Evaluation of Health Information Applications in a Lifecycle Perspective

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Abstract: Healthcare is facing huge challenges in terms of implementation of the Information Age, the technological advanced, in combination with the political and societal changes that at the same time leads to structural changes. Constructive evaluation, evaluation being the act of bringing about the decision-making basis, is perceived as the means with which to minimise failure and maximise success from the very beginning of the development or implementation ("better prevent than cure problems"). Lessons from case studies on criteria for success and failure, as well as obstacles and barriers towards the success of health information applications (IT-based solutions) are discussed within a lifecycle perspective of these systems.

Keywords: Evaluation; Assessment; Information Systems; Success Criteria; Obstacles and barriers; Lifecycle.

Introduction

Dramatic advances in the technology, combined with continuous changes in the economy, political and regulatory environments, seems to be the rule today for society in general and healthcare in particular. Stephen Dinan brilliantly expresses the evolution of man's conditions over time, and from this perspective clearly deduces the fast approaching challenges that mankind will face [9]. Today political, business and economical changes take place at an incredible speed, affecting regions and nations alike as well as people and professions. The Transformation Age is beginning, while the Information Age is barely implemented to its full extension. Considering the multiple aspects of societal evolution, it becomes obvious that there is a parallel pattern of evolution for organizations and practices, not least in healthcare while still in the beginning of its Information Age.

Who would imagine a financial institute, like a bank, being run by paper and pen? Healthcare's analogue of paper-based clinical practice still exists many, many places even in the western world. So the strive for healthcare to catch up with the technical opportunities and the environmental push necessitating this, is a huge transformation task that is ahead of us. Implementing non-trivial, state-of-the-art IT-based solutions within a healthcare environment is a change process of proportions. So much more than other domains, as healthcare not yet to the same extent as other domains has adopted the opportunities provided by information technology. We see evaluation as the means with which to minimise failure and maximise success from the very beginning of the development or implementation of IT-based solutions, health information applications.

In the context of IT-based systems and solutions in healthcare, *Evaluation is the act of measuring or exploring properties of a health information system (in planning, development, implementation, or operation), the result of which informs a decision to be made concerning that system in a specific context* [1].

Evaluation has no justification in itself, - it has to have a purpose. Metaphorically speaking, evaluation is like a torch being waved in the dark in front of you, screening for options, obstacles and barriers, diagnosing problems within a vast of observations, prognosing risks, while monitoring success and failure factors. Subsequent to evaluation, it is the responsibility of the project management and its team members to treat identified obstacles and symptoms of failure by adapting and refining the trail of activities within the plan pursued, with respect to content, emphasis and/or approach.

One may identify an infinite number of evaluation activities during planning, development, implementation, or operation of a health information application. As system development and implementation activities of for instance an electronic healthcare record are utterly complex and virtually indeterministic, so are the evaluation activities to be employed. A substantial number of evaluation methods exist [6], but are not appropriately known to its target users [1], as also concluded by a study of pitfalls and perils in assessment of IT-based solution in healthcare [5]. This makes the statement made by Symons & Walsh in 1988 so important, see the text box, still unfulfilled in the year of 2004. A Delphi study on research needs and priorities involving a panel of highly esteemed experts in the field of health informatics ranked both usefulness (or relevance) and cost-effectiveness of business process re-engineering at the very top of the total list of research needs and priorities [7]. To guide healthcare safely through its information and transformation age, evaluation has to proceed from the summative evaluation it was formerly held to be and onto the challenges of formative evaluation (also called constructive evaluation) throughout the lifecycle of its IT-based solutions.

> "The recognition that evaluation has covert as well as overt functions necessitates its treatment as a social activity rather than the purely formal procedure it was previously held to be. .... we view evaluation not as the application of a set of tools and techniques, but as a process to be understood. By which we mean an understanding of the functions and nature of evaluation as well as its limitations and problems."

Case Studies on success and failure characteristics

A couple of extensive studies of system development cases inform us of the most likely success and failure characteristics. Note however, the differences in their approach, which might influence the completeness of the details of the outcome, but maybe not influencing the relative scoring of success and failure characteristics. The first study is an in depth case study, the second study is a literature study based on mainly proceeding papers, and the third study is an extensive interview study.

Bikson and Evelyn in [2] report from the analysis of 55 cases on computerization of information intensive work. The authors are US-based but do not state whether or not all of their cases also are. They conclude "properties of the implementation process--the sequence of events that starts with the selection of a new tool and ends with its incorporation into ongoing work--are strong predictors of subsequent organizational outcomes." and "Successful transfer of flexible interactive tools is associated with continued and reciprocal changes in tasks and their supporting technologies, while unchanging routines are more likely to signal failure." Thus, they point at the implementation process and change management as strong predictors of successful implementation rather than technical issues. They identify 5 specific indicators of success, see the text box. These are all of an organisational nature. They also note that "precise plans were typically observed to be rigid and centralised, allowing little opportunity for technology adaptation, task reinvention, experimentation, or even mid-course correction", i.e. a barrier to successful implementation of an IT-based solution.

