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Methodological Review

Evaluating user interactions with clinical information systems: A model based on human–computer interaction models

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Abstract

Objectives: This article proposes a model for dimensions involved in user evaluation of clinical information systems (CIS). The model links the dimensions in traditional CIS evaluation and the dimensions from the human–computer interaction (HCI) perspective.

Proposed method: In this article, variables are defined as the properties measured in an evaluation, and dimensions are defined as the factors contributing to the values of the measured variables. The proposed model is based on a two-step methodology with: (1) a general review of information systems (IS) evaluations to highlight studied variables, existing models and frameworks, and (2) a review of HCI literature to provide the theoretical basis to key dimensions of user evaluation.

Results: The review of literature led to the identification of eight key variables, among which satisfaction, acceptance, and success were found to be the most referenced.

Discussion: Among those variables, IS acceptance is a relevant candidate to reflect user evaluation of CIS. While their goals are similar, the fields of traditional CIS evaluation, and HCI are not closely connected. Combining those two fields allows for the development of an integrated model which provides a model for summative and comprehensive user evaluation of CIS. All dimensions identified in existing studies can be linked to this model and such an integrated model could provide a new perspective to compare investigations of different CIS systems.

Keywords: User attitude; Evaluation; Clinical information systems; Acceptance; Model; Human–computer interaction

1. Introduction

Several studies reported sub-optimal adoption rates of clinical information systems (CIS) [1–4]. These failures typically fall into four categories: technical failures, project mismanagement, organizational issues, and the explosive growth of information systems [4,5]. Various studies indicate that organizational issues are the main culprit [1,2,4,6,7], but these studies do not provide clear quantification of the failure rates. What we do know is that less than 20% of all failures are related to technical problems [6]. The implementation of a CIS affects three fundamental aspects of health care systems: structures, processes, and outcomes [8]. The growing presence of computer solutions in clinical and managerial settings [2,9], along with the many problems their adoptions generate, obviate the need for reliable evaluations of user interactions with CIS [10–13].

Evaluation is a widely studied subject and is not specific to medical informatics. It is not a simple process [14]. Rather, it is a multidisciplinary field with no single and straight answers to questions about what and how to do evaluation [4,8,15]. The intricacy of evaluation is widely recognized, and this issue is more obvious in healthcare than in any other domains [16]. In the long list of difficulties about evaluations

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encountered in healthcare, the following stand out: the complexity of the evaluated object [14]; the importance of the professional status [17]; the particularity of the communication patterns [18]; and the difficulties encountered to measure impacts such as outcomes for patients [4]. These stumbling blocks lead to a central question: are existing frameworks and tools, designed for evaluating generic information system (IS), suitable for CIS assessment? The literature provides no evidence for cross-context appropriateness of measures [19]. Furthermore, several studies provided negative answers to this question [16,17,20]. Some investigators tried to solve this problem by modifying existing frameworks and tools to include overlooked components [16]. However, this approach has been proven to be ineffective because it does not have enough consensuses and it does not have sufficient comparisons across different claims.

In the context of general CIS evaluation, there is a clear need for a reliable model of dimensions involved in user evaluation of CIS. This model must include a wide range of aspects ranging from characteristics of technology, social and behavioral processes, to impact or influences on users, and organizations [2,8,21]. It requires the use of multiple approaches including both objectivist and subjectivist methods [8,16,22].

The purpose of the current work is to develop such a model for summative evaluations of user interactions with CIS from the end-user point of view. More precisely, it aims at formalizing the attitude of users towards CIS, to identify the dimensions for evaluation. The methodology used to identify core dimensions of acceptance is a literature review combined with a human–computer interaction (HCI) model.

2. Proposed method

To answer the questions of *what* and *how to evaluate*, we performed a review of the literature to identify:

- variables investigated and their definitions;
- indicators used to assess these variables;
- theoretical background;
- study design;
- proposed approaches;
- principal results obtained.

This review is based on articles, proceedings, and books about satisfaction and acceptance surveys published from 1983 to 2003. These papers are a subset of a large repository of papers collected on evaluation and closely related fields such as impact issues, organizational issues, or evaluation processes in general. They are not limited to medical informatics. Selected papers address the following themes:

- focus on user evaluation of information systems;
- identification of dimensions involved in the measured variables;
- critical review or new proposals about existing works (not merely an application of an existing model or framework).

Based on this set of data, a variable was extracted and defined: *IS acceptance*. IS acceptance is not a simple and directly measurable construction, the question of *how to evaluate* requires the identification of dimensions and indicators implied in acceptance building.

