Towards Technology Acceptance Assessment in Ambient Intelligence Environments

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***Abstract*— This paper discusses technology acceptance in the context of Ambient Intelligence (AmI) environments. Determining what would make a technology acceptable by users was widely recognized as a significant field of research since the seventies. Ever since several models have been developed, while recent advances in technology have led to increased research interest in assessing technology acceptance in a variety of domains. This has resulted in a plethora of studies and an extensive number of parameters that can be considered important towards predicting the acceptance of a given technology by its target audience. An important concern is how to practically employ these models for the assessment of AmI environments, given their high complexity and the wide range of potential contexts and target users. To this end, this paper carries out a review of the most important models and their evolution over time, as well as a review of studies extending these models in a variety of domains beyond the workplace. Furthermore, a classification of the parameters studied across these models is carried out, identifying a common feature across existing technology acceptance studies, namely that all assessments are based on self-reported metrics. This highlights the need for a synergistic evaluation approach, where assessment will move beyond self-reported or observed metrics and will be supported and assisted by the AmI environment itself.**

Keywords-Technology Acceptance; Models classification; Ambient Intelligence;

I. INTRODUCTION

Determining what would make a technology acceptable by users was widely recognized as a significant field of research since the seventies, when approaches towards defining factors that seem to influence the use of technology have been proposed. Nevertheless, it was in the mid-eighties when researchers concentrated their efforts on developing and testing models that could help predicting system use [1]. Several theoretical models have been proposed to this end, with roots in information systems, psychology, and sociology [2]. Over time, as new technological advancements occurred, the research interest in technology acceptance moved beyond the workplace (where technology and more specifically computers were initially used) to other domains and contexts of use.

Ambient Intelligence is an emerging field of research and development, constituting a new technological paradigm, moving beyond the Ubiquitous Computing paradigm. The notion of Ambient Intelligence is becoming a de facto key dimension of today's Information Society, spanning across every Human-Computer Interaction (HCI) research and development domain, since next generation digital products and services are explicitly designed in view of an overall intelligent computational environment [3]. Although Ambient Intelligence is a multidisciplinary field, its objective is to offer proper services to users, therefore the implications of user evaluation should be considered in this "service-evaluation-research" loop [4].

As AmI environments are equipped with various sensors and monitoring capabilities, privacy and trust become issues of paramount importance for their inhabitants [5], while technology acceptance needs to be studied from a new perspective. Ambient Intelligence may be found in any potential daily living environment, such as the home, the workplace, health care, educational setting, or public spaces [6], embracing any activity carried out in these environments. Therefore, the parameters that may impact user acceptance of an Ambient Intelligence environment definitely extend beyond the parameters suggested in the first models studying computer acceptance in workplace environments. As a first step towards studying acceptance in AmI environments, this paper carries out a short review of the initial technology acceptance models and their evolution, as well as their adaptations to address different contexts of use. Furthermore, a classification of the parameters studied in these models is provided, with the aim to assist researchers in identifying parameters that should be included in studying user acceptance of AmI environments, according to the target environment and context of use.

The purpose of this paper is not to carry out a detailed literature review; instead, it focuses on identifying parameters that have been suggested to influence technology adoption in various contexts. Therefore, the main criteria for including a paper in this review were: (i) the paper should propose a specific model directly relevant with technology acceptance, and (ii) at least one novel variable should be contributed by the model. The main focus of this work is on proposing a classification of the parameters explored in such models and - through this - highlight the potential of moving from self-rated experiences towards technology-assisted assessment of user experience in Ambient Intelligence environments.

The paper is structured as follows: Section 2 introduces the most significant technology acceptance and adoption models, while Section 3 presents models for technology acceptance beyond the organizational context, organized in categories. Section 4 provides a classification of the parameters examined in the presented models. Section 5 concludes the paper by discussing directions towards technology acceptance assessment in AmI environments.

