were more likely to adopt an innovation if they could see the benefits. For this reason, he theorized that hardware innovations would have a higher rate of adoption than software innovations.³¹

What remains unknown is how information moves through the unique social network of the fire service. Is the IDT bell curve of innovation identical for fire departments? The social network within a fire department is complex and multilayered. Some social bonds—such as those found in companies, shifts, and stations—are obvious, but others are not as clear. Firefighters have other lasting social connections from previous shift assignments, relationships outside work, and other casual friendships that may be a key variable in the flow of innovation through the department.

²⁸ Rogers.

²⁹ Rogers.

³⁰ Rogers.

³¹ Rogers.

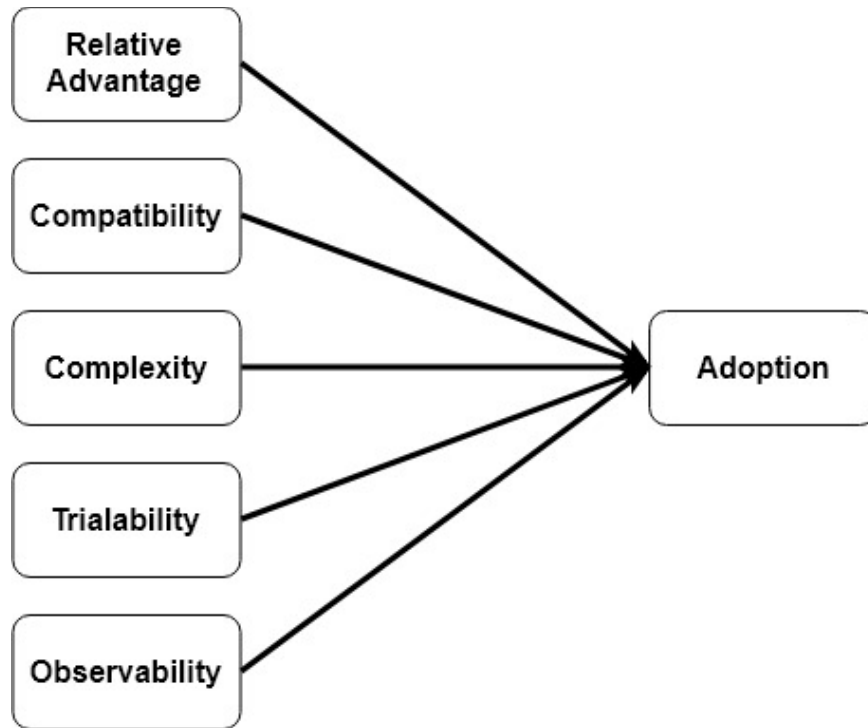


Figure 1. Roger's Innovation Diffusion Theory³²

B. COGNITIVE PSYCHOLOGY

Research from the field of cognitive psychology focuses on how an individual forms beliefs based on interactions with the environment and experiences. These interactions shape the individual's expectations and, therefore, guide behavior. Understanding the formation of individual beliefs can lead to a better understanding of behavior.

1. Social Learning Theory

Albert Bandura initially proposed the social learning theory (SLT), which he later modified to the social cognitive theory (SCT) to emphasize the individual's cognition and influence on the social system.³³ Figure 2 represents Bandura's proposed relationships

³² Rogers, 207.

³³ Ali Tarhini et al., "A Critical Review of Theories and Models of Technology Adoption and Acceptance in Information System Research," *International Journal of Technology Diffusion (IJTD)* 6, no. 4 (2015): 58–77, <https://doi.org/10.4018/IJTD.2015100104>.

between cognitive, behavioral, and environmental variables. Through their own cognition, individuals are not merely reactive products of their environment; they are capable of making decisions and influencing their social network.³⁴ Bandura proposed that individuals learn by observing others' behaviors and subsequent consequences and then process the observation through an interactive triad of variables.³⁵ The triad includes personal, behavioral, and environmental determinants. Of particular interest is Bandura's work regarding self-efficacy. Bandura posited that self-efficacy was a product of "personal accomplishments, vicarious experience, verbal persuasion, and physiological states."³⁶ In his self-efficacy theory, Bandura referred to these four variables as efficacy expectations.

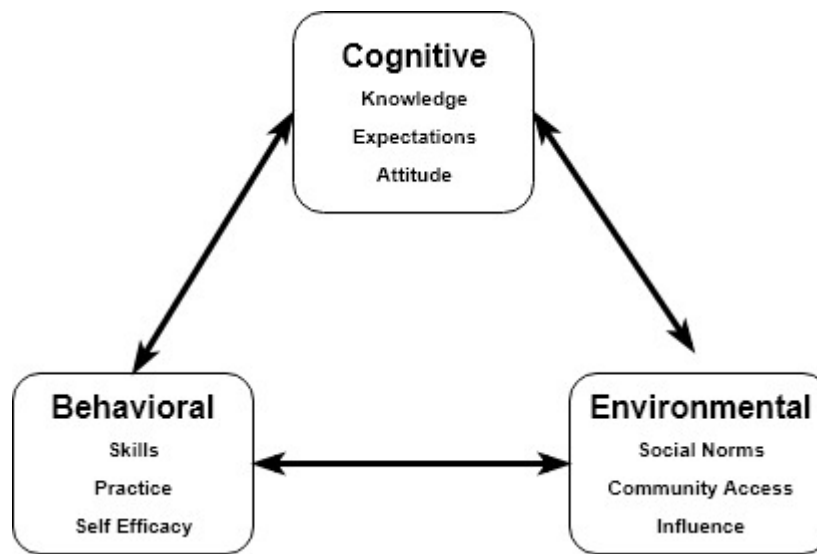


Figure 2. Bandura's Social Learning Theory³⁷

³⁴ Albert Bandura, "Social Cognitive Theory of Mass Communication," *Media Psychology* 3, no. 3 (August 1, 2001): 265–99, https://doi.org/10.1207/S1532785XMEP0303_03.

³⁵ Bandura.

³⁶ Albert Bandura, "Self-Efficacy: Toward a Unifying Theory of Behavioral Change," *Psychological Review* 84, no. 2 (1977): 191–215, <https://doi.org/10.1037/0033-295X.84.2.191>.

³⁷ Albert Bandura, *Social Learning Theory* (Englewood Cliffs, NJ: Prentice Hall, 1977), 35.

The first efficacy expectation is personal accomplishments. Successful completion of an action improves efficacy, while failure lowers it.³⁸ A pattern of success can build resiliency against the occasional failure, but repeated failure will eventually lower efficacy even in an established successful individual.³⁹ Once efficacy is established for one task, confidence improves for similar tasks and can lead to efficacy in unrelated areas.⁴⁰ In short, efficacy tends to create its own momentum.

Another efficacy expectation is vicarious experience. People are able to increase or decrease efficacy by observing the success or failure of others as well.⁴¹ Efficacy expectations based on observations may be weaker than those derived from personal experience.⁴² This is at least partly due to perceptions about the skill level disparity between the observer and the observed; however, observation of multiple people with varying capabilities does increase the likelihood of developing efficacy.⁴³

Verbal persuasion is one of the most-used methods of attempting to increase efficacy due to the relative ease of speech versus demonstration.⁴⁴ Bandura found that efficacy expectations based on verbal persuasion were far weaker than those derived from experience. Interestingly, verbal—persuasion when coupled with an opportunity to have a successful personal experience—was shown to produce lasting efficacy.⁴⁵

The final efficacy expectation is physiological state or emotional arousal. Bandura held that anxiety about performing a task lowered efficacy expectations.⁴⁶ Furthermore, the stress response from the expectation of failure heightened the anxiety, further lowering efficacy expectations into a spiraling effect. Bandura recommended desensitization by

³⁸ Bandura, “Self-Efficacy.”

³⁹ Bandura.

⁴⁰ Bandura.

⁴¹ Bandura.

⁴² Bandura.

⁴³ Bandura.

⁴⁴ Bandura.

⁴⁵ Bandura.

⁴⁶ Bandura.

giving the subject multiple opportunities to observe or attempt the task to lower the emotional response and therefore reduce the lowering effect on efficacy.

Bandura's model addresses the relationships between individuals and their social networks. However, SLT and SCT stop short of assigning weighted value to the variables due to the specific work and/or social environment type. Physiological states are of interest in fire service studies due to the inherent emotional arousal of emergency operations. Further work is needed to address how these models can be applied to the fire service.

2. Theory of Reasoned Action

Research within the field of cognitive psychology has focused on attitude and subjective norms. In the theory of TRA, shown in Figure 3, Ajzen and Fishbein state that one's attitude about a behavior and subjective norms directly influence behavioral intention and, therefore, the behavior itself. Behavioral intention is described as how ready a subject is to perform a given behavior.⁴⁷ Subjective norms are the pressures from peers and other outsiders that influence an individual's desire to perform a behavior.⁴⁸ Ajzen and Fishbein also state that salient beliefs and normative beliefs make up the evaluative process.⁴⁹ Salient beliefs are perceptions of how the behavior will influence outcomes, whether positive or negative.⁵⁰ Salient beliefs are at the forefront of an individual's mind and directly influence attitude. Normative beliefs are perceptions of how others will think of the behavior.⁵¹ Normative beliefs form the basis for subjective norms.

Further research is required on how attitudes and subjective norms in the fire service affect behavioral intent. Attitudes toward new ideas from leadership in general vary

⁴⁷ Martin Fishbein and Icek Ajzen, *Predicting and Changing Behavior : The Reasoned Action Approach* (Psychology Press, 2011), <https://doi.org/10.4324/9780203838020>, 20.

⁴⁸ Fishbein and Ajzen, 20.

⁴⁹ Fishbein and Ajzen, 20.

⁵⁰ Al-Suqri, and Al-Aufi, 188.

⁵¹ Al-Suqri, and Al-Aufi, 188.

greatly across the fire service but are often contagious.⁵² Attitude and behavioral intention may be a more significant variable due to the communicable nature of attitude within the fire service.

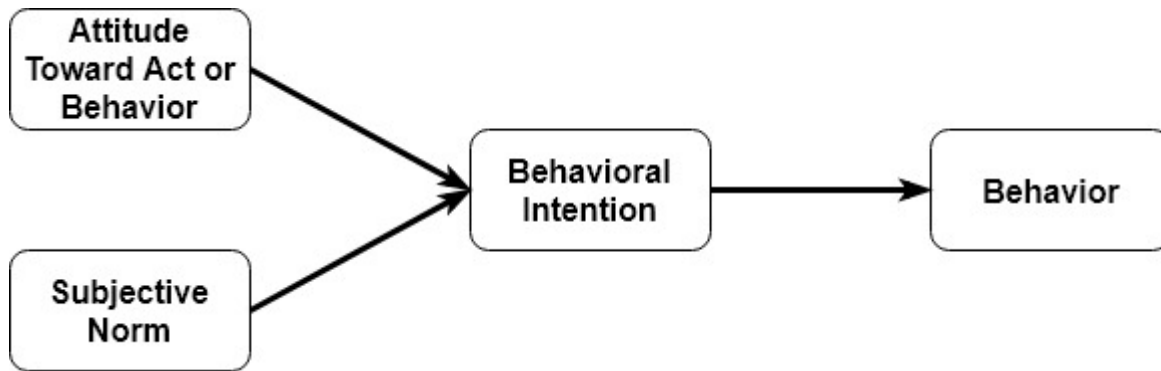


Figure 3. Fishbein and Ajzen's Theory of Reasoned Action⁵³

3. Theory of Planned Behavior

In further cognitive psychology research, Ajzen modified TRA to develop the TPB, which added perceived behavioral control to the equation of TRA. TPB, as shown in Figure 4, adds the variable perceived behavioral control to TRA. Perceived behavioral control is one's belief about the difficulty of the task and one's ability to complete a task. Ajzen points to "attitude, personality traits, social norms and values, and environmental conditions" as predictors of behavior.⁵⁴

⁵² Eddie Buchanan and Scott Thompson, "It's All about Attitude," *Fire Engineering*, July 1, 2004, <https://www.fireengineering.com/articles/print/volume-157/issue-7/features/its-all-about-attitude.html>; Anthony Rowett Jr., "Attitude: The Driving Force in the Fire Service," *Fire Engineering*, May 28, 2018, <https://www.firefighternation.com/articles/2017/07/attitude-the-driving-force-in-the-fire-service.html>.