To provide a theoretical basis for this construction, we examined models proposed by HCI and how this field defines an interaction [23–25]. Consequently, we built a prototype of an interaction model with dimensions identified as intrinsic properties of user acceptance construction. The prototype was later refined with data collected in the literature review and leads to the model proposed in this paper.

3. Results and model construction

3.1. Descriptions of reviewed papers

For our review of previous studies, we selected 42 papers related to user evaluation of IS, and to the dimensions involved in this evaluation. These papers are selected from 25 journals and 2 textbooks. Among them, 12 (29%) are within and 30 (71%) are outside of the medical field. Fig. 1 shows their distribution over the years. Table 1 summarizes variables evaluated in the studies, segregating papers within and without the medical field. Less than 40% of reviewed papers offer a sound definition of the focused variables. Table 2 summarizes the concrete approaches presented by the papers reviewed, segregating papers that within and without the medical field Fig. 2.

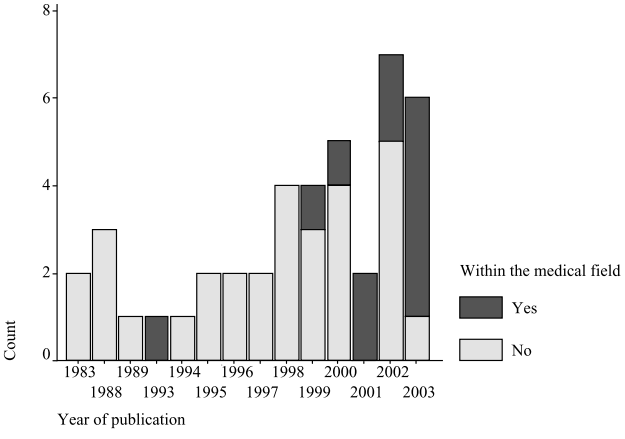

Fig. 1. Distribution of the reviewed papers over years.

Table 1
Assessed variables

Variables	Outside of the medical field	Within the medical field	Total (percentage of the 42 papers reviewed)
Acceptance	2 [26,28]	5 [10,11,17,29,30]	7 (17%)
Affective response	1 [31]		1 (2%)
Crossed[a]	6 [32–37]		6 (14%)
Evaluation in general[b]		5 [4,15,38–40]	5 (12%)
Impact	1 [41]		1 (2%)
Satisfaction	14 [42–55]		14 (33%)
Success, effectiveness or performance	4 [19,56–58]	2 [16,59]	6 (14%)
TTF[c]	2 [60,61]		2 (5%)
Total	30	12	42

[a] Explicit search of dependences between multiple variables.
[b] Papers focus on how to evaluate in general, or on defending mixed approaches.
[c] Task technology fit (TTF).

Table 2
Approaches

Approaches b	Outside of the medical field	Within the medical field	Total percentage of the 42 papers reviewed
Questionnaires	22	3	25 (60%)
Interviews	5	3	8 (19%)
Observations	1	1	2 (5%)
Experimental investigations	2	0	2 (5%)
Literature review	16	6	22 (52%)
Recommendations	8	7	15 (36%)

Among 25 studies that used questionnaires, only 16 (62%) provide the questionnaires in the papers. The latter focuses on acceptance, success, satisfaction, impact, and task technology fit.

3.2. First synthesis of the contents of reviewed papers

As highlighted in Fig. 1, the number of studies focusing on users' interactions with CIS has increased during the past 10 years. This trend reflects the increasing importance of information systems in the workplace, including clinical settings. However, there is mounting evidence showing failures of these systems.

4. Need for frameworks and models

Several studies suggest that a general evaluation framework would be a good tool for descriptions and explanations of findings in these studies [34,57]. This requirement is also emphasized in studies related to CIS [16,20]. In Collins dictionary, framework is defined as: (a) a structural plan or basis of a project; and (b) a structure or frame supporting or containing something. It must allow to: (1) plan an evaluation; (2) understand the implications of the results; and (3) make future predictions [22]. Very few studies take such a formal approach for CIS [20]. The general evaluation process should accompany the entire computerization project [23]. It needs to address all aspects ranging from technical characteristics to individual and organizational issues [8]. Finally, the evaluation process should include usability techniques refined for CIS evaluation [62], cognitive evaluations [63,64], summative evaluations, and quantitative investigations or ethnographic-like observations.

An evaluation framework is a decisional space defined by the characteristics of the evaluation context that helps in the selection of the appropriate approach [19]. Among these characteristics are the project phase, the methods used for evaluation (formative versus summative, qualitative versus quantitative, etc.), and the type of data used (clinical, fictive, etc.). Those characteristics define areas for which sub-frameworks might be implemented to perform specific evaluations.

