IT-acceptance by autonomous professionals: Factors that contribute to success or failure

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Voorwoord

Toen ik in juli 2006 als wetenschappelijk medewerker startte op de Dienst Radiologie van het UZ Gent, kon ik me moeilijk voorstellen dat ik nu, 6 jaar later, afscheid zou nemen van het UZ met dit proefschrift. Ik wil iedereen bedanken die in de loop van deze 6 mooie, boeiende en soms zware jaren een rol gespeeld hebben in het tot stand komen van dit proefschrift.

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List of abbreviations

(C)DSS	(Clinical) Decision Support System
(C)POE	(Computerized) Physician Order Entry
Adj.	Adjusted
AGFI	Adjusted Goodness-of-Fit Index
ANX	Anxiety
ATT	Attitude toward behavior
BI	Behavioral Intention
C-TAM-TPB	Combined TAM and TPB
CFI	Comparative Fit Index
CIO	Chief Information Officer
CIS	Clinical Information System
CT	Computerized Tomography
d-TPB	decomposed Theory of Planned Behavior
EE	Effort Expectancy
EMR	Electronic Medical Record
EOU	Perceived Ease of Use
FC	Facilitating Conditions
Freq	Frequency (of Use)
GFI	Goodness-of-Fit Index
ICR	Internal Consistency Reliability
ICT	Information and Communication Technology
IS	Information System
IT	Information Technology
M	Mean
mcc	Multiple Correlation Coefficient
N/A	Not Applicable

NB	Net Benefits
ns	Not significant
PACS	Picture Archiving and Communication System
PBC	Perceived Behavioral Control
PE	Performance Expectancy
Phys	Physician
PU	Perceived Usefulness
Rad	Radiologist
RMSEA	Root Mean Square Error of Approximation
SD	Standard Deviation
SCI	System Continuance Intention
SCT	Social Cognitive Theory
SE	Self-Efficacy
SI	Social Influence
Sign	Significance
SN	Subjective Norm
s-r Use	Self-reported Use
T1	Time 1
T2	Time 2
T3	Time 3
TAM	Technology Acceptance Model
TAM2/TAM3	Technology Acceptance Model version 2 or 3
Tech	Technologist
TPB	Theory of Planned Behavior
TRA	Theory of Reasoned Action
US	User Satisfaction
UTAUT	Unified Theory of Acceptance and Use of Technology
VOL	Voluntariness

1 General Introduction

Some parts of this chapter are based on:

Pynoo, B., Devolder, P., Tondeur, J., van Braak, J., Duyck, W., & Duyck, P. (2011b). University students' acceptance of a web-based course management system. In T. Teo (Ed.), Technology acceptance in education: Research and issues (pp. 125-144). Rotterdam: Sense Publishers.

Pynoo, B., Devolder, P., Duyck, W., van Braak, J., Sijnave, B., & Duyck, P. (2012). Do hospital physicians attitudes change during PACS implementation? A cross-sectional acceptance study. International Journal of Medical Informatics, 81(2), 88-97.

Pynoo, B., Devolder, P., Voet, T., Sijnave, B., Gemmel, P., Duyck, W., et al. (Submitted). Assessing hospital physicians' acceptance of clinical information systems: A review of the relevant literature. Psychologica Belgica.

Chapter 1

General Introduction

Introduction

In today's information society, computers and the Internet are omnipresent and their importance is only likely to rise, both in our daily life and on the work floor. Throughout this dissertation we will focus on information technologies (ITs) that are used (or intended to be used) by two populations, hospital physicians and teachers. A characteristic shared by these populations is that they have a large degree of autonomy during the performance of their job on how to achieve their goals. Moreover, unlike in business settings where IT is primarily introduced for economic or efficiency reasons, IT in healthcare and education serves primarily for different goals. In addition to IT's supportive role in both healthcare and education, the higher goals of IT in these settings are enhancing quality of patient care, and preparing pupils or students for their future life. Both the healthcare and educational setting have long lagged behind in adopting IT compared to business settings. In the past few years, awareness of the potential benefits of IT for healthcare and education has increased in policy makers, and efforts are made to catch up both in healthcare and education.

In theory, introducing a technology in a specific user group seems straightforward. Based on input of potential / future users, product managers come up with use cases, upon whose specifications programmers design a system which is subsequently implemented within budget and on-time and used by the intended end-users, producing the expected outcomes and benefits. This is, however, not supported by the practice. In fact, a majority of technology implementations are not a success (Devos, 2011; Legris, Ingham, & Collerette, 2003). According to the CHAOS reports of the Standish Group, about one fourth of all IS-implementations are abandoned before they were completed, whereas about half of IS-implementations are challenged (either over time, or over budget, or offering fewer

features and functions than originally specified) (Devos, 2011; Legris, et al., 2003; Standish Group). This illustrates the need for research on identifying the determinants of IT implementation success

It must be stressed that merely introducing an IT does not automatically lead to the expected benefits. In order for an IT to be successfully implemented, time and effort of both the users and the organization is required. The users have to accept and use the new technology. They should take the time to learn to work with the technology and in many cases adapt their way of working. The organization on the other hand should create the optimal conditions to facilitate use of the novel IT.

In order for a technology to be introduced in an organization, several barriers have to be overcome. Paré and Trudel (2007) - building upon the work of Attewell (1992), Tanriverdi and Iacono (1998), and Nambisan and Wang (1999) - discerned four categories of barriers: (a) project/economic: referring to potential financing problems while acquiring an innovation, funding issues, choice of vendor, timeframe adherence; (b) technical: has the organization the knowledge to decide over the hardware, technological infrastructure, the software ...; (c) organizational: is the organization ready to integrate the technology into the existing practices, and to support regular use of the innovation, is training foreseen, is there organizational resistance, do the end-users have the needed equipment at their disposal; and (d) behavioral/human: this refers to resistance to change among the intended users, or users who do not accept the new technology. These barriers can arise on any time during the implementation process, from the moment the implementation is planned until the implementation has succeeded.

Different (f)actors are involved during the implementation of a technology, or when a person starts using an existing technology, and these also affect each other. Main (f)actors are the technology, the user and the organization/implementers.

The focus in this dissertation is on the user. Therefore the following premises are set: (a) the cause for failure lies not always within the technology; (b) organizations insufficiently explain to the users why they should use the new technology: they address the what,

where, when and who question, but do not (or insufficiently) explicate why; and (c) measures or actions taken by the organization to promote the (new) technology should be reflected in users' attitudes or reactions towards the technology (Lewis, Agarwal, & Sambamurthy, 2003). These premisses are illustrated by two cases in which a technology was introduced with varying success.

Case 1: Aarts and Berg (2006): Same systems, different outcome

Aarts and Berg (2006) describe the implementation of an identical Computerized Physician Order Entry (CPOE, an electronic prescribing system aimed at intercepting prescription errors) system in a university (A) and a regional (B) medical center. Setting A aimed to become a reference center for clinical computing with this CPOE which replaced an existing system, whereas in setting B the CPOE was aimed at supporting the clinical work by replacing the paper-based way of working. During the implementation process, concerns were raised over the number of screens that had to be surpassed to complete an action, and physicians resisted to use the CPOE in either setting. In the end, physicians were not using the CPOE although they should have been the main users. In setting A only clerks used the CPOE. In contrast, in setting B the CPOE was used for both administrative (clerks) and clinical (nurses) tasks, and therefore the management decided to omit authorization screens intended for physicians in order to facilitate use of the CPOE.

Case 2: Lapointe and Rivard (2005): Resistance to IT implementation.

Lapointe and Rivard (2005) discuss three hospitals (two university, one private) in which two different electronic medical record (EMR) systems were implemented. At the introduction of the EMR, physicians were either neutral towards the system or they appeared to adopt the EMR. After the introduction, resistance behavior developed as the physicians experienced that the EMR affected their job performance and in some cases their power vis-à-vis the nurses. The nurses on the other hand were quite positive and happy with the

> *EMR. In all three hospitals the management intervened, reacting to the concerns and resistance of the physicians. In two cases, physicians were (threatened to be) sanctioned by denying them the right to admit patients. In these hospitals, this ultimately led to the EMR being either retracted or severely cut down in functionality. In the third hospital, a university hospital, the management addressed the requests for changes wherever possible and by slowing down the implementation process, thus allowing to improve the module that triggered initial resistance. Four years later all parties are using the EMR and the implementation is considered a success in this hospital.*

These cases illustrate that implementers can never be sure: a system that proves to be successful in one setting might fail in another, while a system that appears to be adopted at first might suddenly trigger resistance. These cases also illustrate that implementation success or acceptance depends at least partly on user characteristics (physician vs. nurses).

Upon the introduction of a technology, an organization should maximize efforts to make the technology a success, including understanding why the users (under)use the technology. One way for organizations to achieve this is by setting up an acceptance study. Based upon the results of such a study, organizations should get a view on the actions they can undertake to promote use of that technology. The purpose of the studies reported throughout this dissertation is to contribute to a better understanding by investigating which factors contribute to physicians' and teachers' (as autonomous professionals) acceptance and use of different technologies (PACS, Smartschool & KlasCement). Hereto, we will draw on existing theoretical frameworks derived from base social psychology and sociology theories.

This chapter proceeds as follows. First, the most important theories and models to assess user acceptance are presented, followed by an introduction on the populations and technologies under study. Then we will propose the research questions and how they fit within the studies in this dissertation.

Theoretical framework: Acceptance of Information Systems

To assess physicians' and teachers' technology acceptance, we will draw on existing frameworks developed and utilized in previous IS-acceptance research. In the past, researchers put much effort in the search for the optimal set of variables to explain and predict acceptance, typically measured as behavioral intention, attitude and / or use. This resulted in a plethora of models that were subsequently refined and modified, in which variance explained (Adjusted R square) fluctuates typically within the range .35 - .55 (e.g. Davis, Bagozzi, & Warshaw, 1989; Dishaw & Strong, 1999; Szajna, 1996; Taylor & Todd, 1995b; Venkatesh, 2000; Venkatesh & Speier, 1999), with exceptions from as low as .04 (Adams, Nelson, & Todd, 1992) to .70 (Davis, 1989; Mathieson, 1991; Venkatesh, Morris, Davis, & Davis, 2003). Below, we will first give a brief overview of the most important (technology) acceptance models / theories used throughout this dissertation, ending with a section on the operationalization of technology acceptance.

IS-acceptance theories

Acceptance models emerged from two distinct research traditions: on the one hand from base social psychology theories such as Theory of Reasoned Action and the Social Cognitive Theory, and on the other hand from sociology with the Diffusion of Innovations Theory (Rogers, 1995). Yet, one line of models stands out, those stemming from the Theory of Reasoned Action (Fishbein & Ajzen, 1975), with the Technology Acceptance Model (Davis, 1985) as the dominant model. The constructs that are used in these models are listed in Table 1.1, with a representative item that is adapted to the technologies studied throughout this dissertation.

The basic assumption underlying user acceptance theories is that a person's individual reactions to using an IT influence his/her intention to use and use of that IT, while intention influences her/his actual use of that IT (Venkatesh, et al., 2003). Historically, two types of individual reactions towards objects were discerned (Fishbein & Ajzen, 1975): affective reactions (or attitudes) and cognitions (or beliefs). Attitudes can be considered as the

amount of affect for or against some object, whereas beliefs refer to the information one has about an object.

Theory of Reasoned Action

According to the Theory of Reasoned Action (TRA; Figure 1.1), behavioral intention (BI) predicts the performance of behaviors that are under a person's volitional control. Intention is modeled as a function of attitude (ATT) towards the behavior: "an individual's positive or negative feelings (evaluative affect) about performing the targeted behavior" (Fishbein & Ajzen, 1975); and subjective norms (SN): "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); representative items of attitude and subjective norms are in Table 1.1. According to this theory, external variables that influence behavior do so only indirectly by influencing attitude, subjective norm, or their relative weights. This theory was extended in two directions, leading to the Theory of Planned Behavior (TPB; Figure 1.2) (Ajzen, 1991) and the Technology Acceptance Model (TAM; Figure 1.3) (Davis, 1989).

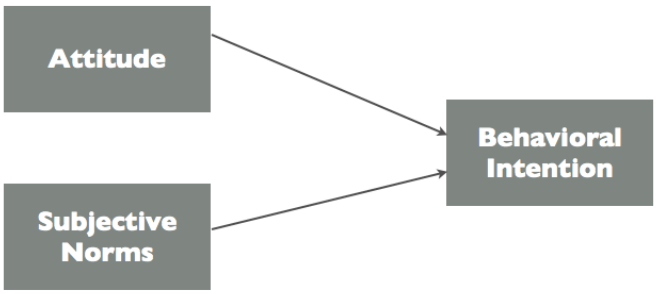

Figure 1.1 Theory of Reasoned Action

Theory of Planned Behavior

The most important limitation of the TRA is its' restriction to predicting behaviors that are under a person's volitional control (Ajzen, 1991; Sheppard, Hartwick, & Warshaw, 1988). To overcome this problem, the theory of reasoned action was extended with one construct,

perceived behavioral control (PBC), to account for conditions where individuals do no not have complete control over their behavior, thus forming the Theory of Planned Behavior (Ajzen, 1991). Perceived behavioral control reflects "perceptions of internal and external constraints on behavior" (Venkatesh, et al., 2003), and it can vary across situations and actions. It serves as a predictor of both behavioral intention and the behavior.

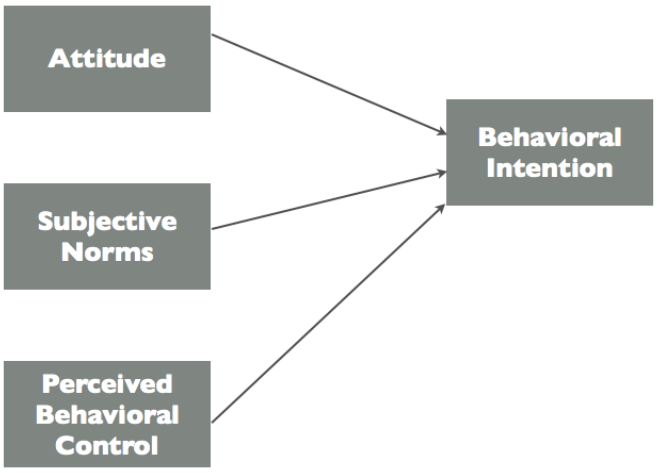

Figure 1.2 Theory of Planned Behavior

Technology Acceptance Model

Davis and colleagues (Davis, 1985, 1989; Davis, Bagozzi, & Warshaw, 1989) came up with the Technology Acceptance Model, an adaptation of the Theory of Reasoned Action specifically tailored to study the acceptance of computer-based information systems. In TAM, two beliefs are included as antecedents of attitude: perceived usefulness (PU), "the degree to which a person believes that using a particular system would enhance his job performance" (Venkatesh, et al., 2003), and perceived ease of use (EOU), being "the degree to which a person believes that using a particular system would be free of effort" (Venkatesh, et al., 2003). In this first version, subjective norms was omitted, but in later versions of TAM (TAM2 or extended TAM; Venkatesh and Davis, 2000), subjective norms was again added as a predictor of intention for cases in which use of the technology was mandatory. Several versions of TAM exist and in some versions, the attitude construct is excluded so that perceived usefulness and perceived ease of use are modeled as direct

antecedents of behavioral intention. In TAM3 (Venkatesh & Bala, 2008), the latest version of TAM, practitioners are given a better insight in the actions they can take to influence the two core beliefs of TAM. The abundant previous research on TAM showed that it is a very powerful and parsimonious model to study technology acceptance (Taylor & Todd, 1995b; Venkatesh, et al., 2003). Some researchers even claim that the model is too dominant and has over conquered the field of research (Straub & Burton-Jones, 2007).

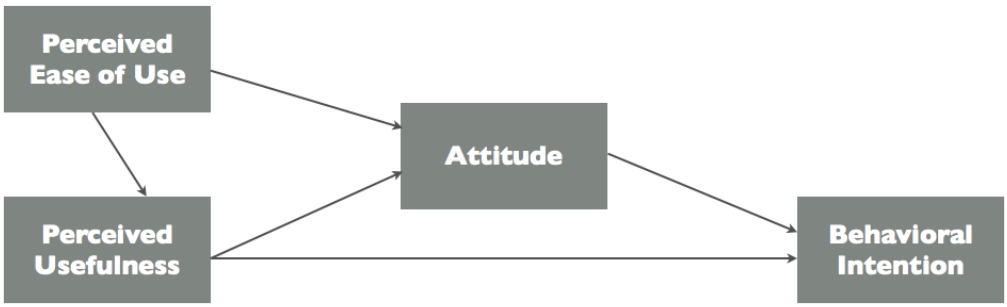

Figure 1.3 Technology Acceptance Model

Table 1.1 Overview of the constructs in TRA, TAM, TPB and UTAUT, and a representative item

Construct	Representative item, adapted from Venkatesh, et al. (2003) to the technologies studied in this dissertation
Anxiety[a]	It scares me to think that I could lose a lot of information using Smartschool by hitting the wrong key
Attitude	Using Smartschool is a bad/good idea
Behavioral Intention	I intend to use KlasCement in the next <n> months
Effort Expectancy	I would find PACS easy to use
Facilitating Conditions	A specific person (or group) is available for assistance with Smartschool difficulties
Perceived Behavioral Control	I have the knowledge necessary to use Smartschool
Perceived Ease of Use	I would find it easy to get PACS to do what I want to do
Perceived Usefulness	Using KlasCement would improve my job performance
Performance Expectancy	Using Smartschool enables me to accomplish my tasks more quickly
Self-efficacy[a]	I could complete a job or task using PACS if there was no one around to tell me what to do as I go
Social Influence	People who influence my behavior think that I should use KlasCement
Subjective Norms	People who are important to me think that I should use PACS

Note: [a] constructs from Social Cognitive Theory (Bandura, 1986), not withheld for UTAUT

Combined TAM and TPB

As both the technology acceptance model and the theory of planned behavior stem from the theory of reasoned action and extend this theory in a different manner, it makes sense to integrate both models into one, thus forming C-TAM-TPB, see Figure 1.4, which is also referred to as augmented TAM or decomposed TPB (Chau & Hu, 2001, 2002a, 2002b; Taylor & Todd, 1995a). An advantage of this model is that it covers more ground than the original models, whereas it remains easy and fast to administer. Another advantage is that there is no need to develop new scales as the scales of TAM and TPB have been administered in hundreds of studies, see for example the meta-analyses of King and He (2006), Manning (2009), and Schepers and Wetzels (2007).

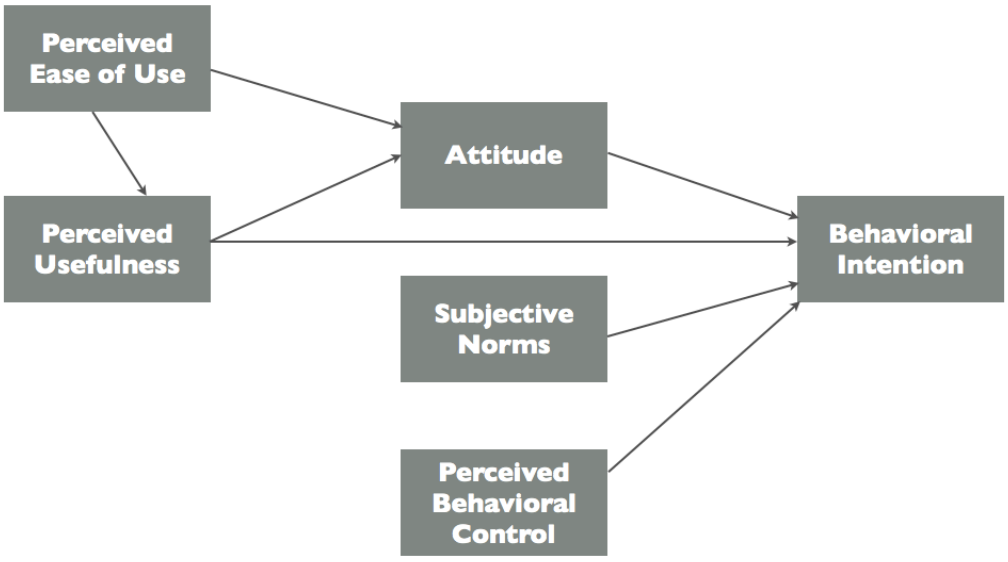

Figure 1.4 Combined TAM and TPB

Unified Theory of Acceptance and Use of Technology

To halt the plethora of model refinements and extensions, and synthesize the abundant existing knowledge on IS-acceptance, Venkatesh, et al. (2003) reviewed the existing (technology) acceptance models and constructed the Unified Theory of Acceptance and Use of Technology, following an exploratory and a validation study. First seven factors were identified that influenced technology acceptance, see Table 1.2. In the end, only four

factors were withheld as predictors of behavioral intention and use: (1) performance expectancy (PE): this encompasses perceived usefulness (Davis, 1989) and other constructs regarding the usefulness of the technology and is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh, et al., 2003); (2) effort expectancy (EE): this encompasses constructs concerning the ease of use of the technology, such as perceived ease of use (Davis, 1989), and is defined as "the degree of ease associated with the use of the system" (Venkatesh, et al., 2003); (3) social influence (SI), encompassing constructs relating to norms in the social environment of the individual on his/her use of the technology, e.g. subjective norms (Fishbein & Ajzen, 1975). Social influence is defined as "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh, et al., 2003); and (4) facilitating conditions (FC): this construct encompasses training, support, infrastructure, and knowledge. This construct was distilled from perceived behavioral control (Ajzen, 1991), facilitating conditions (Thompson, Higgins, & Howell, 1991) and compatibility (Moore & Benbasat, 1991). Facilitating conditions is defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh, et al., 2003). The three constructs that were omitted from UTAUT were attitude, which was estimated to be redundant in the presence of both effort and performance expectancy, and self-efficacy and anxiety because their influence on behavioral intention was completely mediated by effort expectancy. Next to the four predictor variables, UTAUT also contains four variables that moderate the relationships between the predictors and intention or use: gender, age, experience with the technology and voluntariness of use. Although conceived as a synthesis of the existing models, UTAUT may be situated within the line of models derived from the Theory of Reasoned Action and can thus also be considered as an extended version of the technology acceptance model. This is shown in Table 1.2, whereas UTAUT is depicted in Figure 1.5.

Table 1.2 Overview of the constructs identified by Venkatesh, et al. (2003) and the constructs they are related to in previous models.

Construct in UTAUT[a]	TRA	TAM	TAM2	TAM3	TPB	C-TAM-TPB
Performance Expectancy		PU	PU	PU		PU
Effort Expectancy		EOU	EOU	EOU		EOU[b]
Social Influence	SN		SN	SN	SN	SN
Facilitating Conditions				FC	PBC	PBC
Attitude	ATT	ATT[c]	ATT[c]	ATT[c]	ATT	ATT
Self-efficacy						
Anxiety						

Notes: [a] Only the constructs in bold are included in UTAUT; [b] serves as an antecedent of ATT; [c] included as a dependent variable in some conceptualizations of TAM

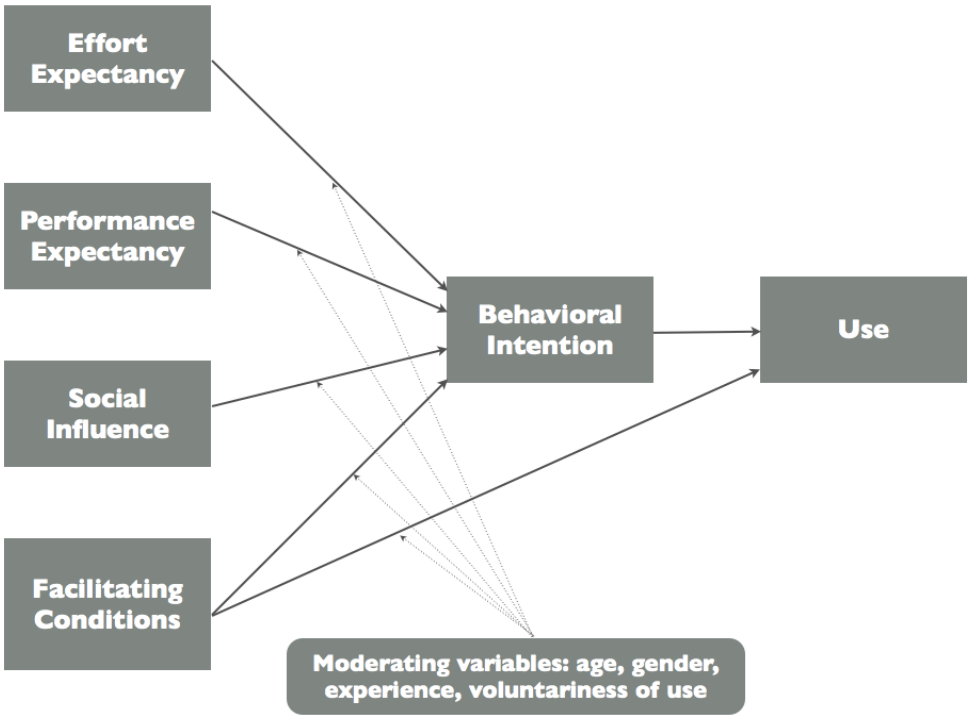

Figure 1.5 Unified Theory of Acceptance and Use of Technology

An empirical test of UTAUT found that UTAUT explained 70% of the variance in intention, hereby outperforming the models it stems from (Venkatesh, et al., 2003). By reaching this level of variance explained, UTAUT is claimed to be the "ultimate" model to study the acceptance of information systems, gathering the existing knowledge.

Operationalizing technology acceptance

Acceptance models aim to explain or predict as much of the variance in use or user acceptance as possible. User acceptance has been defined as "the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support" (Dillon & Morris, 1996). From this definition, several ways to measure user or technology acceptance can be proposed. The most common operationalizations of acceptance are listed below:

- *Use or use behavior* (Halawi & McCarthy, 2008; Landry, Griffeth, & Hartman, 2006; Venkatesh, et al., 2003): either observed or self-reported. Both observed and self-reported use can be measured in multiple ways. Observed use has been measured as duration of use (Venkatesh, et al., 2003) or by recording the actions a subject undertakes while completing a task (Shapka & Ferrari, 2003), and self-reported use as frequency, duration, intensity, extent... A problem with observed use is that it requires subjects to have at least some experience with the technology.
- *Behavioral intention* (Marchewka, Liu, & Kostiwa, 2007; Venkatesh, et al., 2003): the models mentioned above are also called intention-based models, as they take behavioral intention - as an antecedent to use - as a measure for acceptance. So, behavioral intention is the key construct in this line of research. Unlike observed use, intention can be used in situations in which the technology has already been introduced, as well as for cases where it is still under planning.
- *Behavioral expectation* (Davis, 1985; Venkatesh, Brown, Maruping, & Bala, 2008): this measure is closely related to and has frequently been confounded in the past with behavioral intention (Warshaw & Davis, 1985a). Unlike intention, behavioral expectation takes into account that something might interfere between the intention and the actual performance of the behavior. Behavioral expectation has been found to correlate more strongly with behavior than behavioral intention (Warshaw & Davis, 1985b), but it passed into disuse due to its conceptual overlap with behavioral intention (Warshaw & Davis, 1985a).

- *Attitude toward use of the technology*: attitude already appeared in the first version of TAM. Attitude has been used as a measure for acceptance in both mandatory (Brown, Massey, Montoya-Weiss, & Burkman, 2002; Pynoo, et al., 2007) and voluntary (Teo, Lee, & Chai, 2008) settings.

Throughout this dissertation, attitude, behavioral intention and use will be included as measures for acceptance. In view of the conceptual overlap with and dominance of behavioral intention in this field of research, behavioral expectation will not be taken into account. Use will be measured as self-reported frequency of use and observed use from log files.

Autonomous professionals: Physicians and teachers

As stated in the title of this dissertation, the acceptance of autonomous professionals will be studied. In the past, a variety of populations has been studied in technology acceptance research. The largest part of the studies involve students (studies performed in academic settings) or business workers (most studies are performed in business settings). In general, theory-building studies are performed with students or business workers, whereas specific populations are utilized to perform exploratory research or to assess whether other variables influence technology acceptance in that specific population. The practice of utilizing students and business workers in theory building studies, might pose problems when other occupations are involved. Technologies are in most cases introduced for a specific purpose, and this is definitely the case for job-related technologies. Students who don't use a mandated technology are not that much at risk; not using that technology might just have an impact on their grades. On the other hand, for business workers in a bureaucratic organization, such as a bank, using a computer is vital for a bank employee and s/he has no option - except losing his/her job - but using the given technology. A different story arises when it comes to occupations with a large degree of autonomy in their job-performance, such as physicians and teachers, who - because of their autonomy - cannot really be mandated (and sanctioned) to use a specific technology. Hence, the primary aim of the term 'autonomous professionals' in the title is to indicate that the studies reported here are conducted in populations of professional users and not students,

and moreover professional users with a large degree of freedom during the performance of their job.

The term "professional" also has implications when evaluated from a sociological perspective. Professionalism and professionalization can be regarded in different ways. One constant, medicine is always a profession, whereas teaching is either labeled a profession (in the International Standard Classification of Occupation, version of 1988) or a semi-profession. Historically, sociologists made a distinction between professions (medical, legal, clerical, academic, engineering, and architecture) and non-professions. In this view, teaching is a semi-profession mainly due to the practice of teaching not being based upon academic knowledge (Dreeben, 2005; Etzioni, 1969; Verhoeven, Aelterman, Rots, & Buvens, 2006). Meanwhile, efforts are made to further professionalize the teaching practice. Verhoeven et al. (2006) describe three processes towards professionalization: (1) the development of specialized knowledge supported by university education; (2) control over the market of clients with the exclusion of other professionals from that market; and (3) the organization of a control system by the profession itself for the control of the delivery of services to the exclusion of a governmental agency. In this respect medicine is serving as the lodestar (Dreeben, 2005) and a lot of progress has been made since 1985 (Moore Johnson, 2005; Verhoeven, et al., 2006). Yet, although both physicians and teachers hold a high status in our society, albeit physicians higher than teachers (Verhoeven, et al., 2006), a large difference persists in terms of education level and salary.

Labeling professionals as autonomous is somewhat a pleonasm as autonomy is crucial in discerning professional from proletarian work (Hargreaves, 2000). Autonomy is important in the professionalization (or de-professionalization) of teaching. It has been argued that teachers are losing autonomy since their autonomy peaked in the sixties to early eighties (Hargreaves, 2000), and that with the advent of computer technologies, autonomy gets lost, which leads to the deprofessionalization of the teaching profession (Runté, 1995). Yet, other authors state that teachers still decide on when to use computers, and that school administration has only a limited impact on this decision (Jedeskog, 1998; Ma, Andersson, & Streith, 2005).

A parallel can be drawn with the medical world in which physicians might also feel threatened in their professional status or fear a loss of power by the introduction of clinical information systems (Lapointe & Rivard, 2005).

Important for this dissertation is that physicians and teachers share two important characteristics, when it comes to the performance of their job and the use of computers: (a) their autonomy while performing their job and their amount of freedom on how to reach their goals; and (b) both teachers and physicians can perform their job without constantly having to use a computer (although they could be forced to). Below, an overview of the literature on physicians' and teachers' technology acceptance is presented.

Hospital physicians' technology acceptance

Through the Web-of-Science database, ten studies were identified on hospital physicians' acceptance of clinical information systems (CIS), see Table 1.3. The search was narrowed down to physicians working in hospitals for two reasons. First, cost is a major impediment for a CIS to be implemented (Pare & Trudel, 2007), and in small practices the cost might be the most determining factor for not adopting such technology. Second, a physician in a small practice who does not like a system can more easily abandon its use. If a hospital physician abandons use of a technology, this has also an impact on other clinical users (nurses, other physicians) who rely on information entered through that technology.

The dominance of the models derived from the theory of reasoned action is reflected in Table 1.3: eight studies utilized TAM, TPB, C-TAM-TPB or UTAUT. Therefore, the findings from the review were combined within the framework of UTAUT as shown in Figure 1.6 in which the 'other factors' are the constructs that could not be classified within one of the four UTAUT constructs.

Table 1.3 Overview of studies on hospital physicians' acceptance of CIS

	Clinical Information System	Setting	Population	Timing of the Study	Model	Dependent variable (Variance Explained)
(A) Chang, Hwang, Hung, & Li (2007)	CDSS (prototype)	3 hospitals (a medical center, a district teaching, and a local hospital	115 physicians	system is in use	UTAUT	BI (.28) s-r Use (.43)
(B) Bhattacherjee & Hikmet (2007)	CPOE	acute care hospital	129 physicians	system is in use by 25% of the hospital physicians	TAM + resistance to change	BI (.55)
(C) Ilie, Van Slyke, Parikh, & Courtney (2009)	EMR	multi-site acute care community hospital	199 physicians	system is in use by a large majority of physicians	TAM + logical & physical accessibility	BI (.64)
(D) Duyck, Pynoo, Devolder, Adang, et al. (2008b)	PACS	university hospital	19 radiologists & 37 technologists	pre-implementation	UTAUT	BI (.48)
(E) Paré, Lepanto, Aubry, & Sicotte (2005)	PACS	multi-site university hospital	24 radiologists, 77 technologists & 117 physicians	system is in use	D&M IS success framework. Dependent variables: system continuance intention (SCI); net benefits (NB); user satisfaction (US)	SCI (Phys . 43; Rad .41; Tech .47) NB (Phys . 34; Rad .23; Tech .40) US (Phys . 64; Rad .79; Tech.59)
(F) Alapetite, Andersen, & Hertzum (2009)	Speech recognition (for EMR)	2 hospitals of one regional association	112 physicians of which 39 on two occasions	T1: one month before introduction; T2: 4 or 8-12 months after introduction (depending on hospital department	UTAUT	overall assessment of speech recognition - attitude (N/A)
(G) Chau & Hu (2001, 2002a, 2002b)	Telemedicine	8 tertiary care hospitals	408 physicians	during the early stages of telemedicine implementation	TAM; TPB; decomposed TPB	BI (TPB: . 32; TAM: . 40/.42; d-TPB: . 42/.43)
(H) Gagnon, et al. (2003)	Telemedicine	32 hospitals in one telemedicine network	220 GP's and 286 hospital physicians	system in use for pediatric cardiology; expected diffusion to other specialties	Theory of Interpersonal Behavior	BI (.81)

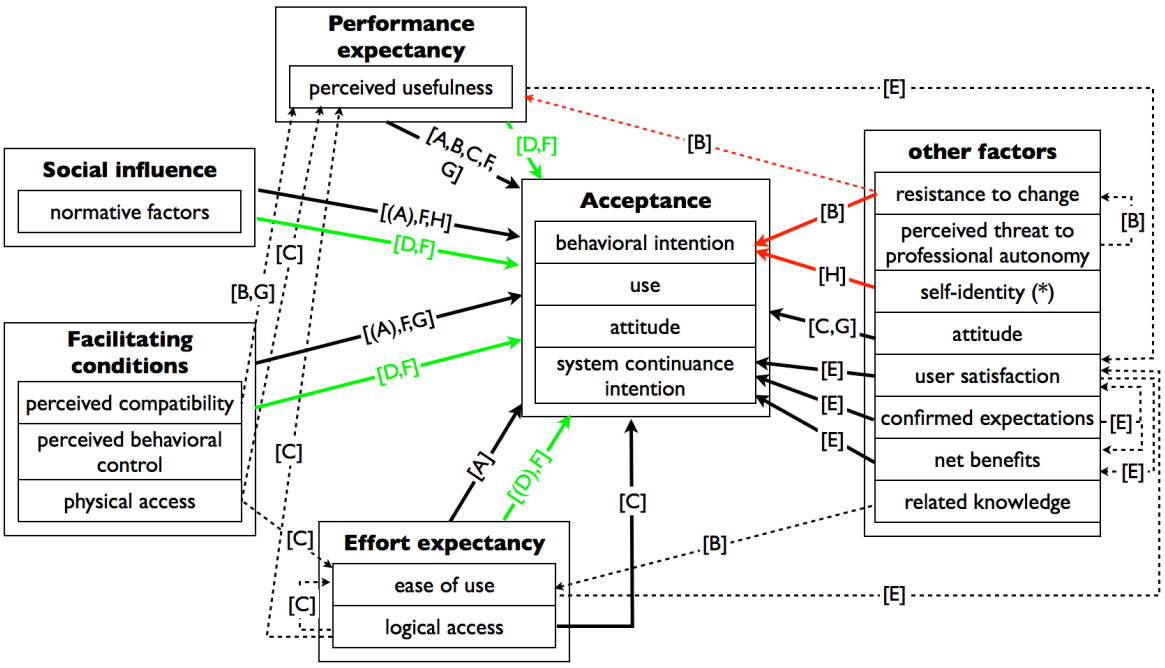

Figure 1.6 Integration of the findings of the review on physicians' acceptance of CIS.

