A Study on the Relationship of the Task Technology Fit Theory and the Perceived Usefulness of Information Technology by Firefighters

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Abstract

Emergency and disaster response teams utilize information technology (IT) systems heavily to get up-to-the-minute information that will help them do their jobs effectively and safely. The use of new communication and information technologies not only allows for better exchange of information among organizations, but can also improve both disaster response operations and disaster prevention efforts. Researchers in the field of IT are frequently puzzled by the difficult task of making the connection between the use of information systems (IS) and how these systems impact organizational performance or individual performance performing the rescue task in the field of emergency management. The purpose of this quantitative research was to analyze the theory of task-technology fit as it is applied to disaster management examining the relationships among the individual characteristics, task characteristics, and technology characteristics to the perceived usefulness of information of firefighters to come up with rational decisions during disaster and emergency situations. The findings of the study would help fire-fighting institution administrators in developing programs with better processes and IT tools to enhance the capability of firefighters in responding to emergency situations.

Dedication

I dedicate my dissertation work to my awesome family, especially to my wife Mayra, who has been very supportive to me during this hard and long journey. A special gratitude goes to my beautiful daughters, Christine, Rosalynn, and Liane. You have been my motivation throughout my life, but more importantly now when I needed it the most. I dedicate this work and give special thanks to my parents Alcides Melendez-Rivera and Rosa Maria Velez-Colon, who are resting in peace and I know are watching down to me from heaven.

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Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Introduction to the Problem

Emergency and disaster response teams rely heavily on information technology (IT) systems to receive up-to-the-minute information that helps do their job more efficiently and safely (Mendonca, Jefferson, & Harrald, 2007). The inaccuracy of any information received by responders can lessen the effectiveness of the emergency responders' efforts (Dawes, Birkland, & Schneider, 2004).

For instance, during the infamous 9/11 attacks, critical information that pertained to the structural composition of the World Trade Center (WTC) Twin Towers was not shared in a timely manner with responders, causing unnecessary confusion, chaos, and death (Dawes et al., 2004). Unawareness by responders about the hazards that can be encountered during emergencies can increase the amount of pressure when making important decisions (Lee, Bharosa, Yang, Janssen, & Rao, 2011).

Background of the Study

To manage disasters in an effective and well-coordinated manner, there must be a favorable condition that induces reliable information on the situation. Without timely information, disaster response will not be effective. Police, fire departments, and other agencies should respond to disasters and emergencies not only quickly but also in a coordinated manner. Therefore, there is a necessity for both intra- and inter-organization coordination and collaboration across different hierarchy levels (Meissner, Luckenbach, Risse, Kirste, & Kirchner, 2002). Coordination cannot happen without current and timely information. Meissner et al. (2002) also claimed that information should be communicated in a timely

manner upwards and downwards within an organization as well as exchanged between organizations in real time. For these to take place, a unified communication and information technology system for emergency management should be established, that can lead to an efficient, reliable and secure exchange and processing of related and important information (Meissner et al., 2002).

The advances in human civilization and their effect on nature have made disaster management an essential component of plans created by government and private agencies. Well-directed disaster management procedures have the potential of diminishing human affliction and any significant harm to natural and artificial habitats (Tomaszewski, 2011; Underwood, 2010). The extent to which these measures are implemented in governments or private institutions depends upon leaders and executives. Earthquakes, volcanoes, and hurricanes are forces of nature that cannot be controlled. Adequate preparation concerning enhancing efficient warning mechanisms, applying updates on construction techniques for dwellings, and dealing with panic can be organized using IT (Tomaszewski, 2011; Underwood, 2010). The human knowledge about natural disasters has increased significantly over the past few decades (Tomaszewski, 2011). This has allowed organizations to track them down and set up clear plans of execution. Using the right technologies ensures that when a disaster takes place, societal standing is reinstated back to normal as early as feasible. It is a responsibility shared equally amongst the residents living in that society and the government making the decisions. It is directed towards safeguarding the environment, defending personal and public assets, stabilizing the economy, and saving lives (Tomaszewski, 2011; Underwood, 2010).

Statement of the Problem

Researchers in the field of IT are frequently puzzled by the difficult task of making the connection between the uses of information systems (IS) and how these systems impact organizational performance or individual performance performing the disaster response task (Lee et al., 2011). Previous studies on information systems success were focused primarily in a private sector atmosphere, where decisions are made in less demanding and stressful conditions compared to disaster situations (DeLone & McLean, 2003). Few studies have looked at the effects of using technologies in a more tension-filled and time-pressured environment and conditions, such as during disasters.