Summative and qualitative investigations are widely documented and investigated areas. Almost 60% of the studies summarized in Table 2 use questionnaires to measure one or several of the variables presented in Table 1.

5. Variables evaluated

Among the variables summarized in Table 1, three can be identified as important: satisfaction, acceptance, and success.

5.1. IS success

In several studies, success is defined as a variable which is a function of several dimensions [15,57]. It is considered as a multifactor construction depending on context, objectives and stakeholders [15]. In other studies, IS success is presented as a surrogate of user satisfaction [34,47,50,52]. In these cases, it is a one-dimensional construction.

The definition of IS success also depends on the point of view [10]. The criteria that define success for the end-user may not be necessarily used by administrators. In addition, success from one point of view does not

translate to overall success of the project. The latter depends on the integration of the CIS in the complex organizational settings [2]. Kaplan and Shaw [4] classified barriers to successful deployment in the medical field into four categories: (a) insufficiency; (b) factors inherent to a medical environment; (c) project management; and (d) people, organizational, and social issues.

5.2. IS satisfaction and IS acceptance

Among the 42 articles reviewed, half of them evaluated satisfaction (33%) and acceptance (17%). Satisfaction is a complex concept, especially in the context of CIS evaluation. Collins dictionary defines satisfaction as:

(1) the act of satisfying or state of being satisfied;
(2) the fulfillment of a desire;
(3) the pleasure obtained from such fulfillment; and
(4) a source of fulfillment.

More specifically, Bailey and Pearson [43] defined satisfaction in a given situation as "the sum of one's feelings or attitudes towards a variety of factors affecting that situation." In the same year, Ives et al. [50] described satisfaction as "the extent to which users believe the information system available to them meets their information requirements." A recent article of Chin defines satisfaction as "the overall affective evaluation an end-user has regarding his or her experience related with the information system" [46]. Au et al. [42] performed a literature review on user satisfaction to propose a framework for evaluation. Based on a review of existing definitions they characterized user satisfaction as the "overall affective and cognitive evaluation of the pleasurable level of consumption-related fulfillment experienced with the IS."

All of the above-mentioned definitions refer to satisfaction from a user's perspective, but they all shed a different light on what is evaluated and how. Satisfaction can be affective, cognitive, or both when presented as an attitude or a result of attitude measurement. Users' experiences and expectations are important for some researchers, while immediate feelings are essential for others. In addition, as mentioned earlier, satisfaction is widely used as a surrogate of IS success or IS effectiveness [34,43,47,50,57], and it acts as a subjective measure of IS success [50]. Although numerous studies have used this variable replacement, others reported inconclusive, and even contradictory results [37]. Satisfaction is a critical construction [42] that typically lacks comprehensive definitions and agreements among studies [34,37].

Acceptance and satisfaction are treated as equivalent in some studies [11], whereas in other studies acceptance is defined as an encompassment of user satisfaction and IS usage [66]. In Collins dictionary, acceptance is defined as:

(1) the act of accepting or the state of being accepted or acceptable; and
(2) a favorable reception; an approval.

In some studies, user acceptance is often treated as a reflection of whether a system adequately fits the characteristics of the users and those of the task [10]. Acceptance is used more often for CIS evaluation than for IS evaluation. It reflects the achievement of a dynamic construction and thus fits better with the evaluation of an interaction. To our knowledge, acceptance has not been presented as a surrogate of system success, although it is recognized to play an important role in successful adoption of IS [17,28].

Satisfaction and acceptance address the quality of the interaction between the users and the technology, and they can be considered as user attitudes. Attitudes are a compound of three components: affective, cognitive, and behavioral. Scales are a standard method to measure attitudes. They are not absolute measures. They only give a reasonable estimation of the feelings and intentions users express towards an IS [11]. Although generally not very useful on their own [11], such approaches can be used to clarify problems [44] and help decide what further investigations are required. As highlighted by Olson and co-workers [50] an a priori "good" system can prove to be a "poor" solution if users judge it so.

In this paper, we propose the following definition for IS acceptance:

IS acceptance is an attitude of users towards an information system or an information technology. It is a multifactor construction based on an affective and cognitive evaluation of all components surrounding and influencing the interaction process between a user and an IS.

6. Models of literature review

There are many theoretical studies that focus on reviews and refinements of existing models. Several models have been widely used or referenced. As summarized in Table 2, more than 50% of considered papers are literature reviews. As reported by Garrity and Sanders [49], most existing studies are built and derived from previous ones. Furthermore, several subsequent studies show the existence of contradictory or mixed results [10,42], and a lack of agreement among researchers [49]. It seems that these common investigations failed to reveal psychological intricacies and the underlying mechanisms of user evaluation [42]. In addition, some concepts are ill-defined [49].

