MEDINFO 2010
C. Safran et al. (Eds.)
IOS Press, 2010

doi:10.3233/978-1-60750-588-4-691

Why don't innovation models help with informatics implementations?

Rod Ward

Faculty of Health and Life Sciences, University of the West of England, UK

Abstract

This paper describes various models that have been postulated to understand and explain the acceptance and diffusion of technological innovation. The wide range of factors relating to the innovation itself, and, most importantly, the human and organisational factors which will impinge on these processes, is detailed. Attempts to apply the model to healthcare settings are explored. In particular a systematic review in 2005 which attempted to integrate the models and apply them in the UK's National Health Service will be critiqued. The strengths and weaknesses of the models are explored, particularly in relation to the minimal testing they have been subjected to. It is argued that the complexity of the theoretical models makes them difficult to apply and questions their efficacy in supporting informatics implementations. The need for a clearer understanding of the factors which make staff positively disposed towards informatics innovation, and those which are likely to make them resist them is made apparent.

Keywords:

Computers; Attitude of Health Personnel; Diffusion of Innovation; Organizational Innovation; Models, Theoretical

Introduction

The process by which new technological innovations are adopted and disseminated has been extensively studied for many years. Data have been collected from many settings internationally and within different academic paradigms [1]. However, many of the models of innovation development and diffusion are developed from a limited empirical evidence base and have only been tested by post hoc application to previously published reports and fail to demonstrate predictive capabilities. More recently these models have been applied to the introduction of Informatics applications in healthcare; however the components of the models which relate to human and organisational factors are often considered secondary to technological issues when it comes to real world use.

This paper will argue that complex theoretical models are not currently helping to predict the factors that will lead to the success or failure of informatics developments. The models have similar components, but each with slightly different emphasis, and have increased in complexity over the years.

Models

Many of the models that attempt to explain the factors affecting whether an innovation will be shared and adopted by other individuals and organisations have been based on Rogers Diffusion of Innovation Theory [2]. Rogers argued that each adopter's willingness and ability to adopt an innovation would depend on their awareness, interest, evaluation, trial, and adoption. This led to the proposal of a five stage model for the diffusion of innovation [3]:

- Knowledge - learning about the existence and function of the innovation;
- Persuasion - becoming convinced of the value of the innovation;
- Decision - committing to the adoption of the innovation
- Implementation - putting it to use and
- Confirmation - the ultimate acceptance (or rejection) of the innovation.

An alternative approach to Roger's work is the Technology Acceptance Model (TAM) that focuses on the factors and decision processes an individual will go through in any decision to accept and use a technology or other innovation. The model suggests that when users are presented with a new innovation, two key factors influence their decision about how and when they will use it. Perceived Usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or her job performance" and the Perceived Ease-of-Use: "the degree to which a person believes that using a particular system would be free from effort" [4]. The TAM can be seen as an extension of Ajzen and Fishbein's theory of reasoned action [5, 6], which suggests people's volitional (voluntary) behaviour is predicted by their attitude toward that behaviour and how they think other people would view them if they performed the behaviour. A person's attitude, combined with subjective norms, forms behavioural intention.

Several researchers have replicated Davis's original study to provide empirical evidence on the relationships that exist between usefulness, ease of use and system use; [6-11]. Davis, [12] using newly developed scales, demonstrated that perceived

usefulness was 50% more influential than ease of use in determining usage.

Malhotra and Galletta [13] argued for much greater emphasis on social influences, rather than the nature of the technology, and developed and tested constructs based around these factors which may be particularly significant in complex organisations in which many different players are likely to be in a position to influence the success or failure of the innovation, even if they are not involved in adoption decisions.

Further work has tried to integrate individual and organisational factors. Venkatesh et al [14] compared existing models in an attempt to identify and test a model that integrates elements across them. Based on their work in a variety of settings they produced a set of hypotheses to explore and explain the variables which impinge on acceptance and use.

