Fit Between Individuals, Tasks, Technology, and Environment (FITTE) Framework: A Proposed Extension of FITT to Evaluate and Optimise Health Information Technology Use

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Abstract

Evaluating and optimising 'fit' between technology and clinical work is critical to ensure the intended benefits of technology implementations are achieved. Using a mixed method approach (structured observation, interviews, field notes) we collected data regarding users, tasks, technology, and factors impeding technology use from a sample of 38 clinicians on two wards at an Australian hospital. We used the FITT framework to assess the relationships between users, tasks, and technology.

Our findings showed that even when adequate fit between users, tasks, and technology was attained additional factors related to the environment (including the temporal rhythms of a ward, infection control rooms, or space limitations) ultimately affected technology use. Thus, we propose the fit between individuals, task, technology and environment (FITTE) framework as a means to evaluate and optimise technology use by explicating the relationships between users, tasks, technology, and the environment in which they operate.

Keywords:

Computers; Health services research; Models, theoretical

Introduction

Health information technologies (HITs) undoubtedly have the potential to make care delivery more efficient and effective. However, HITs can also result in unintended consequences, including: unfavourable workflow issues; paper persistence; changes in work practices (such as altering of the pace and sequencing of clinical activities); and only partial support for the information needs and work practices of clinicians [1; 2]. Researchers indicate that the 'fit' between technology and clinical work is what leads to HITs being either used and incorporated into routine, worked around, or rejected [3]. Where there is a mismatch between technology and work practices, the intended benefits of the HIT may not be achieved.

Research investigating fit between technology and clinical work has, by and large, focused on software applications with limited consideration regarding hardware computing devices. In order to achieve optimal beneficial outcomes from HITs, it is also essential to ensure the right fit of hardware devices. Fixed computing devices, such as desktop computers, may constrain the work practices of clinicians by mandating where information can be accessed or documented. Mobile computing devices, on the other hand, are not tied to one location but rely on battery and wireless connectivity, and have different screen sizes and data input mechanisms (keyboard, stylus, and/or touchscreen), all of which impact their usability. Considering that computers play an integral part in the success of software

implementations, how fixed and mobile devices fit into and support clinical work practices warrants attention.

Theoretical Frameworks

The Technology Acceptance Model (TAM) and Task-Technology Fit (TTF) model are two prominent theories that describe potential means by which to explore the notion of fit between technology and work practices. TAM has been widely used in health care and employs the constructs of perceived usefulness and perceived ease of use as determinants of: attitudes towards using technology; intention to use technology; and the actual use of technology [4]. Findings from Holden and Karsh's seminal review of TAM, and its application in health care literature, underscored TAM's value as a theoretical framework to assess the relationship between users and technology [3]. However, the review also pointed to the need for additional constructs to allow for further relationships to be explored. Dishaw and Strong, likewise, highlight that a shortcoming of TAM in aiding understanding of the use of technology may lie in the absence of an explicit construct examining tasks [5]. They indicate that, unlike TAM, the TTF model provides explicit inclusion of a task–technology construct.

The TTF model looks at task characteristics and technology characteristics, which together determine task–technology fit and influence technology utilisation [6]. The premise of the model is that technology will be used if it adequately supports the demands of a task. In applying the TTF model to assess the fit of a picture archiving and communications system (PACS), Lepanto et al. concluded that "TTF is a valid tool to assess perceived benefits, but it is important to take into account the characteristics of users" [7]. Others have similarly indicated that a limitation of TTF is that it does not explicitly include a construct that examines user characteristics [5].

Ammenwerth et al.'s propose Fit between Individuals, Tasks, and Technology (FITT) as a framework that encompasses the interactions of users and technology (i.e. TAM concepts) and tasks and technology (i.e. TFF concepts), and the interaction between users and tasks [8]. FITT was developed specifically for the health care domain and was based on an analysis of literature on technology adoption. FITT posits that the use of technology is dependent on the fit between the attributes of the individuals (users), attributes of the tasks, and attributes of the technology.

The framework defines individuals as either an individual user or a user group. Examples of user attributes include: knowledge of the technology; motivation to execute tasks; openness to new ways of working; cooperation within a team; and organisational context. Tasks comprise whole tasks or work processes (such as, documentation or order entry), the attributes of which can

include: organisation of tasks; activities and their interdependence; and task complexity. Technology is defined as any tool required to execute a task; encompassing both computer-based and paper-based tools. Examples of technology attributes include: usability of the tool; functionality of the tool to support a given task; integration of tools; and availability of tools. Where fit between attributes of the users, tasks, or technology is lacking, problems with the adoption of technology arise [8].