Notes: Letters [A] to [H] refer to the studies in Table 1.3; red lines: negative influence; green lines: pre-implementation; black (and red) lines: CIS already in use; () marginally significant influence; dotted lines: indirect influence on acceptance

The main finding is that performance expectancy (or perceived usefulness) is the most important (and consistent) predictor of CIS acceptance. Only one study found that (PACS-) usefulness was not significant, but only for radiologists (Pare, Lepanto, Aubry, & Sicotte, 2005). Effort expectancy (or perceived ease of use) also predicted CIS' acceptance, but in particular pre-implementation and to a lesser extent post-implementation. Logical access, referring to "the ease of logging into a system" (Ilie, Van Slyke, Parikh, & Courtney, 2009), correlated significantly with ease of use pre-implementation and with acceptance post-implementation. Because of the conceptual overlap with ease of use, logical access was categorized under effort expectancy, although it was originally not considered by Venkatesh, et al. (2003). Subjective norms (or social influence) was also a significant predictor of CIS' acceptance in most cases, albeit marginally in Chang et al. (2007). Only in Chau and Hu (2001, 2002a, 2002b) no effect of social influence on acceptance was found. Facilitating conditions present an interesting case. In the studies that utilized

UTAUT and TPB, facilitating conditions and perceived behavioral control were direct predictors of acceptance, albeit only marginally in Chang et al. (2007). Compatibility "the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters" (Venkatesh, et al., 2003) and physical access "the availability of computers that can be used to access [the technology]" (Ilie, et al., 2009), are significant predictors of perceived usefulness (Bhattacherjee & Hikmet, 2007; Chau & Hu, 2001, 2002a, 2002b; Ilie, et al., 2009) and perceived ease of use (Ilie, et al., 2009), and not of acceptance. This is somewhat strange as compatibility is part of the facilitating conditions construct, whereas physical access shares a large degree of overlap with an aspect of facilitating conditions, namely the availability of resources. Next to these constructs that can be categorized within the UTAUT-framework other factors that influenced physicians' acceptance were resistance to change, attitude and satisfaction. Moderating variables were not explicitly tested. Although UTAUT holds four moderators, none of the studies that tested UTAUT included moderating variables (Alapetite, Andersen, & Hertzum, 2009; Chang, et al., 2007; Duyck, et al., 2008b). Alapetite, et al. (2009) performed two measurements, yet, the influence of growing experience on user acceptance was not statistically tested.

Two more observations stand out. First, we found that, except for Alapetite, et al. (2009), all studies adopted a one shot approach, of which only Duyck, et al. (2008b) assessed acceptance pre-implementation. This difference in timing might explain seemingly inconsistent findings, in particular for effort expectancy (or ease of use). In pre-implementation studies (Alapetite, et al., 2009; Duyck, et al., 2008b) effort expectancy directly influenced acceptance, whereas only Chang, et al. (2007) found this construct to be important post-implementation. Second, as stated above, model refinement or extension studies are often performed within specific populations. This is illustrated by on the one hand successful extensions of TAM with resistance to change (Bhattacherjee & Hikmet, 2007), and logical and physical access (Ilie, et al., 2009), and on the other Duyck, et al. (2008b) who hand found that the prediction of intention by UTAUT could not be improved by adding either attitude, self-efficacy or anxiety.

Teachers' technology acceptance

Articles on teachers' acceptance of educational technologies were also primarily retrieved through the Web-of-Science database. Focus was on in-service teachers, but the distinction with teachers in training is not clearcut as a lot of the latter are already effectively teaching. Acceptance studies on two types of educational technologies were withheld, either studies on general computer acceptance or on the acceptance of supportive educational technologies (technologies whose primary aim is not to be used as a teaching tool). The findings were also interpreted in terms of the constructs in UTAUT and C-TAM-TPB.

Two major lines of research are discerned: on the one hand acceptance studies, as in Table 1.4, and on the other hand more educational research in which computer attitudes, teacher beliefs and the integration of computers in the classroom are studied (e.g. Hermans, Tondeur, van Braak, & Valcke, 2008; Mueller, Wood, Willoughby, Ross, & Specht, 2008; Sang, Valcke, van Braak, & Tondeur, 2010; Shapka & Ferrari, 2003; van Braak, 2001; van Braak, Tondeur, & Valcke, 2004; Williams, Coles, Wilson, Richardson, & Tuson, 2000).

The findings of the acceptance studies are integrated in Figure 1.7. It was found that perceived usefulness was a consistently strong predictor of acceptance, just as in acceptance studies in settings other than education (Gong, Xu, & Yu, 2004; Hu, Clark, & Ma, 2003; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008; Wang & Wang, 2009). Perceived ease of use is a significant predictor of attitude (Gong, Xu, & Yu, 2004; Teo, 2009; Teo, et al., 2008), but its effect on intention was in general not that strong or only indirect through perceived usefulness (Gong, et al., 2004; Hu, Clark, & Ma, 2003; Ma, et al., 2005; Wang & Wang, 2009). The effect of subjective norms on acceptance was inconsistent. Teo, et al. (2008) and Wang and Wang (2009) identified it as a direct predictor of acceptance, while Hu, et al. (2003) found it to be influential only in the beginning, and Ma, et al. (2005) found no effect. Three studies found facilitating conditions (Teo, 2009; Teo, et al., 2008) or the related construct compatibility (Hu, et al., 2003) to influence acceptance indirectly through perceived ease of use and/or perceived usefulness. Other predictors of computer acceptance were attitude (Gong, et al., 2004; Teo, 2009), (computer) self-efficacy (Gong,

et al., 2004; Hu, et al., 2003; Teo, 2009), job relevance (Hu, et al., 2003) and technological complexity (Teo, 2009).

Table 1.4 Overview of studies on teachers' acceptance of educational technologies

	Educational technology	Population	Timing of the Study	Model	Dependent variable (Variance Explained)
[1] Hu, et al. (2003)	PowerPoint	Teachers following a 4 week training program: N=138 at T1; 134 at T2	beginning (T1) and end (T2) of a training program	TAM + job relevance + compatibility + self-efficacy	Intention T1: (.47) T2: (.72)
[2] Ma, et al. (2005)	Computer	84 student teachers of a Swedish university	not specified	TAM2	Intention (.43)
[3] Teo (2009)	Computer	475 student teachers at a teacher training institute	not specified	TAM + self-efficacy + facilitating conditions + technological complexity	Attitude (.45) Intention (.27)
[4] Teo, et al. (2008)	Computer	239 pre-service teachers	not specified	TAM3/UTAUT	Attitude
[5] Gong, et al. (2004)	Web-based learning system	280 teachers in part-time bachelor degree program	not specified	TAM + self-efficacy	Attitude (.41) Intention (.56)
[6] Wang & Wang (2009)	Web-based learning system	268 instructors of 3 Taiwanese universities	not specified	TAM2 + self-efficacy + Information, System & Service Quality	Intention (.69) System use (. 56)

In educational research, several studies found that computer attitudes have a positive influence on the integration of computers in education. In these studies, the term (computer) attitudes may refer to very diverse constructs:

- General computer attitude: this encompasses confidence, anxiety and enjoyment/liking (Hermans, Tondeur, van Braak, & Valcke, 2008; Shapka & Ferrari, 2003; van Braak, 2001)
- Attitude towards computers in the classroom (Mueller, Wood, Willoughby, Ross, & Specht, 2008; Sang, Valcke, van Braak, & Tondeur, 2010; van Braak, 2001) enclosing items related to the usefulness of a computer as a tool.

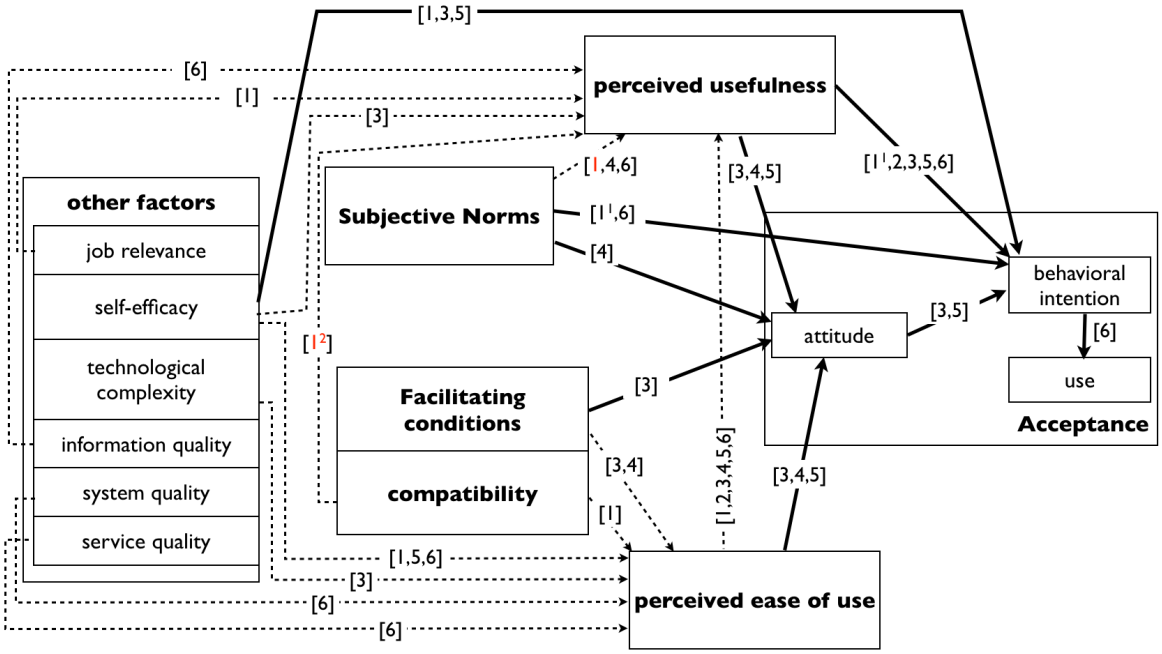

Figure 1.7 Integration of the studies on teachers' acceptance of educational technologies

Notes: Numbers [1] to [6] refer to the studies in Table 1.4; red numbers: negative influence; [1] effect only at T1; [2] effect only at T2; dotted lines: indirect influence on acceptance

The importance of providing facilitating conditions is also a recurrent theme in this line of research. The following constructs that may be considered as categories of facilitating conditions were mentioned as important for integrating computers in education: support (Kadijevich, 2006; Smarkola, 2008; Williams, Coles, Wilson, Richardson, & Tuson, 2000), equipment or ICT resources (Smarkola, 2008; Williams, et al., 2000), and training (van Braak, Tondeur, & Valcke, 2004; Williams, et al., 2000). Other factors with a positive

influence on the integration of computers in the classroom were self-efficacy (Sang, et al., 2010; Shapka & Ferrari, 2003) and teacher beliefs (Hermans, et al., 2008; Mueller, et al., 2008).

Summary of the literature on physicians' and teachers' acceptance

The review of the literature showed that perceived usefulness or performance expectancy is the main predictor of physicians' and teachers' technology acceptance. The three other UTAUT-constructs are also predictors of acceptance, direct or indirect, but their significance depends on the technology, population and timing of the study. Facilitating conditions and to a lesser extent social influence are multifaceted constructs and their effect on acceptance depends on the facets measured. In educational research, a greater weight is given to attitude compared to medical research. Next to these core determinants, several other variables were tested, which were sometimes found to influence physicians' or teachers' acceptance. In conclusion, taking UTAUT or C-TAM-TPB as theoretical framework to conduct the studies will give a good view on physicians' and teachers' acceptance of (newly introduced) job-related technologies.

Technologies studied

Three technologies are studied throughout this dissertation: a Picture Archiving and Communication System in two populations of referring hospital physicians, and two educational portals, Smartschool and KlasCement, in two populations of teachers. These technologies bear in common that the users interact with them through some kind of web page in which s/he can perform different actions and in which several functionalities are provided. The main difference - set aside their target population - is that PACS refers to the infrastructure behind the web page and different brands of PACS exist, whereas Smartschool and KlasCement refer to specific portals. Another difference is that PACS is closely connected with or integrated in other clinical information system such as the electronic medical record system and the radiology information system, whereas Smartschool and KlasCement are rather stand-alone technologies.

Picture Archiving and Communication System (PACS)

Picture archiving and communication systems arose as a logical consequence of the evolution of the medical field of radiology from an analog into a digital workspace. PACS is responsible for distributing and visualizing the now digital images and radiological reports. In the early days of PACS, the main emphasis was put on storage and PACS was regarded as a digital repository of image data. This gradually evolved to the point where many advanced image processing functions are incorporated into the system, such as rendering the human body in 3D. Radiologists and referring physicians (Bramson & Bramson, 2005; Trumm, et al., 2006) use PACS for different purposes: radiologists to review radiological images and write, review or dictate reports (hereto they have to use a radiological workstation); referring physicians to consult radiological images and reports which can be achieved from their own PC, see figure 1.8 for a screenshot. This analog to digital switch opens up new possibilities, e.g. teleradiology (Frohlich, et al., 2007), and PACS is very beneficial for its users, yet it has a great impact on work methods as is shown in Figure 1.9.

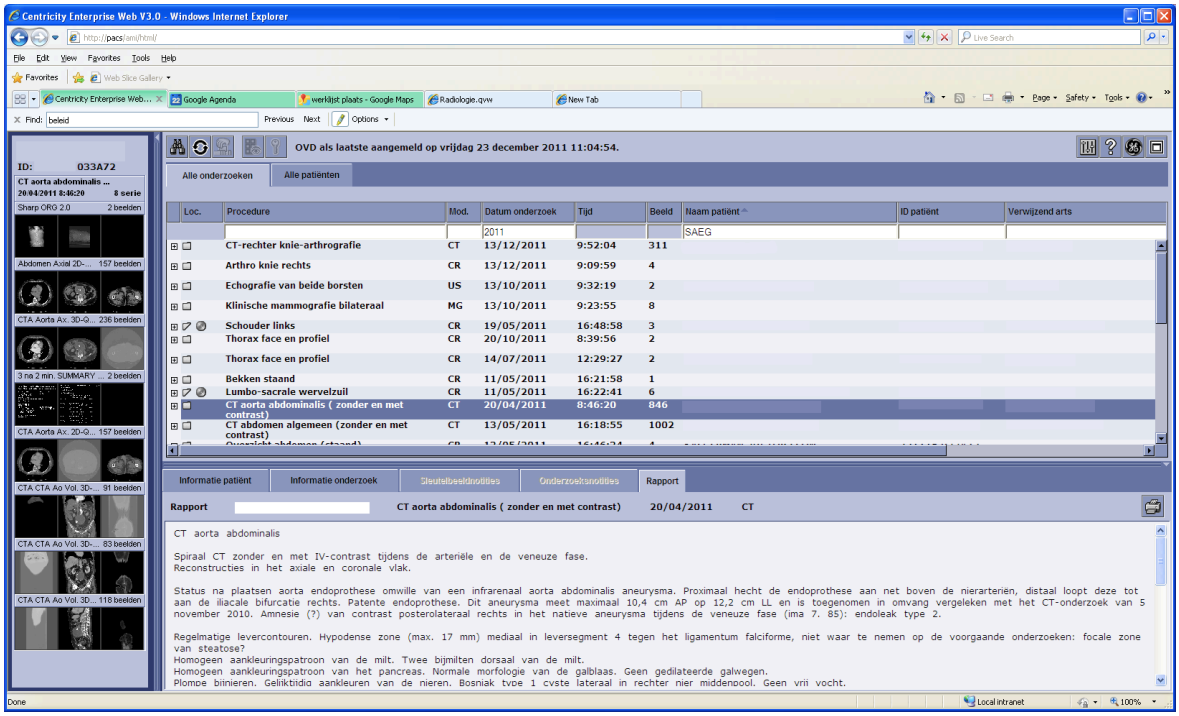

Figure 1.8 Screenshot of PACSweb

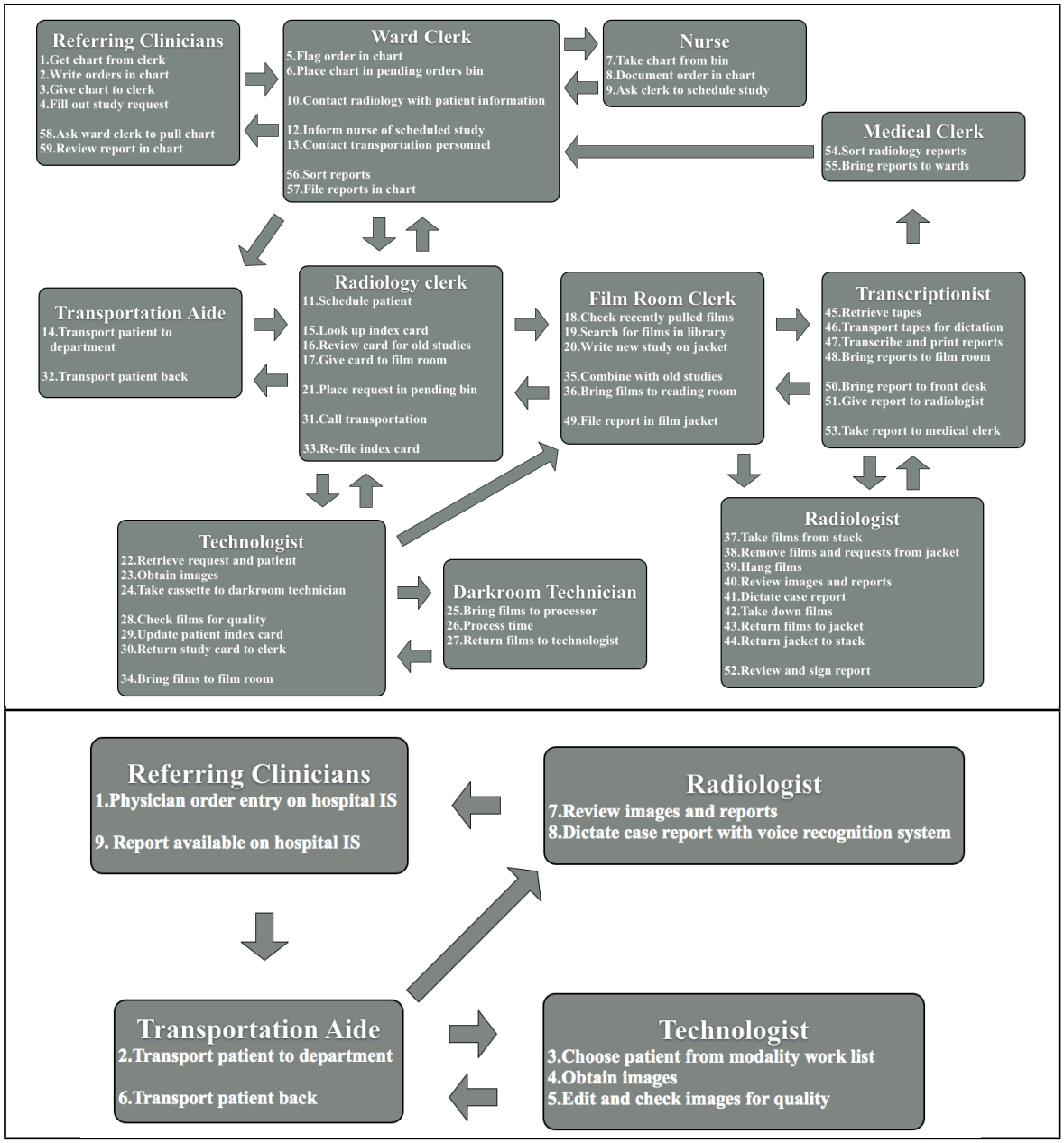

Figure 1.9 Workflow before (upper panel) and with (lower panel) PACS. Figure adapted from Siegel and Reiner (2002)

Smartschool

Smartschool is a digital learning environment that offers its users (administrative force, school board, teachers and pupils) both basic and very advanced opportunities. At this time, Smartschool is the market leader in secondary schools in Flanders with, depending on the source, 72 (De Smet & Schellens, 2009) to over 90% (www.smartschool.be) of

Flemish secondary schools making use of it. Smartschool is in constant development and at the time of writing, the core web-based application consists of over 20 modules and integrates four functionalities: (1) a digital learning environment consisting of 14 modules. In the DLE, teachers can set up learning paths, create exercises, take tests, collect and store tasks, etc.; (2) communication: Smartschool has an internal messaging system for communication between users, public discussions can be conducted in forums, and users can read important messages from the school board on the bulletin board; (3) administration: this comprises for example taking surveys, online timetables, and an intradesk where users can submit important documents; and (4) a pupil tracking system.

Extra features and modules can be integrated in Smartschool, like an online scorecard, or linking the upload zone with Ephorus (www.ephorus.nl) to control for plagiarism in student papers. School administrators and the users have a large degree of freedom to customize Smartschool to their needs. The screenshot in Figure 1.10 shows which messages the teacher has not yet read, with his courses on the left and the different functionalities on the right.

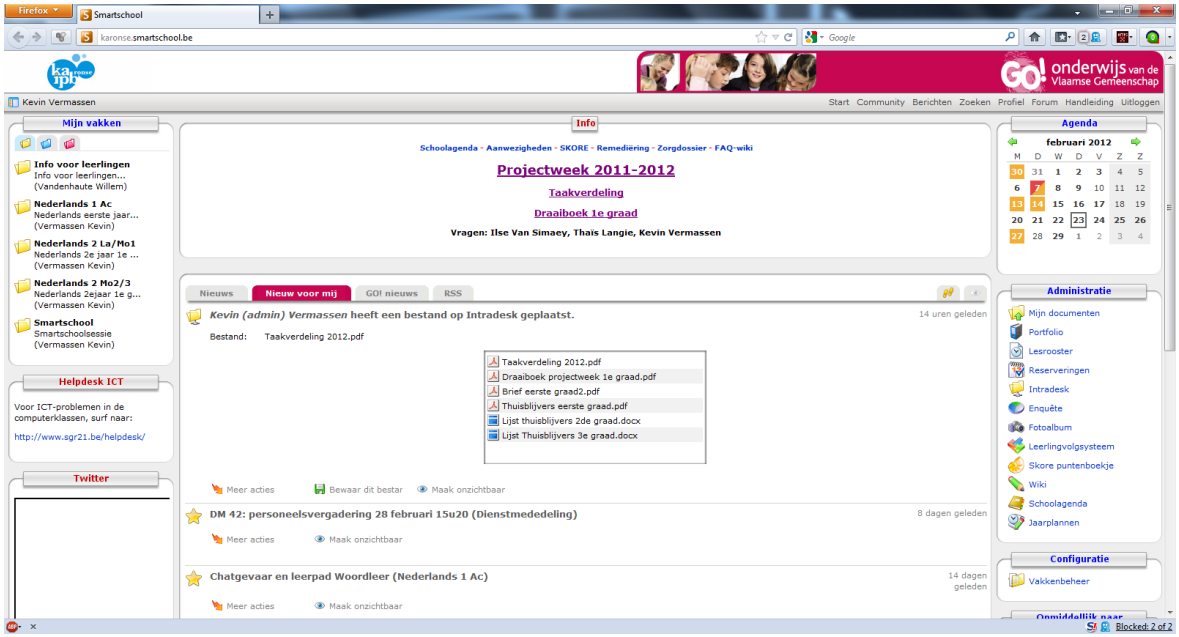

Figure 1.10. Screenshot of Smartschool

KlasCement

KlasCement (www.klascement.net), is an educational portal which is supported by the Flemish department of education. Although the portal is targeted at Flemish and Dutch teachers, everybody can join. The portal can be consulted in Dutch and English and separate Belgian (.be) and Dutch (.nl) versions have been developed. In order to obtain full access to all functionalities of the portal, a user has to register. At the time of writing, KlasCement had over 67000 members and about 22500 contributions. A screenshot of the portal is provided in Figure 1.11, which shows that the portal is build around the contributions of the members (central sections) and that extensive search (left part) and select (upper part) facilities are provided to the users in order to find the needed information as efficient as possible. A member can contribute different types of material. A distinction is made between calendar items (notification of interesting activities), learning objects (documents, articles, websites, software), interactive exercises, and multimedia (video, audio, pictures). Upon the uploading of information, a Creative Commons license is created, so that copyright is retained. Other members can download and use the contributions of other members if they credit the uploader and respect the terms specified in the Creative Commons license. Other functions that are provided are a forum (country-specific, accessible through the .be or .nl site only) and an overview of the projects that can be of interest to the members of KlasCement or that are supported by KlasCement, for example under the project Digilessons, all information on digital boards is gathered and links to interesting sites are provided.

Learning material cannot be downloaded without limits: upon enrollment, a user receives points to download material and consult specific parts of the portal. Points can be gained by contributing (= uploading information or reacting on uploaded information). To retain membership, a member has to login at least once per year. Members can use the portal in several ways, the main being: (a) searching for information posted by other members or by the portal administrators in order to download the retrieved material; and/or (b) sharing information or knowledge, either by uploading, or by reacting on earlier uploads.

Figure 1.11 Screenshot of KlasCement

Research questions

With this dissertation, we aim to provide insight into the factors that influence physicians' and teachers' technology acceptance. The findings should benefit or offer guidance for hospital/school boards, CIO's, product managers, implementers, etc. Four research questions are put forward.

The first research question is exploratory in nature, arising from a disparity between the literature and the practice. The reviews of the relevant literature were not systematic, and thus very likely not exhaustive, yet, they made clear that the knowledge base on physicians' and teachers' acceptance of job-related technologies is rather sparse. This sparsity might be plausible in the case where every (new) technology is introduced successfully, but this prerequisite is contradicted by the practice (Devos, 2011; Legris, et al., 2003; Standish Group). To add to this knowledge base, I will draw on two acceptance models that are typically applied in research in business settings: UTAUT and C-TAM-TPB. These models hold, apart from attitude, conceptually the same constructs, which are also the constructs that should give a good insight in teachers' and physicians' acceptance of job-related technologies. Hence, the first research question becomes:

- *RQ1: To what extent can physicians' and teachers' acceptance be explained by the predictor variables in UTAUT and C-TAM-TPB*

One of the features distinguishing the study of Venkatesh, et al. (2003) from most other IS-acceptance studies is that multiple measurements were taken. In the literature reviews only two studies were identified in which teachers' (Hu, et al., 2003) or physicians' (Alapetite, et al., 2009) acceptance was measured on more than one occasion. In those studies differences were observed in the significance level of the predictor variables. Differences were also observed in the significance levels of the predictor variables when comparing the findings of different one-shot studies, which might be - at least in part - due to the timing of the measurement. I want to investigate whether the determinants of acceptance change over time as the users gain in experience with the technology, hence the second research question:

- *RQ2: To what extent do the determinants of acceptance change with growing experience with the technology?*

IS-acceptance research is mainly grounded on psychological theories for explaining and predicting behaviors. It is however not always possible to collect actual use, for example when anonymity is a prerequisite, in which case self-reported measures for acceptance serve as substitutes. Behavioral intention is in this respect the key construct, yet self-reported use and attitude have also been utilized as measures for acceptance. Studies in which actual use behavior is taken into account are also rather sparse in IS-acceptance research - the study of Venkatesh, et al. (2003) is again an exception - and also in none of the acceptance studies identified through the literature reviews actual use of the technology was measured. In this dissertation, I want to investigate the extent to which these self-reported measures are predictors of actual use, and the third research question is:

- *RQ3: To what extent can self-reported measures for acceptance predict observed use?*

Users of a particular technology are typically evaluated as a single group, in which no personal characteristics except for gender and/or age are taken into account. I argue, in line with the gender similarities hypothesis (Hyde, 2005), that personal characteristics other than gender and age exist that have a more profound impact on technology acceptance. Previous studies have already found that personality influences users' technology acceptance (Devolder, Pynoo, Duyck, & Sijnave, 2008; Pynoo, Devolder, Duyck, & Sijnave, 2009; Sykes, Venkatesh, & Johnson, 2007) whereas technology users also differ in terms of technology readiness (Parasuraman, 2000) and innovativeness (Marcinkiewicz, 1993; Rogers & Shoemaker, 1971; van Braak, 2001). In the past, portal users were grouped based on their average number of logins per month (Lee, Zufryden, & Drèze, 2003), and it was found that users who logged in more frequently used the portal more effectively. Assuming that this is also a personal characteristic, we investigate whether considering differences in use behavior leads to a better understanding of acceptance. Hence the fourth research question becomes:

- *RQ4: To what extent do user characteristics impact technology acceptance?*

These research questions should be addressed throughout the four studies that are reported in this dissertation. Two studies involve hospital physicians, and these studies had to be administered anonymously. The study in Chapter 2 is a cross-sectional study in which hospital physicians' acceptance of PACS is accessed on two occasions, at the introduction of PACS and about 1.5 years later. The theoretical framework for this study is UTAUT. The study in Chapter 3 is performed in a private, multi-site hospital. In this study, PACS acceptance is assessed on three occasions, with UTAUT as theoretical framework. The other studies involve teachers. In the study in Chapter 4, secondary school teachers' acceptance of Smartschool was assessed on three occasions during the same school year, with UTAUT serving as theoretical framework. For this study, actual use data was also collected and paired to the self-reported questionnaire data. Contrary to Chapters 2, 3, and 4, in which use of the technology was mandatory, and within one organization, Chapter 5 reports a study in which teachers' acceptance of a portal for education was assessed in a user group of both new and existing users. Acceptance was measured through an online questionnaire, while actual use was extracted on two occasions from the portal's database, and coupled to the questionnaire data. Table 1.5 shows which research questions will be addressed in the four studies.

Table 1.5 Overview of the research questions that will be addressed per empirical chapter

	Chapter 2 Study I	Chapter 3 Study II	Chapter 4 Study III	Chapter 5 Study IV
RQ1	X	X	X	X
RQ2	X	X	X	
RQ3			X	
RQ4				X

The studies are reported in a chronological manner, based on the date of the first data-collection. This way they are also a reflection of my personal growth in the field of research of IS-acceptance. Knowledge was gained in many ways, which led to the

utilization of different theoretical frameworks and statistical techniques. In cases where this might pose a problem to compare between studies, an addendum was inserted at the end of that empirical chapter for clarification.

2 Do hospital physicians really want to go digital? Acceptance of a picture archiving and communication system in a university hospital

Based on:

Duyck, P., Pynoo, B., Devolder, P., Adang, L., Vercruysse, J. & Voet, T. (2008). Do hospital physicians really want to go digital? Acceptance of a picture archiving and communication system in a university hospital. Röfo-Fortschritte Auf dem Gebiet der Röntgenstrahlen und der Bildgebenden Verfahren, 180, 631-638.

Chapter 2

Do hospital physicians really want to go digital? Acceptance of a picture archiving and communication system in a university hospital

Abstract

Purpose

Radiology departments are making the transition from analog film to digital images by means of PACS (Picture Archiving and Communication System). It is critical for the hospital that its physicians adopt and accept the new digital work method regarding radiological information. The aim of this study is to investigate hospital physicians' acceptance of PACS using questionnaires pre- and post-implementation and to identify main influencing factors.

Materials and Methods

The study was conducted in an 1169 bed university hospital. The UTAUT (Unified Theory of Acceptance and Use of Technology) questionnaire (Venkatesh, et al., 2003) was administered at two times: one month pre-implementation (T1) and 1.5 years post-implementation (T2) of PACS, targeting all hospital physicians with the exemption of radiologists. The UTAUT scales (Behavioral Intention BI; Facilitating Conditions FC; Effort Expectancy EE; Performance Expectancy PE; Anxiety ANX; Social Influence SI; System Use USE; Attitude toward technology ATT; Self-Efficacy SE) were used to assess questions regarding: (a) PACS' usefulness, (b) PACS' ease of learning/using, (c) PACS support availability, (d) the perceived pressure to use PACS, (e) physicians' attitude towards PACS and (f) physicians' intention to use and actual use of PACS.

Results

At T1, scale ratings were positive toward the PACS implementation. The ratings on all scales, with the exception of self-efficacy improved at T2. Regression analysis revealed that the key factor for intention to use PACS at T1 was the usefulness of PACS, while the availability and awareness of support was its most important predictor at T2. Overall, PE was the best predictor of BI, but all four UTAUT-determinants (PE, FC, EE and SI) were salient for its prediction. Variance explained in BI ranged from 31 to 37% while variance explained in USE was very low (3%).

Conclusion

The implementation of PACS has succeeded. At T1, the physicians were welcoming PACS and this was confirmed at T2. Experience with PACS led to an overall improved attitude toward PACS. The key factors for physicians' intentions to use PACS were the usefulness of PACS (at T1 and overall) and the availability of support (at T2).

Introduction

The medical field of radiology has evolved from an analog into a digital workspace. The change-over to a digital workflow has been made in numerous hospitals. The Information System (IS) responsible for distributing and visualizing the now digital images is called PACS, an acronym which stands for Picture Archiving and Communication System. In days gone by the main emphasis of PACS was put on storage and PACS was regarded as a digital repository of image data. This gradually evolved to the point where many advanced image processing functions are incorporated into the system. Medical professionals now even have the possibility of rendering the human body in 3D. The digital transition naturally has great impact on work methods both for radiologists and referring physicians (Bramson & Bramson, 2005; Trumm, et al., 2006). The review process no longer involves the physical handling of films but has transformed into working with workstations and PCs. This analog to digital switch opens up new possibilities, e.g. teleradiology (Frohlich, et al., 2007) and remote control (Kramer & Schlemmer, 2007), but can as well lead to some change management issues (Meyer & Hamm, 2007; Mildenberger, et al., 2007) and if these matters are not overcome they could be the pitfall of the entire project. In view of the importance of the project's success it would be interesting to be able to assess whether PACS is accepted by the medical professionals. In the literature we find several papers on this issue. Some describe personal experiences with the system (Johnson & Dye, 1995; Kywi, 2005), while others distribute surveys to users within a hospital or to representatives of different hospitals respectively (Bauman & Gell, 2000; Bryan, Weatherburn, Watkins, & Buxton, 1999; Pilling, 2003). Recently, Frund et al. (2007) performed an interesting study in which they assessed the change in workflow due to PACS pre- and one year post-implementation and linked this to the acceptance of PACS. They found a high acceptance of PACS as the main part of the physicians (93%) would recommend the introduction of PACS to fellow physicians. Our paper differs from these previous studies as we use IS acceptance models to quantify the acceptance of PACS by hospital physicians. There are several technology acceptance models, each using different or overlapping sets of determinants for the prediction of 'intention to use' or 'usage' as a surrogate for

acceptance. Venkatesh, et al. (2003) made a comprehensive review of the existing technology acceptance literature and merged eight prominent models into the Unified Theory of Acceptance and Use of Technology (UTAUT, Figure 2.1).