II. Technology Acceptance

One of the most influential models, the Technology Acceptance Model (TAM), has been proposed by Davis [7] and defines two components that affect a user's attitude towards using a technology, namely: (i) perceived usefulness, described as the degree to which an individual believes that using a particular system would enhance their job performance and (ii) perceived ease of use, defined as the degree to which an individual believes that using a particular system would be free of physical and mental effort. Extending the initial TAM model and taking into account theoretical constructs spanning from social influence processes to cognitive instrumental processes, Venkatesh and Davis introduced the TAM2 model [8], which added seven components to the initial TAM model, and namely:

- Subjective norm: a person's perception that most people who are important to him think he should or should not perform the behavior in question.
- Voluntariness: the extent to which potential adopters perceive the adoption decision to be non-mandatory.
- Image: the degree to which use of an innovation is perceived to enhance one's status in one's social system.
- Experience: the experience gained while using a given technology over time.
- Job relevance: an individual's perception regarding the degree to which the target system is applicable to his or her job.
- Output quality: how well the system performs tasks.
- Result demonstrability: the tangibility of the results using the innovation.

TAM has been widely adopted and studied by the research community, resulting in a considerable number of external variables that have been introduced as factors influencing how users perceive the usefulness and ease of use of a technology, while reviews of TAM have constituted the objective of several meta-studies [9]-[11]. Variables extending the initial TAM model include [9]:

- Relative advantage: the degree to which an innovation is perceived as being better than its precursor.
- Compatibility: the degree to which an innovation is perceived as being consistent with the existing values, needs, and past experiences of potential adopters.
- Trialability: the degree to which an innovation may be experimented with before adoption.
- Self-efficacy: an individual's convictions about his or her abilities to mobilize motivation, cognitive resources and courses of action needed to successfully execute a specific task within a given context.
- End user support: specialized instruction, guidance, coaching and consulting.
- Objective usability: the actual level of system effect on the completion of specific tasks.
- Personal innovativeness: the individual's willingness to try out any new technology.
- Cognitive playfulness: the individual's cognitive spontaneity when using a technology.
- Social presence: the degree to which a medium permits users to experience others as being psychologically present.
- Visibility: the degree to which the innovation is visible in the organization.
- Computer attitude: the degree to which a person likes or dislikes the object.
- Accessibility: physical and information accessibility.
- Management support: the degree of support from managers to ensure sufficient allocation of resources.
- Computer anxiety: an individual's apprehension, or even fear, when she/he is faced with the possibility of using computers.
- Perceived enjoyment: the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system usage.
- Facilitating conditions: resource factors (such as time and money) and technology compatibility issues that may constrain usage.

Addressing the need for defining the determinants of perceived ease of use, TAM3 was proposed [12] by extending TAM 2 to include the following determinants: computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment and objective usability.

Following a different approach, Thompson, Higgins, and Howell [13] utilized a subset of the theory of human behavior [14] to create a model of personal computer utilization. Applying this theory implied that the utilization of a Personal Computer (PC) by a knowledge worker in an optional use environment would be influenced by the individual's feelings toward using PCs, social norms in the work place concerning PC use, habits associated with computer usage, the individual's expected consequences of using a PC, and facilitating conditions in the environment conducive to PC use.

A significant theoretical framework in the area of technology diffusion and adoption was proposed by Rogers [15] and described the innovation-diffusion process as an uncertainty reduction process. Five attributes of innovation were proposed, which are important for technology adoption: relative advantage, compatibility, complexity, trialability, and observability. Other variables determining the rate of adoption of innovations are: the type of innovation decision (optional, collective, authority), the communication channels used to diffuse an innovation, the nature of the social systems (its norms and the degree to which the communication network structure is highly interconnected), as well as the promotion efforts of change agents. Moore and Benbasat [16] also adopted the Innovation Diffusion Theory (IDT), and further extended it with two constructs, namely image and voluntariness of use. Tornatzky and Klein [17] carried out a review and meta-analysis of seventy-five articles concerned with innovation characteristics and their relationship to innovation adoption and implementation, and extracted ten characteristics as the most important and frequent ones, five of which are the attributes of innovation of IDT. The additional five innovation characteristics are:

- Cost: the cost of an innovation is assumed to be negatively related to the adoption and implementation of the innovation; the less expensive the innovation, the more likely it will be quickly adopted and implemented.
- Communicability: the degree to which aspects of an innovation may be conveyed to others.
- Divisibility: the extent to which an innovation can be tried on a small scale prior to adoption, which is closely related to trialability.
- Profitability: the level of profit to be gained from adoption of the innovation.
- Social approval: refers to status gained in one's reference group, a nonfinancial aspect of reward as a function of adopting a particular innovation.