The article where FITT was introduced was focused on a retrospective analysis of a case study that assessed the adoption of a nursing documentation system in three wards to test and validate FITT [8]. Application of FITT was shown to facilitate understanding of the relationships between users, tasks, and technology, and the factors leading to either the failure, or the successful adoption, of technology in each ward. For example, a factor that affected overall fit in the paediatric ward was identified as the fit between tasks and technology dimension, whereby the unavailability of mobile computing devices or fixed computing devices located at the patient bedside disrupted the workflow of nurses who were accustomed to undertaking documentation at the patient bedside. By pinpointing the issues affecting the use of technology, FITT helped to determine areas where changes could be introduced in order to optimise fit.

The aim of our research was to (i) evaluate clinicians' use of fixed and mobile computing devices using the FITT framework and (ii) identify factors affecting the optimal use of devices.

Methods

A mixed method approach comprising structured observation, interviews, and field notes was used for data collection. Observation can be particularly valuable for determining whether technology is used in expected or unexpected ways, while interviews can complement observation by providing clarification about what was seen in the field.

Data collection was conducted on two wards (a surgical and a general medical ward) at a 320-bed teaching hospital in Sydney, Australia. The hospital had several HITs, including: an electronic medical record (for documenting discharge summaries); computerised provider order entry (for test ordering and results viewing); an electronic medications management system; and PACS. Tasks such as recording vital sign observations and progress notes were paper-based. Both fixed (desktop computers) and mobile computing devices (computers on wheels (COWs)) were available on the wards. Some doctors also had tablet computers that were connected to the hospital's information system.

A paper-based data collection form was developed and used to capture variables regarding users, tasks, and technology, including the: activity being conducted (i.e., ward round, medication round, or outside of round); task being performed (e.g., administer medication, order medication, order test, document progress notes); technology used to perform the task (e.g., desktop computer, COW, paper medical record); and factors impeding the use of technology. The data collection form was also used to document free text field notes and interviews. Definitions for the observed work tasks were based on classifications used in previous observational studies [9; 10].

A sample of 38 clinicians (26 nurses (19 female) and 12 doctors (6 female)) were observed for 90 hours and 45 minutes. Medication administration rounds accounted for 45 hours and 10 minutes, ward rounds 28 hours and 50 minutes, and outside of rounds 16 hours and 45 minutes of the observation time. In total, 4,423 clinical tasks were recorded: 2,321 during medication administration rounds, 1,444 during ward rounds,

and 658 outside of rounds. Twenty-seven clinicians also participated in informal interviews, providing explanations regarding observed events.

Clinicians were observed in the course of their daily work (between 7am and 5pm, Monday to Friday). Each observation session lasted a maximum of two hours. There were no set criteria for the selection of observed clinicians; they were chosen at random from those that were on the study ward on any given day that observations were conducted. Informal interviews were carried out opportunistically when clarification was needed and the situation allowed. Ethics approval for the research was obtained from the hospital Human Research Ethics Committee.

The quantitative data were analysed in SPSS using descriptive statistics to calculate frequencies of the collected variables, including: tasks conducted by doctors and nurses; devices used to conduct tasks; and locations in which tasks were conducted. Qualitative data from interviews and field notes were analysed for common themes, particularly regarding the factors affecting device use. FITT was applied in order to assess the relationships between users, tasks, and technology.

Results

FITT: Doctors, Tasks, and Technology

Doctors and Tasks

Doctors' work differed on ward rounds and outside of rounds. Ward rounds were conducted in teams, with doctors moving from one bedside to the next as they reviewed each patient. Ward round tasks occurred across several locations, including the patient bedside, the corridors, and while doctors were in transit between locations.

The main types of tasks doctors conducted on ward rounds included reviewing the patient record, reviewing test results, documenting progress notes, ordering medications, and ordering tests. Outside of rounds, tasks were largely conducted independently and doctors were observed conducting 93.8% (n=212) in a stationary location. The main tasks observed outside of rounds included reviewing the patient record, documenting discharge summaries, ordering medications and ordering tests.