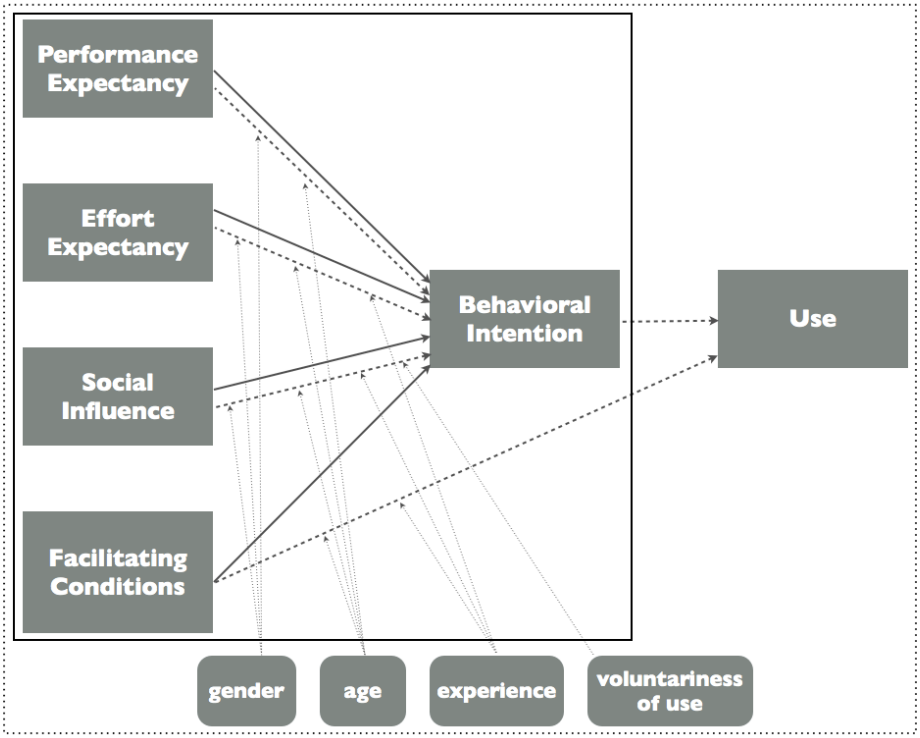

Figure 2.1 UTAUT. The basic, direct effects only, model we tested is in bold, original UTAUT is displayed in dotted lines.

As Figure 2.1 shows, UTAUT contains four core determinants or predictors of behavioral intention and usage: performance expectancy, effort expectancy, social influence and facilitating conditions. A conceptual definition of these constructs can be found in Table 2.1. Furthermore UTAUT incorporates four moderators – gender, age, experience and voluntariness of use – that mediate the relationship between the determinants and intention or usage. Venkatesh, et al. (2003) found that UTAUT outperformed the acceptance models it is deduced from, explaining up to 70 % of the variance in intention to use an IS. However, when only one measurement was taken into account, UTAUT performed equally well as the other models and explained about 37% of the variance in intention (Venkatesh, et al., 2003). Duyck, et al. (2008b) conducted a study in which the individual acceptance of

PACS by radiologists and technologists was measured and found that UTAUT is an adequate model to predict the intentions of radiology medical professionals to use PACS. It was found that the radiology department staff, as other healthcare professionals (Chismar & Wiley-Patton, 2003; Hu, Chau, Sheng, & Tam, 1999; Pare, Sicotte, & Jacques, 2006) form a special population compared to other populations that are commonly used in IS research. To be specific, Duyck, et al. (2008b) found that healthcare professionals make their technology acceptance independent of their superiors and that they focus first on the usefulness of the new technology, rather than on it's ease of use. In terms of variance explained, UTAUT was found to be a good model for predicting intention to use PACS pre-implementation (Adj. R^2 .48). The purpose of this study is to gain insight into the acceptance of PACS by the physicians of the Ghent University Hospital, both pre- and post-implementation. Hereto we will assess UTAUT. It was envisioned that a study similar to the study of Duyck, et al. (2008b) should be performed incorporating the non-radiology medical professionals of a hospital. Primary end-users of PACS are the referring physicians which therefore form the target population of this study. Duyck, et al. (2008b) used a rather homogenic target population who had a good view on the benefits of PACS and the problems associated with the use of PACS, as it is their domain. This is not the case with our target population. Use of PACS could be a burden for the referring physicians as they will have to use a computer to view their images. For some, this could be a dramatic change of working method.

Materials and Methods

The Ghent University Hospital is the second-largest (1169 beds) single campus hospital in Belgium. The total number of employees varies around 4800 among which about 600 physicians and 1700 nurses. The radiology department led the hospital into the PACS-era in March 2005. The remainder of the hospital i.e. all physicians gained access to the PACS in the course of July 2005. A dual "analog film printing / digital PACS delivery" situation persisted until the hospital went completely filmless on February 14th 2006. In the course of these 7 months physicians were given the opportunity to learn the new system. Hereto a digital learning environment was developed, which is described in detail in Devolder, et al.

(2009). It's an interactive presentation in which all functionalities of PACS are covered. The information is presented in small pieces, with the text integrated into the corresponding screenshot. It is designed so that users with different levels of PACS-experience can use it and it can be consulted from within and outside the PACS web viewer, as well as from home. The first questionnaire consisted of eight scales constructed by Venkatesh, et al. (2003) to assess UTAUT, while the follow-up questionnaire at T2 had one extra item questioning the self reported frequency of PACS use of the physicians. The items were translated and minor adaptations were made to fit in our study. The complete questionnaire is presented in Table 2.1.

All items had to be assessed on a 7-point Likert scale, ranging from "completely disagree (1)" to "completely agree (7)" with four being the neutral point. Taking this questionnaire allows us to answer the following questions:

- Is PACS useful?
- Is PACS easy (to learn) to use?
- Do the physicians experience pressure from the hospital management or their peers to use PACS?
- Are the necessary resources (training, computers, support) provided to facilitate PACS use?
- What is the attitude of the physicians toward PACS?
- Do the physicians (intend to) use PACS?

The first questionnaire was administered throughout the whole hospital about one month prior to PACS-implementation (T1). The follow-up questionnaire was administered about 1.5 years post-PACS-implementation, which is about one year after the radiology department stopped printing film (T2). All non-radiology hospital physicians, both staff and interns were contacted to fill in the questionnaires. The questionnaires including cover letter were distributed and returned through the internal mail system of the hospital. Table 2.2 displays an overview of the demographic data. Data were analyzed with SPSS 12©.

Table 2.1 Questionnaire. The tense of the items differs according to the timing of the questionnaire: future tense at T1 and present/past tense at T2.

Performance Expectancy: the degree to which one believes that using PACS will help him / her to attain gains in job performance
PE1 I will find PACS useful in my job
PE2 Using PACS will enable me to accomplish my tasks more quickly
PE3 Using PACS will increase my productivity
PE4 If I use PACS, I will increase my chances of getting a raise
Effort Expectancy: the degree of ease associated with the use of the system
EE1 My interaction with PACS will be clear and understandable
EE2 It will be easy for me to become skillful at using PACS
EE3 I will find PACS easy to use
EE4 Learning to operate PACS will be easy for me
Social Influence: the degree to which one perceives that important others believe he / she should use the new system
SI1 People who influence my behavior think that I should use PACS
SI2 People who are important to me think that I should use PACS
SI3 The senior management of the hospital has been helpful in the use of the system
SI4 In general, the hospital has supported the use of the system
Facilitating Conditions: the degree to which one believes that an organizational and technical infrastructure exists to support use of PACS
FC1 I will have the resources necessary to use PACS
FC2 PACS will not be compatible with other systems I use
FC3 A specific person or group will be available for assistance with PACS difficulties
Attitude Toward using Technology: one's positive feelings towards use of PACS
ATT1 Using PACS is a good idea
ATT2 PACS will make work more interesting
ATT3 Working with PACS will be fun
ATT4 I will like to work with PACS
Self-efficacy: judgment of one's capability to use PACS
I will be able to complete a task using PACS …
SE1 …if there was no one around to tell me what to do as I go
SE2 …if I could call someone for help if I got stuck
SE3 …if I had a lot of time to complete the job for which PACS is provided
SE4 …if I had just the built-in help facility for assistance
Anxiety: one's negative or emotional feelings towards use of PACS
ANX1 I feel apprehensive about using PACS
ANX2 It scares me to think that I could lose a lot of information using PACS by hitting a wrong key
ANX3 I will hesitate to use PACS for fear of making mistakes I cannot correct
ANX4 PACS is somewhat intimidating for me

Behavioral Intention*: one's intention to use PACS in the next 9 months
BI1 I intend to use PACS in the next 9 months
BI2 I plan to use the system in the next 9 months
BI3 I predict I would use the system in the next 9 months
Self-reported Usage:** frequency of PACS-use, scored on a 7-point scale ranging from "never" to "daily"
USE How many times have you used PACS during the past month?

*Notes: *at T2, this scale has only 2 items, as BI1 and BI2 are almost equal in Dutch **this item was taken at T2 only*

Table 2.2 Demographic data of the respondents

	T1	**T2**
Subjects	184 / 570	147 / 585
Net response rate	32.3 %	25.1 %
Gender	**n**	**n**
♂	101	69
♀	71	75
missing	12	3
Age	**%**	**%**
<25	-	0.7
25-30	24.5	28.6
31-35	19.0	19.7
36-40	12.0	17.7
41-45	8.7	10.9
46-50	7.6	9.5
51-55	4.3	4.8
56-65	6.5	5.4
missing	17.4	2.7

Results

The descriptive statistics are displayed in Table 2.3; the results of the regression analysis are shown in Table 2.4. Unless specified otherwise, 2-sided significance levels stemming from t-tests are reported. Overall, physicians' mean ratings on all scales differed significantly from the neutral point (One-sample t-test, all $p<.001$) except for the SI scale at T2, $t(146)=1.592$, $p=.11$. Mean ratings on all scales, except SE ($t<1$, ns), changed from T1 to T2 (independent samples t-test, all $p<.01$). Furthermore, no significant differences were found between men and women on mean ratings, albeit only marginal for SI, $t(314)$

=1.802, p=.07. A closer inspection does reveal some statistically significant differences in ratings between men and women. These differences are elaborated below, together with the results of the regression analysis.

Table 2.3 Descriptive statistics

	T1	T2
Scale	**mean (SD)**	**mean (SD)**
PE	5.14 (1.60)	5.73 (1.25)
♂	5.34 (1.61)	5.79 (1.17)
♀	4.85 (1.60)	5.71 (1.34)
EE	4.42 (1.20)	5.27 (1.19)
♂	4.55 (1.22)	5.43 (1.19)
♀	4.34 (1.17)	5.13 (1.19)
SI	3.39 (1.19)	4.17 (1.28)
♂	3.41 (1.23)	3.96 (1.32)
♀	3.40 (1.04)	4.36 (1.22)
FC	4.39 (1.14)	5.31 (0.94)
♂	4.34 (1.14)	5.47 (0.82)
♀	4.50 (1.15)	5.16 (1.03)
ATT	5.04 (1.31)	5.42 (1.19)
♂	5.13 (1.43)	5.44 (1.08)
♀	5.03 (1.11)	5.41 (1.30)
ANX	2.32 (1.27)	1.59 (0.87)
♂	2.19 (1.21)	1.43 (0.72)
♀	2.43 (1.36)	1.74 (0.97)
SE	4.72 (0.90)	4.62 (1.11)
♂	4.71 (0.93)	4.68 (1.12)
♀	4.76 (0.92)	4.56 (1.13)
BI	5.66 (1.34)	6.60 (0.72)
♂	5.73 (1.41)	6.57 (0.70)
♀	5.58 (1.30)	6.63 (0.73)

Usefulness of PACS

At both times, physicians' mean ratings on the performance expectancy scale were well above the neutral point (one-sample t-test, all p <.001). At T2, with extensive PACS-experience, both male and female physicians rated the usefulness of PACS higher than at T1. At T1, the male physicians rated the usefulness of PACS significantly higher than the female, t(170)=1.951, p=.05, while at T2 no such difference existed anymore. The regression analysis shows that performance expectancy is a very consistent determinant of

intention to use PACS. Overall, it is the best determinant of behavioral intention and particularly important pre-implementation.

Is PACS easy to learn/use?

At both times, physicians indicated that they have the capacities to work with PACS (SE, all p<.001). These ratings do not significantly change over time, neither for the male nor for the female physicians. Physicians' ratings at T1 of the estimated ease of learning to use PACS were only slightly higher than the neutral point (all p<.02), but at T2 PACS was estimated as being easy to use (all p<.001). At both times, male physicians estimated PACS as being easier to (learn to) use compared to the female physicians, but this difference was not significant (T1: t(170)=1.165, p=.25; T2: t(142)=1.512, p=.13). The regression analysis revealed that ease of use is important when the physicians are still learning to work with PACS. When experienced, ease of use is not salient for predicting behavioral intention.

Table 2.4 Regression analysis with behavioral intention (upper part) and use (lower part) as dependent variables. The values reported are standardized beta regression coefficients.

Dependent variable: Behavioral intention			
	T1 (n=184)	T2 (n=147)	pooled (n=331)
PE	.41***	.29**	.34***
EE	.16*	.00	.13*
SI	.09	.12†	.12*
FC	.13*	.34***	.23***
Adj. R^2	.35	.31	.37
Model-test	F(4,179)=25.797, p<.001	F(4,142)=17.670, p<.001	F(4,326)=48.995, p<.001
Dependent variable: Use			
		T2 (n=147)	
BI	§	.10	§
FC	§	.14 (p=.13)	§
Adj. R^2	§	.03	§
Model-test	§	F(2,145)=3.237, p=.04	§

*Notes: *p≤.05 **p<.01 ***p<.001 †p≤.10. §N/A*

Perceived social pressure to use PACS

The physicians felt no social pressure to use PACS at T1, on the contrary, the mean ratings on the social influence scale were well below the neutral point (all p<.001). The ratings of male and female physicians were equally low. At T2, when use of PACS was mandatory, higher ratings on the social influence scale were reported, albeit not significantly higher than the neutral point (t(146)=1.592, p=.11), by the male and the female physicians (both p<.001). Here, a difference arose between the male and female physicians: the female physicians experienced more pressure to use PACS, albeit only marginally significant (t (142)=1.852, p=.07). When pooled over the two periods, social influence was salient for predicting BI. However, social influence was the least important predictor of behavioral intention, emerging particularly at T2, when use of PACS was mandatory.

Provision of resources to facilitate PACS use?

All physicians were aware of the available resources on which they could rely in case of problems (all p<.01), and the ratings at T2 were a lot higher than at T1 (all p<.001). But while at T1 no statistical difference was found in ratings on the facilitating conditions scale between the male and female physicians, the male physicians had a better view on the available resources than the female physicians at T2, t(142)=1.938, p=.05. Overall, facilitating conditions was the second best determinant of behavioral intention, and particularly salient at T2, when PACS had to be used. According to UTAUT, facilitating conditions should have a direct influence on use. This was only partly supported by the regression analysis on use. Facilitating conditions was a better determinant of use than intention, but the link between facilitating conditions and use was not significant (β=.15, p=.11) and the variance explained in use by facilitating conditions and behavioral intention was very low (Adj. R^2=.03).

Attitude toward PACS

Do the physicians fear PACS? No, not at all! Experience with PACS doesn't heighten their anxiousness, on the contrary, the ratings on the anxiety scale at T2 were a lot lower than at T1 (all p<.001). At T2, the male physicians were less anxious than the female (t(136.162)

=2.219, p=.03), while at T1 no such difference existed (t(170)=1.206, p=.23). However, more important is: are the physicians positive toward PACS? Yes they are, but the ratings on the attitude scale at T2 were only slightly higher than at T1, both for the female (t(144) =1.899, p=.06) and the male (t(168)=1.558, p=.12) physicians. No differences were found between the male and the female groups on any time (both t<1, ns).

Intention to use and usage of PACS

At T1, intention to use PACS was already very high and no statistical differences were found between the male and female physicians at any time (both t<1, ns). The ratings at T2 were still a lot higher than at T1 (all p<.001), but this was as expected as the physicians had to use PACS if they wanted to see radiological images. There were only two consistent determinants of intention to use PACS: performance expectancy and facilitating conditions. The amount of variance explained was higher at T1 than at T2, when use of PACS was mandatory in order to see radiological images. Self-reported frequency of use of PACS was equal between male and female physicians, Pearson $\chi^2(5)=6.235$, p=.28. The mean self reported frequency of use is shown in Figure 2.2. The main observation is that almost 80% of the physicians state that they use PACS at least almost daily. The variance explained in use was very low.

Discussion

Prior to the implementation of PACS, some actions were taken to stimulate the acceptance of PACS by the clinicians. The IT department upgraded all computers so that they would meet the minimum requirements to use PACS. The radiology department PACS project team, who is responsible for the implementation of PACS and for providing first-level support, took several measures to promote the use of PACS. On the one hand, they developed the e-learning environment; and they designed a mouse mat and blotting pad with a summary of the most important functions when using PACS. On the other hand, they introduced PACS to the clinicians in different steps. First, a letter was sent to all heads of departments. Next, staff meetings of each department (45 in total) were visited by a member of the PACS project cell to introduce PACS and the project cell to the staff

members. Finally, each department throughout the hospital was visited on three occasions (one introduction and two follow-up visits) by members of the PACS project cell. These investments paid off as the results showed. We will now discuss the results in more detail.

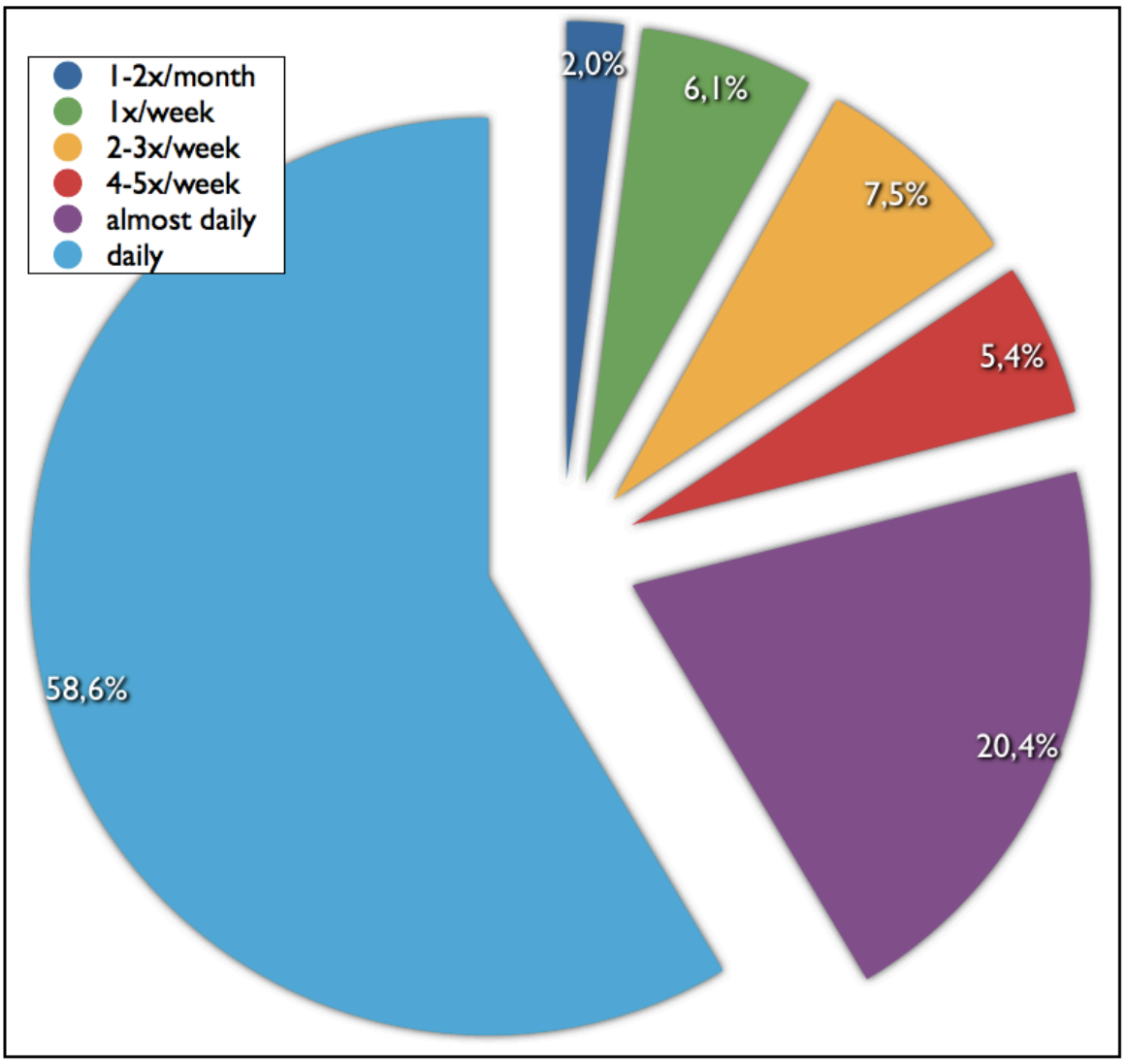

Figure 2.2 Self-reported frequency of PACS use in the past month

Usefulness of PACS

Just as in earlier studies (Hu, et al., 1999; Pare, et al., 2006; Venkatesh, et al., 2003), performance expectancy was overall the strongest predictor of behavioral intention. Our study shows that the usefulness of the new technology, in our case PACS, is a key factor

when the technology is first introduced. This is consistent with earlier studies involving medical workers showing that the usefulness, rather than the ease of use, is of primordial importance (Duyck, et al., 2008b; Hu, et al., 1999). So to enhance early acceptance, the usefulness of PACS should be emphasized, especially to the female physicians who rated the usefulness of PACS lower than their male colleagues.

Is PACS easy to learn/use?

Previous research indicated that physicians, as other professionals, have a higher level of competence, intellectual and cognitive capacity, and adaptability to new technologies in comparison with other target populations that are commonly used in IS acceptance literature (Chau & Hu, 2002a; Chismar & Wiley-Patton, 2003). This was reflected in the ratings on the self-efficacy scale. The physicians indicated that they were able to work with PACS and these ratings were not affected by experience with PACS! The physicians thought that use of PACS would be easy to learn, and this was important at T1, when PACS was implemented. This is in contrast with earlier studies in a medical setting which found that ease of use was not important at T1 (Chau & Hu, 2002a). At T2, the physicians indicated that PACS was easy to use, however this had no effect on their intention to use PACS. These findings are consistent with earlier studies who found that ease of use or effort expectancy is particularly important when users are introduced to the new technology (Venkatesh, et al., 2003).

Perceived social pressure to use PACS

Overall, social influence has a role in predicting the intention to use PACS. Social influence was more important at T2, when use was mandatory, than at T1, when use was voluntary. Although the mean ratings were not significantly higher than the neutral point, social influence seemed to be important at T2, when use of PACS was mandatory. More perceived social pressure led to a higher intention to use PACS. This is consistent with earlier findings in a business setting (Venkatesh, et al., 2003). However, these findings are in contrast with earlier studies in a medical setting who found that physicians make their

technology acceptance decision independently from their peers or superiors (Chau & Hu, 2002a; Duyck, et al., 2008b).

Provision of resources to facilitate PACS use?

While gaining experience with PACS, the physicians got a better view on the availability of resources to rely on in case of problems with PACS. This holds particularly for the male physicians. The regression analyses revealed that the provision of facilitating conditions is particularly important when one is already using the new technology. Facilitating conditions was a good secondary predictor of intention, although according to Venkatesh, et al. (2003) it should have an influence on use rather than on intention to use. There were indications that facilitating conditions was important for the prediction of use, and even more important than behavioral intention. An explanation for this rather weird outcome could lie in the mandatory use of PACS. Thus, it doesn't matter if physicians intend to use PACS or not, if they need to see radiological images, they must use PACS. But, maybe some physicians consult radiological images only if they know that they can call somebody in case they should get stuck.

Attitude toward PACS

The attitude toward PACS has two sides, on the one hand the negative, anxious feelings toward use of PACS, and on the other hand the positive feelings toward PACS. The ratings on both scales indicated that the physicians were very positive and confident toward the introduction and use of PACS. While becoming more proficient in the use of PACS, one's feelings become less anxious rather than more positive, this applies particularly for the male physicians.

Intention to use and use of PACS

The intention to use PACS was already high pre-implementation, and still higher at T2. The high ratings at T1 were a good sign, indicating that the physicians were ready for PACS. This made us hopeful for a swift transition from analog to digital images. An explanation for the high ratings at T2 is simple: in order to see radiological images, one has

to use PACS. There are no alternatives. The variance explained by UTAUT in behavioral intention was comparable to the .37 Venkatesh, et al. (2003) (p. 465, Table 21) reported at T1 (direct effects only), but low compared to the .70 they found, when pooling over three measurements. The physicians not only had strong intentions to use PACS, they equally used PACS very frequently. Almost 80% of the physicians indicated that they used PACS at least almost daily. So not only during weekdays but also in the weekend. This could be at home or anyplace outside of the hospital, through a virtual private network. This constitutes a major advantage of PACS: the availability of radiological images from anywhere.

Conclusion

Pre-implementation, the physicians were welcoming the introduction of PACS. They expected PACS to be useful for their job and the patients and seem to be quite confident that they will be able to work with PACS. It should also be clear that at first physicians make their technology acceptance decision independently. Although use of PACS will be mandatory when the hospital stops printing film, the physicians don't feel that they are pressured to use PACS. Physicians also seem to have a good view on the people or services they can contact in case of problems. A slightly different, but in the eyes of the implementers better image arose at T2. The physicians are now really convinced of the usefulness of PACS and they have a positive attitude toward use of PACS. The physicians also have a better view on the available support to rely on. By using UTAUT to assess the acceptance of PACS we got a view on the key factors at T1 and T2. At T1, pre-implementation, it is especially important that the potential users are convinced of the usefulness of the new technology, in casu PACS. While gaining experience, the users must feel they can rely on support in case of problems.

Addendum

In Duyck (2009), the data of this study were reanalyzed through path-analyses, and the results of these analyses are in Table 2.5, thus allowing a comparison with the results of the path-analyses in Chapter 3. When comparing the results in Table 2.5 with the results of the regression analyses in Table 2.4, the first observation is that the predictors of intention are the same in both analyses. The most surprising finding however is that performance and effort expectancy were significant predictors of self-reported use, and not behavioral intention or facilitating conditions. Significant correlations between performance expectancy, effort expectancy and facilitating conditions were observed on both times.

Table 2.5 Reanalysis of the data through path-analysis, reported in Duyck (2009).

	T1	T2
pe <-> ee	.59	.62
pe <-> fc	.26	.38
ee <-> fc	.45	.52
bi <- pe	.38	.28
bi <- ee	.18	--
bi <- si	--	.14
bi <- fc	.18	.33
use <- bi	N/A	--
use <- fc	N/A	--
use <- pe	N/A	.21
use <- ee	N/A	.15
Multiple correlation coefficients (mcc)		
BI	.36	.28
Use Freq	N/A	.10
Fit-indices		
GFI	.97	.97
CFI	.94	.96
AGFI	.87	.90
RMSEA	.13	.09

Notes: --: p > .10; N/A: use was not measured at T1

Compared to the path-analyses (at T1 and T3) in Chapter 3, Figure 3.2, the main observation is that the significance of the predictors variables differed depending on the

study. The main differences are that in Chapter 3 at T1, effort expectancy is the strongest predictor of intention and performance expectancy and facilitating conditions are not significant. At T3 on the other hand, social influence was the strongest predictor of intention and facilitating conditions was not significant. Also in Chapter 3, no effect of performance or effort expectancy on self-reported use was found.

3 Do hospital physicians attitudes change during PACS implementation? A cross-sectional acceptance study

Based on:

Pynoo, B., Devolder, P., Duyck, W., van Braak, J., Sijnave, B. & Duyck, P. (2012). Do hospital physicians attitudes change during PACS implementation? A cross-sectional acceptance study. International Journal of Medical Informatics, 81(2), 88-97

Chapter 3

Do hospital physicians attitudes change during PACS implementation? A cross-sectional acceptance study

Abstract

Purpose: The purpose of this study is to gain a better insight into the reasons why hospital physicians accept and use a Picture Archiving and Communication System (PACS). Two research questions are put forward, pertaining to (1) factors that contribute to physicians' acceptance of PACS, and (2) whether these factors change as physicians gain experience in using PACS.

Methods: Questionnaires were administered at three moments in time during the PACS implementation process in a private hospital: just before its introduction (T1), four months later (T2), and about fifteen months after the introduction of PACS (T3). The Unified Theory of Acceptance and Use of Technology was chosen as the theoretical framework for this study. Hence, the following scales were measured: performance expectancy, effort expectancy, social influence, facilitating conditions, behavioral intention, and self-reported frequency of use.

Results: Forty-six usable responses were obtained at T1, 52 at T2 and 61 at T3. Three variables directly influenced PACS acceptance (measured as behavioral intention and use of PACS): effort expectancy, performance expectancy, and social influence; and their influence evolved over time. Effort expectancy was of particular importance at T1, whereas performance expectancy influenced acceptance at T2 and T3; social influence was the only consistent predictor of PACS acceptance at all times. Variance explained in behavioral intention ranged from .26 at T1 to .58 at T3.

Conclusions: In this setting, the main motivation for physicians to start using PACS is effort expectancy, whereas performance expectancy only becomes important after the physicians started using PACS. It is also very important that physicians perceive that their social environment encourages the use of PACS.

Keywords: PACS (radiology), attitude to computers, medical staff hospital, acceptance process

Introduction

Clinical Information Systems in healthcare

Technology can facilitate our daily life, just as it can be a burden if it does not work as intended, or while you are still learning to work with a new technology, and do not fully experience its advantages. Although clinical information systems (CIS) have clearly proven their value for health care (Bates, et al., 1999; Hayt & Alexander, 2001), it took healthcare decision makers longer to acknowledge the beneficial effects of CIS than is typical for commercial or business settings (in which economic efficiency is often the primary motive, unlike in the healthcare sector). These benefits pertain to a wide range of effects, including reduction of report turnaround time, lower number of medication and transcription errors, elimination of adverse drug effects and many others (Bates, 2000; Bates, et al., 1998; Ford, McAlearney, Phillips, Menachemi, & Rudolph, 2008). As such, different studies report that CIS ultimately lead to an improved quality of patient care. In view of the potential benefits, it is surprising that only a minority of implemented healthcare information systems may be considered a complete success (Heeks, 2006; Kaplan & Harris-Salamone, 2009). This indicates that merely introducing a CIS to users does not automatically lead to the expected benefits. Instead, a prerequisite for success is that the (intended) users actually use the CIS and exploit its features to the full extent (Holden & Karsh, 2009). This requires efforts both from users and their organization. Users have to adapt their working method (Siegel & Reiner, 2002) and take the time to learn how to work with the new system in order to make full use of the technology, while the organization needs to provide the necessary conditions to facilitate the use of the new technology, e.g. through training and support (Devolder, et al., 2009; Kaplan & Harris-Salamone, 2009). It is the aim of this article to gain more insight into the factors that determine CIS' implementation success, so that the healthcare sector may maximally benefit from their advantages.

Barriers to the implementation of a Picture Archiving and Communication System

In this paper, the implementation of a Picture Archiving and Communication System (PACS) in a private hospital is studied. In PACS, medical images are collected from the imaging modalities, stored with their corresponding reports, and distributed to the referring physicians. Unlike many other clinical information systems, PACS can be considered a success story (Zitner, 2006); its benefits are considerable (Buccoliero, Calciolari, Marsilio, & Mattavelli, 2009) and tangible on different levels, going from patients to management (Duyck, et al., 2010). Yet, between the moment when the implementation is considered, and implementation success, there are four threats for a PACS-implementation project (Pare & Trudel, 2007):

- project / economic: e.g. funding issues, choice of vendor, timeframe adherence;
- technical: e.g. product / vendor immaturity, server & storage space, network capability;
- organizational: e.g. training issues, organizational resistance, end-user equipment availability;
- behavioral / human: e.g. acceptance and use by the end-user, physician resistance.

Getting end-users to accept and actually use PACS is one of the final obstacles that an organization has to overcome. In view of the financial impact of a PACS project, regardless of whether an entirely new installation or the replacement of an existing PACS is concerned, it is vital to keep the transition phase, in which both systems coexist, as short as possible. Probing users' attitudes towards PACS should give insight into (1) what actions an organization can undertake to speed up the acceptance process when PACS is introduced; and (2) when PACS is already in use, what steps an organization can take to maximize the use of PACS.

Technology acceptance theories

Building on established social psychology and sociology theories like the Theory of Reasoned Action (Fishbein & Ajzen, 1975) and the Innovation Diffusion Theory (Rogers

& Shoemaker, 1971), several theoretical models were developed to explain user acceptance of (information) technology, which has been operationalized as *attitude* towards the technology (Brown, et al., 2002), *behavioral intention* to use the technology (Venkatesh, et al., 2003), and / or technology *use* (Venkatesh, et al., 2003). An overview of models that have been used to study technology acceptance is provided in Venkatesh, et al. (2003). The most prominent model in this domain is the Technology Acceptance Model (TAM) (Davis, et al., 1989). TAM states that a user's *attitude* towards a technology depends on the *perceived usefulness* of that technology and its *perceived ease of use*; *attitude* and *perceived usefulness* then jointly predict a user's intention to use that technology. Several versions of TAM exist, and in many cases *attitude* is omitted from the model. In TAM2, *subjective norms* are added as predictors of intention (Venkatesh & Davis, 2000), while TAM3 adds individual differences and system characteristics as antecedents to *perceived usefulness* and *perceived ease of use*, next to constructs relating to *subjective norms* and *facilitating conditions* (Venkatesh & Bala, 2008).

The abundance of model development and refinement studies gave rise to the development of an overarching theory, the Unified Theory of Acceptance and Use of Technology (UTAUT). Venkatesh, et al. (2003) reviewed models and constructs utilized to study technology acceptance, and carried out an empirical study to test their conclusions. They identified, next to four moderating variables (gender, age, experience with the technology, and perceived voluntariness of use), seven overarching constructs of which only four were withheld as determinants of user acceptance (operationalized as *behavioral intention* and *use*): (a) *performance expectancy*, referring to the usefulness of a technology; (b) *effort expectancy*, referring to the ease of use of a technology; (c) *social influence*, referring to perceived norms in the social environment concerning the use of a technology; and (d) *facilitating conditions*, referring to objective factors that facilitate the use of a technology, such as training, support and compatibility between the new and existing systems.

The main difference between UTAUT and TAM3 is that *social influence* and *facilitating conditions* are modeled as direct predictors of acceptance in UTAUT, whereas in TAM3

they are modeled as antecedents to *perceived usefulness* and *perceived ease of use* (Venkatesh & Bala, 2008; Venkatesh, et al., 2003).

Technology acceptance in healthcare

A very diverse range of information systems is in use in hospitals, all belonging to one of three clusters: strategic, administrative or clinical (Bhattacherjee, Hikmet, Menachemi, Kayhan, & Brooks, 2007). Systems like PACS, electronic patient records and clinical decision support systems belong to the latter category, the clinical information systems (CIS). As these systems can have a profound impact on the quality of patient care, their acceptance and use by physicians is crucial. Below we present the findings of a literature search in the Web-of-Science on quantitative studies of hospital physicians' acceptance of CIS in the time span 2000-2009.