With the aim to facilitate researchers confronted with a choice among a multitude of models, Venkatesh et al. [18] proposed the Unified Theory of Acceptance and Use of Technology (UTAUT). According to this theory, four constructs are direct determinants of user acceptance and user behavior: performance expectancy, effort expectancy, social influence and facilitating conditions. In addition, four moderators have been identified for the aforementioned determinants, namely gender, age, experience, and voluntariness of use. An extension to the UTAUT model, named UTAUT2, has been proposed by Venkatesh, Thong, & Xu [19] to study acceptance and use of technology in a consumer context and incorporates three additional constructs:

- Hedonic motivation: the fun or pleasure derived from using a technology.
- Price value: the consumers' cognitive trade-off between the perceived benefits of the applications and the monetary cost for using them.
- Habit: the extent to which people tend to automatically perform learnt behaviors.

III. TECHNOLOGY ACCEPTANCE BEYOND THE WORKPLACE

The majority of the aforementioned fundamental models have initially been applied in organizational settings and examined technology adoption in the workplace context, since when they were initially created, computers were not used in the home or other environments, while technology mostly referred to PC usage. Recent advances in technology have led however to increased research interest in assessing technology acceptance in a variety of domains. This section reports on efforts utilizing or extending the aforementioned models by adding new variables, towards assessing other contexts or technologies, focusing on the most prevalent contexts, as well as contexts relevant to AmI (e.g., ubiquitous computing, Ambient Assisted Living).

A. Technology Adoption in Households

As a result of studying technology adoption in households, Brown and Venkatesh [20] introduced the Model of Adoption of Technology in Households (MATH), which includes the following constructs:

- Utilitarian outcomes, which can be divided into beliefs related to personal use, children, and work.
- Hedonic outcomes, defined as the pleasure derived from the consumption, or use, of a product.
- Social outcomes, which are described as the "public" recognition that would be achieved as a result of adopting an innovation.
- Social influence that is the extent to which members of a social network influence one another's behavior, and can be further classified into friends and family influences, secondary sources influences, as well as workplace referents' influences.
- External constraints, which are characteristics of the PC and its environment and include the rapid change in technology and/or fear of obsolescence, declining cost, and cost.
- Internal constraints, reflecting perceptions of the individual's relationship with technology and include the perceived ease of use and requisite knowledge.

Furthermore, the model defines the following moderators, which are related to household life: marital status, age, child's age and income.

B. World Wide Web (WWW)

Moon and Kim [21] extended and empirically validated TAM for the WWW context. The results of their study indicate that perceived usefulness, perceived ease of use and perceived playfulness are important determinants of users' perceptions towards using the WWW, but also that playfulness and perceived ease of use (intrinsic motivations) had a more powerful impact than perceived usefulness (extrinsic motivation) in the case of the WWW. The effect of Internet experience and website experience has also been studied, highlighting the positive impact of experience [22]. More specifically, it was found that in users with high experience, (a) the influence of perceived usefulness on the process of forming the attitude to the website is substantially greater than in users with low experience, while (b) the influence of perceived ease of use on the attitude towards the website is substantially smaller than in users with low experience.

C. Gaming and Virtual Worlds

In the domain of WWW and especially with regard to online games, TAM was extended with the constructs of social norms, critical mass and flow experience [23], concluding that social norms and flow affect users' intention to play an online game, while critical mass affects users' attitude towards playing an online game, but not intention directly. Perceived connectedness and perceived mobility were constructs introduced in the domain of mobile social network games [24]. Focusing on serious games, Yusoff, Crowder, and Gilbert extended TAM with the concepts of transfer of learnt skills, learner control, reward, as well as situated and authentic learning [25]. In the context of virtual worlds, the application of TAM highlighted that communication, collaboration, and cooperation are central in influencing behavioral intention to use and acceptance of the virtual world [26].