Tasks and Technology

The hospital's hybrid information system required doctors to have access to both computing devices and paper-based medical records. For ward rounds, mobile devices fit the mobile nature in which tasks were conducted by meeting doctors' information needs as they moved throughout the ward. Of the tasks completed on a computer on ward rounds (n=762), almost all were completed with the use of mobile devices (n=759; 99.6%). The mobile cart design of the COWs also provided a convenient means to store items, allowing doctors to transport several paper-based medical records at a time.Outside of rounds, desktop computers provided a better fit. Of the computerised tasks conducted outside of rounds (n=120), the substantial majority were completed on desktop computers (n=116; 96.7%). The desks on which the computers were stationed provided space to set opened paper-based medical records so that paper-based and electronic information could be viewed at the same time.

Doctors and Technology

While conducting ward rounds doctors had one COW to use amongst the team. One of the junior doctors used the COW on the medical ward, while the senior doctor leading the ward round used the COW on the surgical ward. Thus, on the surgical ward, the junior doctors were observed using paper to document

details regarding the test orders, medication orders, or medication modifications and the information was entered electronically after the ward round.

Several doctors expressed a preference for electronically available information ,as paper-based records were often misplaced and time had to be spent searching for them. While searching for a printed pathology form that he ultimately failed to locate, *Doctor 4* stated that a benefit of information being computerised was that the pathology form could have just reprinted. Doctors also reported a preference for accessing electronic information via mobile devices, with two doctors further explaining that they needed mobile devices for ward rounds as their work practices are mobile *(Doctor 1 and 7)*. While doctors said they liked the COWs, many conveyed a desire for tablet computers: *Doctor 3* stated it would be easier to conduct his work with a tablet computer than with the COWs, which were bulky and had battery issues.

FITT: Nurses, Tasks, and Technology

Nurses and Tasks

Nurses were observed to largely undertake their work independently during medication administration rounds and outside of rounds. Nurses on medication rounds were constantly on-the-move throughout the ward, often going from a patient's bedside, to the medication room to obtain medications, and back to the bedside.

Nurses' main types of tasks on medication rounds included accessing information to prepare medications, documenting administration of medications and reviewing patient records. When conducting tasks outside of rounds nurses tended to have a base location (at a desk or parked COW) where they completed most tasks (n=382; 88.4%). The main tasks observed outside of rounds included reviewing the patient record, documenting notes and patient observations (such as vital signs).

Tasks and Technology

As with doctors, the hybrid information system required nurses to use both computing devices and paper-based medical records. Mobile devices suited mobile tasks of medication round by providing nurses access to information while moving around the ward. Of the computerised tasks on medication administration rounds (n=1,966), the substantial majority were completed using COWs (n=1,885; 95.9%). Desktop computers were considered not to be conducive to medication round tasks *(Nurse 2 and 9)* and were rarely used.

Outside of rounds both mobile and fixed computing devices appeared suited to undertaking tasks. Despite the availability of several desktop computers throughout the ward most of the computerised tasks conducted outside of rounds (n=92) were completed on COWs (n=58; 63%),. As tasks conducted outside of rounds were predominantly non-mobile, the COWs were largely observed being used in a stationary manner. Nurses were often observed in the corridor using the COW as a bench to complete paper-based records.

Nurses and Technology

Several nurses perceived that it was quicker and easier to complete tasks using paper *(Nurse 4, Nurse 5, Nurse 8, and Nurse 11)*. Nurses sometimes used a computing device to access information regarding medications, which they transcribed onto paper and then used the information to prepare the necessary medication. Nurses explained that when they only needed to prepare one or two medications (particularly for medications such as paracetamol or vitamins) they found it quicker and easier not to wheel a COW around with them *(Nurse 12, Nurse 20, and Nurse 21)*. Nurses were also observed using printed handover sheets and scrap pieces of paper to

document notes, such as self-reminders, or to temporarily document vital sign observations that they later transcribed into the paper-based medical record.

The general consensus, however, was that the computer system, particularly mobile devices, provided several benefits over paper-based medical records. A key benefit identified by the nurses was the ease of access to patient information and clinical information when the need for it arose *(Nurse 12, 13, 15, 16, and 19)*. Not having to carry around several paper-based records at a time, being able to stow other necessary items in the COW (such as medications and wound dressings), and not needing to search paper-based textbooks were also seen as benefits *(Nurse 2, 12, 13, and 15)*. *Nurse 2* explained that if there were special instructions on how to administer a medication then that information would appear on the system next to the medication order, and saved time in not having to look in a textbook. The nurse also liked having a COW to conduct medication round tasks, and preferred to sit down and use the desktop computer for tasks outside of rounds.