Eleven relevant studies are retrieved and from these studies we learn that just as in business settings (Venkatesh, et al., 2003), the usefulness of the system is the main predictor of physicians' CIS-acceptance (Bhattacherjee & Hikmet, 2007; Chang, et al., 2007; Chau & Hu, 2001, 2002a, 2002b; Duyck, et al., 2008a; Duyck, et al., 2010; Duyck, et al., 2008b; Ilie, et al., 2009), while the system's ease of use is of minor importance (Chang, et al., 2007; Duyck, et al., 2008a; Duyck, et al., 2010). Although physicians have a large degree of professional autonomy and are considered to independently make technology acceptance decisions, some studies have found that *social influence* is positively associated with CIS-acceptance (Duyck, et al., 2008a; Duyck, et al., 2010; Gagnon, et al., 2003), whereas other studies found no effect of *social influence* (Chau & Hu, 2001, 2002a, 2002b). Constructs relating to *facilitating conditions* were also important predictors of CIS-acceptance, either directly (Chau & Hu, 2001, 2002a, 2002b; Duyck, et al., 2008a; Duyck, et al., 2010; Duyck, et al., 2008b) or indirectly through *perceived usefulness* (Bhattacherjee & Hikmet, 2007; Chau & Hu, 2001, 2002a, 2002b) or *perceived ease of use* (Ilie, et al., 2009).

Furthermore, from this search of the literature we can also conclude that:

- approximately the same factors contribute to physicians' acceptance of CIS as in business settings, with system usefulness as the dominant construct;
- only very few PACS acceptance studies have been conducted: we identified four studies reporting on PACS acceptance in two university hospitals situated in Canada (Pare, et al., 2005) and Belgium (Duyck, et al., 2008a; Duyck, et al., 2010; Duyck, et al., 2008b). This limited body of research contrasts with the widespread use of the system;
- the most frequent format in the literature is a one-shot approach, in which CIS-acceptance is typically assessed on only one moment in time. Exceptions are Alapetite et al. (2009) who questioned physicians before and about four months after the introduction of speech recognition, and Duyck, et al. (2008a, 2010) who took questionnaires at the introduction of PACS and about two years later. By taking only one measurement, researchers get a static view of user acceptance, whereas multiple measurements could yield important insights into how user acceptance evolves over time. It can be expected that shortly after the introduction of a new technology, users' attitudes are subject to changes due to insufficient knowledge of, and experience with the new technology. Also, more importantly, only a repeated measurements methodology allows to investigate whether and how the above-mentioned facilitating factors may have differential effects on technology acceptance, in the same physicians, at different moments in time.

Purpose

In this study, hospital physicians' PACS acceptance will be assessed at three occasions (before, shortly after and about one year after the introduction of PACS) in a multi-site private hospital. The research model (Figure 3.1) draws on the Unified Theory of Acceptance and Use of Technology as a theoretical framework. Two research questions are put forward:

RQ1: To what extent can performance expectancy, effort expectancy, social influence and facilitating conditions explain hospital physicians' acceptance of a Picture Archiving and Communication System?

RQ2: Does experience with PACS moderate the relationships between the independent variables (performance & effort expectancy, social influence, and facilitating conditions) and physicians' acceptance (behavioral intention and use) of PACS?

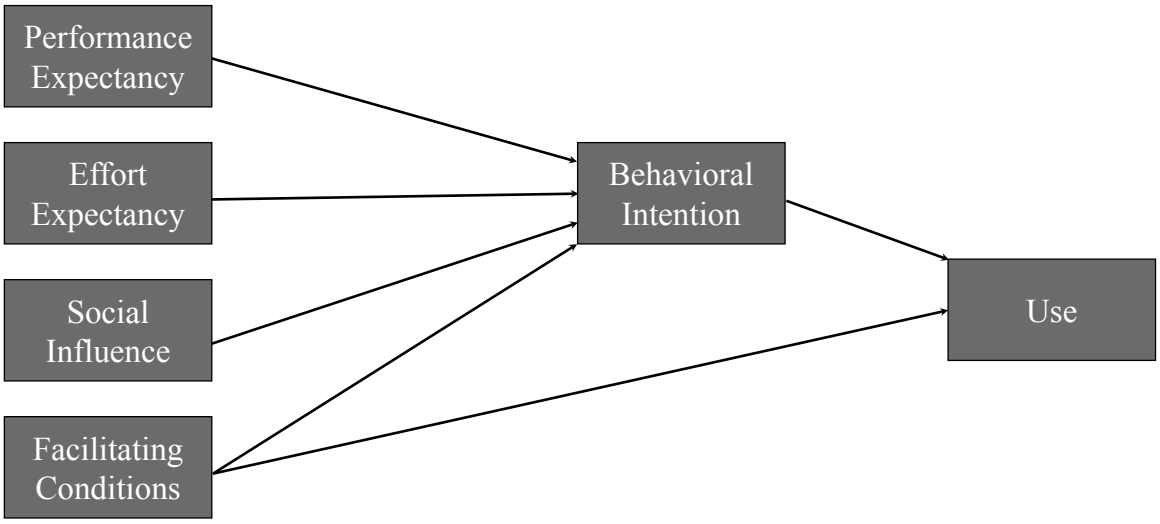

Figure 3.1 Research model.

By addressing these questions, our study contributes to the literature in three ways. First, it adds to the literature on factors related to physicians' acceptance of clinical information systems. Second, by taking multiple measurements, it will give more insight into the evolution of users' attitudes towards a technology that is estimated to be very beneficial for its users. In this respect, the measurement shortly after the introduction of PACS should be of particular relevance. Private/non-academic/for-profit (PNF) and university/academic/ not-for-profit (UAN) hospitals differ in several respects (Bhattacherjee & Hikmet, 2007; Heeks, 2006), amongst others on (a) IT infrastructure: UAN hospitals have either a strong (Bhattacherjee & Hikmet, 2007) or limited and old infrastructure (Heeks, 2006); (b) support: UAN hospitals have either better support (Bhattacherjee & Hikmet, 2007) or fewer technology-related staff (Heeks, 2006) than PNF hospitals; and (c) culture: UAN

hospitals have a more pro-technology culture aimed at healthcare education (Bhattacherjee & Hikmet, 2007). These differences most likely affect user acceptance of PACS. As the other retrieved PACS acceptance studies were all performed in university hospitals (Duyck, et al., 2008a; Duyck, et al., 2010; Duyck, et al., 2008b; Pare, et al., 2005), the third contribution of this study is that it is the first empirical study assessing PACS acceptance in a private hospital.

Methods

Instrument development

The questionnaire consisted of six scales that were originally developed by Venkatesh, et al. (2003). The items were translated into Dutch and adapted to the study context (hospital setting and PACS). The following scales were included: *performance expectancy*, *effort expectancy*, *social influence*, *facilitating conditions*, and *behavioral intention*. 7-point Likert scales were used, ranging from *completely disagree* ("1") to *completely agree* ("7"). The questionnaires collected post-implementation included an extra item measuring the self-reported frequency of *use* on a scale ranging from *never* ("1") to *daily* ("7"). Next to the acceptance scales, demographic information (gender, age) was also collected.

Setting

The study setting was a multi-site private hospital with approximately 1100 beds. At the time of data collection, about 2300 people were employed in one of the four locations, among which about 200 physicians and 910 nurses. Originally, the different sites were four distinct hospitals - situated within walking distance in the same city - that merged in the period 1998-2000. In anticipation of the newly-built single site hospital by 2016, the hospital reorganized in 2003 grouping physicians at the same location as a function of their area of expertise.

In the course of May 2006, introductory meetings were organized to announce the introduction of PACS and outline some of its key features. The physicians could start using PACS after these meetings. Following the introductory meetings, follow-up sessions were

organized to solve user problems. Hard-copy film printing was largely stopped about four months later; upon request physicians could still receive printed images.

Data collection

The first questionnaire (T1) was issued to all physicians attending the introductory meetings and was collected at the end of the meeting. The second (T2) and third (T3) questionnaires were issued to and collected from all 200 physicians through the internal mail of the hospital. The second questionnaire was handed out about four months after the first, when users were expected to have a limited experience with PACS, the third was handed out one year after the second, when the users were expected to have extensive experience using PACS. All questionnaires were taken anonymously.

Data analysis

For the first research question, investigating which factors contribute to physicians' acceptance of PACS, path analysis using AMOS 6.0 is applied. The theoretical overview of technology acceptance models shows that four factors (*performance expectancy* / *perceived usefulness*, *effort expectancy* / *perceived ease of use*, *social influence* / *subjective norms*, *facilitating conditions* / *perceived behavioral control*) contribute to users' acceptance of a particular technology. There is however disagreement as to whether these constructs affect acceptance directly (UTAUT) or rather indirectly through *perceived usefulness* and/or *perceived ease of use* (TAM/TAM3). By performing path analysis, we will be able to model both the direct and indirect effects. To assess goodness-of-fit, the following fit parameters are taken into account: comparative fit index (CFI), goodness of fit index (GFI), root mean square error of approximation (RMSEA), and normed Chi^2. The following thresholds are used: CFI and GFI above .90 (Yu, Li, & Gagnon, 2009), RMSEA below .08 (Hair, Anderson, Tatham, & Black, 1998) and normed Chi^2 below 3.0 (Hair, et al., 1998).

To investigate the second research question, two hierarchical regression analyses are performed, in which Model 1 contains the direct effects (Figure 3.1), and Model 2 the interaction terms. For the first regression the measurements at T1 and T2 are analyzed

together; for the second regression the measurements at T2 and T3. In order to interpret the interaction effects, linear regressions per measurement are performed.

Results

Over the three measurements, a total of 173 questionnaires were collected. Prior to the analysis, 14 questionnaires were excluded because they contained too many missing values on either the dependent or independent variables. This way, 46 (T1), 52 (T2) and 61 (T3) usable responses were retained. The three groups did not differ in terms of gender ($Chi^2(2) =3.777$, p=.15) and age ($Chi^2(8)=11.879$, p=.16).

Reliability and descriptives

The reliability (expressed as cronbach alpha) of the scales is displayed in Table 3.1. Two scales (performance expectancy and behavioral intention) met the minimal requirements for acceptable reliability (.70) (Nunnally & Bernstein, 1994). The reliability of the other scales was below this threshold, especially in the case of social influence (α = .45). A closer inspection of the latter scale showed that one item did not correlate with all other items. After removal of this item, the reliability increased significantly but remained quite low (α = .54). As cronbach alpha is highly dependent of scale length, the reliability might be underestimated. Therefore a multidimensional confirmatory factor analysis (in AMOS 6.0) with the remaining items was conducted. The goodness-of-fit indicators showed a reasonable fit (CFI .937, GFI .903, RMSEA .084), and therefore all scales were withheld for further analysis.

In a next step, the scale means and standard deviations were calculated (Table 3.1). Independent samples t-tests were used to compare scale means. The t-tests showed that all mean scale ratings, except on *social influence*, dropped significantly from T1 to T2, and only the ratings on the *performance expectancy* and *effort expectancy* scales improved significantly from T2 to T3. This means that while the physicians were still learning to work with PACS (at T2), they found PACS less useful and easy to use compared to T1, while they also estimated the provision of *facilitating conditions* to be higher at T1. However, when the physicians had become experienced PACS-users (at T3), they found

PACS much more useful and easy to use than at T2. This suggests that the T2 results primarily reflect PACS learning efforts.

Table 3.1 Reliability and descriptive statistics (Mean and Standard Deviation) of the scales used for this study.

Measurement		T1 (n=46)		T2 (n=52)		T3 (n=61)	
scale	α	M	SD	M	SD	M	SD
Performance expectancy	.78	4.17[a,c]	1.01	3.22[a,b]	1.39	4.70[b,c]	1.51
Effort expectancy	.61	5.41[a]	0.97	4.43[a,b]	1.59	5.06[b]	1.65
Social influence[$]	.54	6.15	0.89	6.14	1.24	5.96	1.34
Facilitating conditions	.61	5.40[a,c]	0.85	4.50[a]	1.43	4.87[c]	1.15
Behavioral intention	.94	6.40[a]	0.74	5.73[a]	1.66	6.29	1.33
Frequency of use				5.77[b]	1.64	6.44[b]	1.18

Notes: Scale means with the same superscript differ on p<.05 (independent samples t-test, 2-sided): [a]T1 vs. T2; [b]T2 vs. T3; [c]T1 vs. T3; [$]values obtained after removal of the bad item.

Comparing T1 and T3, we see that in general the mean scale ratings were higher at T1, although only significantly for the *facilitating conditions* scale, with one exception: the rating on *performance expectancy* was significantly higher at T3 compared to T1. This indicates that at T1, the physicians overestimated the provision of *facilitating conditions*, while they underestimated the usefulness of PACS.

Other findings that stand out are the high ratings on the *social influence* and *behavioral intention* scales and the moderate ratings on the *performance expectancy* scale. This indicates that the physicians strongly intend to start using the system and that their social environment is very supportive concerning the use of PACS, but also that the physicians are not that convinced that use of PACS will have a beneficial influence on their job performance.

Research Question 1: explaining acceptance and use

To examine which factors contributed to physicians' acceptance and use of PACS, two models were tested per measurement: the research model (Figure 3.1) and a final model in which the fit was maximized. These final models are displayed in Figure 3.2.

At the introduction of PACS (T1)

The path analysis at T1 (Figure 3.2) revealed that PACS acceptance was primarily determined by *effort expectancy* and *social influence*, while *performance expectancy* and *facilitating conditions* only indirectly influenced *behavioral intention* through their connections with *social influence* and/or *effort expectancy*. Variance explained in *behavioral intention* was rather low (multiple correlation coefficient [mcc] of .26), but the fit parameters of the final model indicated a good fit between model and data (GFI: .952, CFI: .996, RMSEA: .021, normed chi^2: 1.020).

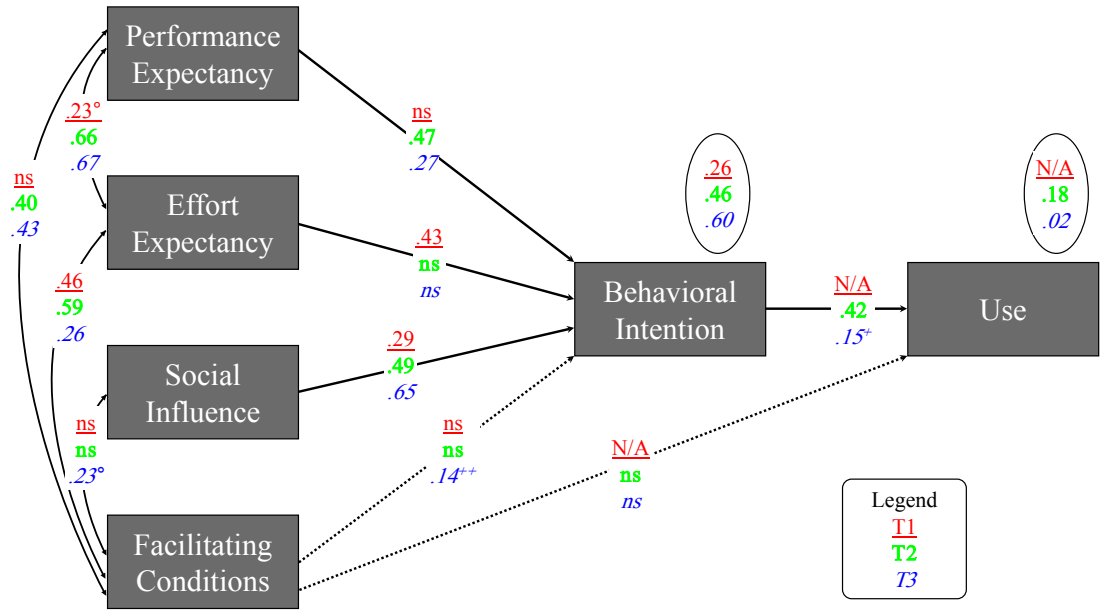

Figure 3.2 Results of path analysis: standardized regression coefficients (on the arrows) and multiple correlation coefficients (in the ellipses) per time of measurement (T1: top value; T2: middle value; T3: bottom value).

Notes: ns: nonsignificant relationship ($p > .10$) removed from model to maximize fit; N/A: not applicable; °$p < .10$; $^{+}p = .25$; $^{++}p = .13$; dotted lines indicate hypothesized relationships that were non-significant on all three measurements

Limited experience with use of PACS (T2)

Path modeling at T2 gave rise to a different final model. Now, *effort expectancy* only had an indirect influence on *behavioral intention* through *performance expectancy*, while

social influence and *performance expectancy* had a strong direct influence on *behavioral intention*. *Facilitating conditions* did not affect *use* and influenced *behavioral intention* indirectly through *performance expectancy*. Variance explained in *behavioral intention* (mcc .46) was higher than at T1 (mcc .26) while *behavioral intention* explained about one fifth of the variance in *use* (mcc .18). The fit parameters of the final model indicated a good fit between model and data (GFI: .959, CFI: 1.000, RMSEA: 0.000, normed chi^2: . 762).

Extensive experience as PACS-user (T3)

At T3, *performance expectancy* and *social influence* determined physicians' *behavioral intention* to use PACS, while *effort expectancy* and *facilitating conditions* only indirectly influenced *behavioral intention* through their connections with respectively *social influence* and *performance expectancy*. Variance explained in *behavioral intention* was high (mcc .58), whereas *use* was hardly associated with *behavioral intention* (ß .15, p = . 25, mcc .02). The fit-parameters indicated moderate to good fit (GFI: .952, CFI: .976, RMSEA: .081, normed chi^2: 1.390).

Explaining self-reported frequency of use

The path analyses (Figure 3.2) showed that *behavioral intention* explained only a small part of the variance in *use*, while *facilitating conditions* were not associated with *use*. This low correlation between *behavioral intention* and *use* can be attributed to the overall high average scores on these scales at T2 and T3 (see Table 3.1). So, this low correlation may be due to a ceiling effect in PACS use, which is confirmed by a deeper inspection of the data showing that at T2 26 (50%) and at T3 46 (75%) physicians used PACS daily (= 7).

Research Question 2: Moderating effect of experience

Table 3.2 reports the results of the regression analyses. Only the beta coefficients of the interaction terms, and of the main effect of experience are relevant for research question 2, while regular linear regressions are needed to interpret the interaction effects. No main

effect of experience was found indicating that there was no change in acceptance (*behavioral intention*) from T1 to T2, nor from T2 to T3.

Table 3.2 Results of regression analyses, values reported are standardized regression coefficients (ß).

	T1	T2	T3	T1&T2		T2&T3	
				Model 1	Model 2	Model 1	Model 2
Adj. R^2 (in BI)	.25	.45	.63	.39	.45	.53	.54
Sign. R^2 change[$]	N/A	N/A	N/A	N/A	p=.01	N/A	p=.15
Experience				.07	.02	-.03	-.02
PE	-.01	.53***	.18	.34**	.62***	.39***	.64***
EE	.39*	-.19	.13	.01	-.21	-.02	-.19
SI	.27°	.48***	.60***	.42***	.52***	.51***	.54***
FC	.05	.16	.14	.15	.17	.12	.15
PE*Experience					-.33**		.33*
EE*Experience					.26*		-.22°
SI*Experience					-.19°		.03
FC*Experience					-.06		.01

*Notes: Columns "T1", "T2" and "T3" report ordinary linear regressions; columns "T1&T2" and "T2&T3" hierarchical linear regressions, with model 1 only direct effects, and model 2 both direct effects and interactions; empty cells depict relationships that could not be tested; [$]significance level of the change in R^2 by adding the interaction terms; N/A: not applicable; ***p<.001; **p<.01; *p<.05; °p<.10; BI: behavioral intention; PE: performance expectancy; EE: effort expectancy; SI: social influence; FC: facilitating conditions*

Evolution in the early stages after PACS-introduction (from T1 to T2)

The first hierarchical linear regression revealed one marginally significant (SI*Experience) and two significant (PE*Experience and EE*Experience) interaction effects. These interaction effects can be interpreted in this way: *performance expectancy* was not important at T1 (ß -.01, ns[1]), but became much more important while the physicians gained experience with PACS (ß .53, p < .001). *Effort expectancy* on the other hand was estimated

[1] ns = not significant (p-value greater than .10)

to be very important at T1 (ß .39, $p < .05$), but was of no importance at T2 (ß -.19, ns). The marginal significant interaction between *social influence* and experience (ß .21, $p < .10$) indicates that norms concerning the use of PACS became more important as the physicians started using the system. Adding the interaction terms led to a significant increase of variance explained ($F(4,88) = 3.396$, $p = .01$).

Evolution from limited (T2) to extensive (T3) experience

Only one significant interaction effect was found when pooling T2 and T3: the influence of *performance expectancy* on physicians' *behavioral intention* to use PACS decreased significantly (ß -.33, $p < .05$) from T2 (ß .53, $p < .001$) to T3 (ß .18, ns). The marginally significant interaction between *effort expectancy* and experience (ß .22, $p < .10$) indicates that *effort expectancy* becomes more important again when users gain experience; however, *effort expectancy* influenced *behavioral intention* neither at T2 (ß -.19, ns) nor at T3 (ß .13, ns). Adding the interaction terms did not significantly increase the amount of explained variance ($F(4,103) = 1.742$, $p = .15$).

Discussion

In this study, hospital physicians' PACS acceptance was assessed at three moments in time during the implementation process. The Unified Theory of Acceptance and Use of Technology was used as the theoretical framework for this study, aiming to address two research questions: (1) what factors influence PACS-acceptance, and (2) do these factors evolve over time. It was found that PACS acceptance was directly influenced by:

- *performance expectancy*: physicians are more likely to accept PACS if they believe that PACS enhances their job performance;
- *effort expectancy*: physicians are more likely to accept PACS if they believe that they will not have to invest a lot of time in mastering the skills required to do so; and
- *social influence*: physicians are more likely to accept PACS if they believe that their social environment encourages use of PACS.

No consensus exists in the literature as to whether *facilitating conditions* influence acceptance directly (Venkatesh, et al., 2003) or indirectly (Venkatesh & Bala, 2008). Although we did not test the direct influence of *facilitating conditions*, strong correlations were observed between *facilitating conditions* and the three other variables, so *facilitating conditions* most likely exert an indirect influence on acceptance.

We also found some evolution over time, especially in the early stages after the introduction of PACS: *effort expectancy* was of particular importance at T1, but lost significance at T2, while the inverse was observed for *performance expectancy*. No such evolution was observed between T2 and T3.

Getting physicians to accept and use PACS is one of the last hurdles implementers or the organization have to overcome (Pare & Trudel, 2007) in order to succeed. We will now discuss how the findings of our study can help implementers and/or the organization to overcome physicians' resistance and enhance acceptance and use of PACS. This is followed by a discussion of the contributions and limitations of this study, and options for follow-up research.

Managerial implications

By probing physicians' attitudes towards PACS we aimed to address two questions (see §1.2): (1) what actions to take to speed up PACS-acceptance from the beginning onwards; and (2) when PACS is already in use, how to maximize the use of PACS.

These questions are addressed in the action plan below. The assumption underlying this action plan is that physicians see no need to change their workflow to a new way of working.

- **Create an environment in which use of PACS is strongly supported.** Although pressuring physicians to (start to) use a technology could lead to adverse reactions (Lapointe & Rivard, 2005), in the organization under study, strong pressure to (start to) use PACS was exerted, and this positively effected PACS acceptance.

- **Adjust training strategy while physicians are still learning to work with PACS.** Major shifts in significance were found between T1 and T2, but not between T2 and T3; and only the significance level of *performance* and *effort expectancy* varied depending on the time of measurement (see Table 3.2). Therefore, at the introduction of PACS, training should be focused on ease of use (*effort expectancy*), thus on mastering the "basic" tasks, the tasks that physicians already perform on radiological images on the negatoscope. Training should then gradually shift to increasingly harder tasks involving advanced functionalities that make the true gain of PACS. In the setting under study, an opportunity was missed to maximize acceptance and use of PACS as illustrated in Figure 3.3. In Figure 3.3, the observed mean scale ratings (Table 3.1) on *performance* and *effort expectancy* are coupled to the corresponding ß standardized regression coefficients (Table 3.2), per time of measurement. We found that despite the strong influence of *performance expectancy* on *behavioral intention* at T2, physicians' mean rating on *performance expectancy* was quite low (M=3.22). So the organization or implementers should have focused on highlighting the usefulness of PACS: a theoretical increase of *performance expectancy* by one unit would result in an increase of .63 on *behavioral intention*.
- **Provide *facilitating conditions*.** We did not explicitly investigate the causal effect of *facilitating conditions* on the other independent variables, as proposed in Venkatesh and Bala (2008). Yet, from the correlations we can conclude that setting up a good training program and providing adequate support and compatible systems should positively influence perceptions of system usefulness (*performance expectancy*) and ease of use (*effort expectancy*), while physicians would also feel more supported and encouraged by their social environment to use PACS. Which would ultimately lead to an enhancement of physicians' acceptance of PACS.

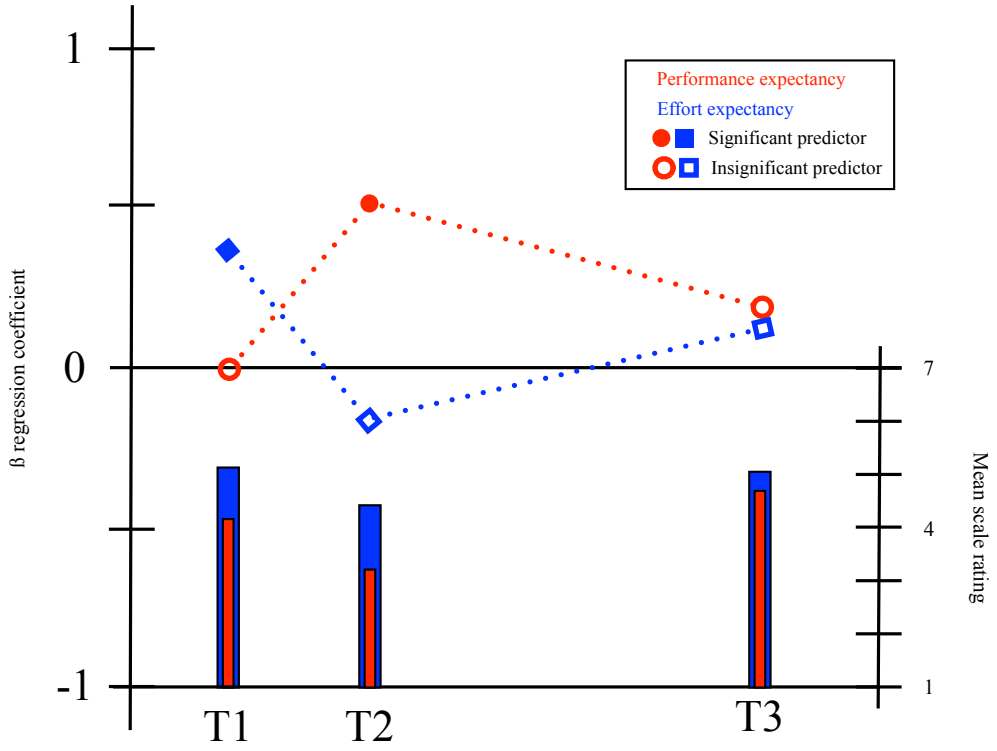

Figure 3.3 Graphical representation of the mean scale ratings (bars; for exact values see Table 3.1) and beta regression coefficients (squares and circles, see Table 3.2) of performance (in red) and effort expectancy (in blue) per time of measurement.

Note: dotted lines connecting the squares and circles do not imply linearity, but were inserted for clarity and aesthetic reasons

Study contributions

As stated in §1.5, our study should contribute to the literature in three respects: (1) come to a better understanding of the factors that influence physicians' acceptance of a CIS, in this case PACS; (2) gain insight into the dynamics underlying acceptance by taking multiple measurements; and (3) give insight in the acceptance process in a private hospital.

Factors influencing physicians' acceptance of PACS

The Unified Theory of Acceptance and Use of Technology was used as a theoretical framework, and as stated above, three out of four constructs directly influenced

physicians' *behavioral intention* to use PACS, while *facilitating conditions* might exert an indirect influence.

Multiple measurements

By taking multiple measurements, we found that the determinants for physicians' acceptance of PACS vary over time. This was especially the case in the early stages after the introduction of PACS.

Private (vs University) setting

The findings of this study differ remarkably from previous studies that identified *perceived usefulness* or *performance expectancy* as the main driver for physicians to accept and use a CIS (Bhattacherjee & Hikmet, 2007; Chang, et al., 2007; Chau & Hu, 2001, 2002a, 2002b; Duyck, et al., 2008a; Duyck, et al., 2010; Duyck, et al., 2008b; Ilie, et al., 2009). As pointed out by Heeks (2006) and Bhattacherjee and Hikmet (2007), private and public hospitals differ fundamentally in several respects, for instance in terms of staffing, IT infrastructure and education. The focus in private hospitals is rather on the impact of a technology on raising efficiency: in the hospital under study, physicians are paid on a fee-for-service basis and therefore using a new technology should be as effortless and fast as possible, hence the primary importance of *effort expectancy*. In a university setting such as in Devolder, et al. (2009), where physicians receive a fixed salary and in which a physician should fulfill, next to caring for and curing patients, other duties (such as educating physicians in training, and participating in scientific research); the applicability of a technology is evaluated in a wider perspective, e.g. in respect to its added value as a training or instruction tool, hence the primary importance of *perceived usefulness* or *performance expectancy.* Moreover, with respect to *facilitating conditions*, it is worth mentioning that the physicians in this setting were responsible for acquiring their own personal computers on which they had to consult PACS. This is not always the case in university hospitals, e.g. Devolder, et al. (2009). These differences offer a plausible explanation for the divergent results obtained in this study, which is the first to investigate PACS acceptance in a private hospital.

Limitations

The main limitation of this study pertains to the relatively low number of respondents, necessarily associated with the relatively small population in this setting. Fortunately, the response rate (25-30%) was comparable to or higher than in other studies involving hospital physicians (Alapetite, et al., 2009; Bhattacherjee & Hikmet, 2007; Chau & Hu, 2001, 2002a, 2002b; Duyck, et al., 2008a; Gagnon, et al., 2003; Ilie, et al., 2009; Pare, et al., 2005), so that we may be confident about the validity of our results. A larger number of respondents would also have benefited scale reliability.

Another limitation of this study lies in the tradeoff between social desirability and the degree to which evolutions may be traced among participants. In order to avoid socially desirable answers (e.g. caused by hospital management pressure), questionnaires were taken anonymously, leading to a cross-sectional instead of a longitudinal design. Although we estimate that our study led to some valuable insights, a longitudinal study is better in dissociating experience effects from between-subject variability.

Directions for further research

This study also raised some issues that can be addressed in follow-up research. First, the differences between our study and previous studies were striking and can possibly be attributed to differences between private and public hospitals (Bhattacherjee & Hikmet, 2007; Heeks, 2006). As most studies are performed in university or teaching hospitals, more research should be performed in private hospitals, or preferably even comparing both types of settings.

From a theoretical point of view, our study also raised questions concerning the operationalization of user acceptance. We found a ceiling effect when trying to explain use. It is of course an excellent finding that such a large proportion of the physicians used PACS daily, but use of PACS was mandatory so they had no other option than to use PACS to perform their job. The necessity of PACS use (does a physicians use PACS whenever possible, or only if absolutely necessary) is at this time not taken into account. So, follow-

up research should aim at identifying alternatives for self-reported frequency of use in which the necessity of a technology is taken into account.

Conclusion

In this study, physicians' acceptance of PACS was assessed on three occasions in a private hospital. Findings differed heavily from similar studies in university hospitals. First of all, *social influence* was identified as a major influencing variable: pressuring physicians to use PACS in this case positively effected PACS-acceptance. Second, physicians primary focus was on ease of use while usefulness of PACS became only later important.

When introducing PACS in a private hospital, the organization or implementers should create an environment in which use of PACS is strongly supported. Training should first focus on the tasks a physician already performs, introducing only later on the more advanced functionalities that make up the true gain of a PACS.

Our study demonstrated the added value of taking multiple measurements. It should be an onset to deeper research into the differences between private and university settings.

Addendum

In Chapter 5, variance explained in behavioral intention was considerably higher than in the other studies, see Figure 6.1. This might be due to the inclusion of attitude as predictor of intention. In order to find out whether including attitude adds to the prediction of behavioral intention or is redundant, due to the presence of both performance and effort expectancy, as claimed by Venkatesh, et al. (2003) additional hierarchical regression analyses were run. The results are displayed in Table 3.3.

Table 3.3 Hierarchical linear regression to investigate the added value of attitude

	T1		T2		T3	
	model 1	model 2	model 1	model 2	model 1	model 2
pe	-.01	-.08	.53***	.09	.18	-.07
ee	.39*	.18	-.19	-.31*	.13	-.05
si	.27°	.30*	.48***	.32**	.60***	.53***
fc	.05	-.06	.16	-.03	.14	.11
att		.45**		.80***		.50***
Adj. R^2 in BI	.25	.36	.45	.64	.63	.70
Sign. F Change		p=.009		p<.001		p<.001

Adding attitude led to a significant increase in variance explained on every instance, yet information was also lost: effort expectancy at T1 and performance expectancy at T2 lost significance, and a contra-intuitive, significantly negative influence of effort expectancy was observed at T2. The correlation between effort expectancy and behavioral intention was nonetheless positive and significant on all times (Pearson r respectively .50, p<.001; .31, p=.03; and .47, p<.001). So, the significantly negative β regression coefficient of effort expectancy at T2, can be explained as a net suppression effect (Cohen & Cohen, 1983), caused by the significant positive correlations among effort expectancy, attitude and behavioral intention: a large degree of overlap between attitude and effort expectancy (Pearson r = .68, p<.001), and intention correlated stronger with attitude (r=.72, p<.001) than with effort expectancy (r=.31, p=.03).

4 Predicting secondary school teachers' acceptance and use of a digital learning environment: a cross-sectional study

Based on:

Pynoo, B., Devolder, P., Tondeur, J., van Braak, J., Duyck, W. & Duyck, P. (2011). Predicting secondary school teachers' acceptance and use of a digital learning environment: a cross-sectional study. Computers in Human Behavior, 27, 568-575.

Chapter 4

Predicting secondary school teachers' acceptance and use of a digital learning environment: a cross-sectional study

Abstract

In this study, secondary school teachers' acceptance of a digital learning environment (DLE) was investigated. Questionnaires were taken on three times (T1 / T2 / T3) during the same school year, with the Unified Theory of Acceptance and Use of Technology (UTAUT) as theoretical framework. Next to questionnaires, user-logs were collected during the entire school year. A total of 72 teachers completed a questionnaire on at least one occasion: 64 teachers responded at T1, 41 at T2, and 55 at T3. We first investigated which factors influence teachers' acceptance of a DLE. The main predictors of DLE acceptance were performance expectancy and social influence by superiors to use the DLE. Effort expectancy and facilitating conditions were of minor importance. We then investigated how well the amount of final observed use could be predicted, and found that at T1 about one third, at T2 about one fourth and at T3 about half of the variance in observed use was predicted by attitude, behavioral intention and self-reported frequency of use. Our study showed that to maximize use of a DLE, its usefulness should be demonstrated, while school boards or principals should strongly encourage teachers to (start to) use the DLE.

Keywords: technology acceptance, UTAUT, digital learning environment, teacher, observed use

Abbreviations:
DLE: digital learning environment
EE: effort expectancy
FC: facilitating conditions
IS: information system
PE: performance expectancy
SI: social influence
TAM: technology acceptance model
TRA: theory of reasoned action
UTAUT: unified theory of acceptance and use of technology

Introduction

"I've come up with a set of rules that describe our reactions to technologies:

1. *Anything that is in the world when you're born is normal and ordinary and is just a natural part of the way the world works.*
2. *Anything that's invented between when you're fifteen and thirty-five is new and exciting and revolutionary and you can probably get a career in it.*
3. *Anything invented after you're thirty-five is against the natural order of things."*

Douglas Adams (2003), The Salmon of Doubt, p. 95

In today's information society, computers and the Internet are omnipresent, and their importance is only likely to rise. This is also the case in education where there is an increased use of technology in the classroom. And although the use of computers in education is not a new issue (Eteokleous-Grigoriou, 2009) technology can be a challenge for teachers. In view of the fast rate of technological development, teachers constantly need to adapt to new technologies and refine their skills in order to integrate technology into the classroom. One such new technology is a digital learning environment (DLE). A DLE offers new learning and teaching opportunities and novel ways of interacting to both students and teachers. It is up to the teacher to explore and exploit these opportunities. In view of teachers' central role in students' attitude formation concerning technology (Hu, et al., 2003) and their central role in integrating technology in the classroom (Chen, Looi, & Chen, 2009), it is important to understand what factors drive teachers to accept and use a new technology. Moreover, from an implementer's or school board's point of view, it is interesting to know whether the future use of the technology by its users can be predicted as soon as the technology is introduced. A technology acceptance study can provide an answer to these questions.

