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Cognitive Evaluation for the Assessment of Information Technology in Healthcare

Marie-Catherine BEUSCART-ZEPHIR[1], Jytte BRENDER[2], Nathalie SOUF[3], Isabelle MENAGER-DEPRIESTER[3]

[1)]*Laboratoire de Psychologie Cognitive, Université Charles de Gaulle, Lille, France;*
[2)]*Medical Informatics Laboratory ApS, Stengårds Allé 33d, DK-2800 Lyngby, Denmark;*
[3)]*CERIM. Faculté de Médecine. Université de Lille 2, Lille, France*

Abstract. The adoption of information technology has increased, and so have the demands that these systems adapt to the physicians' and nurses' work activities. Employment of quality management techniques during the development of IT-based solutions is necessary to ensure that they satisfy the users' requirements.

Some evaluation methodologies, such as KAVAS's, chose to use a continuous assessment protocol as a key strategy for quality management. At each stage of the conception and development of a prototype, it is assessed whether the prototype conforms with the expectation expressed in the users' requirements. The methodology of evaluation is then seen as a dynamic process able to improve the design and development of a dedicated system. The User Requirements Document is cardinal in this respect.

The purpose of this paper is to demonstrate the necessity of including an evaluation of cognitive aspects in the process of evaluation by:

1)evaluation of usability of the Information Technology when integrated in the activities of the users,

2)understanding the motives underlying the users' management of information.

This enables integration of information management in the workload of the Healthcare professionals and the compatibility of IT-prototypes with the daily activity of the users.

1. Introduction

The increasing accessibility of Information Technology (IT) systems during the recent years has had a significant effect upon the Healthcare field. Many Healthcare establishments now operate heterogeneous IT environments with equipment ranging from stand-alone PCs to minicomputers and mainframe installations. There is an ever increasing number and variety of medical IT systems in most areas of Healthcare.

Evaluation methodologies are required to assess the success or failure of these systems. The KAVAS (A1021) and KAVAS-2 (A2019) AIM Projects developed a methodology for assessment during the development of IT-systems [1]. Although it was originally designed for the development of medical Knowledge-Based Systems, the methodology is adaptable to application for assessment of other medical IT applications [2]. The methodology uses a frame of reference, which is based on an analysis of the users' requirements. Thus, elicitation of the users' requirements becomes a critical (first) phase for the whole methodology as well as for the quality management approach in general. For instance, it is necessary for the later Cognitive Evaluation to understand how the IT will be integrated in the users' activities, when a physician or a nurse is performing a cognitive task.

2. Background

The University Hospital of Lille is developing an Integrated Hospital Information System (HIS) to improve the management of information within the medical units and to facilitate the communication of data between these units. The functionalities of the HIS were defined after a complete analysis of data and information flows, using an exhaustive users' requirements analysis [3]. As the HIS develops, new needs appear. The physicians, after the first benefit of the basic procedures, want to develop or to acquire complementary applications, which can help them in their daily work to improve the diagnosis or treatment processes.

The aim of the ISAR (A2052) AIM Project is to integrate prototypes or pre-competitive products from 6 AIM Projects into the HIS platform in the University Hospital of Lille. The issues, when introducing new information systems in a medical department, are:

- How can the IT-system be anchored to the clinical processes in order to support them in an efficacious, effective and efficient way ?
- How can the IT-system adapt to the changes in the clinical processes ?

3. KAVAS's Evaluation Methodology

This Evaluation Methodology suggests an intimate relation between the development and the assessment activities throughout the entire system life cycle, in which the purpose of the assessment is to provide constructive feed-back to the development activities. The main idea is to use the users' requirements (or derivatives of it) as a norm, and to check at each step of the life-cycle if the development of the prototype is consistent with the initial objectives, as defined by the users' requirements.