Other Factors Affecting FITT: Environment

Temporal Rhythms

The timing of medication rounds and ward rounds and the number of available mobile devices was found to influence device use. On the surgical ward eight nurses concurrently undertook the morning medication administration rounds. As there were eight COWs on the ward, nurses explained that there was competition for the use of COWs for morning medication rounds, as doctors were conducting their morning ward round at the same time. *Nurse 8* referred to this competition as a "battle", which doctors often won. *Nurse 2* reported that when no COWs were available she would use a desktop computer and transcribe details onto paper about patients required medications so that she could take the information with her. She would then prepare the medications, administer them to her patients, and locate an available computing device to document the adminstration of the medications. Doctors similarly conveyed it was sometimes a struggle to access a COW when ward rounds occurred at the same time as medication administration rounds *(Doctor 2, 5 and 7)*.

Space Limitations

During medication rounds, nurses were generally observed positioning the COW beside the patient bedside so that they were in reach of the patient's bedside drawers (where most medications corresponding to the patient's specific needs were kept). However, several instances were observed where lack of space directly beside the patient bedside was an issue and the COW had to be positioned elsewhere in the room. Similarly, doctors on ward rounds would usually use the COW at the foot of the patients' bed but when lack of space directly at the bedside was an issue doctors had to find adequate space to use the COW elsewhere within the patient room.

Infection Control

In instances where the patient was quarantined in an infection control room both doctors and nurses were observed having to use COWs in the corridor just outside the patient's room. This often required them to walk back and forth between the patient bedside and the COW when needing to access or document information.

Low Battery

On occasions when low battery was an issue, nurses plugged the COW into an available power outlet either in the patient room or in the corridor, and moved between the patient bedside and the COW when they needed to access to document information. Doctors were observed plugging the COW into a power outlet in the corridor while they engaged in discussions

in between visiting patients. When moving on from the corridor to visit their next patient, doctors were observed unplugging the COW from the power outlet in order to take the device with them to the bedside despite the low battery.

Discussion

We found that clinicians' use of devices could be largely attributed to a relationship between attributes of the tasks and attributes of the technology. The mobile nature of ward rounds and medication administration rounds suited the mobile nature of COWs, while the substantially less mobile nature of tasks conducted outside of rounds suited the stationary nature of desktop computers. However, this relationship alone did not account for all the device use behaviours that were observed.

Ammenwerth et al.'s fit between individuals, task, and technology (FITT) framework, posits that the optimal use of technology is dependent on the interaction between three key dimensions: attributes of users, tasks, and technology [8]. A distinctive feature of the FITT framework, compared to other theoretical frameworks aimed at understanding technology use, is the emphasis on the interaction between users and tasks and the subsequent impact that this interaction has on the use of technology. Application of the FITT framework in this present study aided in the identification of distinct differences between the attributes of the observed user groups and how they conduct tasks. Nurses were found to largely conduct their work independently and, hence, could select the computing device that they perceived provided the best fit for their tasks. Doctors, on the other hand, worked in teams during ward rounds, thus device use amongst the team was influenced by the team leader. When junior doctors were not the primary users of the COW it meant they had to document patient treatment decisions on paper, which they then had to enter electronically after the ward round. These findings highlight that, irrespective of a congruent relationship between mobile computing devices and the mobile nature of ward rounds, user attributes affected optimal fit. Thus, validating Ammenwerth et al.'s argument about the importance of the user dimension when examining the use of technology.

Nonetheless, even when adequate fit between the attributes of users, tasks, and technology was attained additional factors related to the environment were found to affect the use of technology. Environmental attributes included: department type (levels and timing of ward activities); physical environment (space, layout, power outlet locations); or organisational policies and procedures (infection control requirements).

Environment Factors Affecting Use of Technology

One of the key factors found to affect the use of devices was the temporal rhythms of the ward. When the timing of ward rounds and medication administration rounds coincided it resulted in more clinicians requiring the concurrent use of COWs than were available. Nurses that were not able to access a COW reported instead having to use a desktop computer. As desktop computers were not available at the patient bedside, where information was largely needed during medication administration rounds, nurses would transcribe information from the desktop computer onto paper. Although transcribing allowed information to be taken to the bedside it also introduced the potential for errors, as well as negatively impacting efficiency as a result of the additional documentation.