Technology Acceptance

The field of research on technology or information systems (IS) acceptance is very comprehensive. Building on the basis of social psychology and sociology theories like the Theory of Reasoned Action (Fishbein & Ajzen, 1975), Social Cognitive Theory (Bandura, 1986), Innovation Diffusion Theory (Rogers & Shoemaker, 1971), or the Theory of Interpersonal Behavior (Triandis, 1980), several models were developed, with the Technology Acceptance Model (TAM) (Davis, et al., 1989) as the most prominent model. TAM, building on the Theory of Reasoned Action, states that the acceptance of a technology depends on two types of beliefs: the technology's perceived usefulness and its perceived ease of use. TAM has been applied in several hundreds of studies in a wide range of settings, also in the field of education (e.g. Sanchez-Franco, 2010; Teo, et al., 2008). Typically no more than 40% of the variance in the dependent variable is explained, leaving room for additional antecedents of acceptance (Legris, et al., 2003), resulting in many follow-up studies focusing on model expansion or refinement. Ultimately, this led to a field of research in which the knowledge was dispersed and lacked structure, until Venkatesh, et al. (2003) synthesized the available body of evidence. Eight widespread (technology) acceptance theories were taken into account, and through an empirical study, four recurrent constructs were withheld and form the base of the development of the Unified Theory of Acceptance and Use of Technology (UTAUT):

- performance expectancy (PE): this encompasses perceived usefulness (Davis, 1989) and other constructs regarding the usefulness of the technology and is defined as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance" (Venkatesh, et al., 2003);
- effort expectancy (EE): this encompasses constructs concerning the ease of use of the technology, such as perceived ease of use (Davis, 1989), and is defined as "the degree of ease associated with the use of the system" (Venkatesh, et al., 2003);
- social influence (SI), encompassing constructs relating to norms in the social environment of the individual on his/her use of the technology, e.g. subjective norms

(Fishbein & Ajzen, 1975). Social influence is defined as "the degree to which an individual perceives that important others believe he or she should use the new system" (Venkatesh, et al., 2003);

- facilitating conditions (FC): this construct is very broad as it encompasses training, support, infrastructure, and knowledge. This construct was distilled from perceived behavioral control (Ajzen, 1991), facilitating conditions (Thompson, et al., 1991) and compatibility (Moore & Benbasat, 1991). It is defined as "the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system" (Venkatesh, et al., 2003).

Next to these four constructs, UTAUT also contains four variables that moderate the relationships between the predictors and intention or use: gender, age, experience with the technology and voluntariness of use. UTAUT was found to explain up to 70% of the variance in behavioral intention, thereby outperforming its originating models (Venkatesh, et al., 2003).

Technology Acceptance in Education

The introduction and use of computers (or technology in general) in education attracted the attention of several researchers in the past. Two major lines of research can be discerned: on the one hand acceptance studies (e.g. Hu, et al., 2003; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008) and on the other hand more educational research in which computer attitudes, teacher beliefs and the integration of computers in the classroom are studied (e.g. Hermans, et al., 2008; Mueller, et al., 2008; Sang, et al., 2010; Shapka & Ferrari, 2003; van Braak, et al., 2004).

Acceptance studies measure teachers' or student teachers' acceptance of computers (Kao & Tsai, 2009) operationalized as the intention to use (Hu, et al., 2003; Ma, et al., 2005; Teo, 2009) or attitudes towards computer (Teo, et al., 2008). As in acceptance studies in settings other than education, usefulness was a consistently strong predictor of acceptance (Hu, et al., 2003; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008). In general, the effect of ease of use was not that strong (Teo, et al., 2008) or only indirectly significant through usefulness (Hu,

et al., 2003; Ma, et al., 2005; Teo, 2009). The effect of subjective norms on acceptance was inconsistent. Teo, et al. (2008) identified it as a direct predictor of acceptance, while Hu, et al. (2003) found it to be influential only in the beginning, and Ma, et al. (2005) found no effect. Three studies found facilitating conditions (Teo, 2009; Teo, et al., 2008) or the related construct compatibility (Hu, et al., 2003) to influence acceptance indirectly through perceived ease of use and/or perceived usefulness. Other predictors of computer acceptance were attitude (Teo, 2009), (computer) self-efficacy (Hu, et al., 2003; Teo, 2009), job relevance (Hu, et al., 2003) and technological complexity (Teo, 2009)].

In educational sciences, several studies found that computer attitudes have a positive influence on the integration of computers in education. In these studies, the term (computer) attitudes may refer to very diverse constructs:

- General computer attitude: this encompasses confidence, anxiety and enjoyment/ liking (Hermans, et al., 2008; Shapka & Ferrari, 2003; van Braak, et al., 2004)
- Attitude towards computers in the classroom (Mueller, et al., 2008; Sang, et al., 2010; van Braak, et al., 2004) enclosing items related to the usefulness of a computer as a tool.

The importance of providing facilitating conditions is also a recurrent theme in this line of research. The following constructs that may be considered as categories of facilitating conditions were mentioned as important for integrating computers in education: equipment resources and support from school administrators (Smarkola, 2008), institutional support (Kadijevich, 2006), training, access to ICT resources and ongoing support (Williams, et al., 2000), and computer training (van Braak, et al., 2004). Other factors with a positive influence on the integration of computers in the classroom were self-efficacy (Sang, et al., 2010; Shapka & Ferrari, 2003) and computer experience (Hermans, et al., 2008; Mueller, et al., 2008).

Operationalizing Acceptance

Technology acceptance can be measured in several ways. Originally, models were devised for situations where users could choose to use (or not use) a technology, and this was reflected in the operationalization of acceptance: one accepts a technology if s/he uses (or intends to use) the technology. However, in many cases, users do not have a choice; they simply have to use the technology so that other conceptualizations of acceptance might be better (Warshaw & Davis, 1985b). Below, the most common operationalizations of acceptance are listed:

- *Use or use behavior* (Halawi & McCarthy, 2008; Landry, et al., 2006; Venkatesh, et al., 2003): observed or self-reported. Observed use can be considered as the ultimate measure for acceptance: e.g. the duration of use computed from system logs (Venkatesh, et al., 2003), recording the actions a subject undertakes while completing a task (Shapka & Ferrari, 2003). A problem with use (both observed and self-reported) is that it requires subjects to have some experience with the technology. When the implementation of a technology is still being planned, other measures of acceptance should be used.
- *Behavioral intention* (Marchewka, et al., 2007; Venkatesh, et al., 2003): this measure can be used both for cases where the technology has already been introduced, and for cases where it is still under planning.
- *Behavioral expectation* (Davis, 1985; Venkatesh, et al., 2008): this measure is closely related to and has frequently been confounded in the past with behavioral intention (Warshaw & Davis, 1985a). Behavioral expectation takes into account that something might interfere between the intention and the actual performance of the behavior. Behavioral expectation has been found to correlate more strongly with behavior than behavioral intention (Warshaw & Davis, 1985b).
- *Attitude toward use of the technology*: attitude already appeared in the first version of TAM. Attitude has been used as a measure for acceptance in both mandatory (Brown, et al., 2002; Pynoo, et al., 2007) and voluntary (Teo, et al., 2008) settings.

For this study, attitude, behavioral intention and use will be included as measures for acceptance. In view of the conceptual overlap with and dominance of behavioral intention in this field of research, behavioral expectation will not be taken into account. Use will be measured as self-reported frequency of use and observed frequency of use from log files.

Purpose

The purpose of this study is to scrutinize secondary school teachers' acceptance of a digital learning environment. Two research questions are put forward. We will first investigate which factors contribute to secondary school teachers' acceptance of a DLE. As we draw on UTAUT as theoretical framework, the first research question to be addressed in this study is:

RQ1: To what degree can performance expectancy, effort expectancy, social influence and facilitating conditions predict the acceptance of a DLE, measured as attitude, behavioral intention, self-reported frequency of use, and observed near-term use?

Second, we will also investigate if the amount of final observed use of the DLE can be predicted. As we dispose of both self-reported and observed measures, we will assess how well the self-reported measures of acceptance predict actual use. We hypothesize that these measures of acceptance have both a direct and indirect influence on the amount of observed use. A direct influence because attitude, behavioral intention and self-reported use all served in past research as measures for acceptance in the absence of a measure of observed use. An indirect influence because acceptance measures are interrelated: attitude influences intention (Davis, et al., 1989), intention in its turn self-reported use (Venkatesh, et al., 2003). Putting this together leads to the model as depicted in the research question 2 pane of Figure 4.1, while the second research question is formulated as follows:

RQ2: To what degree can attitude toward use of a DLE, behavioral intention to use the DLE and self-reported frequency of use of the DLE predict the final observed use of the DLE?

Combining the two research questions leads to the research model in Figure 4.1. By combining the research questions, we will be able to distill the factors that lead to a maximal use of the DLE.

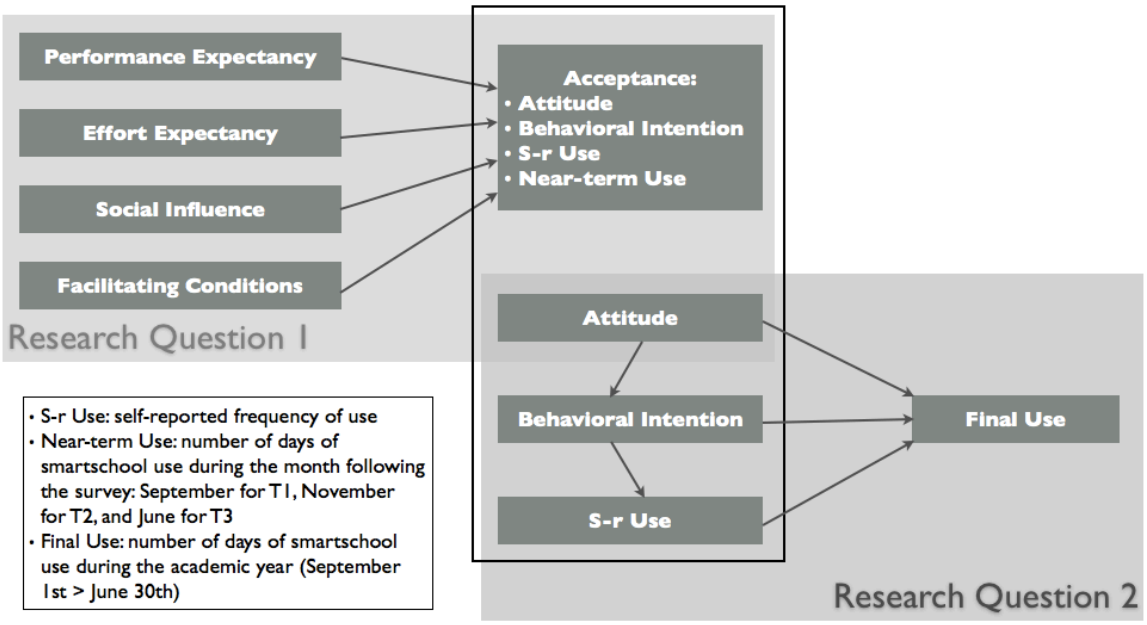

Figure 4.1 Research model

This study intends to add to the current literature on (educational) technology acceptance in three respects:

(1) by examining professional users (teachers);

(2) by administering questionnaires on three occasions during one school year. This way the evolution over time of the teachers' opinions concerning the technology can be revealed;

(3) by collecting, in addition to the questionnaires, use behavior from log-files. This is a major strength of the study, as most studies in this field of research have to rely on self-reported measures of acceptance (Legris, et al., 2003).

The combination of these three characteristics distinguishes this study from other (educational) technology acceptance studies.

Materials and Methods

Technology

The digital learning environment under scrutiny is Smartschool (www.smartschool.be). Smartschool offers its users (administrative force, school board, teachers and pupils) both basic and very advanced opportunities. The three core functionalities of Smartschool are:

- digital learning environment consisting of 16 modules. In the DLE, teachers can set up learning paths, create exercises, take tests, collect and store tasks, etc.;
- communication: Smartschool has an internal messaging system for communication between users, public discussions can be conducted in forums, and users can read important messages from the school board on the bulletin board;
- administration: this comprises for example taking surveys, online timetables, and an intradesk where users can submit important documents.

Next to these core functionalities, extra features can be added to Smartschool, like an online scorecard, or linking the upload zone with Ephorus (www.ephorus.nl) to control for plagiarism in student papers.

Data Collection

Study population.

The participants were members of the teaching staff (total population of 90 teachers) of a secondary school. The school is situated in the Dutch-speaking part of Belgium. In this school, three streams of education are offered: general, technical and vocational education.

Instrument.

The acceptance part of the questionnaire was made up of 21 items (22 at T2 and T3, see the first paragraph of the results section). The items were adapted from Duyck, et al. (2008b), Moore and Benbasat (1991), and Venkatesh, et al. (2003), and tweaked to an educational context. The following scales (number of items per scale between brackets) were included in the questionnaire survey: performance expectancy (four items), effort expectancy (three

items at T1, four at T2 and T3, see the first paragraph of the results section), social influence (four items), facilitating conditions (three items), attitude (three items), behavioral intention (two items), and self-reported frequency of use (two items). As the use of the digital learning environment was mandatory, we were only interested in social influence exerted by superiors and the SI-scale was adjusted in this way. All items had to be rated on a 7-point Likert scale ranging from "completely disagree (1)" to "completely agree (7)", except for self-reported use that ranged from "never (1)" to "daily (7)".

Next to these items, demographic information (gender, age, domain of teaching) was collected while the teachers could also indicate which of the 16 modules in the DLE part they used. At the end of the questionnaire, there was room for remarks or complaints.

For this study, use is derived from system logs containing date and time a user logged in into the system. Two measures were computed:

- Near-term use : number of days a teacher logged in into the system during the month following the survey, respectively the use in September (T1), November (T2) and June (T3);
- Final use: number of days a teacher logged in into the system during the school year 2006-2007 (from September 1st to June 30th).

Procedure.

The questionnaire was administered at three times during the same school year. The first questionnaire (T1) was taken during a plenary preparatory meeting at the end of August prior to the start of school year. At this meeting, Smartschool was formally introduced to the teaching staff, although it was accessible since May and already pretested. At the meeting, the principal strongly encouraged the teachers to use Smartschool during the lessons and for school tasks. He also announced that Smartschool would replace the official bulletin board, hence that use of Smartschool was mandatory. Teachers were given time to complete the questionnaire during the meeting, the responses were collected at the end, this way 64 usable responses were collected.

The second (T2) and third (T3) questionnaires were handed out to the teachers per their personal pigeonhole in the teachers' room. Completed responses could be posted in a sealed box in the teachers' room. The second questionnaire was handed out at the end of October, right before fall break, and 41 usable responses were collected. The last questionnaire was handed out at the end of May, and 55 usable responses were returned. A total of 72 (unique) teachers completed at least one questionnaire; user logs (showing data and time the user logged in into Smartschool) were collected for these 72 teachers.

Data-analysis

Prior to the analysis of the research questions, some preliminary analyses will be run. First, the reliability of the scales will be established using Cronbach α. Then descriptive statistics will be computed and the correlations between the constructs will be calculated.

For the first research question, we want to investigate which factors contribute to the acceptance of the DLE, if this changes over time, and how well the predictors predict the acceptance of the DLE. Hereto, ordinary least squares regression analyses will be run in SPSS 15, per measure of acceptance, pooled over the measurements and per measurement (T1, T2 or T3).

Path analysis using AMOS 6.0 will be applied to address the second research question, as we do not only want to investigate how well the self-reported measures of acceptance predict observed use, but also how the self-reported measures interrelate. To test the fit between our model and the data, the following fit-measures will be used: normed Chi^2, root mean square error of approximation (RMSEA), comparative fit index (CFI), and adjusted goodness-of-fit index (AGFI). The recommendations of Hu and Bentler (1999) are used: below .05 for RMSEA and higher than .95 for CFI and AGFI, while for normed $Chi^2 < 3.0$ (Teo, Lee, Chai, & Wong, 2009).

Results

Preliminary Analyses: Reliability, Descriptive Statistics, Correlations

Table 4.1 displays the reliability and descriptive statistics of the scales and measures that were used throughout this study. The reliability of the FC-scale was below the threshold for acceptable reliability (.70) (Nunnally & Bernstein, 1994), however, by removing the item "Smartschool is not compatible with other systems I use" the reliability of this scale was drastically improved. For the EE-scale, there was a problem with one item ("I fear that learning to work with Smartschool will not go fast and will take a lot of time") at T1, therefore the item was replaced by "Learning to work with Smartschool did not go fast" and "Working with Smartschool costs me little trouble". In order to maximize comparability, only the two items that were measured on all three occasions were withheld for the EE-scale for the remainder of the analyses.

Table 4.1 Reliability and mean of the scales per measurement.

		T1 (n = 64)	T2 (n = 41)	T3 (n = 55)
	Cronbach α	***M* (SD)**	***M* (SD)**	***M* (SD)**
PE	.84	3.52 (1.60)	3.54 (1.68)	3.76 (1.69)
EE	.72	4.15 (1.54)[c]	4.00 (1.48)[b]	4.81 (1.46)[bc]
SI	.73	6.03 (1.01)	5.99 (1.30)	6.24 (0.88)
FC	.84	4.10 (1.36)[a]	4.80 (1.56)[a]	4.28 (1.62)
BI	.84	5.22 (1.58)	5.39 (1.54)	5.42 (1.31)
ATT	.90	4.26 (1.57)	4.29 (1.79)	4.75 (1.50)
s-r USE	.96	4.26 (1.59)[ac]	6.01 (1.09)[a]	6.02 (1.22)[c]
final use[d]		182.33 (62.94)	199.71 (54.05)	193.44 (57.56)
near-term use[e]		21.34 (7.02)	22.20 (5.84)	20.85 (6.50)

Notes: [abc]:values in the same line with the same superscript differ on $p < .05$ (independent samples t-test, 2-sided); [d]: number of days of Smartschool use during the school year; [e]number of days of Smartschool use during the month following the survey

Five significant differences between the mean scale ratings were observed (Table 4.1). Perceptions of the ease of use of Smartschool (EE) were significantly higher at T3

compared to both T1 ($t(117) = 2.392$, $p = .018$) and T2 ($t(94) = 2.670$, $p = .009$). Mean scores on facilitating conditions increased significantly from T1 to T2 ($t(102) = 2.426$, $p = .017$). Finally, self-reported use (s-r use) on T1 was significantly lower compared to both T2 ($t(100.923) = 6.667$, $p < .001$) and T3 ($t(115.741) = 6.823$, $p < .001$).

The descriptive statistics show that the users rated performance expectancy of Smartschool low. Another remarkable, yet expected, finding is the high mean score on the SI-scale at all times.

The correlation analysis did not reveal unexpected findings, but we will highlight some results.

First, at all three times we observed a very high correlation between attitude and PE (r between .86 and .92, all $p < .001$) or EE (r between .72 and .77, all $p < .001$). FC correlated strongly at all times with PE (r between .57 and .64, all $p < .001$) and EE (r between .48 and .64, all $p < .001$).

Looking at the correlations between the dependent variables, we saw that the correlation between near-term and final use was very high at all times (r from .86 to .91). The correlations between the three measures of near-term use of the unique teachers ($n = 72$) were equally high: the correlation between use of Smartschool during September and during November was .65, between September and June .53, and between November and June .78. Apparently, users almost immediately adopt a base-rate of Smartschool use. This base-rate could be subjected to minor changes especially at the beginning of use (period between T1 and T2), while from T2 on only minimal shifts took place. One more trend deserves attention: we found that the correlation between attitude and the observed measures of use increased over time. For final use from $r = .25$, $p < .05$ at T1 to $r = .39$, $p < .01$, while for near-term use from $r = .16$, $p > .10$ at T1 to $r = .42$, $p < .01$ at T3.

Research Question 1: Explaining and Predicting Acceptance

A regression analysis was performed to investigate which factors determine the acceptance of Smartschool. Separate regression analyses per operationalization of acceptance and per

time were run, the results are reported in Table 4.2. To get a view on the changes over time, we also pooled the data over the three measurements and ran hierarchical regression analyses per dependent variable. The first block contained a time variable (T1/T2/T3) and the UTAUT-predictors, while the second block held the interaction terms. The results are displayed in Table 4.3.

Table 4.2 Results of regression analysis.

	Attitude			Behavioral intention			Self-reported USE			Near-term use		
timing	T1	T2	T3	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
PE[a]	.62***	.79***	.79***	.39**	.61**	.33°	.16	.11	.18	.36°	.57*	.29
EE[a]	.31***	.14	.18°	.11	-.14	.37*	.19	.07	.21	-.04	-.40°	.12
SI[a]	-.02	-.01	.00	.36**	.26°	.22*	.43***	.09	.27*	.31*	.23	.07
FC[a]	.04	.03	-.08	.08	.19	-.05	.12	.38°	-.03	-.17	.35°	.03
Adj. R^2	.78	.84	76	.35	.31	.38	.29	.16	.12	.08	.26	.11
Model test[b]	***	***	***	***	**	***	***	*	*	°	**	*

*Notes: [a]The values reported are standardized ß regression coefficients; [b]Model test: significance level of the model test; ***p < .001; **p < .01; *p < .05; °p < .10*

Predicting attitude.

Performance expectancy is the primary predictor of attitude (β = .62), while effort expectancy was only significant for predicting attitude at T1 (β = .31) and marginally at T3 (β = .18, p = .08). At all three measurement moments, social influence and facilitating conditions did not have any direct effect on attitude. The amount of variance explained in attitude was very high, ranging from adjusted R^2 = .77 at T1 to .85 at T2. The pooled analysis revealed nothing new, and adding the interaction terms did not increase the proportion of variance explained.

Predicting behavioral intention.

The primary predictor of behavioral intention at T1 was performance expectancy (β = .39), but the effect of social influence (β = .36) was also significant. The effect of effort expectancy (β = .11) and facilitating conditions (β = .08) was not significant at this time. At T2, when the teachers had acquired some experience with Smartschool, performance

expectancy (β = .61) was the only significant predictor of intention, while the effect of social influence (β = .26, p = .07) appeared to be only marginal. At T3, when the teachers had acquired extensive experience with the use of Smartschool, the most significant predictor was effort expectancy (β = .37), together with social influence (β = .22). Performance expectancy (β = .33, p = .06) was only marginally significant. The proportion of variance explained appeared to be significantly lower compared to that in attitude, ranging from adjusted R^2 between .31 and .38. The pooled analysis showed that only performance expectancy (β = .71) and social influence (β = .28) predicted intention. Adding the interaction terms did not lead to any increase in the amount of variance explained.

Table 4.3 Results of hierarchical regression analysis, pooled over three measurements.

pooled	ATT	BI	s-r USE	USE M+1
time[a]	.04	-.04	.43***	-.07
PE[a]	.71***	.42***	.14	.36**
EE[a]	.24***	.13	.07	-.06
SI[a]	-.02	.28***	.23***	.20*
FC[a]	-.01	.08	.21*	.03
time x PE[a]	.05	-.05	.03	-.02
time x EE[a]	-.05	.08	-.05	.05
time x SI[a]	.01	-.07	-.09	-.10
time x FC[a]	-.05	-.07	-.10	.08
Adj. R^2	.80	.35	.38	.12
sig R^2 change[b]	p = .60	p = .62	p = .29	p = .54

Notes: [a]The values reported are standardized ß regression coefficients; [b]this refers to the significance level of the change in R^2 after adding the interaction terms.

Predicting self-reported use.

At T1, social influence (β = .43) was the sole significant predictor of teachers' self-reported use of Smartschool. The effect of facilitating conditions (β = .38, p = .06) was marginally significant at T2, no other effects were found at this time. Just as at T1, social influence (β = .27) was the sole predictor of self-reported use at T3. Variance explained was low at T2 and T3 (.16 and .12), while at T1 about one third of the variance was explained. The

pooled analysis provided more information. A main effect of time (β = .43) was found, indicating that self-reported use increased over time. Both facilitating conditions (β = .21) and social influence (β = .23) had a direct effect on self-reported use. Variance explained was a lot higher compared to the analyses per measurement. Adding interaction terms did not lead to any increase in the proportion of variance explained.

Predicting near-term use.

At T1, performance expectancy, albeit marginally (β = .36, p = .07), and social influence (β = .31) predicted Smartschool use during the month of September. Variance explained in use was very low (Adj. R^2 .08), and the model just failed to reach significance (p = .06). At T2, variance explained was considerably higher (Adj. R^2 .26) but only performance expectancy (β = .57) was significant for predicting Smartschool use during November. The effects of effort expectancy (ß = -.40, p = .10) and facilitating conditions (ß = .35, p = .05) on use were marginally significant. At T3 none of the predictors were significant and variance explained was equally low (Adj. R^2 = .11). Performance expectancy appeared to be the most important factor (ß = .29, p = .16). The pooled data analysis showed that performance expectancy (β = .36) and social influence (β = .20) were the only predictors of near-term use. Variance explained was low (Adj. R^2 = .12).

Research Question 2: Explaining and Predicting Final Use

The second research question concerned the prediction of the final use of Smartschool. The results of the path model are displayed in Figure 4.2.

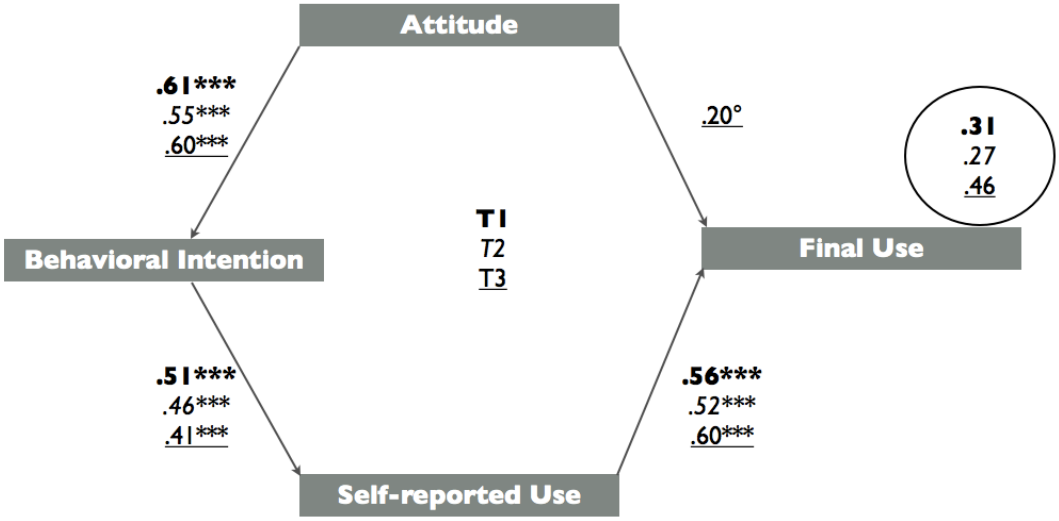

*Figure 4.2 Path analysis: final models. The values displayed are standardized regression coefficients and multiple correlation coefficients. Notes: values in bold refer to the analysis at T1, in italics to T2 and underlined to T3; *** p < .001; ° p < .10*

Per time, two models were analyzed: the original version as displayed in Figure 4.1 (RQ2 pane) and a final model (Figure 4.2) in which goodness-of-fit was maximized. Quality fit measures were very good for all three final models. At all times, normed chi^2 was lower than 1 (respectively .523, .987 and .333), CFI equaled 1 and RMSEA 0. Due to missing values AGFI could not be computed at T2, but at T1 and T3 AGFI also indicated a good measurement fit (.959 and .970 respectively). Already at T1, a substantive portion of the variance in "final use" could be explained (mcc = .31). Variance explained was slightly lower at T2 (mcc = .27), while at T3 variance explained was high as about half of the variance in observed use was explained (mcc = .46).

On all times, the same direction of influences was observed: attitude influences behavioral intention; behavioral intention self-reported use, and self-reported use observed use. There was one minor exception, the influence of attitude on observed use increased over time. While nonexistent at T1 (ß = -.02) and T2 (ß = .07), the influence of attitude on observed use was marginally significant at T3 (ß = .20, p < .10).

Discussion

Predicting Acceptance

The primary aim of this study was to assess which factors contribute to the acceptance of Smartschool. Hereto, acceptance was operationalized in four ways (attitude, behavioral intention, self-reported frequency of use and observed near-term use), and UTAUT was chosen as theoretical framework. This proved to be fruitful, as depending on the operationalization of acceptance, other predictors arose. To summarize: teachers hold a positive attitude of Smartschool because it is useful (PE) and easy to use (EE); they intend to use Smartschool because it is useful (PE) and their superiors expect them to use it (SI); they report that they use Smartschool more frequently the more they feel that their superiors expect them to use it (SI) and if the ideal conditions are created (FC); and their actual use of Smartschool depends on its usefulness (PE) and pressure from superiors to use Smartschool (SI).

Performance expectancy.

Except for self-reported use, the usefulness of the technology (measured as performance expectancy) was the main predictor of DLE-acceptance. This conforms to earlier TAM-studies in educational settings (Hu, et al., 2003; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008). In the case of self-reported use, performance expectancy was of no significance.

Effort expectancy.

In studies involving professional users (Duyck, et al., 2008b; Hu, et al., 2003), ease of use is often subordinate to usefulness and this is also what has been found in the current study. Effort expectancy was a predictor of attitude, especially in the beginning, and interestingly, it was also the strongest predictor of intention at T3.

Social influence.

Although social influence in UTAUT and subjective norms in TAM2 are modeled as antecedents to behavioral intention and not to use, the construct was the main predictor of self-reported frequency of use. The regression analyses per measurement showed that the

effect of social influence on acceptance (measured as behavioral intention, self-reported use and near-term use) was strongest at T1, slightly less strong at T3, while no effect was found at T2.

Facilitating conditions.

According to Venkatesh, et al. (2003), facilitating conditions should only have a direct influence on use. We also found a limited effect of facilitating conditions on acceptance: after pooling the data, the construct was, together with social influence, a predictor of self-reported use. The regression analyses per measurement revealed that facilitating conditions were only a marginally significant predictor of self-reported use at T2. This does not mean that facilitating conditions are of almost no importance, only that their influence is indirect rather than direct. A theoretical foundation hereto is provided by Venkatesh and Bala (2008). In their TAM3 model, facilitating conditions and social influence are modeled as antecedents to perceived usefulness and perceived ease of use, and they argued that constructs related to social influence determine usefulness, while facilitating conditions should load solely on ease of use. This is contrary to what we found. Inspecting the correlations, no relationship was observed between social influence and performance expectancy, while strong correlations were observed between facilitating conditions and both performance and effort expectancy. So, it seems that although the provision of facilitating conditions has no direct effect on acceptance (except marginally on self-reported and near-term use at T2, and pooled on self-reported use), facilitating conditions might have a significant indirect influence on acceptance through performance and effort expectancy.

Predicting Observed Final Use

In order to address the second research question, we investigated to what extent self-reported measures of acceptance could predict the observed final use of Smartschool. Hereto, path analyses were run. Already at T1, we were able to predict about one third of the variance in the use that would be observed throughout the school year. Moreover, correlation analyses indicated that the users almost immediately adopted a base-rate of

Smartschool use. This stresses the importance of preparing teachers to start using a new technology like a digital learning environment.

The path analyses showed that the only predictor of final use was self-reported frequency of use, while indirectly, attitude and intention played a role through self-reported use. As could be expected from Davis, et al. (1989), a linear relationship was found between these constructs: attitude has an effect on intention, while intention has an effect on self-reported frequency of use, and the latter on observed use.

Maximizing Use

Looking at the predictors of self-reported measures for acceptance we can conclude that in order to maximize the final use of the system, teachers should be urged to use the system right from the beginning, while stressing the usefulness of the system. Keeping in mind that the users rated the performance expectancy of Smartschool below four (on a 1-7 Likert scale), a lot of effort should have been invested in detailing the features of the system to maximize its use. Effort expectancy has in this case only a marginal influence through usefulness or attitude.

At T2, social influence becomes less important, but facilitating conditions comes into play, as the only (marginally significant) predictor of self-reported use. So after the technology is introduced, the necessary conditions should be created to facilitate use of the system. The usefulness of the system is also important at this time as it influences a teachers' intention to use the system and attitude toward the system.

At T3, social influence emerged again as sole predictor of self-reported use. Therefore urging teachers to use Smartschool remains important, even after several months of use. At T3, the importance of attitude for predicting final use also emerged. A teacher's attitude toward Smartschool was best explained by the system's usefulness and ease of use. On the other hand, teachers intend to keep using Smartschool, because it is easy to use and because they are urged to use it. So at T3, every factor is important as it can have a direct or indirect effect on the observed use.

Limitations

The main limitation of this study pertains to the sample size of our study. On top of this, the response rate at T2 was rather low. So future researchers should be careful in generalizing our results. Nonetheless, in view of reliability of the scales and as we collected information from two sources - questionnaires and user logs - we feel rather confident on the validity of our results.

Conclusion

In this study, secondary school teachers' acceptance and use of a digital learning environment was scrutinized by administering questionnaires drawing on UTAUT as theoretical framework, on three occasions during the same school year. In addition to the questionnaires, use behavior was extracted from log files. We first investigated which factors contributed to teachers' acceptance of the DLE. Acceptance was operationalized in four ways: attitude, intention, self-reported frequency of use and observed near-term use. The predictors differed depending on the operationalization of acceptance and on the timing of the measurement, but overall, we found that Performance Expectancy and Social Influence exerted by superiors to use the DLE were the main predictors of acceptance, while Effort Expectancy and the provision of Facilitating Conditions were of minor importance. Second, as we derived use behavior from log files, we investigated how well the amount of final observed use could be predicted during the school year. We found that at T1 about one third, at T2 about one fourth, and at T3 about half of the variance in final observed use was predicted by attitude, behavioral intention, and self-reported frequency of use. The user logs also showed that teachers seemed to adopt a base frequency of DLE-use almost from the beginning. Our results show that in order to maximize the use of a digital learning environment, its usefulness should be demonstrated and stressed, while school boards or principals should enforce teachers to (start to) use the DLE.

Addendum

In Chapter 5, variance explained in behavioral intention was considerably higher than in the other studies, see Figure 6.1, which might be due to the inclusion of attitude as a predictor of intention. In order to find out whether including attitude adds to the prediction of behavioral intention or is redundant as claimed by Venkatesh, et al. (2003), due to the presence of both performance and effort expectancy, additional hierarchical regression analyses were run. The results are displayed in Table 4.4. Only at T1, adding attitude led to a significant increase in variance explained, while the (marginally) significant β regression coefficients of performance expectancy (T1, T2 and T3) and effort expectancy (T3) lost significance with the inclusion of attitude.