For example, the users' requirements are converted into a specification book allowing for the development of the software. As soon as a first prototype is created, it must be assessed for conformity, in all its aspects, with the users' requirements as these are expressed in the specification book. This is the Technical Validity Assessment or Technical Verification, and this (second) phase is called the «Validity Phase». In the same way, when the prototype has been installed, a new (third) assessment phase takes place to check if, in real use, the prototype fits with the work flow and work processes and hence conforms with the intentions laid in the users' requirements. This assessment activity is called «Functionality Assessment» [2]. The fourth phase is concerned with assessment of long time impact of the IT-based solution.

4. Assessment of Usability from a Cognitive Perspective

4.1 Experienced Limits of the Current Methodology

As a quality management methodology, KAVAS's Evaluation Methodology is supportive in developing a prototype consistent with the stated users' requirements, but also limited by the conditions and constraints in their formulation. When the users' requirements are defined only from an Information Flow point of view, shortcomings may be experienced:

- Users requirements express general aims and goals that the system is supposed to fulfil. However, directives about the way this aim is reached are not always included. Technical and structural choices may be left to the conceptors' and developers' intuition. Unfortunately, this intuition is sometimes not compatible with the way users perform their task and with their daily activity.

- The current methodology does not include methods for evaluation of the ergonomic and cognitive aspects of the prototype. Thus, although the users' requirements are fulfilled, the result may be a prototype with poor usability and hence poor acceptance [4].

4.2 Objectives: Assessment of Ergonomic and Cognitive Factors

Our hypothesis is that the whole assessment process must take into account human factors, i.e. the users' tasks and the activities underlying the information management activities supported by the new prototype. The main objective of cognitive evaluation is the observation, analysis and modelling of the users' activities when confronted with the IT application. As the users' requirements constitute the norm for the evaluation process, these accordingly has to be extended: users' requirements must include an expression of fundamental constraints linked to main features of the users' activities and tasks.

Doing an activity is not a purpose in itself. An activity is goal-oriented in order to achieve a diagnosis or therapy procedure, or to organise a complex chain of tasks devoted to the management of the patient. So, the activity must be observed not only as the description of the behaviour of the agents but as a series of actions oriented towards an objective that must be identified to understand which strategies the agents develop to achieve their tasks.

Therefore, the first step is the identification of goals or tasks and sub-tasks of the users' activities, and the analysis of the strategies the users develop to perform these tasks (and reach their goals). The second step consists in modelling the activity of the different users inasmuch as this activity is affected by the installation of the new prototype. This model must take into account behavioural as well as cognitive facets of the activities. The third step is to create a normative model which describes the future activity supported by the new tool. The fourth step is to compare the actual and future model to identify the constraints, which the new prototype must respect in terms of activity and tasks. These constraints constitute the additional layer of the users' requirements.

5. Methods

The methods providing the basis for doing the ergonomic and cognitive evaluation are essentially based upon observations and modelling of the users during their activities.

On-site observation of the users' activities, before the installation of the application, is indispensable. The scope of this observation is defined from the users' requirements analysis, the description of the applications, and the characteristics of the prototype. The observation must focus on the part of the users' activities concerned with the IT application to be installed. This observation is supported by video and verbal protocols recorded during the task itself or later while autofacing the videotapes. Interviews and questionnaires are directed to confirm the interpretation of these video and verbal protocols.

Modelling is a schematic description of the activity of the different users and of their interactions within the various phases of their activity. For each user, an activity is divided into cognitive and/or behavioural actions or sequences of actions. For each of them, underlying motives are clearly expressed using the 'scripts ' formalism to express the model. This leads to identification of constraints linked to the goals and which the IT application must respect.

The ergonomic and cognitive evaluation is bi-phasic. One part is realised in a laboratory environment, but with the users. The second part is realised in the unit, where the application is faced with the necessities and constraints of the real activities of the users and their interactions with patients.

6. Results

In ISAR, we applied the extended KAVAS Evaluation Methodology to assess the integration. In this paper, we will use the evaluation of the Anaesthesia Mobile System's (AMS) integration with the Hospital Information System as our example. The AMS was designed in the TANIT (A 2036) AIM Project and developed to collect information before and during the pre-anaesthesia consultation and to give the anaesthetists the possibility of having an understandable summary of the patient's status during anaesthesia. The AMS was integrated with the HIS for importation of administrative and medical history data (stored in the HIS) and for exportation of the anaesthesia report after consultation.