⁵³ Fishbein and Ajzen, *Predicting and Changing Behavior*.

⁵⁴ Icek Ajzen, "The Theory of Planned Behavior," *Organizational Behavior and Human Decision Processes*, Theories of Cognitive Self-Regulation, 50, no. 2 (December 1, 1991): 179–211, [https://doi.org/10.1016/0749-5978\(91\)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T).

In TPB, Ajzen proposes that “behavioral beliefs, normative beliefs, and control beliefs guide behavior.”⁵⁵ Behavioral beliefs are the subject’s expectation that the behavior will yield the anticipated result.⁵⁶ Behavioral beliefs give rise to “attitude towards the behavior.”⁵⁷ Normative beliefs are perceptions of the expectations of peers and peer groups and generate subjective norms.⁵⁸ Control beliefs are perceptions about the factors that affect the individual’s ability to complete the behavior. Ajzen proposed that “control beliefs produce perceived behavioral control.”⁵⁹ In TPB, attitude, behavioral control, and subjective norms are the variables that yield behavioral intention. Ajzen accepts that behavioral intention leads to behavior.

Ajzen’s extension of TRA, to include PBC, adds an important facet to the model. In addition to salient and normative beliefs, TPB considers perceptions about the difficulty of the behavior. Ajzen recognized that not all factors surrounding completing a task were within the control of the individual.⁶⁰ Furthermore, individuals are well aware of this fact; however, the individual assessment of the difficulty is subjective.

TRA and TPB are generalized behavior models. While they have been applied to the use of technology and innovation, their scope is much broader. These models apply to nearly all human behaviors from buying a car to seeking a new job. For the purposes of general technology acceptance, TRA and TPB are useful to help understand the underlying psychological drivers for decision-making. However, a more specific model for the fire service is required to better understand decisions about the use of technology. Firefighters work in a unique environment and, therefore, may make decisions based on different types of experiences than the general population. Firefighters work in tightly organized teams,

⁵⁵ Icek Ajzen, “Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior 1,” *Journal of Applied Social Psychology* 32, no. 4 (2002): 665–83, <https://doi.org/10.1111/j.1559-1816.2002.tb00236.x>.

⁵⁶ Ajzen.

⁵⁷ Ajzen.

⁵⁸ Ajzen.

⁵⁹ Ajzen.

⁶⁰ Ajzen.

indicating that subjective norms could have a greater influence on decision-making than those who work independently. Further research is required to better understand the magnitude of social influence on firefighter behavior.

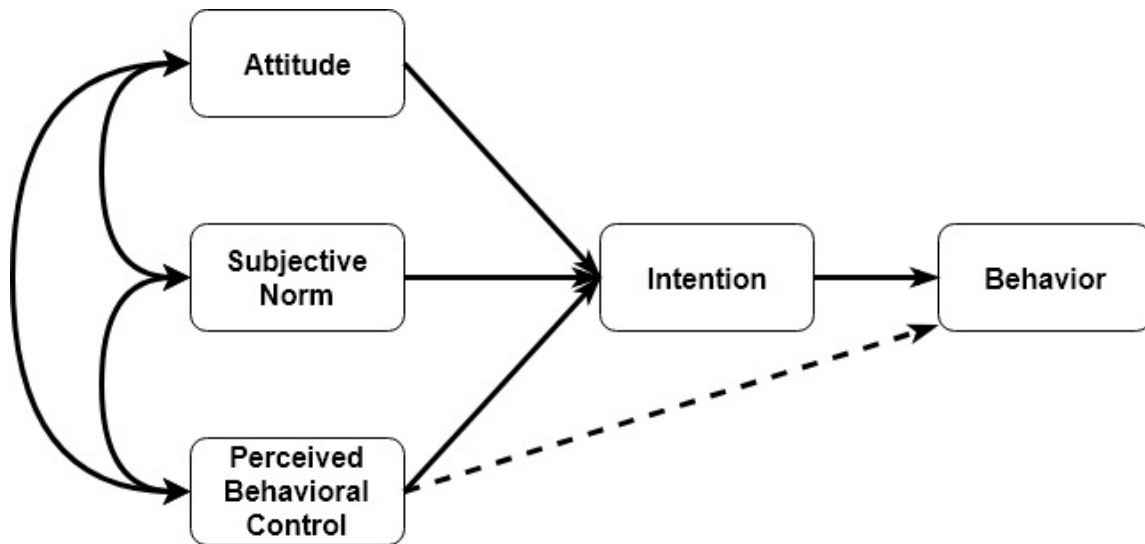


Figure 4. Theory of Planned Behavior⁶¹

C. INFORMATION SCIENCES

While the fields of sociology and cognitive psychology focus on commonalities of groups and individuals accepting new ideas and behaviors, technology acceptance research in the field of IS focuses more narrowly on individual acceptance of technological innovations. The goal of IS research is to better understand the elements of acceptance and, in turn, to facilitate acceptance. IS research draws on both sociology and cognitive psychology research to formulate a lineage of models.

1. TAM

TAM was originally developed by Fred Davis and later modified by countless contributors. The original goal of TAM was twofold: to gain a better understanding of the technology acceptance process and to serve as a tool to help designers and implementers

⁶¹ Ajzen.

evaluate new products prior to implementation. Davis's initial theoretical framework proposed that system features influenced individual users' motivation, which in turn, affected system use.⁶² Davis drew on Fishbein and Ajzen's empirical work in the field of psychology to develop his theoretical model for the field of IS. Davis referenced the "Fishbein Model," pointing out three core formulas. The first formula states that behavior is the direct result of intention, which is a sum of attitude and social influence.⁶³ The second formula indicates that perceived consequences of a behavior multiplied by the evaluations of the consequences yields attitude.⁶⁴ The final Fishbein formula adds that subjective norms can be calculated by multiplying an individual's perceived peer expectations by the motivation to meet those expectations.⁶⁵ Davis's model, shown in Figure 5, further proposes that behavioral intention is the product of PEU and PU.⁶⁶ Later research has shown there is a significant social influence on the PEU and PU.⁶⁷ PEU is the individual's feelings about how much effort the technology will be to use.⁶⁸ PU is the individual's level to which the individual believes the technology will help them do their job.⁶⁹

⁶² Fred D. Davis, *A Technology Acceptance Model for Empirically Testing New End-User Information Systems: Theory and Results* (Cambridge, MA: Massachusetts Institute of Technology, 1985), 24.

⁶³ Davis.

⁶⁴ Davis.

⁶⁵ Davis.

⁶⁶ McCord, Technology Acceptance Model, 306.

⁶⁷ Jeroen Schepers and Martin Wetzels, "A Meta-Analysis of the Technology Acceptance Model: Investigating Subjective Norm and Moderation Effects," *Information & Management* 44, no. 1 (2007): 90, <https://doi.org/10.1016/j.im.2006.10.007>.

⁶⁸ Viswanath Venkatesh and Hillol Bala, "Technology Acceptance Model 3 and a Research Agenda on Interventions," *Decision Sciences* 39, no. 2: 275, accessed June 16, 2018, <https://doi.org/10.1111/j.1540-5915.2008.00192.x>.

⁶⁹ Venkatesh and Bala, 275.

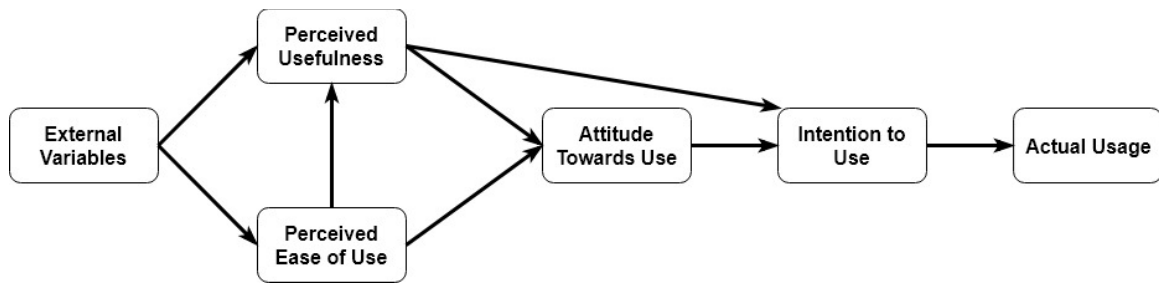


Figure 5. Davis's Technology Acceptance Model⁷⁰

Additional research is needed to distinguish the effect of social influence in fraternal organizations. The fire service carries a tradition of a fraternal culture that can be traced to its inception and the social influence within fraternal organizations may be a critical variable due to the highly social network of relationships.

2. TAM 2 and TAM 3

Venkatesh and Davis later added to the core of TAM to create technology acceptance model 2 (TAM 2) by removing attitude and defining the external variables and their relationships to other variables. TAM 2 proposed that subjective norm, image, job relevance, output quality, and results demonstrability were direct antecedents of usefulness.⁷¹ They further posited that subjective norm had a direct influence on intention with experience and voluntariness as modifiers.⁷²

Venkatesh subsequently defined the antecedents of ease of use as a process of anchoring and adjustment.⁷³ Anchoring and adjustment is a heuristic used by individuals to make estimates about uncertain outcomes based on limited experience and

⁷⁰ Davis, *A Technology Acceptance Model*.

⁷¹ Viswanath Venkatesh and Fred D. Davis, "A Theoretical Extension of the Technology Acceptance Model: Four Longitudinal Field Studies," *Management Science* 46, no. 2 (February 1, 2000): 186–204, <https://doi.org/10.1287/mnsc.46.2.186.11926>.

⁷² Venkatesh and Davis.

⁷³ Viswanath Venkatesh, "Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model," *Information Systems Research* 11, no. 4 (December 2000): 342.

information.⁷⁴ Tversky and Kahneman described the heuristic anchoring and adjustment as time efficient but predictably errant.⁷⁵ Venkatesh proposed that individuals shape their system-specific perceptions (anchors) about ease of use based on control, motivation, and emotion.⁷⁶ The individuals then adjust their perceptions based on experiences with the specific system.⁷⁷

3. Unified Theory of Acceptance and Use of Technology

Venkatesh et al. developed the unified theory of acceptance and use of technology as a hybrid model to include research across the fields of sociology, psychology, and IS. The authors drew on eight established models:

- the theory of reasoned action
- the TAM
- the motivational model
- the theory of planned behavior
- a model combining the technology acceptance model and the theory of planned behavior
- the model of PC [personal computer] utilization
- the innovation diffusion theory
- the social cognitive theory⁷⁸

⁷⁴ Amos Tversky and Daniel Kahneman, “Judgment under Uncertainty: Heuristics and Biases,” *Science* 185, no. 4157 (September 27, 1974): 1124–31, <https://doi.org/10.1126/science.185.4157.1124>.