Table 4.4 Hierarchical linear regression to investigate the added value of attitude

	T1		T2		T3	
	model 1	model 2	model 1	model 2	model 1	model 2
pe	.39*	-.11	.61**	.28	.33°	.05
ee	.11	-.15	-.14	-.20	.37*	.30°
si	.36**	.38***	.26°	.26°	.22*	.22*
fc	.08	.04	.19	.17	-.05	-.02
att		.80***		.42		.35
Adj. R^2 in BI	.35	.48	.31	.32	.38	.40
Sign. F Change		p<.001		p=.24		p=.12

Only 30 teachers filled out the questionnaire on every occasion. From Table 4.1 it was concluded that mean scale ratings did not change much as the school year progressed, which could be due to the cross-sectional nature of the data in Table 4.1. From Table 4.5 about the same conclusions can be drawn as from Table 4.1: no differences on mean scale ratings of performance expectancy, social influence, and behavioral intention; and differences over time on effort expectancy, facilitating conditions, and self-reported use. The only exception is that in Table 4.5 a difference was observed between the ratings on

the attitude scale, whereas in Table 4.1 not. To identify which mean scale ratings differed significantly, paired-samples t-tests were employed. Superscripts [a,b,c] indicate the significant differences.

Table 4.5 Mean scale ratings of the teachers that filled out the questionnaire on every occasion (N=30)

	T1	T2	T3	GLM Repeated Measures
pe	3.53	3.39	3.57	F(2,58)=.441, p=.65
ee	4.37[a]	3.73[a,b]	4.75[b]	F(2,58)=10.874, p<.001
si	6.28	6.28	6.19	F(2,58)=.209, p=.81
fc	4.08[a]	4.80[a,b]	4.27[b]	F(2,58)=5.185, p=.008
bi	5.68	5.52	5.50	F(2,58)=.432, p=.65
use	4.73[a,c]	6.08[a]	6.20[c]	F(2,58)=30.195, p<.001
att	4.38	4.12[b]	4.77[b]	F(2,58)=5.757, p=.005

Notes: [abc]:values in the same line with the same superscript differ on p < .05 (independent samples t-test, 2-sided)

In Chapter 3, rather than pooling over the three measurements to investigate the moderating effect of experience as was performed in this Chapter, T1 and T2, and T2 and T3 were compared. To enable a comparison, the same procedure was followed as in Chapter 3, the results of these hierarchical regression analyses are in Table 4.6. Only one observation counts, namely adding the interaction terms did not lead to an increase in variance explained in behavioral intention. One marginally significant interaction was found, effort expectancy was (marginally) more important at T3 than at T2.

Table 4.6 Results of regression analyses, values reported are standardized regression coefficients (β).

	T1	T2	T3	T1&T2		T2&T3	
				Model 1	**Model 2**	**Model 1**	**Model 2**
Adj. R^2 (in BI)	.35	.31	.38	.34	.33	.34	.34
Sign. R^2 change[$]	N/A	N/A	N/A	N/A	p=.73	N/A	p=.38
Experience				.02	-.01	-.09	-.05
PE	.39**	.61**	.33°	.46***	.57**	.44**	.68**
EE	.11	-.14	.37*	.04	-.12	.18	-.18
SI	.36**	.26°	.22*	.31***	.24*	.25**	.24*
FC	.08	.19	-.05	.13	.17	.03	.23
PE*Experience					.13		-.29
EE*Experience					-.18		.40°
SI*Experience					-.12		.01
FC*Experience					.06		-.21

*Notes: Columns "T1", "T2" and "T3" report ordinary linear regressions (Table 4.2); columns "T1&T2" and "T2&T3" hierarchical linear regressions, with model 1 only direct effects, and model 2 both direct effects and interactions; empty cells depict relationships that could not be tested; [$]significance level of the change in R^2 by adding the interaction terms; N/A: not applicable; ***p<.001; **p<.01; *p<.05; °p<.10; BI: behavioral intention; PE: performance expectancy; EE: effort expectancy; SI: social influence; FC: facilitating conditions*

5 Teachers' acceptance and use of an educational portal

Based on:

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Chapter 5

Teachers' acceptance and use of an educational portal

Abstract

In this study, teachers' acceptance and use of an educational portal is assessed based on data from two sources: usage data (number of logins, downloads, uploads, reactions and pages viewed) and an online acceptance questionnaire. The usage data is extracted on two occasions from the portal's database: at survey completion (T1) and twenty-two months later (T2). Framework for this study is C-TAM-TPB (Combined Technology Acceptance Model and Theory of Planned Behavior). 919 usable responses from teachers are obtained. Based on the observed use data at T1, four types of portal-users are distinguished: 'new' (N=37), 'light' (N=641), 'medium' (N=201), and 'heavy' (N=40). Path analyses show that all predictor variables in C-TAM-TPB influence teachers' portal acceptance, but their significance level varies depending on the user type. The strongest predictors of behavioral intention to use the portal are attitude ('new') and perceived usefulness ('light', 'medium' and 'heavy'), with variance explained ranging from .39 ('medium') to .71 ('heavy'). The observed use data show that the portal is primarily used to search for and download material, rather than for sharing material or information. The use data at T2 show that teachers become more efficient in their search behavior and that the majority of the teachers use the portal more frequently. Guidelines are proposed to policymakers and school boards aiming to introduce a similar technology to teachers.

Key words: learning communities; secondary education; evaluation of CAL systems; human-computer interface

Introduction

With the spectacular growth in the number of users and the amount of information on the Internet, portals gain in significance as they bundle relevant information for their users (Jacoby & Luqi, 2005). The occurrence of portals is a logical next step in the evolution of (non-expert) end-user computing from stand-alone computers for personal use, via personal computers connected enterprise-wide, to computers interconnected throughout the Internet (Al-Mudimigh, Ullah, & Alsubaie, 2011). Within the broad variety of existing portals, a distinction can be made between portals targeting a broad audience, such as MSN or Yahoo! (so-called horizontal portals), portals aimed at specific communities or areas of knowledge (vertical portals or vortals), intranet or enterprise portals and Internet gateways (Pienaar, 2003; Singh, 2006). In view of the rich variety of portals, Singh (2006) first reviewed existing definitions and then defined portals in terms of three characteristics, being: (a) gateways to information, (b) user-centric and community-based, and (c) providing multiple services to the community.

Also in education, portals can prove their value, and the potential benefits of educational portals are acknowledged in many countries, such as Glow in Scotland, Kennisnet in Holland, and the National Educational Portal in Kenya. Previous research shows that teachers use a computer or technology primarily as a preparation or supportive tool (Ottenbreit-Leftwich, Glazewski, Newby, & Ertmer, 2010; Russell, Bebell, O'Dwyer, & O'Connor, 2003) rather than an instructional tool in the classroom (Mahdizadeh, Biemans, & Mulder, 2008). Using a technology or computer as a supportive tool refers to using it for pro-active and administrative tasks (van Braak, et al., 2004), such as for student administration and evaluation, preparing worksheets and keeping track of pupils' learning progress. Technology integration in the classroom seems to be strongly related to and depend on the use of technology as a supportive tool (Wozney, Venkatesh, & Abrami, 2006). Teachers who are already regular ICT users have more confidence in using technology in their teaching (Cox, Preston, & Cox, 1999). In this vein, educational portals can play a facilitating role, as they help teachers to become familiar with and confident in using ICT. Portals are very accessible, not threatening (use can hardly be imposed by

school boards) and prove their value almost immediately (as soon as valuable information is retrieved). Educational portals can be utilized in two ways as a supportive tool during preparation, either to retrieve information or to share knowledge and information. In both cases, teachers benefit from using the portal. On the one hand, while searching for (specific) material, a teacher could gain new insights as fellow teachers might take a different angle on a given subject (Ottenbreit-Leftwich, et al., 2010). Moreover, teachers should also gain in efficiency as someone else may have already shared the sought-after lesson or learning material (Wasko & Faraj, 2000). On the other hand, a teacher who shares material could benefit from "peer review" ultimately leading to improved teaching material (Kankanhalli, Tan, & Wei, 2005; Lai & Chen, 2011; Wasko & Faraj, 2000).

User acceptance

Previous research indicates that it is vital for a portal that its users develop positive attitudes towards the portal from the beginning, and that the portal meets the expectations of its users so that their initially positive attitudes are endorsed (Al-Mudimigh, et al., 2011; Hong, Kim, & Lee, 2008). One way to assess portal users' attitudes is by conducting an acceptance study, as will be done here.

To assess teachers' acceptance of the portal, we draw on the literature on technology acceptance. Numerous models (see Venkatesh, et al. (2003) for an overview) have been developed to explain and predict technology acceptance, which can be operationalized or measured either as attitude, behavioral intention, behavioral expectation, and/or use (either observed or self-reported) (Brown, et al., 2002; Davis, 1989; Pynoo, et al., 2007; Venkatesh, et al., 2008; Venkatesh, et al., 2003; Warshaw & Davis, 1985b). If these different operationalizations for acceptance coexist, attitude serves as an antecedent to behavioral intention/expectation, which in turn predicts use (Davis, et al., 1989; Pynoo, et al., 2011a; Venkatesh, et al., 2003).

Following an extensive review of the literature, four categories of constructs were presented as core determinants of acceptance (Venkatesh, et al., 2003). These pertain to: the usefulness of the technology, the ease of use of the technology, norms in the social

environment concerning use of the technology, and perceived behavioral control or facilitating conditions. The latter of these determinants refers to objective factors that facilitate the use of the technology. There is an ongoing debate as to whether the last two factors have a direct (Venkatesh, et al., 2003) or indirect (Venkatesh & Bala, 2008) effect on acceptance. Attitude is a possible fifth determinant that can serve both as a dependent and an independent variable. For this study, consistent with previous research (Chau & Hu, 2002b; Taylor & Todd, 1995a), we combine the Technology Acceptance Model (TAM) (Davis, 1989) and the Technology of Planned Behavior (TPB) (Ajzen, 1991), two models that build upon the Theory of Reasoned Action (Fishbein & Ajzen, 1975). This combined model incorporates the five determinants; see Figure 1.4.

In business settings, the technology's usefulness is typically identified as the main determinant for acceptance, whereas the impact of the other factors depends on the technology (voluntary or mandatory use) and population (gender, age, experience) studied. Our findings might differ from those in business settings because [a] educational institutions serve very different goals than profit organizations (Hu, et al., 2003) (i.e. economic return and efficiency are inferior to learning goal realizations) and [b] teachers have a large degree of autonomy during teaching and preparation, including the choice of technologies they use (Teo, et al., 2009). Therefore, we consulted the literature on teachers' acceptance of computers or other voluntary educational technologies. The results of this search are presented below.

Wang and Wang (2009) and Gong, Xu, and Yu (2004) investigated teachers‘ acceptance of web-based learning systems. Both studies found that perceived usefulness was the main driver of acceptance, while perceived ease of use only indirectly influences acceptance, through attitude and / or perceived usefulness. Other factors with a direct influence on acceptance of web-based learning systems are subjective norms (Wang & Wang, 2009), or attitude and computer self-efficacy (Gong, et al., 2004). In a study on teachers' adoption of teacher blogs, Lai and Chen (2011) found no effect of peer or supervisor influence or self-efficacy, while perceived usefulness, perceived ease of use, compatibility (closely related to perceived behavioral control or facilitating conditions, see Venkatesh, et al., 2003) and

school support had a positive influence on teacher blog adoption. In the case of student teachers' acceptance of computers, perceived usefulness is a consistently strong predictor of acceptance (Ma, et al., 2005; Teo, 2009; Teo, et al., 2008), while the effect of ease of use is less strong (Teo, et al., 2008) or only indirectly through usefulness (Ma, et al., 2005; Teo, 2009). The effect of subjective norms on teachers' computer acceptance is mixed, Teo et al. (2008) found a direct effect, whereas Ma et al. (2005) found no effect. Facilitating conditions indirectly influenced computer acceptance (Teo, 2009; Teo, et al., 2008). Other variables with a beneficial effect on computer acceptance were attitude, self-efficacy and technological complexity (Teo, 2009). Hu, et al. (2003) assessed teachers' acceptance of PowerPoint at the start and completion of a four week training program. Perceived usefulness was the main predictor, together with self-efficacy, while subjective norms were important in the beginning. Ease of use only indirectly influenced acceptance.

To summarize, the main drivers for teachers to accept a voluntary educational technology or a computer are perceived usefulness and attitude, while perceived ease of use and constructs related to facilitating conditions are either less importance or influence acceptance only indirectly. The evidence on the effect of subjective norms is mixed, depending on the technology and on the source of the norms. Next to these core determinants, several other variables were tested, which were sometimes found to influence teachers' acceptance.

Research questions

Throughout this paper we investigate why teachers accept and use an educational portal, drawing on data from two sources: objective usage data collected through a query of the portal's database and self-reported questionnaire data. Users of a particular technology are typically evaluated as a single group, in which no personal characteristics except for gender and/or age are taken into account: e.g. students using WriteOne (Davis, Bagozzi, & Warshaw, 1992), teachers using Smartschool (Pynoo, et al., 2011a), etc. We argue, in line with the gender similarities hypothesis (Hyde, 2005), that personal characteristics other than gender and age exist that have a more profound impact on technology acceptance.

Previous studies have already found personality to influence users' technology acceptance (Devolder, et al., 2008; Pynoo, et al., 2009; Sykes, et al., 2007) while technology users also differ in terms of technology readiness (Parasuraman, 2000) and innovativeness (Marcinkiewicz, 1993; Rogers & Shoemaker, 1971; van Braak, 2001). Pynoo, et al. (2011a) also found that right from the beginning teachers seem to adopt a base frequency of logging into their institution's portal site. Assuming this is also a personal characteristic, we investigate whether taking differences between teachers in the frequency of portal usage into account leads to a better understanding of portal acceptance. In the past, portal users were grouped based on their average number of logins per month (Lee, et al., 2003), and it was found that users who logged in more frequently used the portal more effectively. For this study, more usage parameters are collected: three parameters relating to search behavior (number of logins, downloads and page views) and two relating to sharing behavior (number of uploads and reactions). Hence, the preliminary question is: *Which user types can be discerned based on the number of logins, downloads, uploads, page views and reactions?*

Teachers' acceptance of the portal is assessed through a questionnaire in which the combined TAM and TPB model serves as the theoretical framework. To account for the differences between the teachers in their usage behavior, as a first step separate analyses per "usage type" are run, to subsequently investigate whether these differences are statistically significant. Hence, two research questions are put forward:

RQ1: for the various user types: to what extent can perceived usefulness, perceived ease of use, attitude, subjective norms and perceived behavioral control explain teachers' intentions and self-reported frequency of use of the portal?
RQ2: to what extent do the different user types differ in their acceptance of the portal?

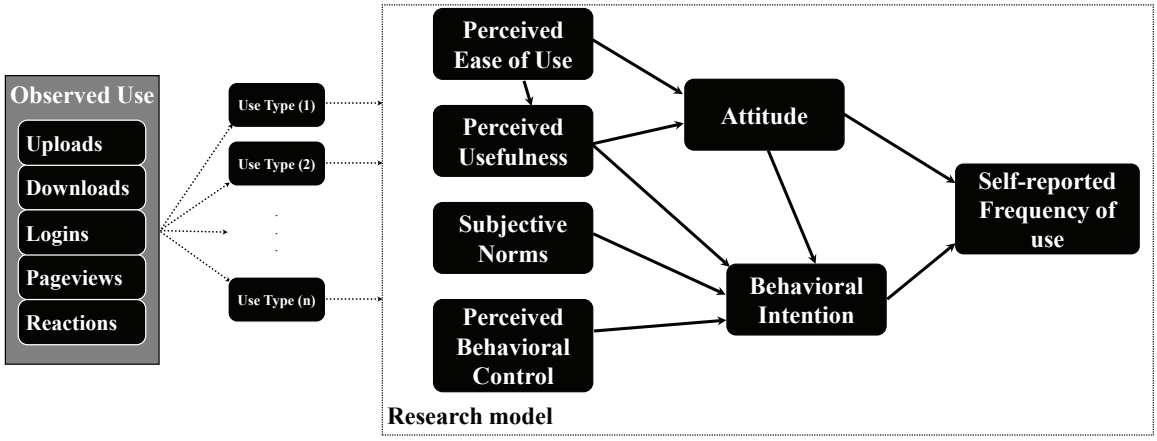

Figure 5.1 Study strategy with the research model on the right. The research model is run per usage type.

Material and methods

The portal: KlasCement

The educational portal in this study is KlasCement (www.klascement.net), a portal created by and for teachers that is supported by the Flemish Ministry of Education and Training. Separate Belgian (www.klascement.be) and Dutch (www.klascement.nl) versions have been developed and the site can be consulted in Dutch and English.

Overall, three types of educational portals can be discerned (networking, organizational, and resource-based portals) (Butcher, 2002), yet a single portal may integrate characteristics of all three types, as is the case for KlasCement.

The networking is reflected in the community of Flemish and Dutch teachers for whom the portal is created. Although primarily intended for Dutch-speaking Belgian teachers when founded in 1998, everybody can now enroll and become part of the community. To retain membership, one has to login at least once per year.

The portal is resource-based as the members can download and upload all kinds of information (documents, articles, websites, software, exercises, video, links to interesting events...), while the administrators also maintain sub-sites on or provide links to interesting (educational) projects such as Hot Potatoes, Open Source Software, Smartboard, etc.

Members cannot download without limits. Upon enrollment, one receives a (limited) amount of points to consult pages, to download information, etc. Points can be gained by uploading information or by reacting on contributions of other members.

The organizational aspect is reflected in the organization behind the portal, EduCentrum vzw, that closely monitors the portal, but also actively searches for new innovations of potential interest to the members of the portal.

Data collection and instruments

The study is an online questionnaire, embedded in a portal evaluation survey, targeting all registered members of KlasCement, and is administered in March and April 2009. The total study covers 18 topics and is estimated to take 10 to 15 minutes to complete. The acceptance part is only a small part of the evaluation, and consists of 22 items (see Appendix A) measuring the following constructs: perceived usefulness, perceived ease of use, perceived behavioral control, subjective norms, attitude, behavioral intention, self-reported frequency and self-reported intensity of use, and voluntariness of use. 7-point Likert scales anchored between '1: completely disagree' and '7: completely agree' are used for scoring, except for voluntariness (anchored between '1: mandatory' and '7: voluntary'), intensity of use ('1: as little as possible' to '7: as much as possible'), and frequency of use (from '1: never' to '6: several times a day'), while for attitude semantic differentials are used. Upon completion of the survey user information is extracted from the database (number of logins, downloads, uploads, page views, reactions; demographic information; etc.) (T1). The same information is extracted a second time on January 11, 2011 (T2).

Sample

Every portal member can fill out the questionnaire. Yet, for this study we are only interested in the responses from teachers. Therefore, out of a total of 1139 responses, 220 non-teachers are removed following an inspection of their member profiles, resulting in a dataset of 919 teachers (649 female and 270 male teachers). The average respondent age is 39.73 years, with an average length of membership (at T1) of 24.70 months. By the time of

the second use data extraction (22 months later), 55 teachers abandoned use of KlasCement.

Data analysis

The data are analyzed as shown in Figure 5.1. First, descriptive statistics and bivariate correlations are calculated. Scale reliability is established through Cronbach's alpha. Cluster analysis in SPSS 15.0 with Schwarz's Bayesian Criterion as clustering criterion is used to unveil user types: to achieve this the use parameters extracted at T1 serve as the input. Path analyses per usage type in AMOS 6.0 are performed to identify the factors contributing to teachers' acceptance of the portal (RQ1). The following fit parameters are taken into account to assess model fit: goodness-of-fit index (GFI), comparative fit index (CFI) and the root mean square error of approximation (RMSEA). For adequate fit, GFI and CFI should exceed .90, while RMSEA should be lower than .08; and for good fit exceed .95 (GFI & CFI) or lower than .06 (RMSEA) (L. Hu & Bentler, 1999). Finally, hierarchical linear regressions in SPSS 15.0 are used for RQ2.

Results

Descriptive statistics and reliability

First, descriptive statistics (mean and standard deviation) and bivariate correlations are calculated for both the questionnaire (Table 5.1) and observed usage (Table 5.2) data. From Table 5.1, we learn that the teachers are positive towards use of KlasCement. They evaluate the portal as useful (PU) and easy to use (EOU). Moreover, they hold a very positive attitude towards use of the portal. Scores on subjective norms and voluntariness reveal that teachers have the option to choose (VOL) whether or not they use KlasCement and that there is no pressure from the social environment (SN) to use it. Furthermore, teachers feel that they are in control (PBC) when they use the portal. Teachers also intend to continue using the portal, and their self-reported frequency of use (2.92) corresponds with the response category "I use KlasCement about once a week", which is close to the observed average number of logins per month (3.16) as displayed in Table 5.2. The reliability of four scales (PU, EOU, BI and ATT) is good; the reliability of the subjective

norms scale is very close to the threshold of .70 for acceptable reliability (Nunnally & Bernstein, 1994), whereas the reliability of perceived behavioral control is low. The correlation analysis reveals no unexpected findings. Two negative correlations are observed, which can easily be interpreted: subjective norms correlate negatively with both perceived behavioral control (Pearson r -.12, p<.001: more/less pressure <=> less/more control over behavior) and voluntariness (r -.13, p<.001: more/less pressure <=> less/more voluntary).

Table 5.1 Questionnaire data: Descriptive statistics (Mean and standard deviation), bivariate correlations (Pearson r) and scale reliability (Cronbach alpha) on the diagonal.

N = 919	Mean (SD)	PU	EOU	SN	PBC	BI	Freq	ATT	Vol
Perceived Usefulness	4.65 (1.33)	.84							
Perceived Ease of Use	5.01 (1.51)	.44***	.92						
Subjective Norms	1.41 (0.66)	.18***	.06°	.69					
Perceived Behavioral Control	6.16 (0.85)	.30***	.63***	-.12***	.45				
Behavioral Intention	4.28 (1.53)	.68***	.33***	.18***	.21***	.92			
Frequency of use	2.94 (0.91)	.41***	.21***	.14***	.13***	.53***	N/A		
Attitude	5.94 (0.97)	.61***	.48***	.11**	.33***	.55***	.40***	.88	
Voluntariness	6.66 (0.80)	.18***	.11**	-.13***	.23***	.12***	.08*	.28***	N/A

*Notes: °p<.10; *p<.05; **p<.01; ***p<.001; N/A: not applicable*

Table 5.2 Descriptive statistics (Mean and standard deviation) and bivariate correlations (Pearson r) of the observed usage parameters at T1 (below the diagonal) and T2 (above the diagonal).

	Mean (SD) at T1[a]	Mean (SD) at T2[b]	t(863); p=	Logins	Uploads	Downloads	Reactions	Page views
logins	3.16 (7.96)	3.82 (8.23)	-1.852; .06		.28***	.49***	-.21***	.85***
uploads	0.11 (0.53)	0.06 (0.50)	2.529; .01	.37***		.07*	-.04	.28***
downloads	4.49 (12.12)	7.14 (12.50)	-5.528; <.001	.77***	.31***		-.20***	.78***
reactions	0.13 (0.76)	-0.10 (0.39)	6.697; <.001	.23***	.50***	.50***		-.27***
page views	52.19 (118.73)	43.71 (77.44)	13.233; <.001	.82***	.43***	.88***	.52***	

*Notes: [a]mean number of logins,... per month of membership; [b]mean number of logins,... per month of membership between T1 and T2; *p<.05; ***p<.001*

Table 5.2 shows a great disparity between the average number of downloads and uploads at both times. This difference even increases from T1 to T2: teachers downloaded significantly more ($t(863) = -5.528$, $p<.001$), while they uploaded significantly less ($t(863) = 2.529$, $p=.01$). It should be stated here that the number of uploads and reactions is a snapshot as teachers can remove uploads (and reactions) leading to a removal of the associated reaction(s). This explains the negative number of reactions at T2. The correlation analysis reveals very high correlations between the number of logins, downloads and page views, with all correlations exceeding .75 except for the correlation between downloads and logins at T2.

Clustering based on observed usage parameters: discerning user types

A cluster analysis is performed to group teachers as a function of portal use. Five variables serve as the input for the cluster analysis: the average number of logins, downloads, uploads, page views and reactions per month of membership between the registration date and the date the teacher fills out the questionnaire (T1). Prior to the clustering, a closer inspection of the usage parameters shows that 37 teachers complete the questionnaire upon enrollment as portal member (number of logins = 0). These teachers are labeled as new members (N=37) and they are not included in the subsequent cluster analysis.

The two-step cluster analysis reveals only two groups, heavy (N=40) and other users (N=842). As the heavy users blur the cluster analysis, we decide to conduct a second cluster analysis without the heavy users. This again results in two groups, light (N=641) and medium (N=201) users. So, in the end, four groups of users are discerned: new, light, medium, and heavy users of the portal. The cluster centers per user type are in Table 5.3, whereas the mean scale ratings are displayed in Table 5.4. Details on post hoc tests (Dunnett's T3) and effect sizes (Cohen's d) are in Appendix B and C.

Paired samples t-tests are used to compare the monthly use of the portal before (T1) and after (T2) the questionnaire. The light users make significantly more use of the portal to search for information: a significant increase in number of logins ($t(601) = -6.537$, $p<.001$), downloads ($t(601) = -10.250$, $p<.001$) and page views ($t(601) = -4.310$, $p<.001$) is

observed. A slightly different picture for the medium users arises. They log in more frequently (t(192) = -2.230, p=.03) and download more (t(192) = -4.674, p<.001) at T2, yet they consult fewer pages (t(192) = 1.987, p=.05) compared to T1. The heavy users use the portal significantly less: they upload (t(39) = 2.076, p=.04) and download (t(39) = 2.368, p=.02) less information while they also consult fewer pages (t(39) = 2.741, p=.01). No difference is observed in the number of logins (t<1). Despite these significant differences in usage behavior, the user types observed at T1 persist at T2.

Table 5.3 Cluster centers: Mean and (standard deviation) per type of user, per time.

	T1				T2			
	light	medium	heavy	new	light	medium	heavy	new
#months portal use[a]	27.88 (16.03)	21.32 (16.64)	13.03 (14.53)	0.46 (0.51)	18.28 (2.48)	18.99 (2.37)	19.98 (1.07)	17.10 (3.28)
logins[b]	1.46 (1.08)	4.99 (3.13)	22.68 (30.48)	0.00 (0.00)	2.20*** (2.83)	6.25* (7.34)	17.49 (29.07)	2.52*** (2.19)
uploads[b]	0.01 (0.03)	0.13 (0.25)	1.48 (1.87)	0.24 (0.72)	0.02° (0.09)	0.07° (0.30)	0.60* (2.14)	0.04 (0.12)
downloads[b]	1.36 (1.57)	8.55 (6.52)	36.13 (42.91)	0.00 (0.00)	4.07*** (6.98)	14.04*** (18.41)	20.41* (20.43)	6.66*** (9.07)
reactions[b]	0.02 (0.06)	0.21 (0.33)	1.52 (3.23)	0.11 (0.52)	-0.03*** (0.08)	-0.19*** (0.34)	-0.71** (1.46)	-0.01 (0.03)
page views[b]	18.77 (15.04)	87.86 (49.33)	380.89 (391.25)	108.43 (158.78)	23.90*** (29.12)	76.12* (84.29)	190.02** (223.53)	37.37** (44.70)

*Notes: [a]for T1: months since enrollment; for T2: number of months between filling out the questionnaire and last login; [b]average number of logins,... per month of portal use (see [a]); significance level of paired samples t-test: °p<.10; *p<.05; **p<.01; ***p<.001*

Mean scale ratings (Table 5.4), the duration of membership and observed usage measures differ significantly between the user types at both times (all Oneway ANOVA's p<.05). Post hoc tests (Appendix B) show that at both times light users score significantly lower on almost all scales and observed usage parameters compared to the medium and heavy users. At T1, light & new users on the one hand, and medium & heavy users on the other differ only on the observed usage parameters, not on the acceptance scales (except on attitude or frequency of use), whereas at T2, the differences in observed usage are also eradicated. Overall, the strongest differences are observed between the heavy and new users. Table 5.3 also shows that the heavier the use of the portal, the shorter the length of membership. This could be an indication that use of the portal lessens gradually over time, but this is

contradicted by the data at T2, which show that the portal is used more (in terms of downloads and pages viewed) by the majority of the teachers. Interestingly, none of the 55 teachers that discontinued use of the portal between T1 and T2 is a heavy user.

Table 5.4 Questionnaire data: Mean and standard deviation per user type. Right part of the table displays the outcome of Oneway ANOVA's (F-value, significance level, and effect size).

	light	medium	heavy	new	F(3,915)	p	Partial Eta squared
N	641	201	40	37			
Age	40.25 (10.20)	38.72 (10.95)	37.70 (10.69)	38.41 (12.18)			
PU	4.43 (1.30)	5.28 (1.17)	5.39 (1.20)	4.17 (1.40)	29.255	<.001	.088
EOU	4.86 (1.54)	5.44 (1.32)	5.81 (1.12)	4.41 (1.56)	13.650	<.001	.043
SN	1.39 (0.64)	1.42 (0.67)	1.66 (0.89)	1.42 (0.74)	2.096	.10	.007
PBC	6.10 (0.88)	6.34 (0.67)	6.41 (0.85)	5.96 (1.04)	5.845	.001	.019
BI	4.03 (1.49)	4.92 (1.42)	5.23 (1.53)	4.15 (1.40)	24.136	<.001	.073
Frequency of use	2.76 (0.81)	3.32 (0.93)	3.93 (1.12)	2.81 (0.88)	40.527	<.001	.117
ATT	5.80 (0.98)	6.37 (0.77)	6.55 (0.65)	5.32 (0.88)	30.461	<.001	.091
VOL	6.64 (0.82)	6.82 (0.49)	6.63 (0.93)	6.14 (1.29)	8.288	<.001	.026

Portal use per session/login

Table 5.2 shows that teachers use the portal primarily for downloading and searching for information rather than for uploading material. To get a better view on what happens during one login/session, some extra parameters are calculated. These are displayed in Table 5.5. Although not every teacher uses the portal to download information, the average teacher downloads at least one item per login, but contributes only very rarely. Not much difference is observed in the number of pages a teacher views per login, yet a huge difference is observed in the number of pages viewed per download. It can be stated that the light and medium users consult the portal for specific information, and that the medium users browse more efficiently. The heavy users appear to browse just for fun or without a specific goal. Inspection of the portal evaluation data shows that the heavy users are

significantly more aware of the different functionalities of the portal and that they also use these functions more often compared to the medium and light users. This is also the case for the medium versus the light users. Finally, we also find an evolution over time. Light ($t(601) = -6.039$, $p<.001$) and medium ($t(192) = -2.013$, $p=.05$) users download more per login and need to consult fewer pages per download at T2 (respectively $t(505) = 6.769$, $p<.001$; $t(187) = 3.637$, $p<.001$). This indicates that these users become more efficient in searching for information, which is consistent with Rebelo, Brito, Soares and Jorge (2006). No such differences are found for the heavy user group: both the number of downloads per login ($t(39 < 1)$ and page views per download ($t(37) < 1$) remain stable. A significant decrease in pages viewed per session ($t(39) = 3.596$, $p=.001$) is observed in this user group.

Table 5.5 Portal usage per login per time.

	T1				T2			
	light	**medium**	**heavy**	**new**	**light**	**medium**	**heavy**	**new**
Downloads per login	1.07	2.25	2.56	N/A	1.63***	2.57*	2.51	1.91
Page views per login	15.21	23.77	26.49	N/A	11.36***	13.86***	15.35**	12.72
Uploads per login	0.01	0.05	0.11	N/A	0.00	0.00**	0.01°	0.01
Reactions per login	0.02	0.06	0.13	N/A	-0.02***	-0.06***	-0.10**	-0.00
Page views per download	24.69	17.33	75.97	N/A	15.33***	13.96***	38.79	19.06

*Notes: significance level of paired samples t-test: °p<.10; *p<.05; **p<.01; ***p<.001*

Determinants of portal acceptance: influence of usage profile?

Thirty-seven teachers filled out the questionnaire at their first login. Data from these "new users" is an opportunity to investigate why a teacher decides to start using the portal. On the other hand, as these teachers have never used the portal, their ratings on self-reported frequency of use is an inaccurate estimation of their future behavior, and is therefore omitted from the path analyses in that user group. Below, the findings of the path analyses are summarized; a distinction is made between the new and existing users of the portal.

New users

The path analysis with the new users, see Table 5.6, shows that attitude is the best predictor of behavioral intention, whereas subjective norms and perceived usefulness exert a marginally significant direct effect on intention. Perceived behavioral control, perceived ease of use and perceived usefulness indirectly influence intention through respectively, ease of use, perceived usefulness and attitude. Up to 55% of the variance in BI is explained and the model shows reasonable to good fit, depending on the fit measure (GFI .919, RMSEA .089, CFI .975). A strong correlation between ease of use and perceived behavioral control is observed.

Existing users

The results of the path analyses per usage profile (light/medium/heavy) are displayed in Table 5.4. Across groups, usage is best predicted by behavioral intention and to a lesser extent by attitude, with variance explained ranging from .24 (light) to .45 (heavy). Perceived usefulness is a good predictor of both behavioral intention and attitude, whereas ease of use and, depending on the type, subjective norms and perceived behavioral control influence perceived usefulness. Model fit is good to excellent in all cases: GFI ranging from .962 (heavy users) to .997 (light users), CFI either .993 (medium) or 1.000 (light & heavy), and RMSEA between .000 (light & heavy) and .033 (medium). Only a few differences between the types appear to exist. Perceived behavioral control seems to be somewhat more important for the heavy users (direct effect on BI, β .22, $p<.05$), less important for the medium users (indirectly on BI through PU, β .23, $p\leq.001$) and not important for the light users. Subjective norms and ease of use are more important for the light and medium groups.

To test whether these differences are statistically reliable, pairwise moderated linear regressions (Kankanhalli, et al., 2005) are performed. These are hierarchical linear regressions, with the main effects as the first block of predictors, and the interaction effects in the second block. Differences between the user types exist if F change is significant. All paths in Table 5.6 are tested, so 12 regressions are needed (four dependent variables:

perceived usefulness, attitude, behavioral intention, use; three pairs: light/medium, light/heavy, medium/heavy). Results of these analyses are displayed in Table 5.7.

Table 5.6 Results of path analysis (RQ 1).

	New	light	medium	heavy
Dependent variable	Behavioral Intention	Frequency of use	Frequency of use	Frequency of use
pu <- eou	.59***	.40***	.21**	.40**
pu <- sn	--	.16***	.23***	--
pu <- pbc	--	--	.23**	--
att <- eou	.34*	.26***	.29***	--
att <- pu	.45**	.50***	.37***	.46**
bi <- pu	.27°	.51***	.57***	.58***
bi <- att	.50***	.23***	.10 (p=.11)	.27**
bi <- sn	.21°	.07*	--	.16°
bi <- pbc	--	--	--	.22*
use <- bi	N/A	.41***	.42***	.50***
use <- att	N/A	.12**	.18**	.25°
eou <-> pbc	.70***	.62***	.60***	.66***
sn <-> pbc	--	-.15***	--	--
eou <-> sn	--	.07°	--	--
	Multiple correlation coefficients (mcc)			
PU	.35	.20	.21	.16
ATT	.50	.42	.29	.22
BI	.55	.48	.39	.71
Use Freq	N/A	.24	.27	.45

Notes: N/A: relationship could not be tested; --: insignificant relationship that was fixated on 0.

Table 5.7 shows how the various user types differ in the way they accept and use the portal. When comparing the light and medium users, we find that the portal's usefulness is more important for light users in their attitude formation (β -.09, p=.01). Comparing the light and heavy users, we see that light users draw more on their social environment when evaluating the usefulness of the portal (β -.10, p=.01). Ease of use is also marginally more important for light users as a determinant of attitude (β -.09, p=.06). A significant increase in variance for frequency of use is observed, but none of the interactions turn out to be significant. Finally, for the medium and heavy users, we find that ease of use is more

important for the heavy users (β .39, p=.05), while norms (β -.36, p=.01) and perceived behavioral control (β -.42, p=.01) are more important for the medium users as determinant of perceived usefulness. A marginally significant increase in variance explained in behavioral intention (perceived behavioral control more important for heavy: β .29, p=.04) and attitude (ease of use more important for medium: β -.32, p=.04) is observed.

