The Influence of Perceived Usefulness, Perceived Ease of Use, and Subjective Norm on the Use of Computed Radiography Systems: A Pilot Study

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Abstract

Perhaps some of the most important decisions made in managing a radiology department are those relating to equipment purchasing. The main goal of upgrading with new equipment or technology is to increase the effectiveness of the radiology department. Thus, implementing a new technology that does not fulfill expectations can yield dramatic consequences. Technology or equipment invested in a radiology department can only prove successful if it is properly utilized by the staff radiographers. This is why it is important to understand the underlying factors that contribute to the degree to which a technology is used. In radiology, the advances in technology are rapid, and the objective of this study is to identify if a relationship exists between a user’s perceived usefulness, perceived ease of use and subjective norm on the user’s intention to operate this technology. The correlation of these variables were measured using a well established questionnaire relating to a newly implemented computed radiography system and the strength of correlations were calculated using the Pearson’s Product Moment Correlation method. The survey was administered to a sample of 21 radiographers randomly selected from a health care facility utilizing a computed radiography system. Analysis of the collected data indicates that a statistically significant relationship exists between perceived ease of use and perceived usefulness as well as perceived usefulness and intention to use the technology. A radiographer’s perceived ease of use of the computed radiography system influences his or her perceived usefulness of the technology; how useful he or she perceives the system to be in regard to their job also influences his or her intention to use the technology. The information that this study provides can prove to be a useful tool when making purchasing decisions if management whishes to delegate resources to measure the radiographers’ perceived thoughts about new equipment. While this is only a small pilot study, research on a larger scale could draw more promising results affecting the way that radiology departments make purchasing decisions. Further informed decisions could decrease the risk of poor technology choices.
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Chapter 1

Problem Statement

Perhaps one of the most prevalent issues regarding any profession that relies heavily on technology are the choices to use the most effective equipment or software to increase efficiency. Implementing a technology that is not willingly accepted and used by staff unnecessarily exhausts resources that are needed for a business to operate to the highest potential. Sichel (1997) refers to this as “productivity paradox.” Productivity paradox can best be described as low usage of installed systems surrounding lackluster returns from organizational investment. (Vankatesh & Davis, 2000). An incredible amount of time and money is wasted on poor investment decisions because the capital spent is not compensated by the level of desired productivity (Tabak & Jain, 2000). Health care is an industry in which innovation is more of a requirement than a profiteering tool. “Evidence has led to public and private pressure for health care delivery organizations to adopt the latest technologies, which is leading many such organizations into a state of continuous technological change” (Karsh & Holden, 2006, p.391). Hospitals are being forced to pay more attention to technology innovation and implementation to gain a business advantage (Tabak & Jain, 2000). The largest challenge has been to maximize profits while delivering excellent patient-care and these two factors seem to contradict often resulting in an improvement of one while decreasing the other (Tabak & Jain, 2000). According to research conducted by Tabak and Jain (2000), radiology is a premier branch of medicine in terms of innovation and adoption of cutting-edge technology. Millions of dollars are spent each year in updating radiographic technology, but this technology is only beneficial if it’s being utilized by radiographers. This is why it is imperative for our professional
community to discover what factors influence technology usage. Research involving technology acceptance has been repeated over the last two decades in other fields such as engineering, communications, information science, software development and few specific modalities of health care (Hauser and Simmie, 1981; Davis, 1989; Gallupe et al., 1988). In 2002, the price of a dedicated CR chest unit ranged from $95,000 to $425,000 (Andriole, 2002). Considering that these units require a high-value investment and that these pieces of equipment are only beneficial if being used by radiographers, then more needs to be known about what factors influence both short term & sustained usage. This study will help identify those factors which influence radiographer’s willingness to use newly implemented technology. Although this is a small pilot study, replication could improve generalizability of the research results.