6.1 Observation of the Users' Activities

Pre-anaesthesia consultation involves simultaneous activities: (1) examination of the patient (behavioural activity); (2) planning the collection of critical information regarding anaesthesia (cognitive activity); (3) writing down the information. During the induction of anaesthesia, the physician frequently glances at the pre-anaesthesia record. In the operating theatre 2 or 3 vital elements of information, which are underlined (or written in red colour) on the sheet of the medical record are read quickly (this sheet often rests on the patient's stomach) while the hypnotic medication is administered.

The above observations demonstrate the difficulty of computerising the anaesthesia record:

- During the pre-anaesthesia consultation, it is difficult for the physician simultaneously to:
  - perform the clinical examination,
  - extract the relevant information (relevant for anaesthesia) to be recorded, and
  - browse through screens and catalogues using check-lists to enter the information.
- Information must be easily reachable in every place of the operating theatre, even if the stomach of the patient is not the best place for a computer.
- During the anaesthesia induction, it is impossible to push a syringe while reading two or three screen pages of data on the computer, unless the data retrieval is very comfortable.

However, this essential description of the physician's activities does not appear in the users' requirements. It is therefore necessary to judge quickly whether or not the tool's integration within the users' activities will cause problems. If there is a risk of this kind, a sufficiently detailed description of this activity is necessary to anticipate the interaction between the users' activities and the future tool. This description must enable constraints to be defined: (1) for the detailed specifications, (2) where necessary for the functional specifications, (3) and in any case, for ergonomic choices concerning the interface.

When data reading/writing activities supported by the computer system are parallel or compatible with the other (reading/writing) activities within which they are integrated, no real problem will occur.

6.2 Motivations and Goals Orienting Data Acquisition and Management

Another key dimension of the prototypes' integration in the users' daily activities concerns the motives underlying these data writing/handling/reading activities. Each user has his/her own representation of his/her task in general, and of each sub-task, sub-sub-task, in particular. These representations enables the derivation of plans to organise and finalise the activi-

ties. The specific data reading/writing activities are a part of these general plans, and can be put to use to perform other activities or sub-activities:

- For the AMS, the consultation involves writing medical data to pinpoint specific risk factors and conditions for the anaesthesia, to avoid catastrophes. A strategy for selecting and underlining some of the data is therefore essential. The general objective is that, on the basis of an electronic record containing the data of the pre-anaesthesia consultation, the anaesthesiologist organises the anaesthesia. The paradox is that if the record is (too) complete, the information is too crowded and this will actually contradict the objective.
- The AMS evolved to offer a «Summary» function, following the users' intuition that whatever the number of pages of the file, these would not enable a fulfilment of its purpose during the consultation, inasmuch as this is tied up with the anaesthesiologist's activities. The expressed users' requirements did not provide any information on the objectives pursued by the users when handling (entering,...) data. Therefore, it is not only the users' usual activities that need to be described, but also the purpose of these activities, and particularly of the data handling activities. Tasks must be described.

7. Discussion and Conclusion

With the development of Information Technologies in the Healthcare domain, the necessity of quality management becomes obvious. More often, the quality plan considers only the technical aspects of software engineering, debugging, performances, transferability. In some cases the Human-Computer Interfaces are also evaluated on subjective scales to identify their quality or the users' mental workload.

There is a crucial need to involve the users in the assessment activities, even if parts of the evaluation are realised in a laboratory environment before installation. KAVAS's Evaluation Methodology provided us with a coherent four phased methodology taking into account the technical and functional issues and the impact. But we demonstrated that even this coherent methodology had to be completed by a cognitive approach to get a better understanding of the connection between data management and the users' activities and with the goals they want to reach. These two axes of evaluation are concerned with the usability of the system.

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