D. Trading, Shopping and Internet banking

The moderating effect of perceived trust has been explored as an extension of TAM in the context of online trading systems [27]. Testing the model supported that trust is an important antecedent of user acceptance in this context, and that perceived security affects user's trust. Trust and perceived risk have also been added as extensions to TAM with regard to e-commerce in order to study the user's intention to transact [28], [29]. Studies that have been carried out to test the extended TAM [28] indicated that trust is positively associated with intention to transact, perceived usefulness and perceived ease of use, and negatively associated with perceived risk. Furthermore, reputation was a significant antecedent of intention to transact, and along with satisfaction with past transactions and web shopping frequency, they were significant antecedents of trust. The concept of consumer trust has been extensively studied and further decomposed in the antecedents of personality-based, cognition-based, knowledge-based, calculative-based and institution-based trust [30].

Previous experience with the Internet was found to be of significant importance for both initial and repeated purchases, while users who consider that they have more competence and capacity also have better perceptions about e-commerce and, as a consequence, carry out more online purchases [31]. E-shopping quality is another factor that was found to be influential in perceptions of usefulness, trust, and enjoyment, which in turn influence consumers' attitudes toward e-shopping [32]. In this study, e-shopping quality consists of four dimensions, namely web site design, customer service, privacy / security and atmospheric / experiential quality.

The role of perceived risk, as well as that of perceived benefit, have been included in a TAM extension studying user acceptance of internet banking [33]. In more details, the results of the study confirmed that perceived benefit has a primary effect on intention to use online banking, as well as that security, financial, time, social, and performance risks all emerged as negative factors in the intention to adopt online banking. Risks have been further explored and analyzed as a parameter for e-services adoption by Featherman and Pavlou [34], comprising the facets of performance, financial, time, psychological, social, privacy and overall risk.

E. eLearning and mLearning

In the context of eLearning, the TAM model has been expanded to include system characteristics, and more specifically: (i) functionality, which refers to the perceived ability of a eLearning system to provide flexible access to instructional and assessment media, (ii) interactivity, which refers to interaction support between teachers and students, and students themselves, and (iii) response time [35]. The model also included the user attributes of self-efficacy and internet experience, and studied the impact of the aforementioned factors on perceived usefulness and perceived ease of use, as well as the use of the system for supplementary learning and for distance education. Saadé and Bahli [36] extended TAM, taking into account the moderating effect of cognitive absorption, which in turn is defined by the user's temporal dissociation, focused immersion and heightened enjoyment when using the online learning system. The role of cognitive absorption, as well as system attributes has been pointed out in a TAM extension based on the expectancy disconfirmation theory [37]. The results of the study suggest that continuance intention is determined by satisfaction, which in turn is jointly determined by perceived usefulness, information quality, confirmation, service quality, system quality, perceived ease of use and cognitive absorption.

eLearning self-efficacy, followed by subjective norm, have been emphasized as the most important constructs explaining eLearning technology adoption by university students [38]. The role of eLearning experience on continuance intention has also been explored by Lin [39], highlighting that (i) negative critical incidents and attitude are the main determinants of the users' intention to continue using the e-learning, irrespective of their level of e-learning experience, (ii) the impact of negative critical incidents on perceived ease of use is greater for less experienced users, while the impact of negative critical incidents on perceived usefulness is greater for more experienced users; and (iii) perceived ease of use has a more critical effect on the attitude and continuance intention of less experienced users, whereas perceived usefulness is found to be a stronger determinant of the attitude and behavioral intention of more experienced users. The importance of digital literacy in eLearning use for professional development has been stressed in a study extending the UTAUT model [40], which found that digital literacy has an impact on users' performance and effort expectations that in turn affect continuance intention and eventually performance. The adoption of IT by educators has also constituted the subject of several studies, highlighting that digital competencies and institutional support have an important role in adoption intentions [41].