**Related Research**

The Technology Acceptance Model (TAM) was developed to address a key problem surrounding the field of information technology. The studies primary objective was to assess why performance gains were often inhibited or obstructed by a user’s unwillingness to accept new technology (Davis, 1989). “Because of the persistence and importance of this problem, explaining user acceptance has been a long-standing issue in MIS research” (Davis, 1989, p.319). The Technology Acceptance Model (TAM) was an adaptation to the Theory of Reasoned Action (TRA) developed in 1980 by Fishbein & Ajzen. TRA was an original theory in the sense that the researchers hypothesized that a person’s intention to perform a behavior (BI) was influenced by a person’s attitude (A) and subjective norm (SN). BI = A + SN. Subjective norm refers to “the person’s perception that most people who are important to him think he should
or should not perform the behavior in question” (Fishbein & Ajzen, 1975, p.302). TRA research found that many human behaviors were context driven. TAM was designed as an adapted version of TRA, but more specifically focused on information systems (IS). TAM focuses more explicitly on a user’s intentions by emphasizing a “person’s attitude towards the IS and his or her perceptions concerning its usefulness” (Szajna, 1996, p. 85). More specifically a person’s perceived level of usefulness and perceived ease of use.

In 1989 Davis, Bagozzi and Warshaw published a study comparing the effectiveness of predicting computer usage using both the TRA model and the TAM model. As stated previously, TRA is a more generalized theory of human behavior whereas TAM “is an adaptation of TRA specifically tailored for modeling user acceptance of information systems” (Davis et al., 1989, p.985). This longitudinal study surveyed 107 MBA students at the University of Michigan researching the technology of interest, the word processing software-WriteOne. The results of the study provided three solid concepts: 1) People’s computer use can be predicted reasonably well from their intentions; 2) Perceived usefulness is a major determinant of people’s intentions to use computers; and 3) Perceived ease of use is a significant secondary determinant of people’s intentions to use computers (Davis et al., 1989). The purpose of this study was not to prove or disprove either theory, but rather to identify common factors and underlying determinants of behavioral intentions. The data provided interesting insights that led to the idea of “Hybrid Intention Models.” Davis, Bagozzi and Warshaw (1989) believed that combining TRA and TAM may produce a more beneficial perspective on the determinants of BI.
One example of a hybrid model was a study conducted by Dishaw and Strong. Dishaw and Strong constructed a model that would incorporate Task-Technology Fit model (TTF) with TAM (1998). TTF focuses on the match between user task needs and the available functionality of the IT. The researchers believed that combining variables from both theories would lead to an improvement over either model alone (Dishaw & Strong, 1998). However, because radiographers do not have a wide variety of “task needs,” the TTF is not an appropriate model for the objectives of this study.

Again the seemingly popular opinion that a hybrid model would provide the most functionality was reiterated by researchers Adams, Ryan, and Todd (1992). Their project was a replication of Davis’ original study. Adams, Ryan and Todd performed two research studies; one concerning e-mail and the other concerning computer software such as Word Perfect, Lotus 1-2-3 and Harvard Graphics. The researchers concluded that further examination of the properties influencing behavioral intention should be conducted. Due to technology acceptance being such a prevalent issue in the world of IS, the researchers suggested that Davis’ model continue to be extended upon, modified and subjected to further test and retest methods (Adams et al., 1992).

The goal of research conducted by Venkatesh and Davis (2000) was to create a better understanding of the key determinants of the construct, “perceived usefulness” (PU). The results of Davis’ original TAM study showed that perceived usefulness was the primary driver of usage intentions; however “perceived ease of use” (PEU) proved less influential and remained primarily overlooked by further researchers (Davis, 1989). In addition, TAM2 reintroduced
subjective norm (SN) into the model, which was originally omitted from the first TAM due to its arguably minimal relevance in interpreting human behavior in a voluntary environment. Some studies found subjective norm to be insignificant while others found it to have a significant effect in work environments where technology use was mandated by the employer. Individual studies conducted by Matheison (1991) and Davis et al (1989) found that subjective norm had no significant effect on intention to use a technology. On the other hand, Taylor and Todd (1995) did find a significant effect (Davis et al., 1989; Matheison, 1991; Taylor and Todd, 1995).