Purpose of the Study

The purpose of this study was to determine the relationships among the individual characteristics, task characteristics, and technology characteristics to the perceived usefulness of information of firefighters to come up with rational decisions during disasters and emergency situations. These characteristics are put forward by the task-technology fit theory (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998). The individual characteristics, task characteristics, and technology characteristics were the independent variables, whereas the dependent variable was the perceived usefulness of information of firefighters to come up with rational decisions during disaster and emergency situations (Yang, Yang, & Plotnick, 2013).

Rationale

Examining how individual, task, and technology characteristics correlates with a perceived usefulness of information of firefighters to come up with rational decisions during disaster and emergency situations helped fire-fighting institution administrators in

developing programs that would enhance the capability of firefighters in responding to emergency situations. Furthermore, by doing a quantitative correlational study, this study provided empirical evidences and insights on how each three aspects of task-technology fit theory relates to the ability of firefighters to respond during emergency situations.

Research Questions

The researcher raised the following research question and made the following hypotheses:

RQ1. How do individual characteristics impact firefighters' perceived usefulness of information to make rational decisions during rescue/emergency situations?

$H1_0$: Individual characteristic has no significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations

$H1_a$: Individual characteristic has a significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations

RQ2. How do task characteristics impact firefighters' perceived usefulness of information to make rational decisions during rescue/emergency situations?

$H2_0$: Task characteristic has no significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations

$H2_a$: Task characteristic has a significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations.

RQ3. How do technology characteristics impact firefighters' perceived usefulness of information to make rational decisions during rescue/emergency situations?

$H3_0$: Technology characteristic has no significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations.

$H3_a$: Technology characteristic has a significant relationship with perceived usefulness of information for firefighters to make rational decisions during disaster and emergency situations.

Significance of the Study

The significance of the study relied on the insights gathered from the relationship between firefighters' performance and information technology that could help emergency or rescue organizations. Through this study, it is demonstrated how effective the theory of task-technology fit in understanding the impacts of information technologies designed for emergency situations in improving individual emergency responders' performance, particularly in fire emergencies (Junglas et al., 2008). Knowing what aspect significantly correlated on the performance during emergency/rescue situations gave decision-makers an idea as to where efforts should be put in improving emergency/rescue services.

Definition of Terms

Individual characteristics. Refers to the performance of an individual during rescue or emergency situations (Junglas, Abraham, & Watson, 2008). Individual characteristics were measured through individuals' responsiveness to come up with decisions after receiving relevant information about the emergency or disaster.

Locatability. Refers to the internal capacity and limitations of any information-processing instrument to obtain its physical location on earth (Junglas et al., 2008).

Mobility. Refers to ability to provide communication without interruptions or boundaries to stationary locations (Junglas et al., 2008).

Task characteristics. Defined as the incitement of an individual by providing a guideline specific to a job or a duty (Yang et al., 2013).

Technology characteristics. Measured through locatability and mobility.

Assumptions and Limitations

Assumptions. Several assumptions were made for the study. First, it was assumed that firefighters were facing problems of making rational decisions during emergency situations (Lee et al., 2011). It was also assumed that some firefighting institutions that had attempted to implement studies or strategies in ensuring effectiveness of firefighters during emergency situations had sufficient knowledge in task-technology fit concept (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998). It was also assumed that firefighting institutions would be willing to share their resources (e.g., firefighters) to make this study possible.

Limitations. The study showed to be limited by the resources and did not allow conducting a cross-national research. The study is based on a limited number of firefighting institutions that could affect the generalization of the findings. The study was also limited by the design used to approach this study, which was quantitative. Even though the approach was appropriate for studies designed to reveal relationships among variables, the researcher would not be able to produce findings based on the perceptions of firefighters or emergency responders themselves.

Nature of the Study (or Theoretical/Conceptual Framework)

The current study utilized the theory of task-technology fit (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998) to demonstrate how information systems (IS) and disaster management success correlated with each other, particularly during multi-agency involvement when answering the call to major disasters. A quantitative correlational research methodology was applied (Lee et al., 2011) in this study. This is the same methodology utilized to test existing IS models on their descriptive strength and relevance in extremely unpredictable and difficult disaster scenarios that require instant harmonized collaborative execution from a large number of response agencies (Lee et al., 2011).

A quantitative research design was used to identify relationships between the two sets of variables, namely the independent variables (individual, task, and technology characteristics) and the dependent variable (individual performance) on developing rational decisions during emergency/rescue situations. Barratt, Choi, and Li (2011) claimed that researchers focused on the relationships between variables frequently use quantitative research methodologies. Quantitative descriptive methods are more appropriate for studies designed to reveal relationships among variables. For studies designed to reveal the effects of an intervention or program, experimental designs are better (Barratt et al., 2011). In descriptive correlational studies, correlational statistical tests are used to determine the relationships between the variables. Explaining the relationship between the variables could lead to revealing of trends (Barratt et al., 2011).

For this study, a quantitative research method was chosen because the purpose of the study was to determine the effects of independent variables on a dependent variable.