On the other hand, in terms of mLearning adoption intention, near-term usefulness, long-term usefulness and personal innovativeness have proved to have significant influence, with the most important predictor being long-term usefulness [42]. Mobile technology adoption by educators has been claimed to be influenced, among others, by mobile device anxiety, as well as resistance to change, defined as the difficulty to break with routines and the emotional stress generated [43].

eLearning is a domain in which many studies have been carried out in terms of user acceptance. A meta-analysis of eLearning technology acceptance studies [44] identified that TAM is indeed the most-used acceptance theory in the specific context, but more importantly that the size of the causal effects between individual TAM-related factors depends on the type of e-learning technology.

F. Mobile Technology

Advances in mobile technology have led to increased interest in exploring adoption intentions and acceptance of services in this domain. Lu, Yao, & Yu [45] modified TAM to explore adoption of wireless internet services via mobile technology, and found strong causal relationships between social influences, personal innovativeness and the perceptual beliefs—usefulness and ease of use, which in turn impact adoption intentions. A model has been proposed by Nysveen, Pedersen, & Thorbjørnsen [46], integrating the motives that are revealed in information systems theories, uses and gratification theory, and domestication theory and examining four mobile services, namely text messaging, contact, payment, and gaming. The model includes the motivational influences of usefulness, ease of use, enjoyment, and expressiveness, attitude towards using the mobile services, normative pressure as a social influence, and behavioral control reflecting resource-related influences such as the user's economy, experience and skills in using a service. The results indicate that attitude towards using the service is moderated by enjoyment, usefulness, and ease of use, while users' intention to use the service is moderated by attitude towards the service, expressiveness, enjoyment, usefulness, ease of use, normative pressure and behavioral control. Taking into account TAM, as well as other models extending it for e-commerce acceptance, Fang, Chan, Brzezinski, & Xu [47] propose a new model focusing on mobile commerce identifying the moderating effects of task type on technology acceptance. A study was carried out to test the proposed model, and the results highlight that perceived usefulness and perceived ease of use were important to user intention to perform general tasks that do not involve transactions and gaming on wireless handheld devices, while perceptions of playfulness influence user intention to play games using wireless technology, and user intention to transact on handheld devices is affected by perceived usefulness and perceived security.

The role of context in the user acceptance of mobile systems was highlighted and studied for mobile ticketing systems [48]. The results of the study indicated that the context of use has an important effect on intention to use the mobile service, as well as a mediating effect of perceived usability on user intention, while other decision factors, such as ease of use and compatibility, had a direct effect. Considering the mobility context, Zarmpou, Saprikis, Markos, and Vlachopoulou [49] extended TAM and introduced the concept of relationship drivers as those dimensions that create a relationship between the consumers and the m-services, including for instance the time and location personalization of m-services, their adaptation to the consumers' profile, the consumers' dynamic permission option and the consumers' reward by the use of the m-services. Testing the model highlighted that relationship drivers have an important effect on perceived usefulness and behavioral intention.

G. Health Technology

Although the success of health Information Technology (IT) certainly goes beyond user acceptance, where users may be health professionals or patients, increasing interest in this application domain has raised the importance of theories that predict and explain health IT acceptance and use [50]. Such theories are based on existing models, such as TAM, while findings of reviews and meta-studies highlight that TAM predicts a substantial portion of user acceptance of health IT, however several additions and modifications have been proposed [50].

An alternative approach to extending TAM aimed at identifying barriers to health IT adoption, instead of extending it with determinants positively influencing acceptance [51]. To this end, the following barriers have been identified: interruption of traditional practice patterns, lack of evidence regarding the benefits of IT, organizational issues, as well as system-specific issues, such as reliability and dependency. An extended TAM model for health IT acceptance suggested information quality and enabling factors as second order constructs that affect perceived usefulness and perceived ease of use [52]. In the proposed model, information quality is posited to be determined by accuracy, content, format and timeliness, while computing support and self-efficacy constitute enabling factors. The results of a study carried out to test the model highlight that the quality of the information provided by the system and the extent to which the user feels they have the technical support or skills to make use of the system are both significant. With a focus on attributes of the individual that have an impact on health IT acceptance, IT feature demands and IT knowledge have been proposed as additional TAM constructs, while the physician's specialty has been studied as a moderator [53]. The individual's technological attitude has also been explored with regard to technology acceptance in a study focusing on mobile electronic medical record adoption by nurses [54], emphasizing the importance of optimism on perceived usefulness and the impact of optimism, innovativeness, insecurity and discomfort on perceived ease of use.