The presence of infection control rooms on a ward was also found to affect the use of devices. In cases where a patient was isolated, clinicians could not take the COW into the room. Instead they had to leave the COW outside the room and walk between the patient bedside and the COW when needing to

access or document information. Similarly, battery issues and lack of space at the bedside, often due to the presence of other medical equipment or furniture, impacted clinicians' ability to use COWs at the bedside. Andersen et al., who observed clinicians' use of devices on hospital wards, similarly found that lack of space was a critical factor preventing the use of COWs at the patient bedside [11]. A survey of nurses reported that a lack of space resulted in the need to undertake double documentation: using paper to document information at the bedside and then copying the data onto the COW [12].

The commonality amongst the identified environmental factors is that they restricted the ability of clinicians to use COWs at the patient bedside and, hence, impacted on the use and optimal fit of computing devices. This meant that, not only were the benefits associated with having a mobile device at the bedside, such as ease of access to information, subsequently lost but the potential for errors was introduced due to clinicians having to work around the restraints imposed by these factors. Often temporary paper resources, such as nurses' handover sheets or scrap pieces of paper were used as an interim means by which clinicians overcame factors affecting the use of computing devices. Examples included nurses transcribing information from desktop computers onto paper when COWs were unavailable or junior doctors' documentation of treatment decisions when senior doctors were using the COW. Temporary paper resources used in such instances have been described as "transitional artefacts" which are used to bridge a gap between clinical workflow needs and formal electronic documentation [13]. The persistence of temporary paper resources in such cases could potentially be decreased, or even eliminated, by addressing environmental factors hindering direct electronic information access or input. For example, evaluating ward activities to identify peak periods of demand for technology and either ensuring sufficient device availability or adjusting the timing of activities. Similarly, providing a dedicated device, that can be sanitised, within each infection control room.

Extending the FITT Framework: FITTE

The above findings highlight the importance of examining environmental factors as an entity in and of themselves and suggest the need for an extension to the FITT framework. While the dimensions of individuals, tasks, and technology were found to be critical in assessing fit, ultimately it was factors within the environment, such as the temporal rhythms of a ward, the presence of infection control rooms, or space limitations, which influenced the optimal use of technology. Presently, the FITT framework enmeshes factors related to the environment (or context) of a setting as an intrinsic part of the user attribute. Yet, context is recognised to be a critically important factor affecting the use of technology [14; 15].

The addition of a separate and overarching "environment" dimension to the FITT framework would aid in the assessment of factors related to the context in which users, tasks, and technology operate. Thus, we propose the FITTE framework: whereby optimal adoption and use of technology is determined by the fit between individuals, tasks, technology and environment (Figure 1). The distinction of environment as a separate dimension is necessary as it is likely that this is where the key differences between different sites and settings lie. As such, an environment dimension may help to explain why a technology that works in one setting does not show the same success in another setting. Future research could look at using a multi-dimensional work observation tool, such as the Work Observation Method By Activity Timing (WOMBAT) [16], to obtain data about users, tasks, technology and environment that could be evaluated through the lens of the FITTE framework.
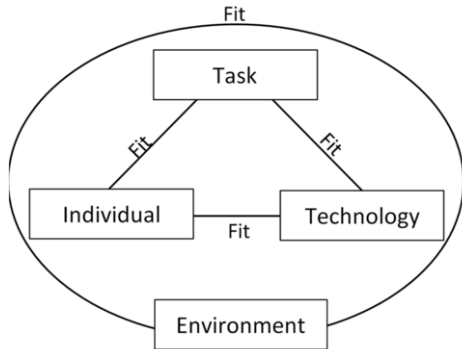
Figure 1 – FITTE Framework: Optimal Adoption and Use of Technology Depends on the Fit between Individuals, Tasks, Technology and Environment.

Limitations

As with any observational research there is a possibility of introducing the Hawthorne effect, where participants modify their behaviour in the presence of the researcher. While it cannot be known whether participants changed their behaviour, given that the focus of the study was examining how computing devices fit clinicians' work and that no assessment of quality was being made, any magnitude of behavioural change is likely to have had minimal influence on the study findings.

Conclusions

Due consideration needs to be given to all the factors that may affect device use, as technology can significantly impact the efficiency and effectiveness of clinical work practices, both in intended and unintended ways. In particular, it is important to identify the environmental nuances that may affect the ideal fit of computing devices. The FITTE framework provides a means to evaluate the use of technology by explicating the relationships between users, tasks, and technology, and the environment in which they operate to identify factors leading to either the failure of or the successful adoption of technology.

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