A qualitative research method was not chosen because the researcher intended to study various research subjects and determine the quantitative effect of quantitative variables on a specific dependent variable. To achieve this purpose, the researcher needed to measure variables, which would require a quantitative analysis. The researcher assumed that the relationships between the independent and dependent variables could be better determined using quantifiable data.

The population of the study consisted of firefighters in Stafford County, Virginia. To answer the research questions, the researcher specifically studied how firefighters responded to fires, forest fires, and other disasters such as earthquakes and natural calamities. The researcher asked permission from the agency to be able to conduct the research.

This study combined two survey instruments. Goodhue's (1998) task-technology fit (TTF) instrument was used to meet the purpose of testing the theory of task-technology fit (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998) as applied in disaster management that compared the individual characteristics, task characteristics, and technology characteristics. The instrument by Davis' (1989) was also used to determine the theoretical practicality of the IT device or system, theoretical usefulness of the IT device or system, and participant's acceptance of the IT device or system (Davis, 1989). The TTF instrument consists of 32 questions for 12 aspects of task-technology fit. These dimensions include (a) lack of confusion, (b) level of detail, (c) locatability, (d) meaning, (f) accessibility, (g) assistance, (i) ease of use, (k) system reliability, (m) accuracy, (n) compatibility, (o) currency, and (p) presentation. Reliability and validity of the instrument were tested when the instrument was administered to 360 individuals in

nine different organizations. The internal consistency of all 12 dimensions achieved a Cronbach's alpha higher than 0.70. Validity of the instrument was tested through exploratory and confirmatory factor analysis and the results revealed that the instrument was valid enough for use. The survey questions were rated by respondents in a 6-point Likert-type scale, with 0 being *not important at all* and 5 being *extremely important*. The instrument has been tested for validity and reliability. To determine the reliability and validity of the instrument, it was administered to 120 users within IBM Canada's Toronto Development Laboratory. Perceived usefulness scale was determined to have attained a Cronbach's alpha reliability of 0.97, whereas perceived ease of use attained a reliability of 0.91. The instrument was also tested for convergent and discriminated validity by conducting a multi-trait multi-method analysis. Results showed that the combined instrument was valid and reliable.

Organization of the Remainder of the Study

The researcher examined the relationships among the individual characteristics, task characteristics, and technology characteristics to the perceived usefulness of information of firefighters to come up with rational decisions during disaster and emergency situations. The current chapter provided the study's background, problem statement and purpose. In this chapter, the researcher also discussed the study's significance, nature, and theoretical orientation. The researcher also defined the terms used in the study and the assumptions and limitations made. The literature review presented in the next chapter rationalizes studies on information technology used during emergency management, information technology risk, risk analysis and security principles, as well as fire crisis management. This chapter is followed by the research

methodology that will discuss the quantitative approach to this study in detail. The remaining chapters will include the findings and the discussion.

Chapter 2: Literature Review

The purpose of this study is to determine the relationships among the individual characteristics, task characteristics, and technology characteristics to the perceived usefulness of information of firefighters to come up with rational decisions during disaster and emergency situations. These characteristics are put forward by the task-technology fit concept (Goodhue & Thompson, 1995; Zigurs & Buckland, 1998).

This section will be a review of the related literature. Because the study sought to evaluate the efficacy of task-technology fit theory during emergency situations, particularly during fire emergencies, the researcher devoted the literature on task characteristics, individual characteristics, and technology characteristics that could affect the effectiveness of information technology use and highlight the research gap of such studies being applied in fire emergency situations. The first section of the literature review will cover how technologies are currently being used in emergency situations and its benefits. The second section of the literature will cover how fire risks are usually managed and controlled. The last section will cover technology characteristics, or the risks associated with using ICTs. These studies highlight how there is a dearth on literature assessing whether task-technology fit theory is applicable in emergency situations and a dearth on literature assessing how ICTs can be used in fire emergencies to improve outcomes.

The review of literature will be able to show that researchers in the field of IT are frequently puzzled by the difficult task of making the connection between the uses of IS and how these systems impact organizational performance or individual performance performing the rescue task (Lee et al., 2011). Previous studies on information systems'

success focused primarily in a private sector atmosphere, where management decisions could be made with better control of the time and information knowledge when compared to emergency scenarios (DeLone & McLean, 2003). Few studies looked at the effects of using technologies in a more tension-filled and time-pressured environment and conditions, such as during disasters.

Technologies and Disaster Management

The advances in human civilization and their effect on nature have made disaster management an essential component of plans created by government and private agencies (Tomaszewski, 2011). Well-directed disaster management procedures have the potential of diminishing human affliction and any significant harm to natural and artificial habitats (Tomaszewski, 2011; Underwood, 2010). Earthquakes, volcanoes, and hurricanes are forces of nature, which cannot be controlled. Adequate preparation concerning enhancing efficient warning mechanisms, applying updates on construction techniques for dwellings, and dealing with panic can be organized using technology (Tomaszewski, 2011; Underwood, 2010).