To identify what is lacking in previous attempts, a review of the most important studies will be very helpful. We begin with a summary of important existing models,

followed by a collection of the main criticisms of these models. This review will also allow us to identify innovative or new dimensions. The important ones will be presented later.

6.1. DeLone and McLean framework

The DeLone and McLean framework (D&M model) focuses on the evaluation of IS success. Success is a multifactor variable of which satisfaction is one of the dimensions. This model was initially built on a literature review of empirical studies with the aim of reducing the number of dimensions measured. The D&M Model have been used and revisited in several studies since its publication in 1992.

The initial model presents six interrelated dimensions of success:

(1) system quality;
(2) information quality;
(3) system use;
(4) user satisfaction;
(5) individual impacts; and
(6) organizational impacts.

The relations between dimensions are presented in the model as following: (1) system quality and information quality lead to system use and user satisfaction that are interdependent; and (2) use and satisfaction induce an individual impact that leads to organizational impact. DeLone and McLean also provided recommendations for concrete evaluations such as measuring interactions between factors identified for each dimension. Their model is theoretical. The selection of concrete measures is context and objective-dependant.

6.2. Technology acceptance model

The technology acceptance model (TAM) aims to predict and explain the user's "intention to use" by understanding factors which lead users to accept or reject an IS. TAM is a specialization of the Theory of Reasoned Action proposed by Ajzen and Fishbein [27] to computer usage. The "intention to use" is assessed and predicted by measuring two variables: IS usefulness and ease of use. Perceived ease of use is defined as "the degree to which a person believes that using a particular system would be free of effort" [28]. Perceived usefulness is "the degree to which a person believes that using a particular system would enhance his or her job performance" [28]. The model is designed for predictions and explicative purposes [65].

In TAM, external variables influence perceived usefulness and perceived ease of use. Both take part in the construction of an attitude that determines the "behavioral intention to use" jointly with perceived usefulness. The actual system use is determined by this behavioral intention to use. In addition, perceived ease of use influences perceived usefulness [65].

6.3. Task technology fit

The task technology fit (TTF) model focuses on performance. Computerization process aims at increasing organizational and individual performance. However, the measurement of such improvements is difficult and requires implementing another dependant variable. Along with other authors, Goodhue et al. [61] argues that user evaluation presents interesting perspectives when it has strong theoretical underpinnings. TTF is presented as one of these theoretical perspectives.

Users belong to an organization in which they have to perform tasks to reach objectives. IS is viewed as a means to achieve these goal-directed tasks. The TTF model hypothesizes that a better fit between user needs and the technology leads to better performances. In addition, users are in a good position to evaluate this fit.

6.4. Disconfirmation theory and dissonance theory

Disconfirmation and dissonance theories are based on the same idea: satisfaction reflects the gap between the perception of the IS in terms of performance and a prior standard [42,46]. This prior standard is expectation. The dissonance theory states that users have a need to maintain consistency by minimizing discomfort created by dissonant ideas. Unmet IS expectations create dissonant ideas (expectations and perceived performance) that have to be reduced by distorting one or both of the ideas [35]. In case of dissonance, users will adapt their level of satisfaction to align it with their prior expectations.

Disconfirmation theory predicts satisfaction by expectations perceived by individuals, perceived performance, and perceived disconfirmation [35]. The disconfirmation theory takes into account the direction of the discrepancy. This is different from dissonance theory where only the size determines satisfaction. Confirmation can take place at three levels: confirmation (no gap), negative disconfirmation (performance $<$ expectation), and positive disconfirmation (performance $>$ expectation) [35]. Based on literature review, Staples [35] showed that there is stronger support for disconfirmation theory than for dissonance.

7. Criticism and refinement of the models

The following criticisms are centered around three issues: (1) modeling discussion; (2) controversial dimensions; and (3) omission of dimensions.

D&M Model is probably one of the most referenced and used models. Among the 42 papers reviewed, 16

(38%) used or referenced this model. In 2002, DeLone and McLean presented a review of 150 articles that referenced their model to highlight improvements and provide recommendations for future measurements [57]. Their review systematically reported most criticisms formulated towards their initial model, with the most important ones leading to a refinement of their model.

The first criticism is about the elements included in the system quality dimension. Because of the development followed by information systems, the organizations also play a role as service providers. Depending of the context and the goal of the evaluation, service quality can weight more or less. Service quality is added to the model at the same level as system quality and information quality. The second criticism is about the importance taken by the impacts and the emergence of new measures. They are highly dependent on the evaluated systems and their purposes. In addition, impacts retroactively influence use and satisfaction. The authors refined their model by merging all impacts (including organizational and individual) in one new component: *net benefits*. They also added a return loop from *net benefits* to *intention of use* and *user satisfaction*. The third improvement suggested by reviewed works is based on studies of Whyte et al. [56] and Seddon et al. [19]. They suggest that the weights of the dimensions depend on factors such as the system evaluated and the stakeholders. DeLone and McLean [57] recognized the importance of the work of Seddon et al. [19] who classified existing measures. Finally, we noticed that because of controversies around the dimension *system use*, it is replaced by *use (intention to use)*.