The point of incorporating subject norm into the revised model was to observe possible correlation of social influences with behavioral intention (BI). In addition, cognitive instrumental processes (job relevance, output quality, voluntariness) were incorporated into the TAM2 model. The researchers conducted a longitudinal study measured at three points in time in four different scenarios, two involving voluntary usage and two involving mandatory usage. As expected the perceived level of usefulness was a primary factor and perceived ease of use showed to be statistically significant, but once again to a lesser degree. What was found to be interesting is that although subject norm did not have a strong influence in the voluntary setting, it did have a significant affect in the mandated environments. Even though the effect of subjective norm was less than that of both PU and PEU, the study revealed that subject norm is indeed a determinant factor in user acceptance. The findings ultimately advanced our understanding of determinant factors and aided in the strengthening of the foundation of the TAM (Venkatesh & Davis, 2000).

Research regarding technology acceptance has primarily been conducted in the information systems (IS) setting. Limited research has been done relating to health care and
even less relating to radiography. My project is based on a modified version of TAM2 (Fig.1).

Figure 1: Proposed Modified TAM2 in a Mandated Setting

The model is a simple flow chart establishing relationships between the constructs of the study. The use of this model in Vankatesh and Davis’ 2000 study provided data that supports its structure regarding technology acceptance among users (Vankatesh & Davis, 2000) The model illustrates the following: the construct intention to use technology is dependent upon subject norm, perceived usefulness and perceived ease of use. Intention to use technology is established as this study’s dependent construct; however it is important to note that the model does illustrate that certain independent constructs do share relationships with one another. Subjective norm also influences perceived usefulness. The model demonstrates a relationship between perceived ease of use and perceived usefulness however; there is no relationship between subjective norm and perceived ease of use. The model clearly shows that the only variable influencing actual use is our dependent construct - intention to use technology.
Objectives of the Study

The objectives of this study are to identify the influence of the independent variables, perceived usefulness, perceived ease of use and subjective norm, on the dependent variable, radiographers’ intention to use a computed radiography system in a mandated setting.

“Perceived usefulness,” “perceived ease of use,” and “subjective norm” will be measured using a well established survey instrument. The research questions are:

1) Does a relationship exist between subjective norm and perceived usefulness?
2) Does a relationship exist between subjective norm and intention to use technology?
3) Does a relationship exist between perceived ease of use and perceived usefulness?
4) Does a relationship exist between perceived usefulness and intention to use technology?
5) Does a relationship exist between perceived ease of use and intention to use technology?
Chapter 2

Methodology

This is a correlational study and assesses the degree to which a relationship exists between the constructs identified in the TAM2 model. The independent constructs for this study are subjective norm, perceived ease of use, and perceived usefulness. The dependent constructs for this study are perceived usefulness and intention to use the technology. A written questionnaire adapted from the TAM2 developed by Venkatesh and Davis (2000) was administered to radiographers utilizing a computed radiographic (CR) system.

Population and Sample

The population of interest is radiographers utilizing a computed radiography (CR) systems. A total of 21 radiographers were employed by Genesis Health Care Systems. All of the radiographers were currently utilizing a CR system and all 21 were surveyed for this research. A request for IRB exemption was approved June 5, 2008. Data was collected using a written questionnaire administered by an individual with no relationship to this study. Participation was voluntary and each individual consented to participate in the study. The study's goals, objectives, and the importance of the radiographers’ participation were explained in a cover letter.

Instrumentation and Data Analysis

The questionnaire used in this study consisted of 35 items divided into three sections: 1) Intentions and Usage of Digital imaging Systems; 2) Demographic Characteristics; and 3) User
Participation. The first section of the questionnaire (items 1-28) consisted of items adapted from TAM and TAM2 developed by Davis, Bagozzi, and Warshaw (1989), Moore & Benbasat (1991), Venkatesh & Davis (2000), and Morris, Venkatesh, and Ackerman (2005). The original instrument had average internal consistency. According to Venkatesh and Davis (2000, p. 194), “All measurement scales showed high reliability, with Cronbach’s alpha coefficients for all four studies and three time periods exceeding .80. Construct validity was strongly supported both by principal components analysis with direct oblique rotation.”