- The influence of performance expectancy on behavioral intention will be moderated by gender and age. The effect will be stronger for men and particularly for younger men.
- The influence of effort expectancy on behavioral intention will be moderated by gender, age, and experience. The effect will be stronger for women, particularly younger women, and particularly at early stages of experiencing the innovation.
- The influence of social influence on behavioral intention will be moderated by gender, age, voluntariness, and experience. The effect will be stronger for women, particularly older women, particularly in mandatory settings.
- Facilitating conditions will not have a significant influence on behavioral intention.
- The influence of facilitating conditions on usage will be moderated by age and experience. The effect will be stronger for older workers, particularly with increasing experience.
- Computer self-efficacy will not have a significant influence on behavioral intention.
- Computer anxiety will not have a significant influence on behavioral intention.
- Attitude toward using technology will not have a significant influence on behavioral intention
- Behavioral intention will have a significant positive influence on usage

Application to Health Informatics

In 2005 a major systematic literature review was undertaken, in an attempt to draw together the research on the diffusion of innovations and apply them to health service organisations. A particular emphasis was placed on the relevance of the work to the United Kingdom's National Health Service which funded the work [1].

The review reaffirmed many of the well known themes such as the importance of the attributes of the innovation itself, of social networks and organisational cultures, but also pointed out the lack of empirical evidence demonstrating that work from product-based innovation in companies can be applied to process innovation in service organisations, such as healthcare providers. The review attempted to integrate work from a variety of paradigms into a single conceptual model. The model seeks to encompass the whole range of factors and was tested against purposively sampled case studies.

The Greenhalgh et al model[1] covers several key areas:

- **Innovations** which covers relative advantage, compatibility, complexity, trialability, observability, reinvention, fuzzy boundaries, task issues, the nature of the knowledge required to use it and support required.
- **Adoption by individuals** which explores general and context specific psychological antecedents to, and the nature of the adoption decision.
- **Assimilation by organisations** where there is a dynamic relationship between initiation, development and implementation.
- **Diffusion and dissemination** which covers network structure, homophily, opinion leaders and harnessing their influence, champions, boundary spanners and formal dissemination programmes.
- **The inner context** addressing organisational antecedents and readiness for innovation, discussing structural determinants of innovativeness, absorptive capacity for new knowledge, the receptive context for change and the resources available.
- **The outer context** which covers inter-organisational networks and collaboration
- **Implementation and routinisation** which includes structure, leadership and management, human resources, funding and communication issues.

The Greenhalgh model accepts the importance of interactions between different components, but argues that it is not possible to make "formulaic, universally applicable recommendations for practice and policy" based on the model. This makes it impossible to use to predict behaviours and outcomes. It also becomes difficult to test or use in implementation projects, and lacks any ability to how much effect will be brought about by different factors.

Greenhalgh et al. [1] sought to test the model with four case studies; integrated care pathways, General Practitioner fundholding, telemedicine and the electronic patient record. Telemedicine is subtitled "the maverick initiative" and was selected partly because it had previously been studied from a diffusion of innovations perspective (e.g. [15, 16]). It was highlighted as being an initiative that tends to be introduced by individual enthusiasts rather than as part of an organisational process. The importance of human actors and the processes between them is described as being more important than the hardware and software of the technologies concerned [1]. The

evidence for the effectiveness and cost-effectiveness of telecare is inconclusive and barriers to adoption are extensive, however small teams of enthusiasts, have devoted time and personal resources to development, often in the face of institutional indifference and made the projects successful. May et al [17] used telehealthcare as a case study in their examination of the processes surrounding health technology assessment. They suggest that although the technology is attractive to policy makers as a "technological fix" for some structural problems that affect access to health care, it is unstable in clinical practice, not widely used and there are doubts about its efficacy, acceptability to patients and cost effectiveness. They suggest that evaluating these sorts of technological developments involves debates about evaluation methodology and professional dynamics that conceal more fundamental difficulties in conceptualising a technology in play, and which are difficult to resolve in practice. May et al [17] produced a set of terminology about how these innovations are adopted including; Ideation, Mobilisation, Clinical specification and Specific application which are not dissimilar to the stages originally set out by Rogers in his diffusion model but do focus this on application to clinical settings.