In 2003, Van Der Meijden et al. [15] performed an extensive literature review to determine if the D&M Model can be used "as is" for CIS evaluations. They found that most dimensions can be linked to one factor of D&M Model. However, in most cases of failures, some dimensions did not fit into any categories, such as the dimensions about organizational culture and context. D&M Model is considered as useful for evaluation of CIS but should be extended to include these two important dimensions.

Concerning TAM, Succi and Walter [17] mentioned that the surveys made with this model are all based on investigations in business fields. For CIS evaluations, they proposed to extend the TAM to include *perceived usefulness towards professional status*. This extension answers the concerns about the importance of the professional status in the acceptance of a new technology. This new dimension has similar relations with the other components of the model. External variables influence this dimension and have an influence on the attitude of the user towards *use*, and *intension to use*.

Another refinement of TAM was performed by Thong et al. [26]. TAM does not provide details about the external variables. Based on other models and theories, Thong et al. proposed to define this dimension precisely. First, they decomposed it into three dimensions: *interface characteristics*, *organizational context*, and *individual differences*. The dimension *interface characteristics* contains terminology used, screen design and navigation. The dimension *organization context* contains relevance of the IS, system accessibility and system visibility. Finally, computer self-efficacy, computer experience and domain knowledge are components of the *individual differences* dimension. Organizational context influences both *perceived usefulness* (but not for all three characteristics) and *ease of use*. However, the interface characteristics and the individual differences only influence *perceived ease of use*.

In the context of medicine, Ammenwerth et al. [30] performed several refinements of TAM dimensions that seem useful for CIS evaluations. The first one is the decomposition of the dimension *perceived usefulness* into four dimensions: *characteristics of the IS*, *characteristics of the users*, *characteristics of the tasks*, and *environmental characteristics* (work of Vassar referenced in [30]). The second refinement is about individual characteristics of the users with inclusion of the notion of "fit" of the individual to the technology [67].

The reviewed papers did not discuss TTF. As stated by Garrity and Sanders [49], implementation of a new system can have profound impacts on task accomplishment. The task support satisfaction is about the fit between the system, the user, and the task. It is evaluated by measuring how the system helps or hampers the user. This dimension is recognized as being important [30], but is not sufficient alone to explain the system success or the satisfaction.

The disconfirmation of expectations construction is widely accepted as being a dimension of end-user satisfaction [42], but several authors mentioned its logical inconsistencies [35,42,46]. Among them, Chin and Lee [46] extended this theory to add the notion of desires in the standard for assessing the gap. In the disconfirmation theory, when the reference for evaluating the gap is only formed by expectations, a user who has poor expectations about a future development is satisfied if the product reaches his expectations. Concretely, if the expectations of a user are poor, because negative previous experiences, he would not be satisfied. The notion of desire allows a disjunction between expectations, generally based on a rational evaluation of the possibilities, and desires that are just what a user expects in the ideal case.

8. Complementary dimensions

Major literature reviews [4,15,16,19,34,42,49] have been published since 1998. Several of them provided interesting developments for the current purpose. New

dimensions and refinements of existing dimensions have been proposed. At a general level of evaluation, a literature review related to the medical field performed by Turunen [16] shows that most existing frameworks and models share three common features. These features are: (1) the emphasis on three components: technology, user, and organization; (2) the evaluation methods used, covering both subjective and objective evaluation methods; and (3) the assumption that the distinct components are highly interconnected, and that outcomes at one level can (but not automatically) lead to impacts on others. In general, it is important to consider the characteristics of the users, the types of activities the users have to perform, the environment of the study and the nature of the system under evaluation [24].

Concerning underlying theories used to explain the construction of the evaluation, Au et al. [42] reported that the expectancy disconfirmation theory is most frequently used but that it failed to explain results obtained. Some problems of this theory have been mentioned above. For the authors, the most significant weakness is the negligence of the inter-individual differences in the construction of the standard used for comparison. Among inter-individual differences, major omissions are the needs of the users and the amount of input or "sacrifice" tolerated in comparison with the reward (fulfillment of needs). Au et al. [42] proposed to add three new referents for comparison: *equitable work performance fulfillment*, *equitable self-development*, and *equitable relatedness fulfillment* extracted from two theories: needs theory and equity theory.