All Items in the first section of the survey are measured on a six-point Likert Scale ranging from strongly disagree to strongly agree and the option to select not applicable (N/A). A Cronbach’s alpha analysis was conducted to assess reliability of the instrument used in this study. The Cronbach’s Alpha value for each of the variables is as follows: perceived usefulness, .936; perceived ease of use, .919; subjective norm, .940; and behavioral intention, .910. All of these results are above average and exceeding the values obtained in the original instrument testing, thus demonstrating high reliability. The second section of the questionnaire (items 29-31) includes questions regarding the demographic characteristics of gender, age and job classification. The set of questions in the third section were used to assess the user’s involvement regarding the implementation of the technology.

Pearson Product Moment Correlation Coefficient’s (p=.05) were calculated using SPSS 17.0 for each research question. This specific type of correlation analysis is determined based on the categorical description of the variables being compared (Ary et al., 1979).
Chapter 3

Results

The purpose of this study was to identify the relationship between factors which influence radiographers’ willingness to use newly implemented technology. The population consisted of the entire staff of technologists (21) Genesis Health Systems. In terms of gender, 19 (90.5%) were female, 1 (4.8%) was male and 1 chose not to indicate gender (4.8%). The small ratio of male-to-female prohibits a comparative analysis of gender to other variables. The age of the population ranged from 20 years of age to over 41 years of age. Respondents between 20 to 30 years of age comprised 14.3% of the population; 23.8% of the respondents were between 31-40 years of age; and 61.9% were 41 years and older. The entire staff completed the questionnaire with an exception of 1 whom did not complete the intention to use portion. This altered the sample size (n) as well as the degrees of freedom (df) for the results involving intention to use.

The instrument was written to answer five principal questions:

1) Does a relationship exist between subject norm and perceived usefulness?

   A significant relationship does not exist.

2) Does a relationship exist between subject norm and intention to use technology?

   A significant relationship does not exist.

3) Does a relationship exist between perceived ease of use and perceived usefulness?

   A very significant relationship exists between PEU and PU (p ≤ 0.01).
4) Does a relationship exist between perceived usefulness and intention to use technology?

*A significant relationship does exist between PU and BI (p ≤ 0.05).*

5) Does a relationship exist between perceived ease of use and intention to use technology?

*A significant relationship does not exist.*

<table>
<thead>
<tr>
<th>Independent Variable (IV)</th>
<th>Dependent Variable (DV)</th>
<th>Pearson Correlation (r)</th>
<th>Significance (2-tailed)</th>
</tr>
</thead>
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<tr>
<td>Subjective Norm (SN)</td>
<td>Perceived Usefulness (PU)</td>
<td>.189</td>
<td>.411</td>
</tr>
<tr>
<td>Subjective Norm (SN)</td>
<td>Behavioral Intention (BI)</td>
<td>.176</td>
<td>.459</td>
</tr>
<tr>
<td>Perceived Ease of Use (PEU)</td>
<td>Perceived Usefulness (PU)</td>
<td><strong>.716</strong></td>
<td><strong>.000</strong></td>
</tr>
<tr>
<td>Perceived Usefulness (PU)</td>
<td>Behavioral Intention (BI)</td>
<td><strong>.542</strong></td>
<td><strong>.014</strong></td>
</tr>
<tr>
<td>Perceived Ease of Use (PEU)</td>
<td>Behavioral Intention (BI)</td>
<td>.252</td>
<td>.283</td>
</tr>
</tbody>
</table>

Table 1 – Correlational data between constructs
*Correlation is significant at the 0.05 level
**Correlation is significant at the 0.01 level
Discussion