H. Assistive Technology and Ubiquitous Computing

Assistive Technology (AT) and robotics is another technological advancement that has led to further exploration of technology acceptance. The Almere model, an extension of the UTAUT model [55], considers the effect of perceived enjoyment, social presence, perceived sociability, trust, and perceived adaptivity. Perceived adaptivity refers to the capability of the system to change over time in order to support the changing conditions and needs of its users. Testing the model identified among others that perceived adaptivity directly affects user attitude and perceived

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usefulness, perceived sociability affects perceived enjoyment and social presence, while intention to use is directly influenced by social influences, attitude, perceived usefulness and ease of use, as well as perceived enjoyment.

The Ubiquitous Computing Acceptance Model [56] has been proposed to predict whether potential users will accept Ubiquitous Computing (UbiComp), by studying the relationships among trust, security, privacy, usefulness, ease of use and intention to use a ubiquitous computing technology. In the UbiComp domain, the Pervasive Technology Acceptance Model (PTAM) [57] has extended TAM by adding the constructs of trust and integration as direct determinants of behavioral intention, while it adds usage motivation, socioeconomic status, age, gender, and expertise as moderators. Trust is examined in terms of keeping the information collected about the individual as confidential and in terms of trusting the application to behave as expected, given its potential to tailor its behavior. Integration refers to how well the technology is integrated into the individual's life (e.g., by not distracting them or interfering with their other activities).

IV. Technology Acceptance And Ambient Intelligence

In summary, research in the direction of technology acceptance has led to the aggregation of a considerable number of parameters that can be considered as important towards predicting the acceptance of a given technology by its target audience. It should be noted that the literature review that has been carried out was not exhaustive, as there are more studies for the aforementioned domains and also there are studies on technology acceptance for other domains that have not been included in this paper. Literature abounds with studies of users' acceptance in wide a variety of domains, such as e-logistics [58], online tax system [59], hotel office front systems [60], Enterprise Resource Planning (ERP) systems [61], electronic mediated commerce using interactive television [62], Radio-frequency Identification (RFID) technology [63], Internet of Things [64], etc.

Instead, the purpose of the current review was to emphasize the plethora of parameters that should be taken into account, especially in the context of AmI environments, due to their technological complexity and diversity in context of use. As a result, the review has included studies mostly relevant to AmI and studies of major everyday life domains, with a focus on those that have introduced new constructs in acceptance models. Indeed, the presented review and classification has resulted in 73 parameters of technology acceptance that act as direct determinants, antecedents or moderators of technology acceptance. Also, it is noteworthy that the overwhelming majority of these parameters (98.92%) is assessed in the various studies through questionnaires, asking users to self-report their characteristics, attitudes and perceptions.

An important concern is how to practically employ these models in the context of the assessment of Ambient Intelligence technologies. To this end, a classification of the aforementioned parameters is required. Attributes that can be used for this classification include:

- Category of reference: if the metric is used to describe an attribute of the individual, of the social environment or the system under evaluation
- Assessment method: which method will be employed to find out the value of the specific metric (e.g., questionnaire, observation, automated system measurement)
- The context in which the specific metric can be applied (e.g., workplace, education, health, home environment, public environments)

Based on this suggestion, the tables below list all the metrics identified in literature, as follows: Table I lists all system-related parameters,

Table II encompasses attributes describing social influences, as well as environment factors, while

Table III features parameters describing system impact on the individual, and

Table IV refers to parameters concerning the individual (user). Each table includes four columns: (i) the parameter evaluated, and its various synonyms met across literature, (ii) the assessment method, (iii) the context, and (iv) references to publications that include the specific parameter in the proposed models. In summary, as shown in Figure 1, more than half of the parameters refer to system attributes.