Table 5.7 Results of moderated regression analysis.

Dependent		light <=> medium	light <=> heavy	medium <=> heavy
PU	Sig F Change	ns	p=.05	p=.007
	Significant interactions	N/A	SN: β -.10 (p=.011)	EOU: β .39 (p=.05) SN: β -.36 (p=.006) PBC: β -.42 (p=.014)
BI	Sig F Change	ns	ns	ns (p=.075)
	Significant interactions	N/A	N/A	PBC: β .29 (p=.045)
ATT	Sig F Change	p=.022	p=.03	ns (p=.095)
	Significant interactions	PU: β -.09 (p=.008)	EOU: -.09 (p=.061)	EOU: β -.32 (p=.036)
Frequency	Sig F Change	ns	p=.008	ns
	Significant interactions	N/A	none	N/A

*Notes: Significant interactions are interactions between user-type and a predictor variable and should be read as e.g. PU*user_type. The interaction term (*user_type) is omitted for clarity*

Discussion and Conclusion

Main findings and discussion

In this study, we investigated how teachers used a portal for education and whether this affects their acceptance of the portal. In order to do this, questionnaire data on portal acceptance (based on a combination of TAM and TPB) are paired to usage data extracted from the portal database on two occasions. In addition to the new users who fill out the questionnaire on their first login to the portal, three user groups (light/medium/heavy) are discerned based on the average number of logins, downloads, uploads, page views and reactions per month of membership between registration and questionnaire completion. Differences between these user groups are found in their ratings of every acceptance scale (PU, EOU, PBC, ATT, BI, frequency of use), except for the subjective norms scale. The

usage parameters show that the teachers use the portal to search for and download information rather than for sharing or uploading. A minority of the teachers appeared to browse through the portal for fun, or without a specific goal. This is consistent with Mahdizadeh, et al. (2008), who found that most teachers use the "basic" aspects of an e-learning environment, whereas only a minority of teachers use the more advanced functions that could really have an added learning value. The largest part of the teachers used the portal more at the time of the second data extraction and they had become more efficient in browsing through the portal to download information. Contrary to what is generally found in the literature, attitude and not perceived usefulness is the main driver for new users to intend to use the portal, with perceived usefulness and subjective norms exerting a marginal direct influence on intention. Perceived usefulness and ease of use are important for attitude formation, whereas perceived behavioral control had no direct effects but was very closely related to perceptions of ease of use. For the existing user, the usefulness of the portal is the major determinant of acceptance. This is consistent with previous teacher' acceptance studies (Gong, et al., 2004; Hu, et al., 2003; Lai & Chen, 2011; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008; Wang & Wang, 2009) and research in business settings. The influence of the other factors depends on the user type; subjective norms and ease of use are more important for the light and medium users; while perceived behavioral control is more important for the heavy users. Up to 71% of the variance in BI and 45% of the variance in frequency of use is explained by our research model.

Study contribution

This study adds to the literature in several respects. The primary contribution of this study is that we assess teachers' acceptance of an educational portal and whose use was entirely voluntary. Although some studies have questioned students' acceptance of (mandatory) educational portals (e.g. Maldonado et al., 2011; Pynoo, et al., 2011b), to our knowledge no such study exists for teachers. As such, the present study meets an important empirical gap in educational technology literature. In view of the emerging educational portals in different countries (e.g. Glow in Scotland and National Education Portal in Kenya), insights from these studies might prove valuable for policymakers planning to develop or

launch educational portals. Moreover, as use of the portal is completely voluntary, our study provides guidance to school boards and policymakers on how to introduce new technologies that cannot be imposed immediately, e.g. interactive whiteboards, etc. Finally, this study adds to the general literature on technology acceptance as we investigated technology acceptance while differentiating between users based on their observed use behavior (and thus beyond gender and age). This way, our findings replicated the somewhat mixed findings of the literature review: perceived usefulness being a consistent predictor of acceptance, and the significance of the other predictors varying slightly depending on the user type. As such, taking a user's base frequency of technology use into account might explain the sometimes mixed findings of technology acceptance studies, especially in the case where use of the technology is voluntary and where a user has a large degree of autonomy while performing his/her job.

Implications

From this study, several guidelines for policymakers and school boards wanting to introduce an educational portal (or another educational innovation), can be derived. The guidelines are outlined below, in "chronological" order.

- Perceived behavioral control: Provide training and resources

In this study perceived behavioral control covers three aspects: skills and knowledge, control over time and location of use, and resources (computer, Internet, etc.). Control correlated strongly with perceptions of ease of use, and also influences either perceived usefulness or behavioral intention. Skills and knowledge can be addressed by providing training and support, but also by safeguarding the ease of use of the portal (or educational technology). Resources and control over time and location of use go hand in hand: school boards could provide a sufficient number of computers that are connected to the Internet to facilitate portal use at school. To facilitate use of a computer during teaching, attention should be payed to the physical location of the computer(s) in the classroom (Tondeur & Van Den Driessche, 2011). Policymakers on the other hand should promote the use of computers at home. Such an example is provided, for instance, by the Belgian federal

government with the initiatives "Internet for all" and "Start to surf"[2], through which a computer and Internet connection could be obtained at a discounted rate.

- Perceived usefulness: Provide content

The usage data show that the majority of the teachers use the portal primarily for searching and downloading material. Next to material provided by teachers, policymakers/school boards could stimulate teachers to contribute, or could even provide additional interesting (yet non-essential as long as use of the portal is not mandatory) information themselves exclusively through the portal. This is in line with other studies that stress the importance of professional development as a permanent process, aimed at extending and updating the professional knowledge of teachers in the context of their work (see e.g. Sang et al., 2010). In this respect, collaboration is a pivotal element in teacher professional development; by sharing their experience, knowledge, and reflection and collaborating in the educational portal. School leaders then have to provide [and] accommodate teachers' need for professional development, and manage existing resources to support teacher development. These findings concur with those of Rhodes et al. (2004) which underlined the importance of school leaders' support and involvement in professional development programs.

- Perceived ease of use: Safeguard portal ease of use

The review showed that ease of use is of secondary importance or influences acceptance only indirectly (Gong, et al., 2004; Hu, et al., 2003; Ma, et al., 2005; Teo, 2009; Teo, et al., 2008; Wang & Wang, 2009). Studies in settings other than education found ease of use to be of particular importance in the early stages following the introduction of a new technology (e.g. Venkatesh, et al., 2003; Pynoo, et al., 2012), but evidence is mixed. Here, we found that ease of use is of particular importance for new and non-heavy users in their attitude formation. Safeguarding portal ease of use should be addressed in two ways: by providing training as mentioned above, and by making the portal as easy to use as possible. However, some room for improvement may exist. A great disparity in the number of

[2] http://www.fedict.belgium.be/nl/over_fedict/realisaties/Start2Surf.jsp; http://www.fedict.belgium.be/nl/over_fedict/realisaties/Internet_voor_iedereen.jsp (in Dutch) website last consulted October 31st, 2011

downloads and uploads was observed, which may in part be explained by a disparity between the ease of downloading and the ease of uploading. Only one click of the mouse is needed to download information, whereas users have to complete a form and are urged to first search for possible duplicates prior to uploading. For example, when uploading a document, users are obliged to indicate the file type and the language; choose the suitable course(s) and education level; indicate who can view it; provide a title, a text with the potential of the document for teaching, and key words; and answer a question concerning copyright. Easing and shortening the procedure for uploading in this case should increase the likeliness of uploading information by non-heavy users, who form the majority of the users.

- Subjective norms: Create an environment that supports and encourages use of the portal

In this case, teachers experience no influence from their colleagues or school boards to use the portal, yet for the majority of the teachers norms enhance perceptions of portal usefulness and/or have a positive influence on teachers' intentions to use the portal. Therefore, the existing members should be urged to promote use of the portal among their colleagues, while policymakers and school boards should put forward guidelines concerning portal use. As stated before, they need to encourage teachers' professional growth, provide an encouraging school environment for collaboration, accommodate teachers' needs for professional development and manage existing resources to support teachers' professional development as and when necessary (Tondeur, Valcke, & van Braak, 2008).

- Attitude: Portal use should be an enjoyable experience

Previous research showed that holding a positive attitude towards computers is beneficial for the integration of computers in the educational practice (Hermans, et al., 2008; Mueller, et al., 2008; Sang, et al., 2010; Shapka & Ferrari, 2003; van Braak, et al., 2004). Here, we saw that teachers' attitudes towards use of the portal are in large part determined by perceptions of usefulness and ease of use. However, attitude also covers the issue of

whether use of the portal is enjoyable and whether the members love/hate using the portal. So next to being easy to use and providing useful information, using the portal should be an enjoyable experience, which could be ensured by the layout of the site, or by the provision of additional content such as facts and figures, cartoons, videos, pictures, etc.

- Differentiate between users

Small yet significant differences between the different types of users were observed in their acceptance and use of the portal. While the majority of the teachers appear to use the portal for retrieving information, a small yet very loyal number of teachers seemed to use the portal not only to download, but also to browse through the more advanced functionalities, or to the "dark corners" of the portal. These are also the teachers who contributed most. As these heavy users are very valuable as "feeders" of the portal and they could serve as promoters of the portal, portal administrators should consider introducing advanced functionalities from time to time, to stimulate these users.

Directions for further research

Small yet significant changes are observed between the user profiles in the way they accept the portal. This indicates that differentiating between users makes sense and could potentially benefit technology acceptance and usage if the technology becomes more finely tuned to the type of users. This offers possibilities for follow-up research in different settings, with different users and both voluntary and mandatory technology, but also for research on other differentiating characteristics.

Addendum

In this Chapter, variance explained in behavioral intention was considerably higher than in the other studies, see Figure 6.1, which might be due to the inclusion of attitude as a predictor of intention. According to Venkatesh, et al. (2003) attitude is obsolete in the presence of performance and effort expectancy (or in terms of TAM perceived usefulness and ease of use). In our research model (Figure 5.1), we did not allow ease of use to influence behavioral intention. However, to be able to compare with the additional analyses in Chapters 3 and 4, and investigate the claim of Venkatesh, et al. (2003), ease of use was also added as a predictor of intention. Table 5.8 displays the results of the hierarchical regression analyses that investigate the added value of attitude.

Table 5.8 Hierarchical linear regression (in which ease of use is also a predictor of BI) to investigate the added value of attitude

	Light		Medium		Heavy		New		Overall	
pu	.64***	.52***	.60***	.57***	.78***	.64***	.64***	.39*	.66***	.58***
eou	.02	-.04	.09	.07	-.12	-.10	-.20	-.40*	.02	-.04
sn	.07*	.07*	-.02	-.02	.18°	.17°	.22	.15	.07**	.07**
pbc	.00	-.00	-.05	-.06	.28°	.29*	.12	.09	.01	.01
att		.25***		.09		.27*		.62***		.20***
Adj. R^2 in BI	.44	.48	.37	.37	.59	.65	.39	.59	.47	.50
Sign. F Change		p<.001		p=.17		p=.02		p<.001		p<.001

Adding attitude led, except for the medium users, to a significant increase in variance explained. Moreover, unlike the regressions reported in Table 3.3 and Table 4.4, the β regression coefficients of perceived usefulness and ease of use remained quite stable when adding attitude. The significant negative β regression coefficient of perceived ease of use in the group of new users was also due to a net suppression effect. The correlation between ease of use and behavioral intention was positive (Pearson r = .26, p=.12), yet a larger correlation was found between attitude and intention (r=.70, p<.001), while ease of use and attitude also correlated significantly (r=.60, p<.001).

6 Discussion and Conclusion

Chapter 6

Discussion & Conclusion

Throughout this dissertation, four studies were reported on autonomous professionals' acceptance of job-related technologies: PACS (in two samples of physicians), and Smartschool and KlasCement in two distinct samples of teachers. These technologies have in common that they are accessible through a web-interface and that they do not need to be used on every instance. A physician does not need to consult PACS for every patient, just like a teacher does not have to use a computer, and thus Smartschool or KlasCement, for every lesson. One important difference among the technologies was that use of PACS and Smartschool was mandatory whereas the use of KlasCement is on a voluntary basis.

This final chapter proceeds in the following manner. First, a short summary of the studies prior to the discussion of the four research questions. Then the strengths, the contributions for the practice and the field of research on IS-acceptance, and the limitations will be discussed. This chapter will be concluded with suggestions for follow-up research and an overall conclusion.

Summary of the studies

Study I: Physicians' acceptance of PACS in a university hospital

The main driver for physicians' *intention* to start to use PACS was *performance expectancy*, and *effort expectancy* and *facilitating conditions* were less strong significant predictors. The strongest predictors of physicians' *intention* to continue using PACS were *facilitating conditions* and to a lesser extent *performance expectancy*. The effect of *social influence* on *intention* was only marginally significant at T2. Neither *behavioral intention*, nor *facilitating conditions* predicted *self-reported frequency of use*. An additional path-analysis confirmed this finding, and also identified *performance* and *effort expectancy* as significant predictors of *self-reported frequency of use*.

Study II: Physicians' acceptance of PACS in a private hospital

In this study, the main driver for physicians to start using PACS was *effort* and not *performance expectancy*. We also found that *social influence* (on all occasions) and to a lesser extent *performance expectancy* (on T2 and T3) were significant predictors of PACS acceptance, whereas *facilitating conditions* had no direct influence on acceptance but correlated strongly with *effort* and *performance expectancy*. The factors influencing PACS acceptance vary over time and are especially in the early stages after the introduction susceptible to changes. *Behavioral intention* was only at T2, and not at T3, a significant predictor of *self-reported frequency of use*.

Study III: Secondary school teachers' acceptance and use of Smartschool

For this study, use behavior from log files (date, time and approximate location of logging in into the system) was paired to questionnaire data. Acceptance was operationalized in four ways: *attitude*, *intention*, *self-reported frequency of use* and *observed near-term use*. Overall, *performance expectancy* and *social influence* were the main predictors of acceptance, whereas *effort expectancy* and the provision of *facilitating conditions* were of minor importance. The extent to which traditional self-reported measures for acceptance could explain and predict observed use was also investigated. At T1 about one third, at T2 about one fourth, and at T3 about half of the variance in final observed use was predicted by *self-reported frequency of use* (significant on all occasions) and *attitude* (marginally significant at T3). *Behavioral intention* was not a significant predictor of observed use, yet *behavioral intention* was a significant predictor of *self-reported frequency of use* on all occasions. The user logs also showed that teachers seemed to adopt a base frequency of Smartschool use almost from the beginning.

Study IV: Teachers' use and acceptance of KlasCement

Also in the study reported in Chapter 5, questionnaire data on teachers' portal acceptance (based on a combination of TAM and TPB) was paired to usage data extracted from the portal database on two occasions. The usage parameters show that the teachers use the portal to search for and download information rather than for sharing or uploading. Four

groups of users were discerned based on the observed use data, and differences between these user groups were found in the ratings on every scale, except *subjective norms*. *Attitude* for the new, and *perceived usefulness* for the existing users were the main drivers of teachers' *behavioral intention* to use the portal. The significance of the other factors on *behavioral intention* depended on the user type. *Perceived usefulness* and *ease of use* (except for the heavy users) were significant predictors of *attitude*. *Attitude* (albeit only marginally for the heavy users) and *behavioral intention* were significant predictors of *self-reported frequency of use*.

Research questions

This dissertation was set up aiming to explore physicians' and teachers' technology acceptance and to identify the key influencing variables. In the following, the findings of the different studies are compared where needed in order to address the four research questions.

RQ1: To what extent can users' acceptance be explained by the predictor variables in UTAUT and C-TAM-TPB?

The first research question was addressed in all four studies. This research question covers both the factors that contribute to user acceptance as the amount of variance explained in user acceptance. The findings of the four studies are integrated in Figure 6.1. Variables are labeled in terms of UTAUT, see Table 1.2 for the correspondence between UTAUT and C-TAM-TPB. Every concept in Figure 6.1 will now be discussed separately, focusing not only on the significant relationships (blue), but also on the insignificant relationships (red).

- ***Performance expectancy*** was overall the most consistent and in many cases also the strongest predictor of both *attitude* and *behavioral intention*. Only in Study II at T1, *performance expectancy* had no effect on *behavioral intention*. Apparently in that setting, PACS' usefulness was of no importance, the most important matter was that PACS would be easy to use. No direct effect on *self-reported use* was observed in study III.

- ***Effort expectancy*** is important in *attitude* formation, especially in the early stages of the introduction of a new technology (Study III), and for those who use a technology not very often (Study IV). *Effort expectancy* also influenced *behavioral intention*, and interestingly a difference between physicians and teachers was observed: *effort expectancy* was only important at the introduction for physicians, whereas for teachers, we found that *effort expectancy* was only important at T3, as a predictor of *intention*. This difference between teachers and physicians might be explained by the technology and the manner in which it is used. Referring physicians use PACS during the consultation, when interacting with a patient during the consultations, so it is important that PACS does not require much effort and is easy to use, especially in the early stages after the introduction of PACS, when the true benefits of PACS become gradually apparent: a decrease in report turnaround time, increased accessibility and availability of radiological images and reports, advanced display features, etc. In view of these benefits (and thus PACS' usefulness, it is normal that *effort expectancy* loses significance as a predictor of *intention*. A different story arises for Smartschool. The main function that Smartschool replaces is the book of announcements in the teachers room which was typically consulted during the breaks. This means that teachers are now required to search for a computer (at home or in school) to consult the announcements. Inspection of the mean scale ratings showed that teachers did not value Smartschool as useful (on any occasion), whereas ratings on *effort expectancy* were higher at T3 compared to T1 and T2 indicating that use of Smartschool becomes easier as teachers gain experience. So at T3 it is normal that *performance expectancy* is of no importance for predicting *intention*: they are required to continue using Smartschool, but not because it is useful, but because it is easy to use. In the reanalysis of the first study (Chapter 2), a direct effect of *effort expectancy* on *self-reported use* was observed at T2. Such an effect was not observed in Chapter 4, *effort expectancy* did not influence self-reported use on any occasion.
- ***Social influence*** was an important predictor of *behavioral intention*, which was somewhat contrary to the expectations in view of physicians' and teachers' autonomy

during the performance of their job. In Study I, *social influence* was of minor importance, but the pressure to use PACS was not that high as in the setting of Study II. In the latter setting, a high pressure was placed on physicians to use PACS, and although previous research (Lapointe & Rivard, 2005) found that this might have an adverse effect on physicians' reactions towards a newly introduced technology, *social influence* in this setting had an increasingly stronger and positive effect on physicians' *intention* to use PACS. One of the differences between light and medium users of the portal in Study IV is the differential influence of *social influence* on *behavioral intention*. *Social influence* was not a significant predictor of *behavioral intention* for the medium users, while significant for the light users. In Study III *social influence* was found to have a direct effect on *behavioral intention* and *self-reported use* in the beginning and at T3, and on observed use at T1.

- ***Facilitating conditions*** appears to be of minor importance as a direct predictor of acceptance. Path analyses (Studies II and IV) showed that *facilitating conditions* correlate strongly with the other predictor variables, so it has an indirect influence on acceptance, as modeled in TAM3 (Venkatesh & Bala, 2008). According to Venkatesh, et al. (2003), *facilitating conditions* should have a direct effect on use, yet only in Study III at T2 a marginally significant effect was observed. When it concerns the influence on *behavioral intention*, an interesting difference between the four studies emerged, which might be explained by either the implementation strategy (Study I <=> Study II & III) or the nature of the user (heavy <=> new, light, medium). In study I, next to providing a custom-made e-learning environment (Devolder, et al., 2009), the IT-department also upgraded all physicians' computers so that they would meet the requirements for working with PACS. Training was also provided in Studies II and III, however in Study II physicians were responsible themselves for acquiring and upgrading their computer. In the secondary school of Study III, it is obvious that teachers are responsible for their own computer at home, and that only a limited amount of computers are available in school. A different picture arose in Study IV. Here, we found that *facilitating conditions* were only

important for the heavy users' *intention* to use KlasCement. It is likely that these heavy users are the most tech-savvy and that they dispose of the necessary material resources to make use of the portal. In Study III the influence of *facilitating conditions* on *attitude* was investigated, yet no effect was found.

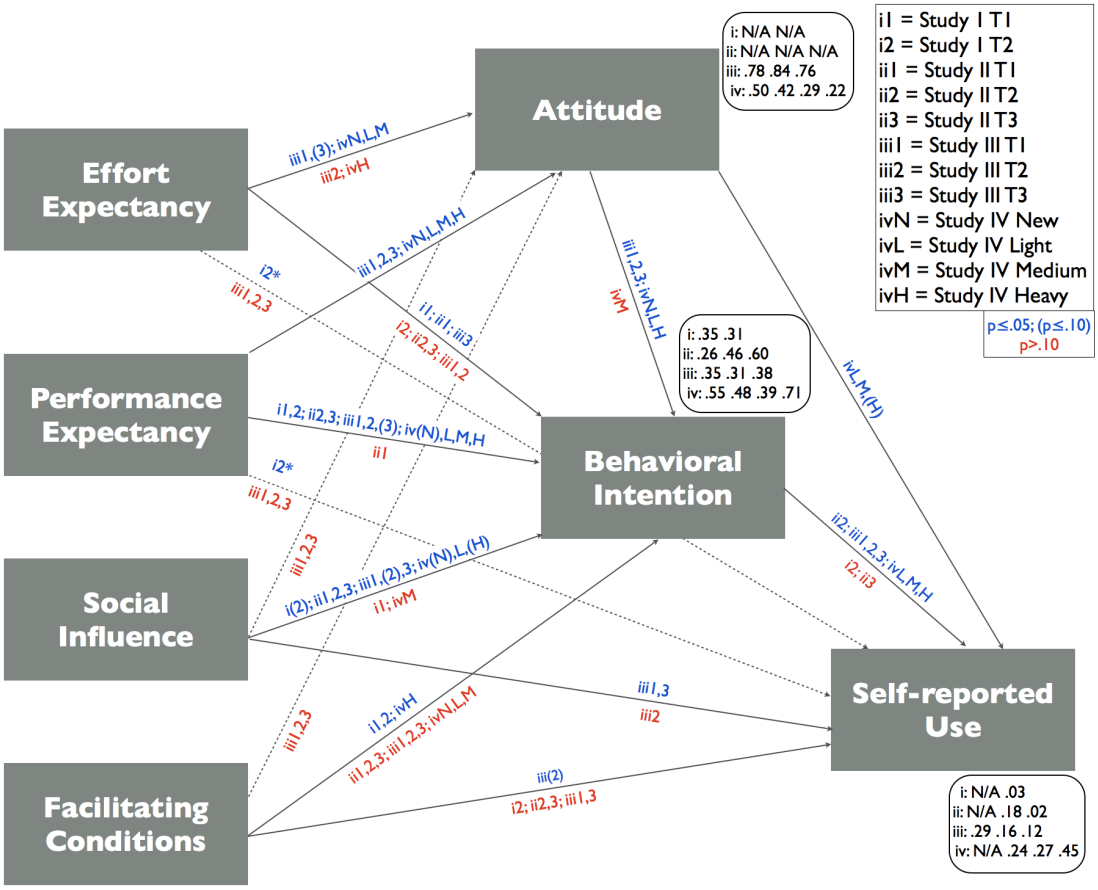

Figure 6.1. Summary of the regression/path analyses results of studies I to IV.

*Note: in blue: significant relationships, marginally significant relationships between brackets; red text: insignificant relationships; dotted lines: relationships that were tested and were never significant; *: additional effect, see Table 2.5 and Duyck (2009); variance explained per study per timing/subpopulation are in the ellipses.*

- ***Attitude*** has two roles, predictor and dependent variable. According to Venkatesh, et al. (2003), *attitude* does not add to the prediction of *intention* in the presence of both effort and *performance expectancy*. The finding was not confirmed in Chapter 5, in which *attitude* had a positive influence on most teachers' *intention* to use technology.

There is one exception which again differentiates between the medium and light users of KlasCement: *attitude* is not important for medium users, whereas it is still important for the light users' *intention* to use KlasCement. From Figure 6.1, it cannot be ignored that the amount of variance explained in BI was a lot higher in Study IV compared to studies I to III. This may be due to the inclusion of the *attitude* construct in study IV, which is confirmed by a hierarchical regression reanalysis of the data in which *attitude* is placed in block 2 and ease of use and the other predictor variables in block 1, see Table 5.8. Adding *attitude* led to a significant increase in variance explained for all users, except the medium. This was also observed in a reanalysis of the data of studies II (on all times, Table 3.3) and III (only at T1, Table 4.4). However, in Studies II and III adding *attitude* had a negative influence on the β regression coefficients of *performance* and/or *effort expectancy*, such that the amount of variance explained increased, while information was lost. This was not the case in Study IV, and may be attributed to the technology not being mandatory, contrary to the technologies in Studies I to III. Variance explained in *attitude* was very high in Study III and a lot lower in Study IV, especially in the case of the medium and heavy users. Only *performance expectancy* (always) and *effort expectancy* (in most cases) are predictors of *attitude*; no effect of *social influence* and *facilitating conditions* was found. This corresponds with the original version of TAM (Davis, et al., 1989).

- The concept of ***behavioral intention*** is central in the line of models derived from the Theory of Reasoned Action, which are also referred to as intention-based models. Variance explained in *behavioral intention* was in most cases in the range that is commonly found in technology acceptance studies (.35-.55). Positive exceptions were 60% of the variance in physicians' *intention* to continue using PACS in Study II at T3 and 71% of the variance in heavy users' *intention* to continue using the system. This latter finding was also confirmed by the data: none of the heavy users abandoned use of KlasCement in the 22 months following the questionnaire. Every predictor was found to influence *behavioral intention* but this varied per study, time and user-group. *Behavioral intention* should in its turn be predictive for users' use of

a technology, however, this was not alway confirmed in our studies. In two cases where physicians were very experienced in using PACS, *behavioral intention* had no influence on *self-reported use*. This may however be caused by a ceiling effect as in those instances physicians' ratings on both *behavioral intention* and *self-reported use* were very high.

- A large variation in amount of variance explained in ***self-reported use*** was observed throughout this dissertation, ranging from .02 (Study II, T3) to .45 (Study IV, heavy users). In general, variance explained in use was lower than in *behavioral intention*. Interestingly, no effect of *facilitating conditions* on use was observed, apart from a marginally significant effect in Study III at T2, whereas *social influence* had a direct significant effect on use in Study III at the introduction and at T3. In Study III, we found that *self-reported frequency of use* - contrary to *behavioral intention* (never) and *attitude* (marginally at T3) - was a significant predictor of actual use.

RQ2: To what extent do the determinants of acceptance change with growing experience with the technology?

One distinguishing feature of three (I, II and III) studies reported throughout this dissertation compared to typical IS-acceptance studies is that multiple measurements were taken into account, aiming to uncover temporal variations in acceptance behavior. A major advantage of qualitative research is that it is especially suited to uncover post-hoc the dynamics during the implementation of a new system. We aimed to achieve this in a quantitative research design by taking measurements at different moments in time, and in a larger population compared to qualitative research.

A first striking observation is that mean scale ratings differed across studies. In Study I, all mean scale ratings were significantly higher at T2 compared to T1 except on self-efficacy. In Study II, all mean scale ratings (except on *social influence*) were significantly lower at T2 and only the ratings on *effort* and *performance expectancy* were significantly higher at T3 compared to T2. Comparing T1 to T3, we found that only the rating on *performance expectancy* was higher at T3. In Study III, the least variation in mean scale ratings was

observed, which was confirmed longitudinally in the reanalysis. Higher scores on *facilitating conditions* and *self-reported use* were found at T2 compared to T1, and on *effort expectancy* at T3 compared to T2. Although all mean scale ratings were higher at T3 compared to T1, this difference was only statistically significant for *effort expectancy* and *self-reported use*.

Next to variations in mean scale ratings, we also found that the significance level of the predictor variables varied over time. In studies II and III we did investigate whether the significance level of the predictor variables varied statistically over time. We found that in Study II, the significance varied most from T1 to T2 with *performance expectancy* becoming more important and *effort expectancy* losing significance. From T2 to T3, *performance expectancy* again lost significance. In Study III, we found, overall, no fluctuation in significance level of the different predictor variables. This was confirmed in the reanalysis (in the addendum of Chapter 4) in which the procedure of Study II was followed and the different measurements were compared pairwise.

RQ3: To what extent can self-reported measures for acceptance predict observed use?

In Studies III and IV, we collected - next to the questionnaires - observed use from user logs. These observed use data served a different purpose though. In Study IV, teachers were grouped according to their profiles of observed use behavior whereas in Study III, we investigated whether observed use behavior could be predicted by self-reported measures for acceptance. In IS-acceptance in which observed use is not or cannot be measured, it is assumed that self-reported measures for acceptance predict observed use; so a major strength of Study III is that we were able to test this assumption explicitly. We found that *attitude*, *behavioral intention* and *self-reported use* were able to explain up to 46% of the variance in observed use. Interestingly, the only direct predictor of observed use was *self-reported use*, with one exception as *attitude* had a marginal significant effect on observed use at T3. The most important finding however is that although *behavioral intention* is a key concept in technology acceptance research, no significant effect on actual use was

observed. Thus, the present work on this research question yields important findings illustrating the limitations of this concept for technology acceptance research. Although it can be argued that *behavioral intention* indirectly influences actual use through *self-reported use*, this does not hold throughout this dissertation as ceiling effects were observed in the prediction of *self-reported use* by *behavioral intention* in studies I and II.

RQ4: To what extent do user characteristics impact technology acceptance?

A group of users could be categorized in different ways in order to come to a better understanding of IS-acceptance. Typically, users of the same technology are assessed as a single group in which gender, age and experience may be taken into account. In Study IV, building on gender similarities hypothesis (Hyde, 2005), which holds that males and females are similar on most psychological variables, and thus that men and women are more alike than different, on Innovation Diffusion Theory in which different types of adopters are discerned (Rogers, 1995), and upon the observation that teachers appeared to adopt a base frequency of Smartschool use almost right from the beginning, we grouped teachers according to their actual use of the portal. A distinction was made between existing users who were grouped based upon five parameters (monthly average number of uploads, downloads, reactions, page views, and logins) and the new users who filled out the questionnaire at their first login. When evaluating patterns of use, meaningful differences between the different groups were observed, which were also reflected in mean scale ratings of the acceptance questionnaires. Regression analyses revealed a few statistically significant differences between the groups of existing KlasCement users indicating that implementers or organizations should slightly adjust their strategy according to the type of user at hand. More research is however needed in order to find out whether the same effects play across all kinds of organizations and technologies or whether this is population- and / or technology-specific.

Study strengths, contributions and limitations

The purpose of this dissertation was to gain insight into the factors that contribute to physicians' and teachers' acceptance of job-related technologies. This goal was achieved

throughout the four empirical studies and several guidelines were proposed to organizations or implementers who are either introducing a novel technology, or who aim to improve the acceptance and use of an already introduced technology. Moreover, due to the setup of the empirical studies - hence the strengths of these studies - several contributions to the general literature on IS-acceptance were made. Otherwise, during the empirical studies, several limitations became apparent. The strengths, contributions to the field of research and the practice, and the limitations will be highlighted in the following paragraphs.

Strengths

Technology acceptance research is typically performed in populations of students or business workers in which the users are treated as a single group, and acceptance is probed on one occasion. Acceptance is measured as *behavioral intention* and *self-reported use*, whereas actual use is not taken into account. Hence, the strengths of the studies reported here is that they are performed in groups of professional users, on either multiple occasions or in multiple groups, and actual use was coupled to the questionnaire data where possible.

Professional Users

As shown by the literature review in Chapter 1, technology acceptance research in populations of teachers and physicians is scarce. Therefore, performing acceptance studies in four different groups of physicians or teachers is a major strength. The scarcity of hospital physicians' acceptance studies might be explained by the busy schedule and the priority of providing qualitative patient care rather than completing questionnaires. For teachers, the 'ease of access' to teachers in training compared to in-service teachers for filling out questionnaires might be one explanation. Another, tentative, explanation could be that in view of the professionalization of the teaching profession, efforts are directed towards investigating the whole picture, in which IT is only a part.

Multiple measurements

A major shortcoming of a typical IS-acceptance study, independent of the setting (medical, education, business,...), is that acceptance is measured on only one occasion. It can however take years before a technology is truly accepted by its users, and certain events might trigger resistance, see for example the cases in Chapter 1, and thus hinder user acceptance. Taking only one measurement makes it also harder to compare findings between different studies. Here, acceptance was measured on two (Study I) or three occasions (Studies II and III). The differences between the measurements were not spectacular, but still some important evolutions were observed, which is potentially very interesting for organizations.

Acceptance coupled to observed Use

In studies III and IV, in which anonymity was not a prerequisite, the questionnaire data were paired to the actual use of Smartschool and KlasCement. By measuring the actual use, we were able to investigate more aspects of technology acceptance than in traditional studies, among which the basic assumption in IS-acceptance research: is actual use predicted by self-reported measures for acceptance?

Contributions to the field of research

Throughout this dissertation, it was showed that even within this developed stream of research (on the direct predictors of acceptance), significant progress could be made by studying professional users in different settings, on multiple occasions, and by collecting actual use. The most important contributions to the field of research are listed below

Further validation of UTAUT and C-TAM-TPB in populations of autonomous professionals:

The empirical studies extend the knowledge base on physicians' and teachers' acceptance of job-related technologies. The factors that explain acceptance in other populations are also valid for physicians and teachers, despite higher job autonomy. We did however find that their significance varied depending on the timing of the questionnaire or the type of

user. Mutual interactions between the predictor variables were also observed, every variable was found to be important either directly or indirectly through the interconnections with other predictors. Constructs also mutually influenced each other and whereas some constructs had no influence at first sight, they exerted an important indirect influence on acceptance through their interconnections with other variables. Variance explained was in most cases comparable to previous research.

It might however be useful to dissociate or extend certain constructs in medical or teaching settings in order to come to an even better understanding of acceptance. This recommendation is based upon two observations. On the one hand the reviews of the literature through which it was found that conceptually similar constructs - see Venkatesh, et al. (2003) - had either a different influence on acceptance (e.g. compatibility influenced *performance expectancy* and not *intention* or *use*, see Figure 1.6), or that some facets might be missing (e.g. the ease of logging in into a system might be lacking in *effort expectancy*). On the other hand this is based upon the observation that the studies reported here found a low reliability of *facilitating conditions* and to a lesser extent *social influence*.

Core predictors of IS-acceptance - Attitude

Fishbein and Ajzen (1975) discerned two types of reactions towards objects, affective reactions (or attitudes) and cognitions (or beliefs). Unlike attitudes, beliefs are formed upon the information one has about that object, and can thus be influenced by giving more or other information. Attitudes are then influenced by those beliefs, which was also observed here: *performance expectancy* (or perceived usefulness) and *effort expectancy* (or ease of use) were strong predictors of *attitude* in Study IV and to a lesser extent in Study III. In the IS-acceptance literature, *attitude* has been used in two roles: predictor and dependent variable. *Attitude* appeared in the theory of reasoned action (Fishbein & Ajzen, 1975) and the theory of planned behavior (Ajzen, 1991) as a predictor variable, and was a mediating variable (between the beliefs and *intention*) in the first version of the technology acceptance model (Davis, 1989). From then on, *attitude* gradually lost importance in IS-acceptance research, which was confirmed with the construction of UTAUT (Venkatesh, et

al., 2003), apart from the researchers who used *attitude* as dependent variable, e.g. Brown, et al. (2002). Also in educational research, computer attitudes is an important construct. The concept computer attitudes in educational research is conceptually broader than the *attitude* construct in IS-acceptance research, as described in the review of the literature on teachers' acceptance of educational technologies in Chapter 1.

