A Theoretical Model of Observed Health Benefits of PACS Implementation

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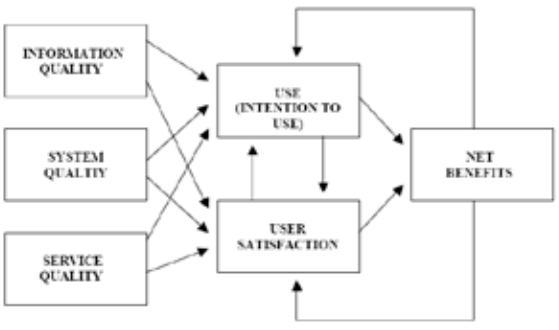
INTRODUCTION

Picture Archiving and Communication Systems (PACS) is an important e-health application, playing a significant operational role within hospitals in electronically transmitting image-based data. Various authors have attributed a range of benefits to PACS, including diagnostic accuracy (Scott et al., 1995; Slasky et al., 1990), interpretation time savings (Kato et al., 1995), workflow (Gale, Gale, Schwartz, Muse & Walker, 2000) and user satisfaction (Philling, 1999). While there is general consensus that PACS brings some or all of these benefits, there is little agreement as to the mechanism through which these benefits are generated.

The work of Delone and McLean (2003) provides a generalized model that attributes information systems success to benefits accruing from relationships between characteristics of the information system (e.g., information quality, system quality, service quality) and user intention to use and user satisfaction (see Figure 1).

Figure 1. Delone and McLean's (2003) model of IS success



This chapter provides empirical evidence that the Delone and McLean (2003) model with modifications explains the source of PACS benefits. Not only do we suggest a new model, but we also recommend that each specific information system context may require specific modification of Delone and McLean's (2003) model to explain the source of success.

BACKGROUND

This model and its earlier incarnation (Delone & McLean, 1992) have been applied to a range of IS contexts, including PACS (Cox & Dawe, 2002; Reiner et al., 2002). While this indicates that Delone and Mclean's (2003) model is robust when applied to PACS, it appears from the literature that other factors are causally related to the net benefits attributed to PACS. In particular, the literature suggests the following:

- The environment in which images are viewed and interpreted (Abdullah & Ng, 2001; Rostenberg, 2006; Reiner & Seigel, 2000) impacts the speed, accuracy, and comfort of interpretation. Rumreich and Johnson (2003) specifically argue that a purpose-designed reading environment improves radiologist satisfaction and efficiency.
- Training offered to users is also said to be important to the benefits from PACS (Protopapas et al., 1996; Watkins, Weatherburn & Bryan, 2000; Law & Zhou, 2003; Huang, 2003). Not only does training improve performance (Barney, 1991; Ulrich, 1991), but the way it is conducted also

increases user satisfaction (Bradford & Florian, 2003).

This suggests that while Delone and McLean's (2003) model may be valuably applied to PACS environments without modification, the inclusion of environmental and training issues may better explain the source of benefits and, thus, IS success.

IDENTIFYING AND EXPLAINING SOURCES OF PACS SUCCESS

The identification of the nature and source of benefits from PACS involved a single-stage case study of 18 PACS users, administrators, and managers at a large private hospital. The hospital has more than 60 departments and service centers, 500 beds, and nine operating theaters. The Medical Imaging Department is equipped with all imaging modalities and provides radiological services throughout the hospital. A mini-PACS was implemented in 1995 covering the intensive care, emergency, and imaging departments. In 2000, a decision was made to implement PACS hospitalwide, and in 2004, this was achieved.

This investigation asked the following: Are the two extra elements (image interpreting environment training) considered to be of importance at the hospital, and would their inclusion improve the relevance of Delone and McLean's 2003 model to the PACS environment? The investigation was part of a larger project that sought to evaluate the recent PACS implementation from three benefit perspectives: the impact on workflow; the impact on timeliness of image delivery and reporting; and the impact on patient throughput. The work presented here cuts across each of these perspectives, to focus on the aim of understanding the nature and source of benefits of PACS.

The investigation had both qualitative and quantitative components. Semistructured interviews around the topics of benefits (perceived or formally evaluated), system quality, service quality, training, viewing environment issues, and the attainment of hospital goals. Each interview was followed by a quantitative survey that was administered by the researcher. The survey addressed issues of self-efficacy and intention to use PACS, training, support, and level of user satisfaction. These questions were drawn from scales developed by Speier and Venkatesh (2002). The interview, survey, and documents were analyzed using open coding to divide the data into concepts and categories of concepts, and to assign properties to those categories (Miles & Huberman, 1994). Following this, axial coding was used to organize the categories and dimensions into groupings of ideas that are thematically related (Strauss, 1987). The quantitative survey data were analyzed descriptively only as the sample was too small for more sophisticated analyses.

The major findings and the modifications that they suggest for Delone and McLean's (2003) model follow:

- Adoption of PACS was universal with no interviewee indicating that he or she still used or preferred film-based images where there is a PACS digital browser-based alternative.
- Users universally reported not only that they were satisfied with PACS, but also that the more they used PACS, the more satisfied they became and the greater intention they had to use PACS' functionality. That is, use/intention to use and satisfaction with PACS are recursively promoted by the benefits that the users perceive. The model would be improved by arrows indicating a reverse loop from benefits to use and satisfaction (see Figure 2).
- DeLone and McLean's (2003) suggestion that where use (intention to use) and user satisfaction exist, net benefits will follow is confirmed. No modification of the model is needed.
- "Information quality" could be meaningfully relabeled "information and image quality" to reflect the multimedia nature of PACS presentation of data.
- For some respondents, information and image quality is directly related to benefits as well as indirectly via user perceptions and responses as Delone and McLean (2003) suggest. This direct benefit was not universally reported. Those that did not report this direct benefit commented that image quality was better, notwithstanding the trade-off between contrast and resolution, but that this benefit was entirely accounted for by the indirect effect through intention to use. Those that did report a direct effect included orthopedic surgeons who commented that because the size of the digital image is not necessarily related to