The other case study by Greenhalgh et al. [1] with direct relevance to Informatics is their review of the electronic health record which they dub "the big roll-out". This major national initiative is seen in the context of the UK's National Health Service which is fragmented across multiple sites and sectors posing obstacles to clinical care, administration, research and public health initiatives. The strong "external mandate" from central government is seen as being in conflict with the response from staff, because of "high complexity, questionable relative advantage and low ease of use" Greenhalgh et al.[1, p208-210]. These problems are identified as being significant because of the critical dependence on simultaneous adoption by multiple users, and low absorptive capacity of many parts of the system. These findings are further reflected by the independent evaluation of the summary care record early adopter programme, which identified positive mediators, including organisational readiness and aspects of the implementation, and negative mediators including the concerns of the potential adopters of the innovation [18].

Weaknesses of the models

The Greenhalgh et al, [1] model could be seen as being rather un-dynamic and undifferentiated, avoiding ranking the importance of the various factors and really providing a checklist rather than a full exploration of the complex factors involved in the diffusion of new technologies. Although highlighting a wide range of factors they did not place these in any order of priority. The research team also postulated that power relations were critical to successful implementation, but suggested they were very difficult to explore systematically. They also bemoaned the lack of research on the complexities in spreading and sustaining innovation in service organisations as opposed to initial innovation.

The general complexities of identifying the factors that contribute to the diffusion of innovations are complicated within specific organisational contexts and interpersonal relations. West [19] showed how, in the UK, the networking behaviours of senior nurses and medical staff, and their cliques, were different. The differences influenced the way in which they gained and shared information with colleagues, and suggested that these were a result of the occupational socialisation within the different professions, which had led to the development of subcultures [20]. Similar work in the USA examining the implementation of an electronic medical record system found that the new working practices which were inherent in the electronic system required "clarification of clinical roles and responsibilities which was traumatic for some individuals" and that "no single leadership style was optimal – a participatory consensus-building style may lead to more effective adoption decisions, whereas decisive leadership could help resolve barriers and resistance during implementations: the process fostered a counter climate of conflict" [21]. These professional variations and the wide variety of roles played by individuals mitigate against finding models which can encompass all the myriad influences of adoption and dissemination of technologies within the healthcare domain.

Resistance to innovation

There is a need for clarity in looking at the "fit" between the technology and the task it is intended to support. System design (from IT people) may not match well with objectives and values of clinical staff [22]. The degree to which a "one size fits all" solution can cause local resistance in organisations and individuals who have been used to "locally grown" systems which have high degrees of customization and localization was also highlighted by Hendy et al [23]. They found this factor was a significant driver in the development of resistance to new systems by clinicians.

Nursing staff reactions and strategies when employed to use software driven algorithms for decision making in a variety of settings, are influenced by the inflexibility imposed by the system which hampered their work. The nurses often overrode the guidance given by the system because it was not seen as being individualized to the specific patient problem [24]. At NHS Direct, nurses using similar software felt it was sometimes unable to consider contextual or other relevant information. They described the software as "interfering with their consultation with the patient, leading either to dependence on, or avoidance of, the software" and it was seen as a limitation imposed by management on the nurses' practice [25]. These types of reactions are to some extent predictable, but are not included in the models and need to be taken into account by system developers and those with responsibility for new implementations.

The 'Design-reality gap' has been given as a label to identify some of the factors which may influence the outcome of eHealth systems taking into account the situation specific factors which are relevant [22]. The Information, Technology, Processes, Objectives and values, Staffing and skills, Management systems

and structures, and Other Resources (ITPOSMO) model is based on a continuum between reality as it exists, and what the design is trying to achieve and helps as a way of identifying the need to reduce the gaps on all dimensions [22]. This model attempts to take into account attitudinal and organisational factors as well as technology based ones, although the models use as a predictor of implementation effectiveness remains to be tested.