⁷⁵ Tversky and Kahneman.

⁷⁶ Venkatesh, “Determinants of Perceived Ease of Use.”

⁷⁷ Venkatesh.

⁷⁸ Viswanath Venkatesh et al., “User Acceptance of Information Technology: Toward a Unified View,” *MIS Quarterly* 27, no. 3 (2003): 425–78, <https://doi.org/10.2307/30036540>.

They noted that the field of technology acceptance had become an increasingly important area of interest for nearly all businesses and work environments.⁷⁹ Furthermore, these business leaders had to choose between behavioral, sociological, and technology acceptance models to make decisions. The developers of unified UTAUT designed the model to be an all-inclusive, one-stop shop for business leaders to be able to predict acceptance of technology by employees and customers.

After review of the eight models, the authors recognized five limitations of prior models. First, the previously studied technologies were too simple. Second, the subjects of previous studies were primarily students, as opposed to employees in a work environment. Third, many of the tests had been conducted after acceptance or rejection instead of during the decision-making process. Fourth, the existing work had focused on cross-sectional studies instead of longitudinal studies. Fifth, the body of work primarily centered on voluntary environments. In response to these limitations, the developers conducted their longitudinal studies across multiple types of organizations during the acceptance process in both voluntary and mandatory settings.⁸⁰

UTAUT, shown in Figure 6, maintains the well-established foundation of technology acceptance models, which is that behavioral intention is the direct antecedent of use. The authors of UTAUT added depth to the acceptance model as well as observing non-students in mandatory use settings. However, the model continues to be generalized for use by a broad range of business leaders.

⁷⁹ Venkatesh et al.

⁸⁰ Venkatesh et al.

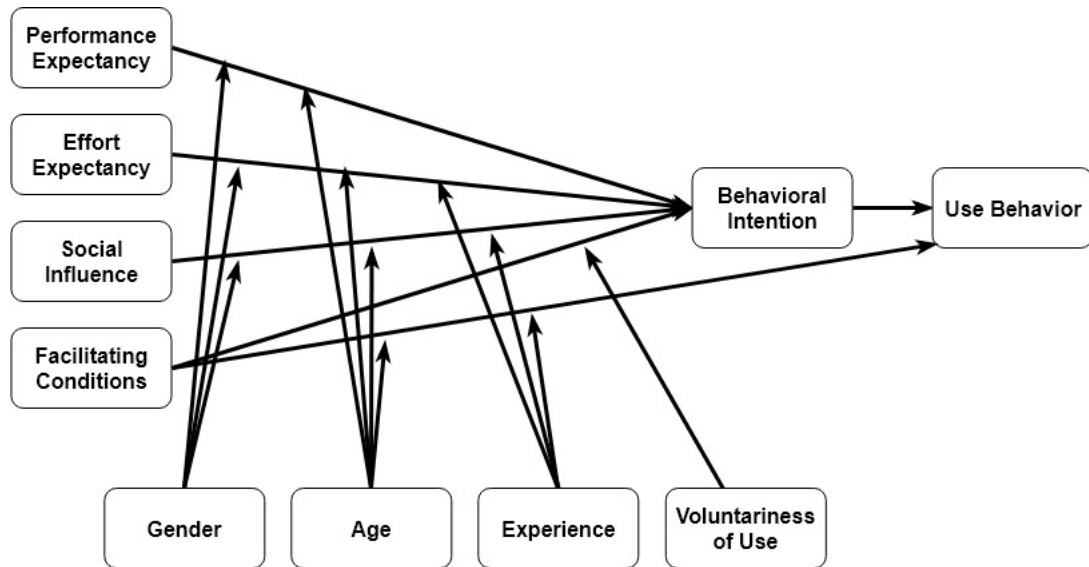


Figure 6. Venkatesh's Unified Theory of Acceptance and Use of Technology⁸¹

4. Literature Summary

In summary, the various established models cover a broad range of social, psychological, and behavioral variables. These known variables include but are not limited to innovativeness, attitude, self-efficacy, peer influence, social norms, personality traits, and environmental conditions. Unfortunately, these models are not one size fits all and may not adequately represent the unique environment of the fire service, which is why further research is warranted to more appropriately apply the existing research.

⁸¹ Venkatesh et al.

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III. SYNTHESIS OF EXISTING WORK

In Chapter II, we presented a literature review on technology acceptance research, organized into three disciplines: sociology, cognitive psychology, and IS. The literature review included summarizations of seminal models from each discipline. This chapter explores the relationships of that research across those disciplines. The streams of research, which are related to the problem of technology acceptance, have formed a woven cord of converging, diverging, and parallel trajectories. Classifying these pathways strictly by their disciplines provides a useful typology for understanding the evolution of thinking on the problem of technology adoption and acceptance within each thread of literature. However, evidenced in the range of theories represented in the literature is the problem of technology acceptance is transdisciplinary. Another approach, for this author's purpose, is to find the common empirically supported relationships that exist between variables across the identified threads of literature in this study.

A. COMMON THEMES IN RESEARCH THREADS

A transdisciplinary review of technology acceptance literature reveals a multitude of variables that can be classified into three groups. The first group of variables relates to an individual's beliefs and perceptions about their own capabilities. The second group of variables relates to both perceived and actual influence of the social group on the individual. The final group of variables encompasses the individual's perceptions about the environment and how it affects their ability to perform a given task.

One commonly recognized variable related to capability perceptions is self-efficacy. Bandura recognized that an individual's beliefs about their own capabilities affected their behavior,⁸² and defined perceived self-efficacy as, "people's beliefs about their capabilities to produce designated levels of performance that exercise influence over events that affect their lives."⁸³ Perceived self-efficacy should not be conflated with the

⁸² Albert Bandura, "Self Efficacy," *Encyclopedia of Human Behavior* 4 (1994): 71.

⁸³ Bandura.

closely related variable perceived behavioral control (PBC), which refers to an individual's beliefs about the ability to perform a task as mediated by variables beyond the individual's control.⁸⁴ Venkatesh and Bala proposed self-efficacy as one of the anchoring variables of PEU in their development of TAM 3.⁸⁵

The actual and perceived influence of the social group on an individual is another common theme among technology acceptance researchers. Bandura proposed social norms and influence as variables of learning in social learning theory.⁸⁶ Social influence, as described by Bandura, occurs through either observation or instruction.⁸⁷ Fishbein considered this influence in the development of TRA as well. Fishbein referred the influence of the peer group as subjective norm.⁸⁸ Subjective norm remained a variable through the development of theory of planned behavior and TAM 3. Venkatesh merged subjective norm, social factors, and image into social influence in the development of UTAUT.⁸⁹ For the purposes of UTAUT, Venkatesh defined social influence as “the degree to which an individual perceives that important others believe he or she should use the new system.”⁹⁰

The final common theme is a group of variables that relate to the individual's perceptions about their environment and its effect on their ability to complete a task. In his SCT, Bandura considered community access to be one of the environmental determinants of behavior.⁹¹ In the development of TAM 3, Venkatesh proposed the variable perceptions

⁸⁴ Ajzen, “Perceived Behavioral Control.”

⁸⁵ Venkatesh and Bala, “Technology Acceptance Model 3.”

⁸⁶ Bandura, Social Learning Theory.

⁸⁷ Bandura.

⁸⁸ Martin Fishbein, “A Behavior Theory Approach to the Relations between Beliefs about an Object and the Attitude Toward the Object,” in *Mathematical Models in Marketing: A Collection of Abstracts*, ed. Ursula H. Funke, *Lecture Notes in Economics and Mathematical Systems* (Berlin, Heidelberg: Springer Berlin Heidelberg, 1976), 87–88, https://doi.org/10.1007/978-3-642-51565-1_25.

⁸⁹ Venkatesh et al., “User Acceptance of Information Technology.”

⁹⁰ Venkatesh et al.

⁹¹ Bandura, “Social Cognitive Theory of Mass Communication.”

of external control (facilitating conditions).⁹² Generally, facilitating conditions refer to those variables that are outside of the control of the individual and the social group.

B. FOUNDATIONAL ACCEPTANCE MODEL

Davis's TAM proposed that the variables PEU and PU heavily influenced behavioral intention.⁹³ Venkatesh's empirical work supports Davis's model, including PEU and PU, as antecedents of behavioral intention and behavioral intention as the antecedent of use.⁹⁴ This model accounts for 40% of the variance between intention and use.⁹⁵ A large body of empirical work has identified a strong relationship between behavioral intention and use.⁹⁶ Venkatesh and Davis's empirical work in a longitudinal study of mandatory and voluntary environments using different systems in varied contexts found strong support for the relationship between behavioral intention and use.⁹⁷ Ajzen, in his 2002 paper "Perceived Behavioral Control, Self-Efficacy, Locus of Control, and the Theory of Planned Behavior, assumed that behavioral intention was the direct antecedent of use when he stated "given a sufficient degree of actual control over the behavior, people are expected to carry out their intentions when the opportunity arises."⁹⁸ Due to the large body of support upholding Davis's original TAM, the model continues to serve as the foundational model for technology acceptance.

⁹² Venkatesh, "Determinants of Perceived Ease of Use."

⁹³ Fred D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *MIS Quarterly* 13, no. 3 (1989): 319–40, <https://doi.org/10.2307/249008>.

⁹⁴ Venkatesh and Bala, "Technology Acceptance Model 3."

⁹⁵ Venkatesh and Bala, 3.

⁹⁶ Venkatesh and Davis, "A Theoretical Extension of the Technology Acceptance Model"; Venkatesh et al., "User Acceptance of Information Technology"; Ajzen, "Perceived Behavioral Control"; M. Fishbein, "A Theory of Reasoned Action: Some Applications and Implications," *Nebraska Symposium on Motivation* 27 (1979): 65–116.

⁹⁷ Venkatesh and Davis, "A Theoretical Extension of the Technology Acceptance Model."

⁹⁸ Ajzen, "Perceived Behavioral Control."

C. APPLICATION OF TECHNOLOGY ACCEPTANCE RESEARCH

Many fields have applied technology acceptance research to their unique environments.⁹⁹ These environments include, but are not limited to, educational institutions (students and faculty), business offices, medical facilities, and the military.¹⁰⁰ These studies show that each environment has a specialized context that affects the weight of the acceptance variables.¹⁰¹ The fire service shares specific aspects with several of the previously studied environments and a closer look at the connection between contextual aspects of unique environments and the specific acceptance variables provide the necessary background to form a model specific to the fire service.

Levy and Green's 2009 study of U.S. Navy personnel examined the applicability of TAM and computer self-efficacy (CSE) to combat information systems.¹⁰² The study found that the models were valid and that the context of combat affected the weight of the antecedent variables.¹⁰³ In combat, PU and CSE continued to be applicable, while PEU had significantly lower importance.¹⁰⁴ Users reported high comfort levels with the technology when meaningful training was provided and low comfort levels when they were only provide with user manuals.¹⁰⁵ This study provides evidence that users are willing to

⁹⁹ Venkatesh et al., "User Acceptance of Information Technology."