With the aim to provide theoretical basis for the evaluated variables, Garrity and Sanders [49] reviewed the satisfaction construction for the purpose of unifying dimensions. They identified four latent constructions which underlie existing IS success instruments: *task support satisfaction*, *quality of work-life satisfaction*, *interface satisfaction*, and *decision making satisfaction*. They compare these dimensions with the system theory approach, which defines the organization as an open system with four components. They found that these four dimensions are the core dimensions of IS success. All dimensions and indicators proposed in existing models can be reattached to these constructions [49].

Among efforts dedicated to seek theoretical basis for user evaluations, few studies proposed real innovative directions. Existing instruments typically state a linear relationship between measured dimensions and user satisfaction. However, obtained results are not conclusive in all situations [51]. To explain this discrepancy, Sethi et al. [51] proposed that the relation between dimensions and satisfaction is non-linear but "cusp-distributed." This proposition refers to the catastrophe theory that can be useful for situations where both smooth and abrupt adoption behaviors cohabit. The central principle is that at a low level of IS usage, the relation between dimensions and satisfaction is almost linear. However, at a higher level of IS usage, catastrophic changes are observed in satisfaction with low changes in the scores of the measured dimensions. This model offers interesting perspectives in the clinical field where it is often reported that users reject the CIS for reasons that seem obsolete for development management.

In parallel with these attempts to establish a theoretical basis to the study of users–CIS interactions, some studies tried to review existing dimensions and to check if they really play a role in the evaluation. For example, Mahmood et al. [34] performed a literature review of 45 empirical studies to evaluate the relations between satisfaction and nine dimensions usually implemented. They found a positive support for all these nine dimensions but at distinct levels. The most important ones are: *user involvement in IS development*, *perceived usefulness*, *user experience*, *organizational support*, and *user attitude* towards the IS.

8.1. Proposition of a HCI model for user evaluation

The synthesis of results presented above shows that there are substantial interrelations among the studies. The review on dimensions involved in user evaluation provides a constellation of dimensions and variables, but without a clear view of the links between them and the existing complementarities. Theoretical foundations must be established [16] to sketch a model of dimensions involved in user evaluation of CIS. To link them, we propose a model of user–CIS interactions, based on the field of human–computer interaction (HCI) and refined by existing models and studies.

The HCI field is positioned at the intersection of social sciences, behavioral sciences, and computer and information technology [68]. The ACM special interest group on computer–human interaction (SIGCHI) defines HCI as "a discipline concerned with the design, evaluation and implementation of interactive computing systems for human use and with the study of major phenomena surrounding them" [25]. The HCI is broader than just the interface design and it takes into account all aspects related to the interaction [24]. In their introduction to the field, Hewett et al. [25] provided an extensive list of dimensions in human–computer interaction. Although the HCI field shares concerns and theoretical backgrounds with the field of evaluation, these two fields are disconnected [69]. The only important bridge found between them is about the interface characteristics [32,42,45].

9. Dimensions highlighted by HCI models

The HCI field defines four main dimensions, which take part in interactions: *CIS characteristics*, *user*

characteristics, *development process*, and *context of use* (including also use). All these dimensions are defined from an external point of view. As the aim of the proposed model concerns user evaluation, these dimensions must be refined to extract their user related component.

9.1. IS characteristics

Each IS can be defined by several characteristics such as input–output devices, dialogue techniques, computer graphics and architecture. From the user point of view, a CIS is an input–output system that provides support to clinical tasks. Such support includes a process and a response. The process contains indicators such as response time, the logic of the progress, physical interaction (keyboard, voice input, etc.), and support provided by the system during the progress. The response obtained from the IS is evaluated in terms of appropriateness with the user's needs and expectations, clinical relevance of information, quality, and reliability of information, etc.

9.2. Human/user characteristics

As shown by cognitive psychology, individual and environmental characteristics influence all kind of human interactions. For the specific area of interactions with computers, the most important influences are human information processing characteristics, communication characteristics, and physical characteristics.

Users construct beliefs and attitudes based on their current and past experiences. The user attitude towards an information system is built by taking into account the current interaction with the evaluated IS, the past interactions with other IS, and individual characteristics. The individual characteristics include attitude towards innovation in general, level of use (expert, beginners, etc.), amount of use, demographic data in general, etc.

9.3. Context of use and environment characteristics

A computer system cannot be abstracted from the setting in which it is being deployed. It belongs to a social and an organizational context in which users have to perform tasks. Implementing and deploying a new system introduces changes into this context. Several studies demonstrated the tight relations between organizational changes and computerization [4,16]. We have to carefully take these relations into consideration to avoid unexpected gaps between deployed applications and work aspects as well as inconsistencies with existing processes and strategies.