Implementation models which accept the importance of involving users require consultation with individuals who will be affected by the change, both on an individual basis and through representative organisations. These require recognition of professional autonomy and an understanding of the different values and assumptions which may be held by different groups such as managers and clinicians. Kaplan [2] illustrated this with examples of the introduction of a computerised records system within one health care institution. She argued that the focus of the project team on a system which provided an automated patient history, rather than providing tools which the physicians thought would facilitate their work caused "information overload and standardization, clerical task load increase, work organisation rigidity and expert autonomy negation" [2, p 44]. The same system was found by nurses to be "highly normative as it tried to impose a new reality, producing uniformity and predictability in thought and behaviour patterns in nurses". These could be summarised as "a failure to appreciate the nature of decision problems and a mismatch in motivations between developers & users" [26].

In 1997 Myers and Young reworked Broadbent et al's [27] application of Habermas' model of societal development to examine the work of the information services unit within a mental healthcare provider in New Zealand, which encountered opposition from clinical staff. Clinicians objected to the "hidden agenda" of time based costing which underpinned managerial attempts to introduce a new recording and communication system. The resistance appeared to be in reaction to a perception that computers were being used to "control professional people" [28].

The systems need to provide user interfaces and response times which are acceptable within a clinical environment where the pace of change in patients' conditions and the interactions with health professionals may be rapid. The effects of the interaction between health professionals and patients in face to face settings have been studied however the social effects of interaction at a distance, mediated by technology in the growing fields of telemedicine and telecare applications are still unclear. The "human factors" need to be taken into account at all stages of the design, implementation and use phases of informatics implementations and need to be included in the models which aim to explain them.

Conclusion

The factors influencing acceptance or adoption of a technology and its subsequent diffusion will be influenced by the application itself, but also by a variety of other factors which will form individuals' attitudes towards the application. It is the individuals within organisations who are the ultimate users and consumers of the technology, [29] and the true benefits and impacts of IT are contingent on the extent to which individual users appropriate and use IT in their ongoing work activities that, in turn, contribute to organisational productivity [30].

Adoption and diffusion models offer us some insights into the myriad of factors which may impinge on the success or failure of informatics innovation; however they also have their limitations. Often they focus on policy drivers and barriers to innovation and do not fully take into account the complex organisational and personal factors which impinge of development and adoption.

Further empirical work to test and refine the existing models is needed, but the more effective approach may be to simplify the models, focusing on the most important or significant factors in the hope of producing something which can be used to predict and support informatics implementations.

References

[1] Greenhalgh T, Robert G, Bate P, Macfarlane F, and Kyriakidou O. Diffusion of Innovations in Health Service organisations: A systematic review of the literature. Oxford: BMJ Books, Blackwell Publishing, 2005

[2] Kaplan B. Evaluating informatics applications – some alternative approaches: theory, social interactionism, and call for methodological pluralism. International Journal of Medical Informatics 2001: 64 39-56

[3] Rogers EM. Diffusion of Innovations (4th Ed.) The Free Press/Simon & Schuster Inc. 1995

[4] Davis FD, Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 1989: 13(3), 319-340.

[5] Bagozzi RP, Davis FD, and Warshaw PR. Development and test of a theory of technological learning and usage. Human Relations 1992: 45(7), 660-686.

[6] Davis FD, Bagozzi RP, and Warshaw PR. User acceptance of computer technology: A comparison of two theoretical models. Management Science, 1989: 35, 982-1003.

[7] Adams DA, Nelson RR, and Todd PA. Perceived usefulness, ease of use, and usage of information technology: A replication. MIS Quarterly 1992: 16, 227-247.

[8] Hendrickson AR, Massey PD, and Cronan TP. On the test-retest reliability of perceived usefulness and perceived ease of use scales. MIS Quarterly, 1993: 17, 227-230.

[9] Segars AH, and Grover V. Re-examining perceived ease of use and usefulness: A confirmatory factor analysis. MIS Quarterly, 1993: 17, 517-525.

[10] Subramanian GH. A replication of perceived usefulness and perceived ease of use measurement. Decision Sciences, 1994: 25(5/6), 863-873.

[11] Szajna B. Software evaluation and choice: predictive evaluation of the Technology Acceptance Instrument. MIS Quarterly, 1994: 18(3), 319-324.