¹⁰⁰ Schepers and Wetzels, "A Meta-Analysis of the Technology Acceptance Model"; William R. King and Jun He, "A Meta-Analysis of the Technology Acceptance Model," *Information & Management* 43, no. 6 (September 1, 2006): 740–55, <https://doi.org/10.1016/j.im.2006.05.003>; Yair Levy and Bruce D. Green, "An Empirical Study of Computer Self-Efficacy and the Technology Acceptance Model in the Military: A Case of a U.S. Navy Combat Information System," *Journal of Organizational and End User Computing (JOEUC)* 21, no. 3 (2009): 1–23, <https://doi.org/10.4018/joeuc.2009070101>; Patrick Y. K. Chau and Paul Jen-Hwa Hu, "Information Technology Acceptance by Individual Professionals: A Model Comparison Approach," *Decision Sciences* 32, no. 4 (December 1, 2001): 699–719, <https://doi.org/10.1111/j.1540-5915.2001.tb00978.x>.

¹⁰¹ Yair Levy and Bruce D. Green, "An Empirical Study of Computer Self-Efficacy and the Technology Acceptance Model in the Military: A Case of a U.S. Navy Combat Information System," *Journal of Organizational and End User Computing (JOEUC)* 21, no. 3 (2009): 1, <https://doi.org/10.4018/joeuc.2009070101>.

¹⁰² Levy and Green, 18.

¹⁰³ Levy and Green, 18.

¹⁰⁴ Levy and Green, 18.

¹⁰⁵ Levy and Green, 18.

compromise ease of use in high stress environments as long as they receive adequate training and the technology is perceived to be useful.

Stinchcomb and Ordaz's 2007 case study on a merger of a law enforcement agency with a fire department indicated that organizational culture plays a significant role in influencing members' behavior.¹⁰⁶ Organizational culture may be an even stronger factor in governmental organizations because they have less ability to guide behavior with merit-based rewards and accountability measures.¹⁰⁷ Baigent notes that there can be competing cultures within the same organization.¹⁰⁸ For example, firefighters generally want to be considered "good firefighters," but different cultural constructs within the organization may define that term differently.¹⁰⁹ While some firefighters place value on having soiled, melted helmets as a sign of experience, other groups see this as unnecessary risk-taking and exposure to carcinogens. Culture is one example of the social pressures that make up the variable called subjective norm.¹¹⁰

Many organizations have used technology acceptance research over the last two decades to assist with the advent of electronic healthcare records (EHR) in hospital settings as well as pre-hospital emergency medical service (EMS) settings.¹¹¹ One study used TAM and TPB to examine physicians' attitudes toward EHR.¹¹² The study found that TPB was a better fit for predicting physician use of EHR, with emphasis on attitude and perceived control as influential variables.¹¹³ Although firefighters generally work in teams

¹⁰⁶ Jeanne B. Stinchcomb and Francisco Ordaz, "The Integration of Two 'Brotherhoods' into One Organizational Culture: A Psycho-Social Perspective on Merging Police and Fire Services," *Public Organization Review; Dordrecht* 7, no. 2 (June 2007): 143, <http://dx.doi.org/10.1007/s11115-006-0026-8>.

¹⁰⁷ Stinchcomb and Ordaz, 147.

¹⁰⁸ D Baigent, "Work in Progress on Culture," accessed August 19, 2018, <http://web.anglia.ac.uk/publicservice/studentsnotes/culture.doc>.

¹⁰⁹ Baigent.

¹¹⁰ Ajzen, "The Theory of Planned Behavior."

¹¹¹ Fan-Yun Pai and Kai-I Huang, "Applying the Technology Acceptance Model to the Introduction of Healthcare Information Systems," *Technological Forecasting & Social Change* 78, no. 4 (2011): 650–60, <https://doi.org/10.1016/j.techfore.2010.11.007>.

¹¹² Elaine Seeman and Shanan Gibson, "Predicting Acceptance of Electronic Medical Records: Is the Technology Acceptance Model Enough?," *S.A.M. Advanced Management Journal* 74, no. 4 (2009): 21–26.

¹¹³ Seeman and Gibson.

in a paramilitary hierarchy, firefighter/paramedics who provide emergency medical treatment are similar to physicians in that they both act independently and autonomously. Furthermore, nearly all firefighter/paramedics presently use some form of EHR. Incident commanders of large-scale incidents also operate with autonomy. In all, this study does offer a useful comparison for the fire service.

Multiple studies have shown that TAM is a good fit for predicting enterprise resource planning (ERP) software.¹¹⁴ One such study showed a very strong relationship between computer self-efficacy, design features, PEU, and PU.¹¹⁵ ERP software serves diverse work groups with different missions in variable environments. It is often sprawling and multifaceted to allow it to serve different divisions of a company while integrating data from multiple sources. For these reasons, work from the field of ERP is valuable to validate TAM as an overarching model. However, the research is too generalized to provide a precise comparison to the fire service.

D. SYNTHESIS OF KEY CONCEPTS AND VARIABLES

Within the disciplines of sociology, cognitive psychology, and IS, researchers have pointed to dozens of technology acceptance variables over the years. This synthesis represents well-supported key concepts and variables across the three referent disciplines. Each variable represents a unique element that influences technology acceptance behavior; however, some variables can be operationalized in a manner that may generate some level of covariance.

1. Behavioral Intention

The aim of technology acceptance research is to explain the acceptance of a technology within a population. Some studies have focused on broad, generalizable models while others have focused on specific technologies in specific populations. The foundational indicator of acceptance is the use of the technology. A large body of work

¹¹⁴ Mouakket, "Extending the Technology Acceptance Model."

¹¹⁵ Mouakket.

supports behavioral intention as the precursor of use.¹¹⁶ Behavioral intention is an individual's perceived likelihood to engage in a given behavior and is synonymous with "actual use." Therefore, behavioral intention is a reliable predictor of actual use.

Studies have considered dozens of independent variables that influence behavioral intention. Two of the most commonly supported predictors of behavioral intention are PEU and PU. PU and PEU have been validated in multiple settings and for the purposes of this thesis, will be considered to be generalizable.¹¹⁷ While a generalizable model is a useful starting place, specific fields must establish reliable predictive antecedents for the user groups, environments, and technologies they wish to study.¹¹⁸ While the fire service is a unique environment, the core predictor of behavior remains to be behavioral intention.

2. Perceived Ease of Use

In his paper, "User Acceptance of Information Technology," Venkatesh et al. define PEU as "the extent to which a person believes that using the system will be free of effort."¹¹⁹ The easier a technology is to use at the outset, the more likely a user is to continue using it. Venkatesh proposed that anchoring and adjustment formed the basis for which individuals formed perceptions of ease of use.¹²⁰ Venkatesh offered computer self-efficacy, computer anxiety, computer playfulness, and perceptions of external control as the anchors for these perceptions.¹²¹ For the purposes of this project, self-efficacy, anxiety, and computer playfulness are referenced collectively as computer self-efficacy. While fire service personnel may place less emphasis on PEU than PU, PEU remains to be an important variable of behavioral intent.

¹¹⁶ Ajzen, "The Theory of Planned Behavior"; Davis, *A Technology Acceptance Model*.

¹¹⁷ Albert H. Segars and Varun Grover, "Re-Examining Perceived Ease of Use and Usefulness: A Confirmatory Factor Analysis," *MIS Quarterly* 17, no. 4 (1993): 517–25, <https://doi.org/10.2307/249590>.

¹¹⁸ Segars and Grover.

¹¹⁹ Venkatesh et al., "User Acceptance of Information Technology."

¹²⁰ Venkatesh and Bala, "Technology Acceptance Model 3."

¹²¹ Venkatesh and Bala.

3. Perceived Usefulness

In his 2003 paper, “User Acceptance of Information Technology,” Venkatesh et al. define PU as “the extent to which a person believes that using the system will enhance his or her job performance.”¹²² PEU has a direct influence on PU.¹²³ Fishbein and subsequently Davis posited that multiple external variables or “design features” affected PEU and PU.¹²⁴ These external variables carry different weight depending on mitigating factors like age, gender, and experience.¹²⁵ For example, if older individuals are less likely to be influenced by a social group, social influence is mitigated by age. While these factors may explain the variance in acceptance, they are beyond the control of fire service administrators. While the demographic composition of the fire service does change over time, it changes slowly. This means that a cross-section of the fire service over the course of a few years would yield a steady similar pattern of age, gender, and experience. Since these mitigating factors are static within the fire service, they need no further exploration in this project. Diversity variables such as age, gender, and experience may explain variance of acceptance, but manipulation of these variables would be counterintuitive and potentially unethical. Levy and Green found that in naval combat environments, PU had a much stronger correlation with behavioral intention than PEU.¹²⁶ This indicates that these individuals were willing to compromise PEU for PU in this specific environment. PU is well established in both empirical and theoretical work as a strong predictor of both behavioral intention and use.

4. Social Influence

Social influence has taken slightly different forms over the years in different models of acceptance. Social support, peer influence, subjective norm, and social norm are several closely related variables. Researchers took different approaches to explain the role of social

¹²² Venkatesh et al., “User Acceptance of Information Technology.”

¹²³ Davis, *A Technology Acceptance Model*, 24.

¹²⁴ Davis, 24.

¹²⁵ Venkatesh et al., “User Acceptance of Information Technology.”

¹²⁶ Levy and Green, “An Empirical Study of Computer Self-Efficacy.”

influence. Some focused on the leaders who were influencing the group, while others studied the traits of the individuals receiving the influence. However, social influence is not a one-way street.

The following theories illustrate the factors that affect technology acceptance.

Bandura posited, in “Social Cognitive Theory of Mass Communication,” that individuals not only received influence but also influenced their social networks.¹²⁷ While some influencers may carry more weight, all members are capable of influencing other members.

Rogers proposed innovations diffused through social systems.¹²⁸ He further pointed to opinion leaders as influencers of the diffusion of innovations.¹²⁹ In the “two-step flow model,” opinion leaders receive information from the media and then distribute the information to their sphere of influence.¹³⁰ Rogers noted that once opinion leaders adopted an innovation, the overall group adoption began increasing exponentially.¹³¹ Rogers also explored the idea of homophily and heterophily. Homophily is the degree to which members of a group share common traits. Heterophily, the opposite of homophily, refers to the differences between members of a group. Communication flows more rapidly in homophilic groups because the members share common traits that facilitate dialogue.¹³² Likewise, communication over time increases the homophily between members. Rogers proposed that homophily actually slowed the diffusion of innovation through a population because it created silos within the population.¹³³ Heterophilic communication bonds are more important for the conduction of ideas than the more common homophilic bonds. Communication networks play an important role in the diffusion of ideas. Rogers’s work

¹²⁷ Bandura, “Social Cognitive Theory of Mass Communication.”

¹²⁸ Rogers, *Diffusion of Innovations*, 5.

¹²⁹ Rogers, 300.

¹³⁰ Rogers, 304.

¹³¹ Rogers, 300.

¹³² Rogers, 306.

¹³³ Rogers, 306.

is specifically applicable to the fire service due to the type of organization and social structure of the networks.

Ajzen described subjective norm as “the perceived social pressure to perform or not to perform the behavior.”¹³⁴ Both TRA and TPB established subjective norm as a reliable predictor of behavioral intent. Subjective norm may have a stronger relationship with behavioral intent in labor organizations.¹³⁵

Kelman described social influence as a set of three processes that affect attitude: “compliance, identification, and internalization.”¹³⁶ Compliance is the acceptance of influence in return for a favorable reaction from an individual or group, identification is the acceptance of influence to maintain a relationship with an individual or group, and internalization is acceptance of influence because it aligns with the individual’s internal values.¹³⁷

Firefighters develop heuristics to aid in rapid decision-making.¹³⁸ One example is the decision whether to use emergency lights and sirens on calls with limited information from the dispatcher.¹³⁹ Based on personal experience and peer influence, a firefighter responding to a fire alarm sounding may choose not to expose the crew and community to the risk of responding emergency status. If the firefighter arrives on the scene to find a locked structure with a fire alarm sounding and no smoke showing, they must make another decision. Should they damage the property by breaching the door to investigate whether there is a fire or wait for a key holder? In his discussion of bounded rationality, Gigerenzer describes this process as *satisficing*. Satisficing is quickly considering options by running

¹³⁴ Ajzen, “The Theory of Planned Behavior.”