As presented by Preece et al. [24] in reference to Eason (1991), each interaction is surrounded by three environments. The interaction comes within the scope of a given situation, a task, and a specific context that is the first environment. This context is included in a more general space: the workspace. It refers to tasks that the user has to perform and general activities linked to his work. A new CIS has to be adapted to its context of use, workflow, communication patterns, constraints of the environment such as mobility, space available, and manipulation of other existing tools. In return, implementing a new system affects all these dimensions of the environment.

9.4. Development process characteristics

Computerization is a dynamic process involving designs, implementations, and evaluations. Users generally participate in the development process, either directly or indirectly. From the user's point of view, several components of the development process have to be taken into consideration. An important and often discussed component is the user involvement. We have to distinguish user involvement and user participation [70]. The first one is the perception that users have to be included in the development process. The second one is the actual participation of users within the project. Another important aspect is perceived support from the technical team by users (are reported problem fixed?, is there a documentation?, etc.) but also from the organization and the administrative hierarchy, such as reward for time invested in the project, added value of the product for users or answers to managerial and legal needs, etc. Based on the studies performed on the computerization process and organizational components [2,4,5,71], we decided to add to these four components a fifth one: real and anticipated impacts perceived by users.

9.5. Impact or outcome of computerization

As outlined before, bringing a new tool into clinical practices influences users, the environment, and processes. From the user point of view, both "real" and "perceived" impacts are important. A "real" impact could be a concrete change in communication pattern or workflow. An anticipated impact can be the feeling of being controlled or stressed to act in a standardized way. The HCI field mentioned impacts, but it does not formalize them in the definition of interaction. The model proposed in this paper explicitly includes impacts as a dimension of user evaluation.

The proposed model shows the intricacy of five dimensions implied in the interaction between users and the CIS. The weight of each dimension in the building of user attitude depends of the context, the CIS evaluated, and the users.

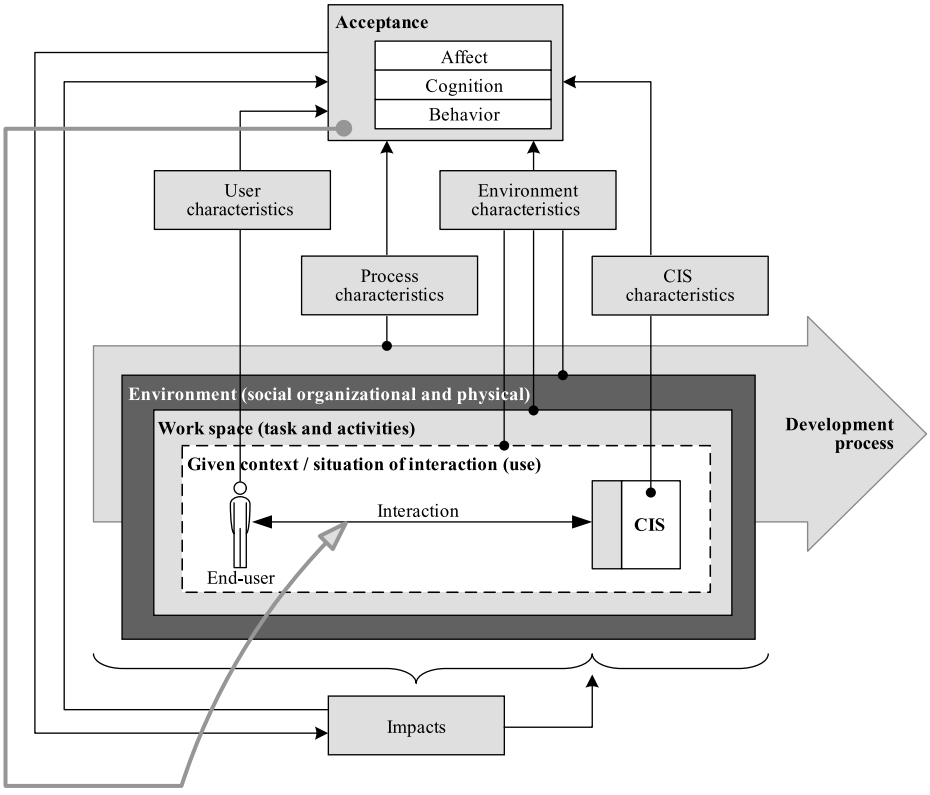

Fig. 2. Dimensions included in the human–computer interaction inspired by HCI models.