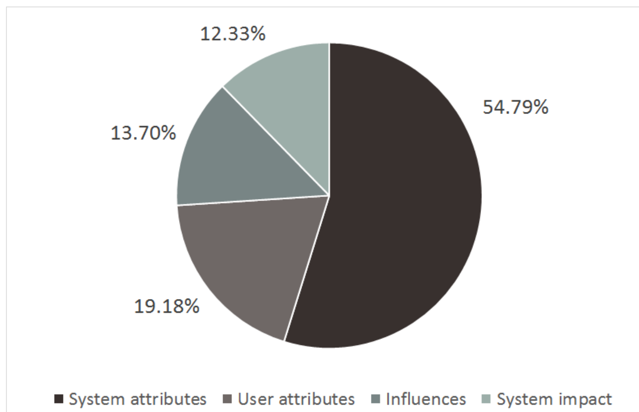

Figure 1 Parameters per category of reference

V. CONCLUSION

Technology acceptance, in terms of prediction and estimation, has been in the focus of research since the seventies. Although technology and its context has largely evolved ever since from a typical computer in the workplace to hidden microcomputers in everyday appliances, technology acceptance remains important and an active research topic. In the light of the new advancements expected in AmI environments, which address a broad range of technologies, users, and contexts, this paper has reviewed technology acceptance models as they have evolved to address a wide range of technologies and contexts of use. Furthermore, a classification has been carried out of the factors that have been found to directly or indirectly impact technology acceptance, organizing them in system-related, individual-related, social and environmental influence, as well as system impact factors. The literature review and the classification have highlighted that all factors have been assessed in previous approaches through questionnaires, as self-reported metrics.

Although the self-reporting approach is inevitable in many cases, and the only possible method when the first studies were carried out, this is no longer an ideal solution in the context of AmI environments. On the one hand, the number of questions to be asked to the user may become unmanageable in such environments, if all the relevant aspects are to be assessed. On the other hand, an AmI environment has the capability to provide measurements through its sensors that will constrain the number of questions that need to be asked to the user. The vision of AmI can bring about new perspectives to technology acceptance and evaluation, facilitating not only the environment in adapting itself to better serve the needs of the user, but also evaluators aiming to assess the overall user acceptance of such environments. This potential highlights the need for a user acceptance evaluation model in AmI environments, aiming to assess a wide range of characteristics and qualities of such environments, taking into account traditional and modern models and evaluation approaches.

TABLE I. PARAMETERS REFERRING TO THE SYSTEM

Parameter	Method	Context	Ref.
Perceived usefulness	Quest.	Organizational	[7], [8]
Perceived ease of use	Quest.	Organizational	[7], [8]
Output quality	Quest.	Organizational, eLearning, Health IT	[8], [37], [52]
Result demonstrability	Quest.	Organizational	[8]
Relative advantage	Quest.	Organizational	[9], [16]
Compatibility	Quest.	Organizational, Mobile services	[9], [16], [48]
Trialability / Divisibility	Quest.	Organizational	[9], [16]
End-user support	Quest.	Organizational	[9]
Objective usability	Quest.	Computer software	[9], [12]
Social presence	Quest.	Organizational, AT	[9], [55]
Accessibility	Quest.	Organizational	[9]
Perceived enjoyment	Quest.	Organizational, Mobile services, AT	[9], [12], [46],[55]
Complexity	Quest.	Organizational	[16]
Cost	Data analysis	Organizational	[17]
Price Value	Quest.	Mobile Internet	[19]
External constraints (PC & environment characteristics)	Quest.	Household	[20]
Transfer of learnt skills	Quest.	Serious games	[24]
Learner control	Quest.	Serious games	[24]
Reward	Quest.	Serious games	[24]
Collaboration / Cooperation, Connectedness	Quest.	Virtual worlds, Mobile social network games	[26], [24]
Mobility	Quest.	Mobile social network games	[24]
Perceived security	Quest.	Online Trading, UbiComp	[27], [56]
Reputation	Quest.	E-commerce	[28]
Perceived risk* * security, financial, time, social risk (internet banking) * performance, financial, time, psychological, social, privacy and overall risk (e-services adoption)	Quest.	E-commerce Internet banking	[28], [33], [34]
Web site design	Quest.	E-commerce	[32]
Customer service	Quest.	E-commerce	[32]
Atmospheric / experiential quality	Quest.	E-commerce	[32]
Perceived benefit	Quest.	Internet banking	[33]
Functionality	Quest.	Moblie sevices eLearning	[35], [49]
Interactivity (between teachers & students, and students themselves)	Quest.	eLearning	[35]
Response time	Quest.	eLearning	[35]
Expressiveness	Quest.	Mobile services	[46]
Perceived adaptivity	Quest.	Mobile services, AT, UbiComp	[49], [55], [57]
Reliability	Quest.	Health IT	[51]
Accuracy	Quest.	Health IT	[52]
Timeliness	Quest.	Health IT	[52]
Personalization	Quest.	Mobile services	[49]
Perceived sociability	Quest.	AT	[55]
Privacy	Quest.	UbiComp	[56], [57]
Integration	Quest.	UbiComp	[57]