¹³⁵ Arthur Brief and Dale Rude, “Voting in Union Certification Elections: A Conceptual Analysis,” *The Academy of Management Review* 6, no. 2 (1981): 261, <https://doi.org/10.5465/AMR.1981.4287826>.

¹³⁶ Herbert C. Kelman, “Compliance, Identification, and Internalization: Three Processes of Attitude Change,” *The Journal of Conflict Resolution* 2, no. 1 (1958): 51–60.

¹³⁷ Kelman.

¹³⁸ Gerd Gigerenzer, *Simple Heuristics That Make Us Smart, Evolution and Cognition* (New York: Oxford University Press, 1999) 14–15.

¹³⁹ Gigerenzer.

them through a brief thought experiment and then choosing the first one that meets the threshold of expected success.

These dilemmas are subjective and relatable to a firefighter's decision to accept a new technology. The firefighter responding to the fire alarm has developed their heuristics from experiences with previous fire alarms and from mentors and peers. Likewise, the firefighter's initial reaction to a new technology is influenced by previous experiences and peer influence. They must make a decision while facing an uncertain outcome. If experiences with fire department technology have been negative, they will be more likely to resist acceptance. Due to the highly social aspect of the fire service, sociological influence may influence heuristics within the cognitive psychology domain.

There are multiple factors that make the fire service a unique work environment and many of these factors are sociological in nature. The fire service culture is fraternal and intimately social. The organizational structure is a paramilitary hierarchy with closely knit companies that communicate and work with adjacent companies. The social and structural networks often create different narratives and counter narratives. Formal leaders, informal leaders, or both can influence individuals. Company officers are the formal leaders, while the informal leaders are senior firefighters who have earned the respect of their peers without becoming an officer.

Within the modern fire service there exists a clash of cultures as fire departments trend toward incorporating EMS units. The paramilitary model of the fire service with rigid hierarchal structures of rank discourages questioning authority. In contrast, contemporary EMS departments employ a flatter span of control and encourage innovation and freethinking. This dichotomy is important to note when assessing the social influences of technology acceptance as it polarizes the fire service population.

The technology acceptance variable of social influence encompasses previously studied variables like subjective norm and culture. Due to the social nature of the fire service, social influence may have a stronger relationship with behavioral intention than in other populations. Many paid fire departments in the United States work under labor contracts and labor/management relationships are inherently adversarial and sometimes

even contentious. In states that require annual bargaining for policy, benefits, pay, and working conditions, the relationship between management and labor representatives can turn into a culture of mistrust.¹⁴⁰ The culture of mistrust is exemplified by an “us versus them” attitude, which improves sub-group cohesion but hinders the overall cooperation within the department. The culture of mistrust has a negative impact on technology acceptance when management introduces an innovation to the members of the labor organization. As a result, members, who perceive that management does not have their best interest in mind, are skeptical of changes management introduces.

A significant amount of technology acceptance research has focused on settings that allow the user a choice to use the product. In contrast with the open market, the fire service is a mandatory setting. Mandatory settings are those in which users are required to use a product as a condition of their employment. Research has shown that failure to accept technology in mandatory settings can result in underutilization, resentment, and even sabotage.¹⁴¹ Research in open markets did not support attitude as a predictor of use; however, work done in mandatory fields did indicate that attitude played a role in use.¹⁴²

5. Perceived Behavioral Control

PBC is an individual’s perception of the difficulty of performing a behavior.¹⁴³ PBC also describes the individual’s perceptions of their control over the behavior.¹⁴⁴ PBC is further deconstructed into self-efficacy, which are beliefs about one’s ability to perform a task, and facilitating condition, which are beliefs about the environment’s effect on one’s

¹⁴⁰ Philippe Aghion, *Can Policy Interact with Culture? Minimum Wage and the Quality of Labor Relations*, NBER Working Paper Series 14327 (Cambridge, MA: National Bureau of Economic Research, 2008).

¹⁴¹ Randolph B. Cooper, “The Inertial Impact of Culture on IT Implementation,” *Information & Management* 27, no. 1 (July 1, 1994): 17–31, [https://doi.org/10.1016/0378-7206\(94\)90099-X](https://doi.org/10.1016/0378-7206(94)90099-X).

¹⁴² S. Brown et al., “Do I Really Have to? User Acceptance of Mandated Technology,” *European Journal of Information Systems* 11, no. 4 (2002): 283–95, <https://doi.org/10.1057/palgrave.ejis.3000438>.

¹⁴³ Ajzen, “Perceived Behavioral Control.”

¹⁴⁴ Shirley Taylor and Peter A. Todd, “Understanding Information Technology Usage: A Test of Competing Models,” *Information Systems Research* 6, no. 2 (June 1, 1995): 144–76, <https://doi.org/10.1287/isre.6.2.144>.

ability to perform a task.¹⁴⁵ Facilitating conditions are resources needed to perform the behavior, including time, money, and technological capability.¹⁴⁶ For the purposes of IS technology, facilitating conditions are further subdivided into resources outside the technology and the internal features within the technology.¹⁴⁷ The outside resources for work environments include training as well as logistical and technical support. The internal features of the technology are the features and adaptability of the technology itself.

6. Self-Efficacy

Self-efficacy is one's level of confidence in being able to perform a given task. Bandura described efficacy and its antecedents in *Social Learning Theory*. Efficacy expectations reduce anxiety about performing a task, but more importantly, they influence how much effort an individual is willing to exert to complete the task. Higher efficacy results in a higher level of effort toward performing a task. Bandura noted that "performance accomplishments are the strongest predictor of efficacy expectations."¹⁴⁸ Repeated success in similar tasks improves efficacy while failures will diminish efficacy. Vicarious experience is another predictor of efficacy expectations.¹⁴⁹ Individuals observing perceived risky behavior without consequence will be more likely to engage in the behavior. Verbal persuasion is a commonly used but weaker antecedent of efficacy expectations.¹⁵⁰ In the fire service, it is common for members to try to talk other members into feeling more confident about a task. But as previously mentioned, verbal persuasion was the weakest variable of efficacy expectations.¹⁵¹ The final antecedent of efficacy expectations that Bandura proposed is emotional arousal. Physiological manifestations of fear have a strong negative relationship with self-efficacy. Levy and Green made a strong

¹⁴⁵ Taylor and Todd.

¹⁴⁶ Taylor and Todd.

¹⁴⁷ Taylor and Todd.

¹⁴⁸ Bandura, *Social Learning Theory*, 80.

¹⁴⁹ Bandura, *Social Learning Theory*.

¹⁵⁰ Bandura.

¹⁵¹ Bandura, "Social Cognitive Theory of Mass Communication."

case for the influence that self-efficacy has on PU and PEU.¹⁵² Research has established computer self-efficacy as a reliable predictor of behavioral intent as related to information systems use.¹⁵³

7. Attitude

Attitude is the user's feelings or desire toward using a technology. Attitude is a product of personal experiences and social influences.¹⁵⁴ Several models have used attitude and behavioral intention as the direct antecedent to system use. Some have used one or the other, while others have proposed that attitude is the precursor to behavioral intention. Davis established attitude as a function of PEU and PU with the product being system use in the original TAM.¹⁵⁵ Venkatesh replaced attitude with behavioral intention in TAM 3.¹⁵⁶ More recent work places attitude in sequence as a predictor of behavioral intention.¹⁵⁷

8. Extrinsic Motivation

Davis defined *extrinsic motivation* as "the perception that users will want to perform an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself, such as improved job performance, pay, or promotions."¹⁵⁸ An example of this variable would be an organization using a specific software in a promotional process. The promoters would be motivated to learn to use and

¹⁵² Levy and Green, "An Empirical Study of Computer Self-Efficacy."

¹⁵³ Jen-Her Wu, Shu-Ching Wang, and Li-Min Lin, "What Drives Mobile Health Care? An Empirical Evaluation of Technology Acceptance," *Proceedings of the 38th Annual Hawaii International Conference On System Sciences*, 2005, 150a-150a, <https://doi.org/10.1109/HICSS.2005.689>.

¹⁵⁴ Biljon and Renaud, "A Qualitative Study," 212.

¹⁵⁵ Davis, *A Technology Acceptance Model*.

¹⁵⁶ Venkatesh and Bala, "Technology Acceptance Model 3."

¹⁵⁷ Chau and Hu, "Information Technology Acceptance by Individual Professionals"; James M. Curran and Matthew L. Meuter, "Self-service Technology Adoption: Comparing Three Technologies," *Journal of Services Marketing* 19, no. 2 (March 1, 2005): 103–13, <https://doi.org/10.1108/08876040510591411>.

¹⁵⁸ Fred D. Davis, Richard P. Bagozzi, and Paul R. Warshaw, "Extrinsic and Intrinsic Motivation to Use Computers in the Workplace1," *Journal of Applied Social Psychology* 22, no. 14 (July 1992): 1111–32, <https://doi.org/10.1111/j.1559-1816.1992.tb00945.x>.

become proficient with the software. In order for extrinsic motivation to be a reliable variable, the user must realize the connection between use of the technology and a return of some benefit beyond the use of the technology. It is possible for managers to manufacture extrinsic motivation by creating opportunities tied to the acceptance and use of a target technology. Extrinsic motivation may be a more important variable in non-mandatory settings since acceptance carries a greater likelihood of favor, advantage, and promotion in those environments. Brown posits that in mandatory settings, the only choice is how wholeheartedly the user accepts the technology.¹⁵⁹ In mandatory settings like the fire service, acceptance assessments may rely more on intrinsic motivation.

The previously discussed variables from the fields of sociology, cognitive psychology, and IS, are not all-inclusive. However, they represent a summarization and synthesis of the variables that are valuable to the understanding of technology acceptance within the fire service. After an examination and synthesis of existing literature, the next step is to develop a TAM for the fire service.

¹⁵⁹ Brown et al., “Do I Really Have to?

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IV. DEVELOPING A TECHNOLOGY ACCEPTANCE MODEL FOR THE FIRE SERVICE

The goal of this thesis is to develop a model that applies existing technology acceptance research to the fire service by understanding which variables are relevant to the firefighter population and its operating environment. One important difference between the fire service population and the general population is the time-sensitive nature of emergency service. In emergency environments, individuals use the representativeness heuristics, availability, and anchoring and adjustment to make decisions.¹⁶⁰ Firefighters work in a high-stress environment and must make lifesaving decisions under austere conditions. Firefighters making decisions in time sensitive-situations do not consider multiple options but instead rely heavily on prior experience.¹⁶¹ Klein, in his recognition-primed decision model, posits that fire commanders run brief mental simulations to find a solution to a problem and select the first one that has a positive outcome in the simulation.¹⁶² A firefighter's assessment of any technology hinges on their expectations of how the innovation will perform in a time-sensitive situation. Firefighters tend to accept technology that has been established a priori as reliable and easy to use under times of crisis. The majority of technology acceptance research has focused on technology acceptance in a non-emergency environment.