10. Discussion

10.1. Merge of approaches

Studies concerning the evaluation focus on several variables other than acceptance. However, models and dimensions presented in this type of work are implied in user evaluation of IS, and are supposed to take part in this construction. Based on the review of HCI literature, we present a model integrating dimensions from the human–computer interaction perspective.

First, we include all dimensions identified during the literature review in our model and specify their links explicitly (see Table 3). Existing studies are also a concrete and important repository of information to find out indicators of dimensions to outline a concrete proposition for an evaluation tool (see Fig. 3).

The only dimension we cannot classify in the proposed model is user satisfaction. It corresponds to the attitude we want to measure. However, in the model presented the user attitude leads to impacts as user satisfaction leads to "Net benefits" in the D&M Model [57].

The second result is that no single model presented in the literature review covers entirely the model proposed in this paper. The omission of dimensions can easily lead to good results when they do not weigh in acceptance. However, it can also bad ones when an important dimension is neglected. For example, in the case of externally developed IS, users encounter fewer difficulties with the development process than for built-in IS.

Table 3
Classification of existing models dimensions in the proposed model

Dimensions proposed	Dimensions of existing models
User characteristics	Individual differences[b] User attitude (other than acceptance)[b] User involvement[b] Expectations Desires
CIS characteristics	IS quality Interface characteristics Information quality
Use/context/environment	IS usage Ease of use[a] Perceived usefulness[a,b] Organizational context Organizational culture
Process characteristics	User participation Organizational support[b]
Impacts	Individual impacts Organizational impacts

[a] Belong to the first described environment: the specific context of the current task.

[b] Dimensions identified by Mahmood et al. [34] to be the most important ones.

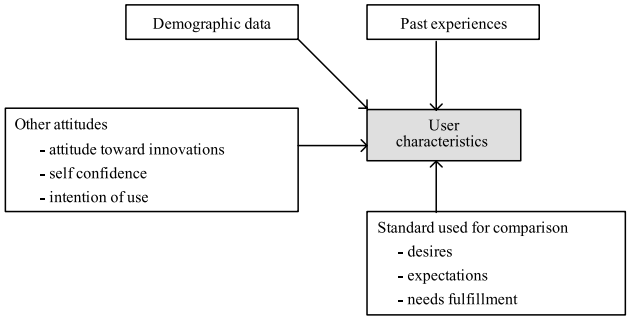

Fig. 3. Sample of indicators included in the proposed HCI model based on the literature review.

Including all dimensions is not always necessary. Depending on the context and the goal of the evaluation a subset of them is sometimes sufficient. However, a model such as ours provides a good reminder of all included components and encourages the identification and justification of omitted dimensions or indicators.

A difficulty remains in the identification of required dimensions and their weight if, according to Sethi et al. [51], we suppose non-linearity. The implementation of a concrete tool depends of the context, the type of applications, and the tasks it addresses. Building a general framework of CIS evaluation should tackle such problems by providing complementary methods to user evaluation. In addition, the proposed model should be detailed using specific results obtained in concrete evaluation studies to highlight influences between dimensions or indicators and their weight in the construction of user acceptance.

11. Conclusion

This paper shows that user evaluation of CIS is a complex task that requires a deep understanding of system, user, and other factors from multiple perspectives. To carry out a successful evaluation, it is necessary to explicitly define the studied variables, to propose a model for dimensions involved in user evaluation, to link existing studies to the model, and to implement an evaluation tool. Our contributions include proposing IS acceptance as a studied variable and developing a corresponding model.

IS acceptance is defined as the attitude of users towards an IS or an information technology. Studying IS acceptance requires an assessment of the way users express this attitude. It is built on the interaction between users and the CIS and includes the assessment of several dimensions.

The field of HCI provides elaborate and systematic descriptions of the nature and properties of interactions between users and systems. Our work shows that HCI is useful in defining and expanding the dimensions in user evaluation of CIS. Our model proposes five dimensions: user's characteristics, development process, context and environment, CIS characteristics, and impacts. All these dimensions contribute to the building of acceptance, and have been refined to reflect the interaction from the user's perspective. In reference to results obtained by the reviewed studies, our model integrated the impact dimension as an antecedent and a successor of IS acceptance.

We have applied our model to a concrete situation as a preliminary testing of the validity and utility of the model. We observed a high degree of agreement with ethnographic-like observations made in parallel. However, the sample size used was too small to validate the model. Further investigations are required to develop a valid and reliable tool with a repository of dimensions usable to evaluate CIS. Further investigations should focus on the concrete implementation of an evaluation tool based on the proposed model. Results obtained from existing studies will certainly help identifying dimensions and the respective weight of each dimension. Finally, the model we presented here, which describes user acceptance evaluation, needs to be included in a more general framework for evaluation of CIS.

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