TABLE II. PARAMETERS REFERRING TO SOCIAL INFLUENCES AND INFLUENCE OF THE ENVIRONMENT

Parameter	Method	Context	Ref.
Social factors / Subjective norm / Normative influences / Normative pressure / Social influence / Social norm	Quest.	Organizational, Household, Online games, Mobile services	[8], [13], [18], [20], [23] [45], [46]
Voluntariness	Quest.	Organizational	[8], [16]
Image, Social approval, Social outcomes	Quest.	Organizational, Household	[8], [16], [20]
Job relevance, Job fit	Quest.	Organizational	[8]
Observability, Result demonstrability, Communicability	Quest.	Organizational	[8]
Visibility	Quest.	Organizational	[9]
Management support, Institutional support	Quest.	Organizational setting, eLearning	[9], [41]
Facilitating conditions, Perceptions of external control	Quest.	Organizational	[9], [12], [13], [18]
Critical mass	Quest.	Online games	[23]
Context of use	Quest.	Mobile services	[48]

TABLE III. SYSTEM IMPACT

Parameter	Method	Context	Ref.
Visibility	Quest.	Organizational	[9]
Outcome expectations (performance & personal)	Quest.	Organizational	[13], [18]
Utilitarian outcomes	Quest.	Household	[20]
Flow experience	Quest.	Online games	[23]
Cognitive absorption	Quest.	eLearning	[36]
Near-term usefuleness	Quest.	mLearning	[42]
Long-term consequences of use, Long-term usefulness	Quest.	mLearning	[42]
Interruption of traditional practice	Quest.	Health IT	[51]
Resistance to change	Quest.	mLearning	[43]

TABLE IV. PARAMETERS REFERRING TO THE INDIVIDUAL

Parameter	Method	Context	Ref.
Experience / Self-efficacy / Digital literacy / IT knowledge	Quest.	Organizational, WWW, E-commerce, e-Learning, Health IT, UbiComp	[8], [9], [12], [22], [31], [36], [38], [39], [40], [41], [46], [52], [53], [57]
Personal innovativeness	Quest.	Organizational, Mobile services, Health IT	[9], [45], [54]
Cognitive playfulness	Quest.	Organizational, WWW	[9], [12], [21]
Affect / Computer attitude / Computer anxiety / Technology anxiety / Anxiety towards the system	Quest.	Organizational, mLearning, Houshold	[9], [12], [13] , [20], [43]
Habit	Quest.	Organizational, Mobile Internet	[13], [19]
Effort expectancy	Quest.	Organizational	[18]
Age	Quest.	Organizational, UbiComp	[18], [19], [57]
Gender	Quest.	Organizational, UbiComp	[18], [19], [57]
Hedonic motivation / Hedonic outcomes	Quest.	Mobile Internet, Household	[19], [20]
Edudcation	Quest.	Household	[19]
Marital status, Child's age	Quest.	Household	[19]
Trust	Quest.	Online Trading, Ecommerce, AT, UbiComp	[27], [28], [30], [55], [56]
Income, Socioeconomic status	Quest.	Mobile services, UbiComp	[46], [57]
Optimism	Quest.	Health IT	[54]

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