Several studies have facilitated the methodology of TRA, TAM and TAM2 to different markets where the pace of advancing technology is steadily increasing. However, thus far no researchers have set forth to apply the findings of user acceptance theories founded in information systems (IS) to the field of radiology. Not only was it not known as to whether the conclusions drawn from the studies conducted in IS held significant relevance to radiology, but there still lied uncertainty as to what specific factors influence intention to use. Following a thorough review of previous literature regarding technology acceptance, one might expect that both perceived ease of use (PEU) and perceived usefulness (PU) would be influencing factors in a person’s intention to use technology (BI). Both the original TAM and TAM2 studies yielded results that supported the idea that the primary factor influencing one’s intention to use technology was perceived usefulness, while perceived ease of use served as a significant determinant but only to a lesser magnitude (Venkatesh and Davis, 2000). Contrary to previous research, this study found that in a mandated setting, PEU does not influence intention to use the technology to a significant extent. However, when one looks at research related only to health care (Chismar & Wiley-Patton, 2003; Chau & Hu, 2001), results do better support our findings. Chismar and Wiley-Patton (2003) performed user acceptance research in regards to physicians and telemedicine. A study conducted by Chau and Hu (2001) theorizes that the strong-staff support available to health care professionals may attribute to the lesser weight placed on PEU; and physicians have a large comprehensive capacity which aids in a quick adoption of technology, thus weakening the effects of PEU on intention to use. While it is
noted that our research did not survey physicians, the survey population was health care professionals with advanced levels of education.

Also contrary to previous research, our study showed that subjective norm (SN) did not have a significant effect on technologists’ perceived usefulness of the computed radiography system. A study conducted by Davis (1989) and the study conducted by Davis, Bagozzi and Warshaw (1989) support the idea that SN does influence a person’s intention to use technology. However, the results of research conducted by Vankatesh and Davis (2000) revealed that SN was a determining factor of initial user acceptance, especially in the mandated setting; but SN was a non-significant factor affecting perceived usefulness and behavioral intention in the measuring period occurring three months post-implementation. This may indicate that as time increases, a user’s PU or intention to use a technology may be less affected by SN. Chau and Hu (2001) hypothesize that this may be due to the promotion of independent thinking derived from advanced formal education, where it is common practice to teach the methods of questioning the logic and integrity of all of your information as well as the credibility of the source. In addition, Chau and Hu (2001) suggest that physicians are likely to develop independent evaluations and consequently may place less weight on others’ opinions.

Previous technology acceptance research demonstrates a significant relationship between a user’s perceived ease of use and a user’s perceived usefulness and the results of our study support this concept, as a positive correlational relationship was demonstrated at a magnitude of .716.

In conclusion, this research led to two key observations. First, the perceived level of usefulness does influence the radiographer’s intention to use a technology. This finding is
supported by several other research studies. The original TAM supplied three key concepts, one of which stated that perceived usefulness is a major determinant of people’s intention to use technology (Davis, 1989). This finding also corresponds to results of studies conducted by Szajna (1996), Vankatesh and Davis (2000), Adams et al. (1992), and Davis et al. (1989). The second key observation was that perceived ease of use significantly influences perceived usefulness. This is a consistent finding when conducting a survey after the technology has been installed. “In all previous studies where usefulness and ease of use were measured after the technology had been implemented (i.e., post-implementation), significant relationships were found between them (PU and PEU), while measurement on a pre-implementation basis yielded a significant relationship in two of four instances” (Szajna, 1996. p. 89). This indicates that the easier a technology is to use, the more useful an individual perceives it to be. However, the more time that a person has to use and familiarize him or herself with the technology the more likely it is that PEU will become less important in determining PU (Szajna, 1996). It would be interesting to administer our survey on a longitudinal scale, recording the strength of correlation between PEU and PU over time.

Limitations

The most profound limitation to this study was the size of the sample. Only 21 radiographer’s were surveyed, nearly all of which were female. Generally, a small sample size makes the study less generalizable to the population of interest and more vulnerable to Type II errors (Peat, 2002). The sample was dominated by a single gender, and the entire sample was from a single health care facility; both of these factors make it more difficult to generalize the findings to other radiography environments.
Conclusion

The purpose of this study was to identify relationships between variables identified in TAM2 and intention to use a computed radiography (CR) system. TRA provides evidence supporting the theory that a person’s performance of a specified behavior (in this case, actual usage of a CR system) is determined by one’s behavioral intention (BI) to perform the specified behavior (Davis et al., 1989).