Should *attitude* be included in UTAUT/TAM3 as a core predictor of acceptance? Evidence from the statistical tests in the addenda of Chapters 3, 4 and 5 is mixed. *Attitude* led to a significant increase of variance explained in eight (out of eleven) hierarchical regressions (see Tables 3.3, 4.4, and 5.9), but potentially interesting information was lost as the significance level of *performance* and *effort expectancy* in Chapters 3 and 4 was quite heavily impacted. On the other hand, in view of the distinction between beliefs and attitudes (Fishbein & Ajzen, 1975), it is easy to see how *performance expectancy*, *effort expectancy*, *social influence* and *facilitating conditions* can be influenced, namely respectively by providing (more) information on the impact of a technology (e.g. by using PACS, you will be able to consult all radiological images from virtually everywhere); by providing training; by mandating users to start to use a technology; and by providing support or computers. This is not the case for *attitude*. Someone's *attitude* towards a technology will be a result of all the information ('beliefs') s/he has about that technology. Thus, *attitude* should not be included as predictor variable, yet as will be argued below, *attitude* should be part of a reconceptualization of acceptance in which it has two dimensions: an attitudinal dimension and a behavioral (intention) dimension.

Importance of taking multiple measurements

This dissertation showed that taking multiple measurements is important for at least three reasons. First, because the predictors of acceptance can vary statistically over time, in particular in the early stages after the introduction of a new technology. So, organizations may have to adjust their strategy during the introduction of a new technology. Second, we saw by taking multiple measurements that the significance level could differ between the different measurements without identifying a significant interaction-effect. So, an

explanation for possible inconsistencies in earlier research is that an effect was missed due to the timing of the single measurement. Third, in Chapter 5, we could clarify, through the actual use data at T2, that use of the portal did not diminish over time.

Actual use as a means to differentiate between users

In Chapter 5, teachers were grouped based upon their (global) portal use behavior since their enrollment. Interestingly, the differences between these groups in past use behavior were also reflected in the (future) use behavior at the second use data extraction, and in the mean ratings on the acceptance scales. Moreover, significant differences were found in the variables that contributed to teachers' acceptance of the portal. So, even if most users are already longstanding and frequent users of a technology, organizations could differentiate between users to promote acceptance and more frequent use of that technology.

Contributions to the practice

Guidelines were already proposed throughout the empirical chapters, and are synthesized and elaborated in Appendix D. These guidelines should be helpful for organizations, school boards, CIO's who are planning to introduce a (similar) new (and mandatory) job-related technology in a population of teachers or physicians.

Limitations

Cross-sectional

The studies reported in Chapters 2 and 3 had to be taken anonymously. This meant that, although acceptance was assessed on multiple occasions in a (quasi) identical population, we still had to adhere to a cross-sectional design rather than a longitudinal design. In Chapter 4, the different questionnaires could be coupled, yet, the number of teachers that filled out the questionnaire on all occasions (N=30) was estimated to be too small to analyze this study as a true longitudinal design, although a longitudinal study is better in dissociating experience effects from between-subject variability.

Reliability

Unlike in Venkatesh, et al. (2003), the reliability of some scales we used, facilitating conditions and to a lesser extent social influence, was not always good. This low reliability might be caused in part by the way in which the UTAUT-scales were developed: based upon an empirical study, the four highest loading items per construct (out of the pool of all items stemming from conceptually similar constructs) were withheld. *Performance expectancy* (the technology's usefulness) and *effort expectancy* (the technology's ease of use) are quite straightforward, and this strategy had no effect on their reliability. *Facilitating conditions* (support, training, resources, control) and *social influence* (from peers, superiors, the organization) are more multi-faceted, and thus more vulnerable. A second cause might lie in cultural differences between either North-America (the roots of IS-acceptance research) and Western Europe, or between business settings and not-for-profit settings. It might be that in North-America and / or business settings, the implementation of a novel technology is more globally addressed (provision of support, training and resources; equal amount of pressure exerted by peers and superiors) and perceived as such as a whole by the technology users. This is however an issue that can only be addressed through cross-cultural research.

A solution to overcome this problem of low reliability might be to dissociate these constructs and investigate the differential impact of the different aspects of these constructs. *Social influence* could be dissociated in peers' and superiors' influence. The source of the influence is of particular importance for physicians, who are a quite special population, sometimes also referred to as a clan (Kohli & Kettinger, 2004). Lapointe and Rivard (2005), as described in the second case in Chapter 1, found that physicians rebelled against pressure exerted by the ('non-physician') hospital administration. When it comes to *facilitating conditions,* the review of the literature showed that *compatibility* and *physical access* behave differently than the overarching construct *facilitating conditions.* Dissociating *facilitating conditions* in control, resources & physical access; training & support; and compatibility should give the organization more information and a better insight in the actions they could undertake.

Self-reported measures for acceptance

The construct of *behavioral intention* is central in IS-acceptance research. Yet, throughout this dissertation we came across several limitations of this construct. *Behavioral intention* was in two instances not predictive of *self-reported use*, due to a ceiling effect - because of high ratings on both intention and self-reported use. This ceiling effect might be attributed to a combination of the mandatory nature of the technology, the necessity of the technology (PACS has to be consulted frequently) and the timing of the measurement (long after the introduction when - frequent - use of the technology has become a habit). In that case, *behavioral intention* ('I intend to use PACS in the next <n> months') is too generic such that users can only (strongly) agree; and the response-categories of *self-reported frequency of use* (see Figure 2.2 and Appendix A) are insufficiently fine-grained. However as it may take years for a technology to be truly accepted by its users, this kind of effect should be avoided and a solution to this problem should be identified. A second indication of the limitations of the behavioral intention construct is provided in the empirical study in Chapter 4 in which we found that *behavioral intention* was not a predictor of observed use, although it should be. It is thus a contribution of this dissertation that we were able to uncover the limitations of the self-reported measures of acceptance, and of *behavioral intention* in particular.

Next to *intention*, *attitude* and *self-reported use* also served as measures for acceptance, and also proved to be of limited value. *Attitude* was only predicted by *performance* and *effort expectancy*, as stated in TAM, while *social influence* and *facilitating conditions* had no significant influence on *attitude*. According to Venkatesh, et al. (2003), *self-reported use* should be predicted by *behavioral intention* and *facilitating conditions.* These effects were however not consistently observed, definitely in the case of *facilitating conditions*. *Performance* and *effort expectancy*, and *social influence* predicted in some instances self-reported use, but the observed effects were not that strong nor consistent.

In conclusion, definitely in the case where use of a technology is mandatory, attention should be paid to the operationalization of the dependent variable. There are several ways

to achieve this. Brown et al. (2010) did this by adding choice 'the percentage of time the individual chose to use [the technology] relative to the overall need'. Adding this construct, or the intensity of use (see Appendix A), might solve at least part of the problem. Taking also the necessity of technology use into account might also be beneficial, and refining *behavioral intention* and the response-categories of *self-reported frequency of use* should also lead to a better self-reported measure of acceptance.

Directions for further research

From the previous paragraphs, several directions for follow-up research can be distilled. Here, three suggestions to researchers interested in performing this kind of research are proposed. An overall recommendation is to conduct longitudinal research in populations of autonomous professionals such as teachers and physicians, and collect observed use.

Operationalization of acceptance and use

A first direction for follow-up research concerns the operationalization of acceptance and use. First, based upon the findings in this dissertation, researchers should strive to always collect observed use. This is however not always possible, for instance in the case where a technology is not yet introduced or if anonymity is a prerequisite for the study to be possible. In that case, a second suggestion is to re-conceptualize user acceptance and define it as "the state in which users intend to use a technology, hold positive attitudes towards use of that technology and whenever needed actually use that technology for the tasks [or one specific task] it is designed to support" which extends the definition provided by Dillon and Morris (1996), being "the demonstrable willingness within a user group to employ information technology for the tasks it is designed to support". Third, little attention is paid to the congruency between the measure for acceptance and the actual usage of the technology. For instance, the portal in Chapter 5, KlasCement, can be used for different purposes, the main being uploading and downloading. Yet, we found that it is mainly used for downloading. The fact that a technology can be used for different purposes is not taken into account in the current acceptance measures, e.g. I intend to use the technology in the ... [*behavioral intention*], I love/hate using the technology [*attitude*], I

use the technology ... times a week [*self-reported frequency of use*]. As we found in a preliminary study that *intention* and *self-reported use* were able to predict download behavior, but not upload behavior (Pynoo, et al., 2011c), it might be valuable to define the kind of use of interest: downloading or uploading in the case of a portal; reading, writing or printing in the case of a word processor.

So, our suggestion for follow-up research on the dependent variable is to investigate actual use or to regard acceptance as a complex construct and investigate to what extent different aspects of actual technology usage can be predicted.

Multilevel research - personal and organizational factors

The second suggestion for follow-up research is to take a broader look on acceptance and the influencing factors, and investigate also personal and organizational factors. The assumption underlying this dissertation and TAM/UTAUT based research is that actions undertaken by the organization are reflected in the users' perceptions of the technology. It has already been proposed to also include organizational variables when studying IS-acceptance (Legris, et al., 2003), a claim we can only support when looking at studies I and II where the same technology was introduced into two samples of physicians and quite different results were obtained. This is also consistent with Tondeur, et al. (2008) and van Braak, et al. (in prep) who found through multilevel studies that a significant part of the variance in computer attitudes is accounted for by the school level. Organizational factors that could be questioned (both at the organizational / implementers' level and at the individual user level) are issues related to the ICT-policy (training and support, technical infrastructure and provision of equipment, timeframe,...) and to the management or leader. This should lead to a better understanding of the obtained mean scale ratings on facilitating conditions and social influence.

In a typical acceptance studies, a population of users is studied as a single group and no personal characteristics, or only gender and/or age are taken into account. Although differences between men and women and between young and old definitely exist; when evaluating technology acceptance in a sub-population of highly skilled users (such as

physicians and teachers), characteristics beyond gender and age might be more meaningful to differentiate between users. This is in line with gender similarities hypothesis (Hyde, 2005). In Chapter 4 we already found that teachers appeared to adopt a base frequency of logging in into the system almost immediately following the introduction, which remained quite stable over time. And in Chapter 5 it was found that the frequency of different kinds of use remained quite stable over time. Moreover, in this latter study, we found that the amount of use impacted acceptance, an effect that would have been missed if the study population would have been treated as a single group. Also, in two preliminary studies on the influence of personality and / or technology readiness we found that physicians' and nurses' acceptance of an electronic medical record was affected by their personality and / or technology readiness (Devolder, et al., 2008; Pynoo, et al., 2009). Taking personality or other personal factors into account should not necessarily lead to a higher amount of variance explained, yet it should provide far more insight in the variables that influence the acceptance of different kinds of users.

Intervention study

Although the studies performed in this dissertation served an exploratory purpose, explicit guidelines - based upon the findings - were already provided in Chapters 3 and 5 for organizations or implementers to promote acceptance and use of the technology. There is however no single universal strategy towards implementation success, yet, organizations or implementers should tweak their strategy to the targeted population. Hence, the final recommendation for follow-up research is to setup an intervention study. In this type of study, a researcher devises a strategy based upon the results of a measurement and s/he intervenes during the implementation process by actually implementing that strategy or those guidelines and then assesses their impact on the implementation process. Systematically performing intervention studies, might be (a) a solution to lower the number of implementation failures or partial successes, and (b) a way to shorten the transition period from the old to the new system (or way of working). Intervening during the implementation process (based upon the findings of an acceptance study), should have a direct effect on acceptance as the concerns of the users can be addressed, while the users

receive more information concerning (usage of) the technology. Moreover, by intervening, users (should also) feel strongly supported by the organization in their use of the technology.

Conclusion

The overarching aim of this dissertation was to gain more insight in variables that contribute to autonomous professionals' acceptance of job-related technologies. Hereto, four empirical studies were conducted with UTAUT or C-TAM-TPB as theoretical framework, in which physicians' or teachers' acceptance of three job-related technologies (PACS, Smartschool and KlasCement). UTAUT and C-TAM-TPB contain, except for *attitude* (only in C-TAM-TPB), conceptually the same constructs: *performance expectancy* / *perceived usefulness*, *effort expectancy* / *perceived ease of use*, *social influence* / *subjective norms*, and *facilitating conditions*. Acceptance was operationalized as *attitude*, *behavioral intention*, and *self-reported frequency of use*. In addition, actual use of Smartschool and KlasCement was also collected and paired to the questionnaire data. Except for the KlasCement study (Chapter 5) in which actual use and not acceptance was measured on two occasions, acceptance was measured on two (just before and long after the introduction of the technology) or three (just before, shortly after and long after the introduction of the technology) occasions. The main findings were that all predictor variables influenced acceptance, yet, depending on the measure for acceptance (*attitude*, *intention*, *use*), and the timing of the measurement or type of KlasCement-user. Only a few significant changes in significance of the predictor-variables over time were observed, indicating that organizations should adapt their strategy while implementing a new technology or to promote the acceptance and use of a technology that is already in use. The most important predictor of *behavioral intention* was *performance expectancy* or *perceived usefulness*. *Social influence* / *subjective norms* were also quite important; although physicians and teachers have been argued to be independent in their technology acceptance decision, putting pressure on them has a positive effect on their *intention* to use, and definitely in the case where use of that technology is or will be mandated. *Effort expectancy* / *perceived ease of use* was important for physicians at T1, and for teachers at

T3 for their intentions to continue using Smartschool. *Facilitating conditions* / *perceived behavioral control* was a direct predictor of *intention* in the first study, where all computers were upgraded or replaced to meet the requirements for working with PACS, and for the tech-savvy heavy users of the portals who are likely to have the needed equipment. Strong correlations between *facilitating conditions*, and *effort* and *performance expectancy* were observed in all studies, so *facilitating conditions* also indirectly influence *behavioral intention*. Although included in different models as predictor, *attitude* should not be utilized as a predictor variable, yet be part of a re-conceptualized self-reported measure for acceptance. In Chapter 4, it was found that actual use could be predicted by self-reported measure of acceptance. Yet only *self-reported frequency of use* predicted actual use, and no significant direct effects of *intention* and *attitude* (only marginally at T3) were observed. This finding, in combination with the ceiling effects observed in Chapters 2 and 3, raised questions about the *behavioral intention* concept, which is central in IS-acceptance research. From this dissertation, different ways to progress were proposed. An overarching recommendation is to conduct longitudinal (or cross-sectional on multiple occasions) research in populations of professional users from whom self-reported questionnaire data and actual use data are collected. Researchers should also differentiate between users based on personal characteristics beyond gender and age. Seven (categories of) constructs are vital in IS-acceptance research (*performance expectancy*, *effort expectancy*, *social influence*, *facilitating conditions*, *attitude*, *behavioral intention* and *use*), and these are also usable for studying physicians' and teachers' acceptance. More insight could be gained by on the one hand refining or extending *effort expectancy*, *social influence* and *facilitating conditions*, and on the other by including personal or organizational variables. When it comes to the dependent variable: this should be actual use. In the case where this is not possible, the concept of acceptance should be re-conceptualized so that it includes an attitudinal and behavioral (intention) aspect.

Appendices

Appendix A: Questionnaire items Chapter 5

Appendix B: Significance level of Dunnett T3 post-hoc test (Chapter 5)

Appendix C: Effect sizes (Cohen's D) reported in Chapter 5

Appendix D: Checklist for a successful implementation of a mandated technology in samples of physicians and teachers

Appendix A: Questionnaire items Chapter 5

Perceived Usefulness

- Using KlasCement allows me to prepare my lessons more quickly
- Using KlasCement allows me to prepare my lessons better
- I estimate KlasCement to be useful for my job

Perceived Ease of Use

- Learning to work with KlasCement is/was easy for me
- It is/was easy for me to become skillful in using KlasCement
- I find KlasCement easy to use

Subjective Norms

- I use KlasCement because my colleagues use KlasCement
- The principal / pedagogic counsellor thinks I should use KlasCement
- My colleagues think I should use KlasCement
- I have to use KlasCement because of my principal / pedagogic counselor

Perceived Behavioral Control

- I have sufficient knowledge and skills to use KlasCement
- I decide how and when I use KlasCement
- I have access to the necessary material resources (computer, Internet, ...) to use KlasCement

Attitude

- Using KlasCement is a [bad/good] idea
- Using KlasCement is a [unwise/wise] idea
- I [hate/love] the idea of using KlasCement
- Using KlasCement is [unpleasant/pleasant]

Behavioral intention

- I intend to use KlasCement a lot in the coming school weeks
- I expect to use KlasCement a lot in the coming school weeks

Selfreported Use

- I use KlasCement during a regular school week [never / less than 1 time / about 1 time / several times / about once a day / several times a day] ("Frequency")
- I use KlasCement during a regular school week [as few/as much] as possible ("Intensity")

Voluntariness of Use

- I experience the use of KlasCement to be [mandatory / voluntary]

Appendix B: Significance level of Dunnett T3 post-hoc test (Chapter 5)

T1	light/medium	light/heavy	light/new	medium/heavy	medium/new	heavy/new
PU	***	***			***	***
EOU	***	***			**	***
SN						
PBC	***					
BI	***	***			*	*
Frequency of use	***	***		*	*	***
ATT	***	***	*		***	***
VOL	***				*	
#months portal use	***	***	***	*	***	***
logins [a]	***	***	***	***	***	***
uploads [a]	***	***		***		**
downloads [a]	***	***	***	***	***	***
reactions [a]	***	*				
pageviews [a]	***	***	**	***		***
Age						

T2	light/medium	light/heavy	light/new	medium/heavy	medium/new	heavy/new
logins [b]	***	**			***	**
uploads [b]	*					
downloads [b]	***	***			**	**
reactions [b]	***	*	*		***	*
pageviews [b]	***	***		*	**	***

*Notes: [a] average number of logins,... per month between registration and the date the questionnaire was filled out; [b] average number of logins,... per month between filling out the questionnaire and date of last login; ***p≤.001; **p<.01; *p<.05; ns: not significant*

Appendix C: Effect sizes (Cohen's D) reported in Chapter 5

T1	light/medium	light/heavy	light/new	medium/heavy	medium/new	heavy/new
PU	0.57	0.62	0.16	0.08	0.72	0.75
EOU	0.34	0.55	0.24	0.25	0.60	0.80
SN	0.04	0.30	0.04	0.24	0.00	0.25
PBC	0.26	0.29	0.12	0.07	0.38	0.37
BI	0.50	0.65	0.07	0.17	0.44	0.61
Frequency of use	0.51	1.03	0.05	0.47	0.46	0.95
ATT	0.55	0.69	0.41	0.21	1.06	1.24
VOL	0.24	0.01	0.41	0.19	0.66	0.34
#months portal use	0.33	0.78	1.71	0.44	1.25	1.22
logins [a]	1.10	0.98	1.35	0.58	1.59	1.05
uploads [a]	0.48	1.11	0.45	0.72	0.19	0.82
downloads [a]	1.09	1.14	0.87	0.64	1.31	1.19
reactions [a]	0.57	0.66	0.24	0.40	0.20	0.60
pageviews [a]	1.37	1.31	0.79	0.75	0.17	0.85
Age	0.12	0.20	0.14	0.08	0.02	0.05
T2	**light/medium**	**light/heavy**	**light/new**	**medium/heavy**	**medium/new**	**heavy/new**
logins [b]	0.24	0.66	0.35	0.5	0.57	0.86
uploads [b]	0.53	0.74	0.10	0.38	0.50	0.72
downloads [b]	0.16	0.38	0.16	0.25	0.10	0.37
reactions [b]	0.52	1.02	0.27	0.26	0.38	0.81
pageviews [b]	0.46	0.66	0.24	0.35	0.53	0.68

Notes: [a] average number of logins,... per month between registration and the date the questionnaire was filled out; [b] average number of logins,... per month between filling out the questionnaire and date of last login

Appendix D: Checklist for a successful implementation of a mandated technology in samples of physicians and teachers

Pre-implementation

EQUIP and PREPARE: provide the necessary resources to facilitate use of the technology

- replace or upgrade all computers so that they would meet the minimum requirements for working with the system
- prepare a training program
- set-up a support team

INFORM the (intended) users:

- why do you change to the new technology, which are the functionalities
- what will be the impact on the way of working
- which training will be provided
- who can be contacted in case of problems

TRAIN: primary focus on the basic tasks that replace the old way of working

ASSESS users' perceptions of the technology

- Scales of UTAUT (Venkatesh, et al., 2003), adapted to your setting, extended and refined
    - Performance expectancy
    - Effort expectancy and logical access (Ilie, et al., 2009)
    - Social influence: make a distinction between peers/colleagues and superiors
    - Facilitating conditions: make a distinction between (1) control or providing resources such as computers, network facilities,...; (2) providing training and support; and (3) compatibility
    - Attitude

- Behavioral intention

re-INFORM / provide more TRAINING if needed based on assessment

Post-implementation

strongly ENCOURAGE use of the technology, from the moment the technology is introduced:

- social influence on using a technology had a positive influence on users' intentions to use the technology

provide SUPPORT: in case of problems or uncertainties

gradually TRAIN the more advanced functionalities

MONITOR the actual use of the technology

- and DIFFERENTIATE between frequent and less frequent users

ASSESS users' perceptions of the technology ("Measuring is knowing") on different times, if needed:

- Scales of UTAUT (Venkatesh, et al., 2003), adapted to your setting, extended and refined
  - Performance expectancy
  - Effort Expectancy and logical access (Ilie, et al., 2009)
  - Social influence: make a distinction between peers/colleagues and superiors
  - Facilitating conditions: make a distinction between (1) control or providing resources such as computers, network facilities,...; (2) providing training and support; and (3) compatibility
  - Attitude
  - Behavioral intention
- and ADJUST strategy based on the assessment

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Nederlandstalige samenvatting

Inleiding

Technologie is alomtegenwoordig, zowel in ons dagelijks leven, als op de werkvloer. Het invoeren van een nieuwe technologie is in theorie gemakkelijk, toch blijkt dit niet uit de praktijk. Tot driekwart van de nieuwe technologieën slaagt niet, of toch niet volledig, en dit aandeel blijft nagenoeg constant ondanks de technologische vooruitgang. In de literatuur worden vier soorten barrières onderscheiden die een organisatie moet overwinnen: (1) project / economische barrières: het financiële luik; (2) technische barrières: wordt de juiste keuze gemaakt qua hardware, software,...; (3) organisatorisch: is de organisatie klaar om de werkwijze te veranderen, is het juiste materieel voorhanden en wordt training en ondersteuning voorzien; en (4) gedragsmatige / menselijke barrière: op het niveau van de gebruiker, is er weerstand, wil men de nieuwe technologie gebruiken.

In dit doctoraat wordt het vierde aspect nader onderzocht, de gedragsmatige component. Dit aspect heeft een organisatie het minst in de hand, maar de bedoeling van dit doctoraat is om na te gaan welke factoren ertoe bijdragen dat gebruikers een technologie aanvaarden en gebruiken. De onderzochte doelgroepen zijn alle autonome professionals, namelijk artsen en leerkrachten. Leden van deze beide beroepscategorieën kunnen (vrij) zelfstandig bepalen hoe ze hun doel bereiken en welke technologieën ze hiertoe aanwenden. De aanvaarding van drie technologieën wordt onderzocht, die gemeen hebben dat ze alle toegankelijk zijn via een browser venster:

- PACS (Picture Archiving and Communication System) in hoofdstukken II en III: het systeem waarop de radiologische beelden en verslagen gearchiveerd worden en verdeeld kunnen worden naar de aanvragende artsen;
- Smartschool in hoofdstuk IV: dit is een (‘schoolgebonden’) portaal waarvan de belangrijkste functies zijn: digitale leeromgeving; communicatie verzorgen tussen leerkrachten, leerlingen, ouders en directie; een administratief luik; en een leerlingenvolgsysteem

- KlasCement in hoofdstuk V: dit is een ('niet-schoolgebonden') onderwijsportaal waarvan iedereen lid kan worden. KlasCement wordt ondersteund door het vlaamse ministerie van onderwijs. Via KlasCement kunnen de leden materiaal en informatie delen met elkaar en ook materiaal downloaden voor eigen gebruik mits inachtneming van de licentievoorwaarden.

Er bestaan verschillende modellen om de aanvaarding van een technologie te verklaren en voorspellen. De belangrijkste lijn stamt af van de 'Theory of Reasoned Action' (Fishbein & Ajzen, 1975). Volgens deze theorie hangt het stellen van een gedrag af van de normen in de sociale omgeving en de attitude ten aanzien van dat gedrag. In dit doctoraat wordt gebruik gemaakt van UTAUT (Unified Theory of Acceptance and Use of Technology) en C-TAM-TPB (de combinatie van het Technology Acceptance Model en de Theory of Planned Behavior). Deze modellen bevatten, afgezien van attitude dat enkel in C-TAM-TPB voorkomt) conceptueel dezelfde concepten: nut, gebruiksgemak, sociale druk en faciliterende omstandigheden (dit laatste construct wordt vanaf hier afgekort als FC). In het algemeen is nut de sterkste voorspeller van aanvaarding. Aanvaarding kan op verschillende manieren gemeten worden, in dit doctoraat via attitude, intentie en zelf-gerapporteerd gebruik. Uit een overzicht van de literatuur rond aanvaarding van technologie door artsen en leerkrachten blijkt dat enerzijds deze literatuur vrij beperkt is, en anderzijds dat de variabelen in UTAUT of C-TAM-TPB wel een goed beeld zouden moeten geven. Het onderzoek in dit doctoraat is explorerend en vier onderzoeksvragen (OV) worden vooropgesteld:

- *OV1: In welke mate kan de aanvaarding van technologie door artsen en leerkrachten verklaard worden door de voorspellende variabelen in UTAUT en C-TAM-TPB?*
- *OV2: In welke mate veranderen de voorspellers van aanvaarding door toenemende ervaring?*
- *OV3: In welke mate kunnen de zelf-gerapporteerde maten voor aanvaarding het werkelijk gebruik voorspellen?*

- *OV4: In welke mate hebben karakteristieken van de gebruikers een invloed op de aanvaarding van technologie?*

Deze onderzoeksvragen zullen onderzocht worden doorheen de vier empirische studies in dit doctoraat: OV1 in alle studies; OV2 in studies 1, 2 en 3; OV3 in studie 3; en OV4 in studie 4.

Aanvaarding van PACS in UZ Gent

De aanvaarding van PACS door de aanvragende artsen in het UZ Gent werd op twee tijdstippen onderzocht (T1: net voor de introductie; T2: 1,5 jaar later) aan de hand van UTAUT. Er vulden 184 artsen op T1 en 147 artsen op T2 anoniem de enquête in. Op T1 was het nut van PACS de belangrijkste voorspeller van intentie en waren gebruiksgemak en FC van ondergeschikt belang. Op T2 was FC het belangrijkst en nut iets minder. Sociale druk had een marginale invloed op T2. De verklaarde variantie in intentie was .35 op T1 en .31 op T2; en in gebruik .03 op T2.

Aanvaarding van PACS in AZ Groeninge

In het AZ Groeninge werden drie enquêtes afgenomen: kort voor de introductie (T1), 4 maanden later (T2) en 15 maanden later (T3). Er werden respectievelijk 46, 52 en 61 bruikbare enquêtes anoniem ingevuld. Hier was het gebruiksgemak van PACS de belangrijkste voorspeller op T1. Sociale druk was op alle tijdstippen belangrijk en nut enkel op T2 en T3. FC had geen direct effect, maar er werden sterke correlaties met nut en gebruiksgemak waargenomen. Verklaarde variantie in intentie was respectievelijk .26, .46 en .60, en in zelf-gerapporteerd gebruik .18 op T2 en .02 op T3.

Aanvaarding van Smartschool

Voor deze studie werd ook het werkelijk gebruik verzameld uit logbestanden. Aanvaarding werd op drie tijdstippen tijdens één schooljaar gemeten: bij aanvang (T1) toen Smartschool ingevoerd werd, eind oktober (T2) en eind mei (T3). Er vulden respectievelijk 64, 41 en 55 leerkrachten de enquête in, waarvan slechts 30 alledrie. Nut en sociale druk waren de belangrijkste voorspellers van attitude, intentie en/of zelf-gerapporteerd gebruik. Gebruiksgemak en FC waren van ondergeschikt belang. Verklaarde variantie in attitude

was respectievelijk .78, .84 en .76, in intentie .35, .31 en .38, en in zelf-gerapporteerd gebruik .29, .16 en .12. Het werkelijk gebruik kon voorspeld worden door zelf-gerapporteerd gebruik terwijl attitude enkel een marginale invloed had op T3 en intentie geen directe voorspellende waarde had. Er werd respectievelijk 31, 27 en 46 % van de variantie in werkelijk gebruik verklaard.

Gebruik en aanvaarding van KlasCement

KlasCement verschilt van de andere technologieën omdat gebruik ervan op vrijwillige basis berust en dit niet kan verplicht worden door een school. De aanvaarding werd eenmaal gemeten en het werkelijk gebruik (aantal logins, downloads, bijdragen, reacties en bekeken pagina's) op twee tijdstippen (bij het invullen van de enquête en ongeveer 22 maanden later). Op basis van het werkelijk gebruik werden vier categorieën gebruikers onderscheiden: nieuwe (N=37), lichte (N=641), matige (N=201) en zware (N=40) gebruikers. Uit de parameters van het werkelijk gebruik kon afgeleid worden dat KlasCement voornamelijk gebruikt wordt om materiaal te downloaden en dat de meeste bestaande gebruikers (behalve de zware) ook zeer gericht zoeken. De verschillende groepen verschilden ook in hun beoordeling van het portaal, hoe zwaarder het gebruik, hoe positiever de beoordeling ervan was. De belangrijkste variabele voor de nieuwe gebruikers was attitude, voor de bestaande het nut van het portaal. Ook de andere variabelen waren van belang maar hun invloed was afhankelijk van het type gebruiker. Er werd tussen 22 en 50% van de variantie in attitude verklaard door nut en gebruiksgemak, tussen 39 en 71% van de variantie in intentie door nut, attitude, sociale druk en FC en tussen 24 en 45% van de variantie in zelf-gerapporteerd gebruik door attitude en intentie.

Algemene discussie en conclusie

Via de empirische studies in dit doctoraat konden de vier onderzoeksvragen beantwoord worden. De belangrijkste bevinden per onderzoeksvraag zijn:

- *OV1: In welke mate kan de aanvaarding van technologie door artsen en leerkrachten verklaard worden door de voorspellende variabelen in UTAUT en C-TAM-TPB?*

  Iedere voorspeller is van belang, afhankelijk van het tijdstip en type gebruiker. Het

nut van een technologie is de belangrijkste en meest constante voorspeller. Gebruiksgemak was voor artsen voornamelijk op T1 van belang, terwijl voor leerkrachten voornamelijk op T3 en voor de niet-zware gebruikers van KlasCement. Sociale druk was, enigszins tegen de verwachtingen in aangezien artsen en leerkrachten autonoom kunnen beslissen, toch een belangrijke factor die een positieve invloed heeft op aanvaarding. FC is voornamelijk van indirect belang, behalve dan voor de zware gebruikers van KlasCement en voor de artsen in het UZ Gent. Attitude bleek een significante voorspellende variabele te zijn, maar onderdrukte dan wel de invloed van nut en gebruiksgemak (behalve in de laatste studie). Het aandeel van verklaarde variantie in intentie was vergelijkbaar met eerdere aanvaardingsstudies in andere settings (vnl. bedrijven). De verklaarde variantie in zelf-gerapporteerd gebruik was vrij laag en in bepaalde gevallen bijna onbestaand.

- *OV2: In welke mate veranderen de voorspellers van aanvaarding door toenemende ervaring?*

  Het significantieniveau van de voorspellers varieerde in bepaalde gevallen afhankelijk van het tijdstip van de meting. In studie II werden deze verschillen ook statistisch significant bevonden, maar dit was niet het geval bij studie III.

- *OV3: In welke mate kunnen de zelf-gerapporteerde maten voor aanvaarding het werkelijk gebruik voorspellen?*

  In studie III vonden we dat enkel zelf-gerapporteerd gebruik het werkelijke gebruik voorspelde. Intentie had geen directe invloed en attitude enkel marginaal op T3. Dit is een bevinding met potentieel verstrekkende gevolgen voor het onderzoeksdomein.

- *OV4: In welke mate hebben karakteristieken van de gebruikers een invloed op de aanvaarding van technologie?*

  Het significantieniveau van de voorspellers verschilde in bepaalde gevallen afhankelijk van het type gebruiker. Er werden kleine doch statistisch significante

verschillen gevonden die aantonen dat een organisatie er baat bij heeft om te differentiëren tussen gebruikers.

De sterktes van dit doctoraat zijn dat de studies uitgevoerd werden bij professionele gebruikers, dat de aanvaarding op verschillende tijdstippen gemeten werd en dat in twee studies aanvaarding gekoppeld werd aan het werkelijk gebruik. Dit doctoraat draagt op verschillende manieren bij aan het onderzoeksveld: verdere validatie van UTAUT en C-TAM-TPB bij artsen en/of leerkrachten, het geeft meer inzicht in de rol van attitude, en ook het belang van meerdere metingen werd aangetoond. Tenslotte werd ook het belang van het meten van werkelijk gebruik aangetoond. De belangrijkste bijdrage voor het werkveld is dat via de bevindingen van deze studies richtlijnen opgesteld werden om de aanvaarding van technologie bij leerkrachten en artsen maximaal positief te beïnvloeden, bijvoorbeeld het creëren van een omgeving die het gebruik van de technologie sterk aanmoedigt en ondersteunt.

Vanuit dit doctoraat kunnen ook meerdere richtingen voor vervolgonderzoek afgeleid worden. Een overkoepelende aanbeveling is het voeren van een longitudinaal onderzoek bij professionele gebruikers, waarbij ook het werkelijk gebruik gemeten wordt. De belangrijkste richting voor vervolgonderzoek is onderzoek naar de afhankelijke variabele: ofwel werkelijk gebruik of een complexe maat met zowel een attitude als intentie aspect. Er moet ook aandacht zijn voor het soort gebruik (bv. bijdragen of downloaden) dat men wil meten. Een tweede richting voor vervolgonderzoek is aanvaarding enerzijds vanuit een breder perspectief te bekijken en ook variabelen met betrekking tot de organisatie op te nemen, of in meerdere organisaties tegelijk onderzoek te doen; en anderzijds ook persoonlijke factoren mee te nemen, anders dan leeftijd en geslacht, zoals persoonlijkheid. Een laatste richting voor vervolgonderzoek is het opzetten van een interventie studie waarin een strategie (of richtlijnen) ontwikkeld wordt aan de hand van de bevindingen van een aanvaardingsstudie en nagegaan wordt in welke mate deze strategie efficiënt is.

Afsluitend, alle voorspellers van UTAUT en C-TAM-TPB spelen een rol, doch het nut van een technologie is de belangrijkste factor. De voorspellers veranderen over tijd en zijn

afhankelijk van het type gebruiker. Sommige constructen kunnen wel nog verfijnd worden, bv. een onderscheid maken tussen verschillende bronnen van sociale druk, om een nog beter beeld te krijgen van aanvaarding bij artsen en leerkrachten. De beperkingen van het centrale construct in deze onderzoekslijn, intentie werden ook duidelijk tijdens dit doctoraat.

List of Publications

Articles published in ISI Web-of-Science (A1)

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Pynoo, B., Devolder, P., Tondeur, J., van Braak, J., Duyck, W., & Duyck, P. (2011). University students' acceptance of a web-based course management system. In T. Teo (Ed.), *Technology acceptance in education: Research and issues* (pp. 125-144). Rotterdam: Sense Publishers.

Presentations (C1, C3)

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