Firefighters also consider whether they will be able to remember how to use the technology when under high stress. Firefighters may go weeks between using some types of technology in an emergency so they may have a strong affinity for intuitive systems that are easy to use and familiar.

¹⁶⁰ Jesse M. Pines, "Profiles in Patient Safety: Confirmation Bias in Emergency Medicine," *Academic Emergency Medicine* 13, no. 1 (2006): 90–94, <https://doi.org/10.1197/j.aem.2005.07.028>.

¹⁶¹ Gary Klein, "Naturalistic Decision-making," *Human Factors* 50, no. 3 (June 1, 2008): 456–60, <https://doi.org/10.1518/001872008X288385>.

¹⁶² Klein.

A. THEORETICAL BASIS

Existing, generalized models provide a foundation upon which to build a TAM for the fire service. The seminal models have been applied to several work environments. Similarities and differences between the fire service environment and other disciplines are considered.

There is a significant volume of empirical work on the problem of technology acceptance from the domain of IS that supports the efficacy of the relationships between PEU, PU, and behavioral intention. Likewise, the same body of research from IS strongly supports the relationship between behavioral intention and actual use. The variables that influence PEU and PU usefulness are more dynamic depending on the environment. Since the purpose of this research is to develop a specific model for the fire service, relatively static variables like age, gender, and ethnicity are not be represented in this model. These variables remain relatively stable and are outside of the influence of technology developers and administrators. Based on the aforementioned, the current model development builds upon and extends the foundational behavioral intention models, such as the TRA and related TAM in developing a model to explain technology acceptance in the fire services.

Working from these foundational models, the next step is to identify the antecedents of the core variables that are relevant to the fire service environment. Researchers have proposed a large number of variables in different disciplines as antecedents of technology acceptance. A common theme in the majority of proposed variables is that they are perceptions or beliefs held by the individual. These perceptions can be divided into two general categories: beliefs about one's own ability and beliefs about outside factors. The underlying beliefs specific to firefighters and their environment guide the selection of antecedents for the proposed model.

In comparing the fire service to other work environments, there are several similarities. Most work environments use some type of information systems technology. As the research on PEU and PU implies, individuals want the technology to be helpful and easy to use. PEU has some variances in different fields, specifically in professional and

highly technical environments. For example, users in highly technical fields are willing to compromise ease of use for function.¹⁶³

When considering differences between the fire environment and other work environments, the most obvious is that firefighters work in the emergency environment. The emergency environment requires members to have a high degree of confidence in themselves, their equipment, and their coworkers. Another important difference is that firefighters operate as a team and live together in highly social networks. While some other work environments may involve teamwork, few involve living together for twenty-four hours or more at a time. Firefighters not only work and train as a team, but they eat, exercise, and share leisure time together. This additional socialization adds an important layer to the social aspect of the environment.

B. PROPOSED MODEL

There is a compelling volume of research to support TAM as a foundational model. TAM 2, TAM 3, and UTAUT provided additional variables and antecedents that improve accuracy. The proposed model accepts the foundational model but challenges that some of the antecedents in the successor models are more or less applicable to the fire service. The proposed model was developed by reviewing the literature on both generalized models of technology acceptance and the application of those models in other work environments. The core of Davis's TAM was appropriated into the proposed model, while the antecedents were drawn from the literature.

Two of the most salient cultural constructs in the fire service are self-confidence and fraternity. In this case, fraternity is gender neutral, meaning kinship or mutual support within a group. In order to work effectively in austere environments, firefighters must feel confident in their abilities. Likewise, they must have confidence that their peers will perform in critical situations. The reliance on one another and an intimate working environment fosters strong bonds among firefighters. Self-confidence and fraternity run parallel with the hypothetical grouping of antecedents of technology acceptance into

¹⁶³ Chau and Hu, "Information Technology Acceptance by Individual Professionals."

internal and external beliefs. Self-confidence represents internal beliefs, while fraternity represents external beliefs.

Researchers of different aspects of the fire service have recognized self-confidence and fraternity as prevalent constructs within the culture. A study of transformational leadership within the fire service recognized self-efficacy and group cohesion as core concepts.¹⁶⁴ Another study about the factors that influence incident command success on the fire scene recognized self-confidence and mutual trust as two of the five major contributors.¹⁶⁵ Work in the field of psychology showed that firefighters with low self-efficacy and social support were more likely to experience traumatic stress and depression.¹⁶⁶ The collective work of multiple disciplines reveals the two common themes of self-efficacy/self-confidence and some type of social influence.

Two important technology acceptance variables that relate to self-confidence are perceived behavioral control and self-efficacy. Self-efficacy captures the individual's assessment of their own ability, while perceived behavioral control encompasses the individual's perceptions about their control over the behavior. Self-efficacy asks the question, "Do I have the skills, knowledge, and ability to complete the task?" Perceived behavioral control asks, "How much control do I have over the task?"

One important variable that applies to external beliefs of technology acceptance in the fire service is social influence. Social influence refers to any variable that derives from what the individual believes others in the peer group think and/or how that will affect the individual's standing in the group. The variable social influence encompasses the previously defined variables' subjective norm, normative beliefs, social factors, and image. These variable definitions vary, but they all refer to the influence from peers in the group.

¹⁶⁴ Rajnandini Pillai and Ethlyn A. Williams, "Transformational Leadership, Self-efficacy, Group Cohesiveness, Commitment, and Performance," *Journal of Organizational Change Management* 17, no. 2 (April 1, 2004): 144–59, <https://doi.org/10.1108/09534810410530584>.

¹⁶⁵ David L. Fender, "Controlling Risk Taking among Firefighters," *Professional Safety; Des Plaines* 48, no. 7 (July 2003): 14.

¹⁶⁶ Cheryl Regehr et al., "Social Support, Self-Efficacy and Trauma in New Recruits and Experienced Firefighters," *Stress and Health* 19, no. 4 (October 1, 2003): 189–93, <https://doi.org/10.1002/smi.974>.

Since the fire service values fraternal relationships and group cohesion, social influence is a significant factor in technology acceptance.

The proposed research model in Figure 7 represents the synthesis of reviewed literature regarding technology acceptance. The proposed relationships are represented with an arrow and an assigned “R” number. Each relationship was assessed in two categories: strength of relationship and contextual relevance. The strength of relationship is based on the body of empirical support in other fields. The contextual relevance is an assessment of how similar the fields studied are to the fire service.

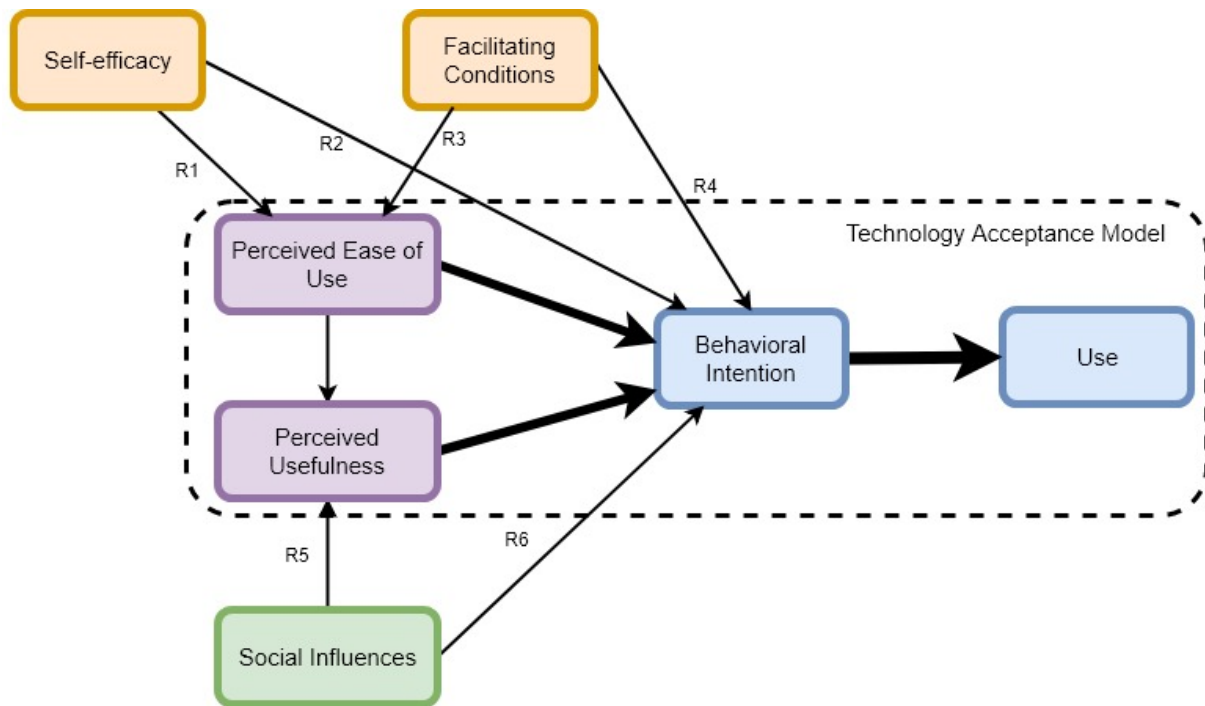


Figure 7. Proposed Research Model

(1) R1: Self-Efficacy → Perceived Ease of Use

There is significant empirical support of self-efficacy as an antecedent of technology acceptance. A study by Atif et al. in the academic field found significant relationships between self-efficacy and PEU (R1) as well as between social influences and intention (R5). In this 2011 Australian study, a population consisting of university

professors was surveyed by questionnaire about their experiences using curriculum-mapping software.¹⁶⁷ R1 was further confirmed in a study by Reinicke and Marakas of business school students' use of email and statistical software in which senior university students were queried about their perceptions with an online questionnaire.¹⁶⁸ Venkatesh's longitudinal study spanned three work environments, which included a retail electronics store help desk, a real estate market, and a financial services payroll department. In each of the three fields, R1 consistently showed a strong causal effect.¹⁶⁹ The three fields were selected to improve heterogeneity. The most compelling comparator for the fire service was a study conducted by Levy and Green in the U.S. Navy, which further supported self-efficacy as an antecedent to PEU.¹⁷⁰ The body of empirical work representing the relationship between self-efficacy and PEU is statistically significant. Similarities between Navy and fire service environments include close-proximity situations in time-sensitive and life-threatening conditions over extended shift structures. Due to these similarities, the study of Navy personnel gives R1 a high degree of contextual relevance.

(2) R2: Self-Efficacy → Behavioral Intention

A 2006 Taiwanese study by Jen-Her Wu et al. of mobile healthcare software use by physicians, nurses, and technicians measured the relationship between self-efficacy and intention (R2).¹⁷¹ The study found moderate empirical support for the relationship. This work in the medical field provides contextual relevance due to parallels between the medical field and the fire service. Physicians, nurses, and technicians in the healthcare setting work as a collaborative, hierarchal team in time-sensitive and often life-threatening scenarios. The shift structures for medical staff are often twelve hours long as opposed to

¹⁶⁷ Amara Atif et al., "Assuring Graduate Competency: A Technology Acceptance Model for Course Guide Tools," *Journal of Computing in Higher Education* 27, no. 2 (2015): 94–113, <https://doi.org/10.1007/s12528-015-9095-4>.

¹⁶⁸ B.A. Reinicke and G.M. Marakas, "Exploring the Psychological Determinants of Perceived Ease of Use and Usefulness," *System Sciences, 2005. HICSS '05. Proceedings of the 38th Annual Hawaii International Conference On*, 2005, 149b-149b, <https://doi.org/10.1109/HICSS.2005.264>.