[12] Davis FD, User acceptance of information technology: systems characteristics, user perceptions and behavioral impacts. Int J Man-Machine Studies. 1993: 38, 475-487

[13] Malhotra Y, and Galletta DF. Extending the Technology Acceptance Model to Account for Social influence: Theoretical Bases and Empirical Validation. Proceedings of the 32nd Hawaii International Conference on System Sciences. 1999

[14] Venkatesh V, Morris MG, Davis GB, and Davis FD. User acceptance of information technology: Toward a unified view. MIS Quarterly, 2003: (27:3), 425-478.

[15] Currell R, Urquhart C, Wainwright P. and Lewis R. Telemedicine versus face to face patient care: effects on professional practice and health care outcomes. Cochrane Database of Systematic Reviews CD002098. 2000

[16] Grigsby J, Rigby M, Hiemstra A, House M, Olsson, S. and Whitten, P. Telemedicine/telehealth: an international perspective. The diffusion of telemedicine. Telemedicine Journal and E-Health. 2002: 8. 79-94

[17] May C, Mort M, Williams T, Mair F, and Gask L. Health technology assessment in it local contexts: studies of telehealthcare. Social Science & Medicine. 2003: 57. 697-710

[18] Greenhalgh T, Stramer K, Bratan T, Byrne E, Russell J, Mohammad Y, Wood G and Hinder S. Summary Care Record Early Adopter Programme. University College London 2008 http://eprints.ucl.ac.uk/6602/

[19] West E, Barron DN, Dowsett J, and Newton JN. Hierarchies and cliques in the social networks of health care professionals: implications for the design of dissemination strategies. Social Science and Medicine. 1999: 48. 633-646

[20] Bowns IR, Rotherham G, and Paisley S. Factors associated with success in the implementation of information management and technology in the NHS. Health Informatics Journal 1999: 5 136-145

[21] Scott JT, Rundell TG, Vogt TM, and Hsu, J. Kaiser Permanente's experience of implementing an electronic medical record: a qualitative study. British Medical Journal 2005: 33(1) 1313-6

[22] Heeks R. Health information systems: Failure, success and improvisation. International Journal of Medical Informatics 2006: 75 125-137

[23] Hendy J, Reeves BC, Fulop N, Hutchings A, and Masseria C. Challenges to implementing the national programme for information technology (NPfIT): a qualitative study. British Medical Journal 2005: 331:331-336

[24] Dowding, D, Mitchell N, Randell R, Foster R, Lattimer V, and Thompson C. Nurses' use of computerised clinical decision support systems: a case site analysis. Journal of Clinical Nursing 2009: 18(8) 1159-1167

[25] O'Cathain A., Sampson FC, Munro JF, Thomas KJ. and Nicholl JP. Nurses' views of using computerized decision support software in NHS Direct. Journal of Advanced Nursing 2004: 45(3), 280–286

[26] Heathfield HA and Wyatt J, Philosophies for the design and development of clinical decision-support systems. Meth. Inform. Med. 1993**:** 32**,** 1–8

[27] Broadbent J, Laughlin R, and Read S. Recent financial and administrative changes in the NHS: a critical theory analysis. Critical perspectives on accounting 1991: 2 87-104

[28] Myers MD, and Young LW. Hidden agendas, power and managerial assumptions in information systems development: An ethnographic study. Information Technology & People. 1997: 10(3) 224-240

[29] Sinclair M, McGlade K, Comac P, Kelly B, Brown H, Hatamleh R, and Stockdale J. Knowledge, Skill and Attitude of NI DHSSPS Healthcare Professionals towards Information and Communication Technology: Report of a Northern Ireland Survey. University of Ulster. 2007

[30] Lewis W, Agarwal R, and Sambamurthy V. Sources of Influences on Beliefs about Information Technology Use: An Empirical Study of Knowledge Workers, MIS Quarterly, 2003: 27 (4) 657-678

Address for correspondence

School of Health and Social Care, University of the West of England, Glenside Campus, Blackberry Hill, Bristol, BS16 1DD, UK
Tel: +44(0)117 32 88477 Email: rod.ward@uwe.ac.uk