The results of this study provided useful insight towards the relationship of subjective norm, perceived ease of use, perceived usefulness and behavioral intention demonstrating that only two significant relationships existed. The perceived usefulness of CR directly influences the radiographers’ behavioral intentions ($r = .542$) and the radiographers’ perception of the ease of operation of the CR system influenced their perceived usefulness ($r = .716$) of the CR system. The information that these two relationships provide can offer those with the responsibility of purchasing radiographic equipment a great advantage. More informed decisions can be made, helping to eliminate the risk of productivity paradox. For example, the field of radiology can push for developers to allow trial runs of equipment. Nearing the end of the trial, a questionnaire could be administered to evaluate the radiographers’ perception of the system’s usefulness and ease of use. Radiology administration can use this information to make a more informed purchasing decision. In addition, this information can be shared with the community of health care professionals so that informed decisions can be made and productivity paradox can be avoided on a much more broad scale.

Equipment vendors can use this information to better delegate resources in equipment development. For example, this study demonstrated that perceived ease of use was a primary
determinant of user acceptance, and that PEU indirectly affects intention to use. Knowing this can allow the developer to focus their primary resources on system usefulness and a lesser amount on system ease of use.
REFERENCES


**APPENDIX A**

**Technology Acceptance Model Questionnaire**

Please place an “X” in the appropriate box to rate the following items using a scale of 1-6:

1= Strongly Disagree  2= Disagree  3= Slightly Disagree  4= Slightly Agree  5= Agree  6= Strongly Agree

<table>
<thead>
<tr>
<th>PU</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>N/A</th>
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<tbody>
<tr>
<td>The digital imaging system enables me to accomplish tasks more quickly.</td>
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<td>The digital imaging system has improved my quality of work.</td>
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<td>The digital imaging system makes it easier to do my job.</td>
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<td>The digital imaging system has improved my productivity.</td>
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<td>The digital imaging system gives me greater control over my job.</td>
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<td>The digital imaging system enhances my effectiveness on the job.</td>
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<tr>
<th>PEU</th>
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<tr>
<td>My interaction with the digital imaging system has been clear and understandable.</td>
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<td>Overall, the digital imaging system is easy to use.</td>
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<td>Learning to operate the digital imaging system was easy for me.</td>
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<td>I rarely become confused when I use the digital imaging system.</td>
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<td>I rarely make errors when using the digital imaging system.</td>
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<td>I am rarely frustrated when using the digital imaging system.</td>
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<tr>
<td>I am able to confidently use the digital imaging system.</td>
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<td>I have the knowledge to use the digital imaging system.</td>
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<td>I have the resources to use the digital imaging system.</td>
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<td>I have the ability to use the digital imaging system.</td>
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<td>I have control over using the digital imaging system.</td>
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<th>SN</th>
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<tr>
<td>People who influence my behavior think I should use the digital imaging system.</td>
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<td>People who are important to me think I should use the digital imaging system.</td>
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<td>My immediate supervisor thinks I should use the digital imaging system.</td>
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<td>My close friends think I should use the digital imaging system.</td>
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<td>My peers think I should use the digital imaging system.</td>
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<td>People whose opinions I value prefer that I use the digital imaging system in my work.</td>
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<th>6</th>
<th>N/A</th>
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<tbody>
<tr>
<td>My use of the digital imaging system is voluntary.</td>
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<td>My supervisor requires me to use the digital imaging system.</td>
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<tr>
<td>Although it might be helpful, using the digital imaging system is not compulsory in my job.</td>
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</table>
I intend to continue using the digital imaging system to perform my job.

I intend to frequently use the digital imaging system to perform my job.

Gender: Male_____ Female _____

Age (in years): 20-30_____ 31-40_____ 41 & above _____

User Participation:

1. Were you a leader of the project team regarding adoption of the digital radiography system?
   Yes_____ No_____

2. Did you have responsibility for selecting the digital imaging system?
   Yes_____ No_____

3. Did you have responsibility for the successful implementation of the digital imaging system?
   Yes_____ No_____

4. Did you have responsibility for user training of the digital imaging system?
   Yes_____ No_____

Thank you for completing this questionnaire!