¹⁶⁹ Venkatesh, "Determinants of Perceived Ease of Use."

¹⁷⁰ Levy and Green, "An Empirical Study of Computer Self-Efficacy."

¹⁷¹ Jen-Her Wu, Shu-Ching Wang, and Li-Min Lin, "What Drives Mobile Health Care?"

the twenty-four hours for most firefighters. The shift length still provides some comparison due to its extension beyond the eight-hour shift of many business settings. A large 2010 Saudi Arabian study by Alenezi et al. on Internet learning programs used by college students also empirically supported R2.¹⁷² While this study provides empirical support for the relationship, it does not contribute to the contextual relevance.

(3) R3: Facilitating Conditions → Perceived Ease of Use

The role of facilitating conditions in technology acceptance has also been supported in multiple fields. One challenge in using facilitating conditions as a variable is that it generalizes several other similar but unique variables. However, since the goal of this model is to help fire service administrators better understand the variables that influence technology acceptance, it is appropriate to include the variables for which they likely have the most control. Administrators ultimately have the most control over facilitating conditions like training, access to resources, and technical support. Venkatesh categorized facilitating conditions as a sub-variable of perceptions of external control.¹⁷³ In the previously mentioned longitudinal, three-field study of the electronics store, financial firm, and real estate agency, external control (including facilitating conditions) was shown to have a relationship with PEU (R3).¹⁷⁴ Venkatesh's work provided significant empirical support, but did not improve contextual relevance.

(4) R4: Social Influences → Perceived Usefulness

Social influence has been recognized as a salient antecedent of technology acceptance in several studies. The previously mentioned work by Atif et al. on curriculum mapping not only empirically supported the relationship between social influence and PU (R4), but also social influence's positive relationship with intention (R5). A 1999 study by

¹⁷² Abdulhameed Rakan Alenezi, Abdul Malek Abdul Karim, and Arsaythamby Veloo, "An Empirical Investigation into the Role of Enjoyment, Computer Anxiety, Computer Self-Efficacy and Internet Experience in Influencing the Students' Intention to Use E-Learning: A Case Study from Saudi Arabian Governmental Universities," *Turkish Online Journal of Educational Technology - TOJET* 9, no. 4 (October 2010): 22–34.

¹⁷³ Venkatesh, "Determinants of Perceived Ease of Use."

¹⁷⁴ Venkatesh.

Karahanna and Straub on email use found support for social influence's relationship with PU (R4), specifically in the form of supervisor's influence on subordinates.¹⁷⁵ The 2006 study by Shen of online learning delivery systems found that instructor and mentor influence had a significant impact on PU (R4).¹⁷⁶ Because the fire service consists of a hierarchal leadership structure with informal mentor relationships, the findings of first-line supervisor and mentor influence adds contextual relevance. Schepers and Wetzels' 2007 meta-analysis of technology acceptance offers an aggregated view of the encompassed studies.¹⁷⁷ Within the meta-analysis, the authors identified a pattern of empirical support for the relationship between subjective norm and PU.¹⁷⁸ Subjective norms represent an individual's perception of peer influence, which is one facet of social influence; therefore, empirical evidence supporting subjective norms will also support social influence as a variable. The body of work empirically supports social influence as an antecedent of PU in the general population.

There are countless different work environments with many different cultural and social constructs. The fire service, arguably, has one of the most social environments. Many firefighters work twenty-four hour shifts together with forty-eight hours off between. They live together for a third of their time, including meals, workouts, chores, training, and often, life and death experiences. These experiences and constant communications can create lasting bonds. Fire companies interact with other companies on their shift during large-scale incidents and weekly training evolutions. Companies interact with other shifts at their station during shift change. Shift change is the time for communication. Firefighters give an official "shift report" to their relief during shift change, but there the communication does not stop there. This social crossroads is an exchange of opinions, rumors, facts, and attitudes. The department rolls out training and technology implementations over three

¹⁷⁵ Elena Karahanna and Detmar W Straub, "The Psychological Origins of Perceived Usefulness and Ease-of-Use," *Information & Management* 35, no. 4 (April 5, 1999): 237–50, [https://doi.org/10.1016/S0378-7206\(98\)00096-2](https://doi.org/10.1016/S0378-7206(98)00096-2).

¹⁷⁶ Demei Shen et al., "Social Influence for Perceived Usefulness and Ease-of-Use of Course Delivery Systems," *Journal of Interactive Online Learning* 5, no. 3 (Winter 2006): 270–82.

¹⁷⁷ Schepers and Wetzels, "A Meta-Analysis of the Technology Acceptance Model."

¹⁷⁸ Schepers and Wetzels.

days to capture all three shifts. Firefighters communicate opinions and attitudes about rollouts after the first and second days, which influences the second and third shift's experience. Most general population workers work either independently or as a team in limited amounts of time. Firefighters work in a team environment nearly all of the time. This intracompany interaction coupled with the intercompany interaction creates a dense social network in the fire service.

(5) R5: Social Influences → Behavioral Intention

Schepers and Wetzels' meta-analysis also synthesized the empirical work on the relationship between subjective norm and behavioral intention. They found only moderate support; however, they suspected that the finding was lower than expected due to the samples coming from voluntary environments.¹⁷⁹ They further stated that "the mechanism is only effective in mandatory settings."¹⁸⁰ Therefore, the true effect of the relationship in mandatory settings, like the fire service, may be higher and more significant. A 2008 study by AlAwadhi and Morris of e-government software use by university students found empirical support for the relationship between peer influence and behavioral intention.¹⁸¹ The study showed that peer influence exhibited more significance in the first four weeks of implementation, which indicates that peer influence is inversely proportionate to experience.¹⁸² The previously mentioned study by Atif et al. provided empirical support for the relationship between social influence and intention to use.¹⁸³ The body of work provides a firm empirical foundation for social influence as an antecedent of behavioral intention. The vast majority of the meta-analysis consisted of studies on student and business populations. The work in education and e-government does not provide strong contextual relevance, but the meta-analysis does give support for relevance in mandatory settings.

¹⁷⁹ Schepers and Wetzels.

¹⁸⁰ Schepers and Wetzels.

¹⁸¹ S. AlAwadhi and A. Morris, "The Use of the UTAUT Model in the Adoption of E-Government Services in Kuwait," in *Proceedings of the 41st Annual Hawaii International Conference on System Sciences (HICSS 2008)*, 2008, 219, <https://doi.org/10.1109/HICSS.2008.452>.

¹⁸² AlAwadhi and Morris.

¹⁸³ Atif et al., "Assuring Graduate Competency."

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V. TESTING THE MODEL: A THOUGHT EXPERIMENT

This chapter contains a thought experiment to test the model developed in Chapter IV. The scenario is the implementation of electronic patient care reporting (ePCR) software in the fire service environment. The implementation of ePCR into the fire service is a useful scenario because it reflects a new technology experienced by nearly all fire departments in the nation. In the late 1990s, EMS leaders identified the need to transition to ePCR.¹⁸⁴ The benefits of ePCR include billing accuracy, legibility, quality assurance, and data collection.¹⁸⁵ From 2000 to 2010, emergency medical providers across the country set out to identify and implement new ePCR software as state regulatory bodies began imposing new reporting requirements that could not be achieved using a paper format.

The following scenario is a hypothetical chronology of a typical implementation of ePCR system within a fire department–based EMS agency. In applying the scenario, the model variables are analyzed for relevance. As a result of the analysis, revisions to the model are proposed.

A. SCENARIO #1: APPLYING THE MODEL RETROSPECTIVELY

The Servewell Fire Department (SFD) is a municipal, mid-sized fire-based EMS agency. In the mid-2000s, SFD administrators recognized the benefits of implementing ePCR software and made the decision to proceed with transitioning from paper patient care reports to ePCR. SFD leadership formed a committee of end users and command staff. The committee was selected solely based on their interest in volunteering to help. The department tasked the committee with identifying and selecting an ePCR product for the department.

The committee previewed several software products and settled on one that met the requirements of state and federal EMS reporting standards. The selection of the software

¹⁸⁴ Adam B. Landman et al., “Prehospital Electronic Patient Care Report Systems: Early Experiences from Emergency Medical Services Agency Leaders,” *PLOS ONE* 7, no. 3 (March 5, 2012): e32692, <https://doi.org/10.1371/journal.pone.0032692>.

¹⁸⁵ Landman et al.

was based heavily on regulatory requirements with only moderate consideration of how well the software would be received by the end users. The product, called RunTix, was purchased and loaded onto newly purchased fire department laptops. The training department provided a three-hour class to help crews become more familiar with the software. Following training evolutions, administrators planned the go-live date for the new software. Because training days were Tuesday, Wednesday, and Thursday, staff decided to implement the software on Friday while the training was fresh. Thursday evening, the laptops were distributed for a 7:00 am Friday start time. The training staff's normal shift schedule was four (4), ten (10) hour shifts beginning on Monday. This meant they were off duty on Friday and were unavailable to assist with implementation over the weekend.

Social influence came in the form of peer-to-peer conversations at shift change. Since SFD has a three shift, rotating schedule of twenty-four hours on and forty-eight hours off, the software rollouts were a three-day event. The first shift crews experienced frustration with the software. The next morning at the firehouse coffee table, they voiced their perceptions to their relief firefighters. This conversation set the tone for a second shift of similar experiences. Second shift's crews passed along their experiences and perceptions to third shift's crews after a second full day. By the fourth morning, the collective assessment of the new technology had been magnified and solidified. By Monday morning, the collective perception of the software had reached a fever pitch of nearly irreversible frustration.

Some of the firefighter paramedics had previous work experience at other EMS agencies. The paramedics who had experience with other ePCR products found RunTix easier to learn. Furthermore, this group used the technology more readily and with less difficulty than the other paramedics. Unfortunately, this experienced subgroup of users was the minority. Most of the users were frustrated with the newly implemented software. Overall, users were vocal about their experiences with the new software. The common theme of the complaints was that they felt ill-prepared to use the software in a live environment, bugs still existed in the software, and they felt abandoned during the rollout. Crews reported that there should have been weeks of beta tests, more extensive training,

and real-time, live tech support in the field. The amount of time a firefighter spent trying to work through problems with new technology was inversely proportional to their confidence in the technology.

The crews learned how to use the software and the software engineers fixed the bugs. However, the leadership suffered a critical loss of social capital in their failure to assess and mitigate factors that would influence the acceptance of the new technology.

B. ANALYSIS

(1) R1: Self-Efficacy → Perceived Ease of Use

The proposed relationship between self-efficacy and PEU was supported. Paramedics with previous experience, as a factor of self-efficacy, found the new product easier to use in spite of the new product's differences from their experiences. Inversely, those with little experience with ePCR systems experienced anxiety and frustration due to a lack of familiarity with the software while trying to use it in a time-sensitive situation. Self-efficacy may have a higher importance in emergency services than in the general work population. Paramedics and firefighters rely on experience and their confidence in their equipment in time sensitive and life-threatening environments.

(2) R2: Self-Efficacy → Behavioral Intention

Self-efficacy's relationship with behavioral intent was also supported. Firefighters with high self-efficacy intended to use the product regardless of their perceptions of ease of use. This indicates that the firefighter's confidence in the ePCR product directly related to their intention to use it, with or without the mediator PEU.