To deal with disasters in an efficient and favorably coordinated manner, there must be an optimal provision of information regarding the situation first. Without timely information, disaster response will not be effective (Oden, Militello, Ross, & Lopez, 2012; Scholl & Patin, 2014). Police, fire departments, and other agencies are designed to respond to disasters and emergencies not only quickly but also in a coordinated manner (Li, Li, Liu, Khan, & Ghani, 2014; Nivolianituou & Synodinou, 2011). Therefore, there is a necessity for both intra- and inter-organization coordination and collaboration across different hierarchy levels (Meissner et al., 2002). Meissner et al. (2002) also claimed that

information should be communicated in a timely matter upwards and downwards within an organization as well as exchanged between organizations in real time. For these to take place, an united communication and information system for emergency management should be established, which can lead to efficient, reliable, and secure exchange and processing of related and important information (Meissner et al., 2002).

In addition, the extent to which these measures are implemented depends upon the leaders. According to Demiroz and Kapucu (2012), good leadership is essential during disasters and emergencies because this can reduce the damages inflicted by an event while ineffective leadership can aggravate the negative effects of a disaster. Leaders should also have specific skills and abilities to manage disasters and emergency situations such as being decisive, flexible, and more importantly, informed. Timely information can only be achieved with the right types of information technologies (Reddick, 2011). Reddick evaluated the impact of the use of information technology in improving disaster readiness and a better and detailed preparation. Reddick surveyed U.S. local government departments of emergency management services. These local governments found that IT is a critical component of emergency planning. The use of IT can help in each phase of the disaster management process, especially during the response phase. Reddick found that throughout the emergency management process, several technologies can be utilized, from the use of the Internet and geographic information systems, to wireless equipment, and to more sophisticated tools and threat analytical systems (Reddick, 2011). All these tools are considered effective and helpful in emergency response. The use of IT during an emergency depends on the type of government. Government that is supportive by giving

financial resources and support are to be expected to use IT for emergency management (Reddick, 2011).

Current Types of Information Technologies Used in Disasters

Mechanisms of disaster management in recent years are almost completely dependent on technology (Underwood, 2010). Emergency management deals with seeking out ways to avoid possible dangers. If a disaster were to happen, it ensures that the societal standing is reinstated back to normal as early as feasible. It is a responsibility shared equally amongst the residents living in that society and the government making the decisions. It is directed towards safeguarding the environment, defending personal and public assets, stabilizing the economy, and saving lives.

Emergency management systems. Emergency management systems (EMS) are means of technological assistance, which facilitate in easing the disaster handling process (Rausch, Niebuhr, Schindler, & Herring, 2009). They take care of planning the evacuation of people residing in the areas affected by the disaster. They are assisted in getting connected to closest shelters and learning shelter etiquettes. They seek out and educate the available manpower with skills required at the time of crisis. Stocking up storehouses is an essential part of dealing with repercussions of natural or man-made disasters. EMSs make sure that there are enough tools available to sustain survivors before assistance from other agencies or jurisdictions come into action.

Disasters are prioritized based on the ability of available resources to mitigate those (Yates & Paquette, 2011). Emergencies transition into disasters when they go beyond that point of control. Such situations usually involve human fatalities, direct influence over a colony of people, and the need to invoke international support. Effective

disaster management requires crucial decision-making and immediate action (Rubin, 2012).

Internet. The Internet is a blessing when it comes to communication across nations or disaster management organizations. A warning about a possible natural disaster sent to the correct authority can help initiate precautionary measures and save many lives. Proposals such as Global Disaster Information Network (GDIN) have proven the importance of critical information related to disasters (Shvartzshnaider & Ott, 2013). The technology is designed to give information accurately and on time to the right person so that the right decisions can be reached during a disaster (GDIN, 2005).

Global positioning system. Global positioning system (GPS) is another technological necessity applicable to disaster management. Originally developed by the United States Department of Defense, it consists of 24 satellites, which allow people to identify their exact location on earth. It is operational even in extreme weather conditions, and can be connected with GIS to track actions in real time. For instance, GPS equipment can be fixed onto vehicles to follow their path on a map. Buoys containing GPS mechanisms can detect changes in wave activity, generating warnings for possible tsunamis. Land movements can be perceived using GPS systems, allowing experienced personnel to deduce the chances of earthquakes or volcanoes (Selvavinayagam, n.d.).

Remote sensing technologies. Remote sensing is another technology that has been widely used in preparing for disasters (Van Westen, 2012). It incorporates electromagnetic radiations (EMRs) to obtain information about an entity without the need for physical contact. EMRs have the property of producing distinct effects on coming in