(3) R3: Facilitating Conditions → Perceived Ease of Use

Facilitating conditions were found to be an important variable affecting PEU. Specifically, training and real-time technical support gave firefighters a higher level of comfort in their ability to use the new software. This would indicate that facilitating conditions not only improved PEU but also had a direct relationship with self-efficacy. While individual self-efficacy varied with prior experience, the individuals who engaged

in training experienced higher self-efficacy. The availability of technical support in real-time minimized downtime and frustration, which improved PEU.

(4) R4: Social Influences → Perceived Usefulness

Social influences were found to have a strong relationship with PU. Firefighters readily shared their views about usefulness with other firefighters. The three-day shift structure created a compounding effect on perceptions with each day that passed. The social network was a conduit of perceptions that were communicated and solidified by personal experience.

(5) R5: Social Influences → Behavioral Intention

Social influences were also found to have a relationship with behavioral intention. Since firefighters trust their counterparts, their behavioral intention was subject to the influence by perceptions of their peers. When a firefighter from the first shift communicated a negative experience to a second-shift firefighter who had not used the software in the live environment, the second-shift firefighters internalized the negative perceptions and lowered their behavioral intention. Much like AlAwadhi and Morris found, social influence is stronger in the earlier stages of experience with a new product.¹⁸⁶

C. MODEL REVISION

Through the course of a thought experiment, all of the relationships were supported and one new relationship was identified. The experiment revealed that facilitating conditions likely influence individual self-efficacy (R6), which was not originally hypothesized. Training, hands-on experience, and responsive technical support improved self-efficacy.

¹⁸⁶ AlAwadhi and Morris, "The Use of the UTAUT Model in the Adoption of E-Government Services in Kuwait."

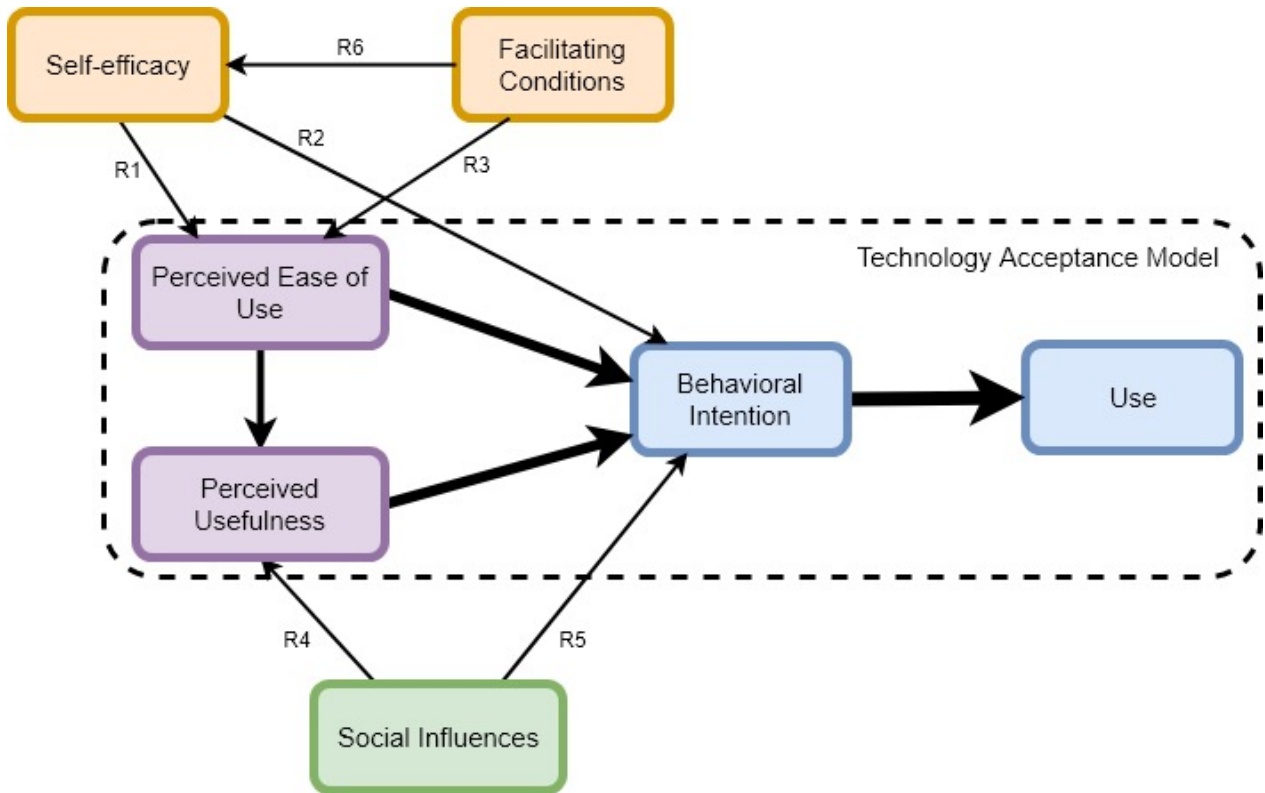


Figure 8. Revised Research Model

D. SCENARIO #2: APPLYING THE MODEL PROSPECTIVELY

In the first scenario, the model was applied retrospectively to an implementation of a new technology. For this scenario, the model is used as a roadmap for successful implementation. The scenario chronicles the implementation of a fire hose tracking and inspection software. Understanding that self-efficacy, facilitating conditions, and social influences affect the SFD implementation team in this scenario, we take proactive steps to improve the likelihood of successful acceptance.

SFD serves the community of Servewell with 10 fire apparatus. Each fire apparatus carries a minimum of 1,200 feet of large-diameter supply hose. Each apparatus also carries approximately 700 feet of 1¾-inch attack line hose and 300 feet of 2½-inch attack line hose. The total hose length carried on each apparatus totals over 2,000 feet in individual sections ranging from 25 feet to 100 feet. In accordance with National Fire Protection Association (NFPA) standards, each section of hose must be inspected and pressure tested

annually. When the hose is originally purchased, staff must mark each section with a unique identifier and record the identifier in a department hose log. This method allows department officials to track a hose through its serviceable life, including annual inspections and, eventually, retirement of the hose.

SFD administrators recognized that the current paper process of tracking and logging hoses could be improved by moving to a digital platform. The advantages of moving from paper to digital included time savings for the firefighters, more accurate tracking, and overall efficiency. The administrators set two parameters for the new digital hose log. First, the hose identifier must be able to be scanned digitally. Second, the software must have unique user access capability to identify who had made changes to the log. With these general parameters in mind, the administration began selecting the implementation team, which would also serve as the product selection committee. This would give them both buy-in and personal investment in the product.

Administrators selected the implementation team using specific criteria. The team members would eventually become the promoters when the product rolled out, so members were selected for their innovative characteristics and social network (R4 and R5). Members with a larger-reaching social network have a greater reach of influence. By giving innovators with large social networks a seat at the table early on, the chances of the product succeeding improved. Another criterion for the implementation team was technical ability or computer self-efficacy. The members with higher computer self-efficacy are more likely to influence other members' PEU by describing and demonstrating the product's features (R1). The final two key members of the team were one member from administration and one member from the materials department. The administrator was responsible for facilitating discussion while maintaining fiduciary responsibility. The materials staff member provided logistical and purchasing expertise.

The team was tasked with identifying a method and product to tag and track all of the department's hose inventory for serviceable life. The team selected a radio-frequency identification (RFID) tagging system that could be scanned with a commercially produced scanner. The selected scanner was versatile enough to connect with a tablet, phone, or laptop. The team also identified that SFD already owned inventory software called Traxis

that could be employed to track hoses. By selecting a product that could be used on existing hardware that the members were familiar with, the team improved overall computer self-efficacy (R1 and R2).

The next phase of implementation was beta testing. Administration purchased the scanner and several RFID tags. Beta testing included ensuring that the RFID tagging system would be durable enough to withstand rugged conditions. The team also tested the new procedure on multiple types of devices to verify compatibility. Extensive pre-implementation testing is necessary to work out preventable challenges and improve the initial experiences of new users. The users' first experience with the new product is critical for early perceptions of ease of use (R1, R2, and R3).

The next phase of implementation was training and familiarization. The team recognized that hands-on training served two purposes: the members improved self-efficacy by becoming familiar with Traxis while also providing an additional layer of pre-implementation testing (R1 and R2). After all members had been trained on Traxis and the RFID scanning system, the team scheduled the roll-out to coincide with annual hose testing.

The team planned the roll-out with attention to the availability of technical support and subject matter experts. The two-week go-live period included on-site representatives from Traxis as well as a member of the implementation team embedded with each crew that was testing hose. The team members oversaw the affixation of the RFID tags and reconciliation of the hose log while remaining available to answer any questions the crews had. This high-level of tech support and attentiveness reduced frustration and improved PEU (R3 and R6).

The selection, development, and implementation of the Traxis system was successful to high degree as a result of attention to the variables influencing technology acceptance. The administrators started with very simple parameters for their technological goal. From the selection of the team members to the roll-out of the new technology, administrators planned each phase while considering computer self-efficacy, facilitating conditions, and social influences. The attention to these variables provided an experience to the end user that improved overall acceptance.

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VI. CONCLUSIONS AND RECOMMENDATIONS

The research question for this thesis is, “How can technology acceptance research be applied to the fire service to better understand and influence the acceptance of information technology?” Through a literature review, proposed model, and thought experiment, the author was able to identify and test three important variables influencing technology acceptance in the fire service. The identified variables were computer self-efficacy, facilitating conditions, and social influence. The thought experiments provided support for all three variables as antecedents of acceptance.

While this theoretical model serves as a starting point, future research should focus on empirically supporting the antecedents of PEU, PU, and behavioral intent as they specifically apply to the fire service. The fire service is unique, but it is not homogenous. Individual departments may be volunteer, paid, or mixed. Some departments have organized labor groups while others do not. Departments may be traditional or progressive. Environmental conditions such as urban and rural settings, and whether the department provides EMS units may impact the model. Future research should consider these variables to help better understand the influences of technology acceptance in individual fire department environments. Exploration of these populations within the fire service could fine-tune the model and narrow the scope for individual departments.

The primary objective of this research is to help fire service administrators better understand the variables that influence technology acceptance. Davis stated, in his original work developing TAM, that his goal was to provide a tool for technology developers and implementers to help them predict successful acceptance of a new technology. Like Davis, this author strives to provide fire chiefs and their technology teams with a model that helps them select, design, and implement technology tools that have a high likelihood of successful acceptance. Technological solutions and their implementation are often costly investments; therefore, fire service administrators should leverage technology acceptance variables like self-efficacy, facilitating conditions, and social influence to improve acceptance outcomes. Selection of technology products with a high level of intuitiveness may improve initial self-efficacy perceptions. Administrators who are

involved in the design process of a new technology should conduct extensive beta testing within the employee group. Beta testing provides some early exposure of the product while simultaneously allowing developers to identify problems with the technology. Facilitating conditions are the most readily available variable of technology acceptance to administrators. Administrators can improve self-efficacy and overall acceptance by providing robust training and technical support during implementation. Social influence may be the most powerful yet most challenging variable for fire service administrators to leverage. Administrators should identify members with high self-efficacy to assist in the training, internal marketing, and implementation of new technology. This strategy leverages the rich social network of the fire service by selecting those who will shape the first impressions of the new product.

The success of fire service technology is dependent on the acceptance by the men and women who serve and protect our communities. By better understanding and leveraging the variables that affect technology acceptance, fire administrators can improve the likelihood of acceptance. This improvement will ultimately result in a more efficient and effective workforce which, in turn, improves overall public safety.

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