Top indicators of success*) [2]:

1) User participation seems to be the most effective way to link complex tool development to substantive task performance, and consequently with a major influence on successful outcomes
2) Successful transfer of computer-based tools is associated with a flexible planning that balances efforts to social and technical components of the implementation process
3) High-quality and long-term learning support
4) The users' attitude towards change as a positive, problem-solving and achievable goal benefiting management and employees alike
5) The users conception of their own status as regards technological innovation, - a perception of being on the leading edge characterized successful implementation

*) Not in order of significance.

Crosswell [8], also US-based, yet this prize-winning study goes beyond American cases, synthesizes common lesson on obstacles for success at the implementation of IT-based solutions, primarily from a literature study of 39 articles on major GIS and information system publications, mainly conference proceedings, analysed within a framework of 33 items containing a mixture of organisational and technical aspects. As major obstacles they identified the issues shown in the text box below. Even if one shall give less evidence to literature studies than to thorough case studies due to the risk of a publication bias, particularly

within proceedings (see the discussion within [5]), Crosswell's study seems to confirm that the organisational environment does include highly significant obstacles and barriers to successful implementation of IT-based solutions.

Price Waterhouse together with the market research company Mori have interviewed and analysed 500 recent development projects world wide, including IT-implementation projects, while looking for challenges and barriers to success [14]. The conclusion is similar to the previous two reviews, albeit more detailed in the results presented. It is not feasible to inspect their line of causal reasoning within the study layout and implied results, and hence, there might be second or third order effects within the list of symptoms looked for. For instance, 'an incomplete or absent vision' as a significant score of barriers to successful change, may be highly correlated to a lacking commitment of the management: their no 4 'lack of middle management support' (38%), no 5 'insufficient communication' (35%), no 6 'insufficient training and coaching' (35%), no 8 'employee opposition' (33%), no 12 'no perceived need for change' (30%), whereas 'an unrealistic vision' itself scored as number 22 out of the 23 registered with 14% experiencing it as a barrier to success [14]. Nevertheless, it is concluded important that a clear corporate vision is shared by the entire organisation. Their framework includes people issues, project management issues, communication / perception issues and technical issues of a general nature. The study's top 15 list of obstacles to success (averaged for Europe) is seen from the text box. Indeed, the organisational issues (people and management and communication) issues do dominate the list.

Major obstacles[#)] to success [8]:

i) Organisational coordination and conflicts, including power struggles
ii) Data and software standards / data integration
iii) Planning / management support
iv) Training / understanding of technology
v) Database structure and source materials
vi) Funding availability or justification
vii) Data communication and networking
viii) Apathy / fear of change
ix) Software complexity / maturity of technology
x) Staffing availability / recruitment

[#)] In decreasing order of significance.

Obstacles to success[§)] [14]:

a) Insufficient management of change skills
b) Competing resource priorities
c) Presence of functional barriers (comment: a technical barrier)
d) Lack of middle management support
e) Insufficient communication
f) Employee opposition
g) Insufficient training and coaching
h) No perceived need for change
i) Long lead-time on IT solutions
j) Initiative fatigue
k) Bottom line benefits not understood
l) Insufficient involvement of employees
m) Insufficient focus on people issues
n) Inappropriate leadership style at the top
o) Lack of clarity of objectives and vision

[§)] In decreasing order of significance.

A factor like 'fear of technology' so often presented was not mentioned in any of the three studies, presumable because information technology today is becoming every family's possession and hence, no longer is seen as the threat it previously was. It was listed on PriceWaterhuse's list of obstacles ([14]) as number 20 globally. Nevertheless, quite a number of items on their list may be second order effects originating from fear or resistance to change. Crosswell included 'fear of change as one of their investigated variable, however, it scored as low as a shared position as no 8 to10 out of 10 scoring factors [8].

These three studies, considered major review efforts, all points at strong indicators of success and failure residing within the IT-system's organisational context, from the beginning of their lifecycle till full-blown operation. Looking at Haimes & Schneiter's definition of a 'system' as,

"All the components, attributes and relationships needed to accomplish an objective" [12],

… this comes as no surprise: the soft human issues, the qualities and characteristics of the organisation, its inhabitants and their mutual interactions at every level from psychology, anthropology and sociology to law and liability are factors shaping the success and failure of IT-based solutions within healthcare. A 'system' covered by an IT-based solution usually are not constrained to a single user's task but includes a conglomerate of activities distributed on one or several departments. From this, one understands partially the reason behind the above concluded obstacles and success criteria: IT-systems are not just technological constructs! They are as much dependent on a number of soft human-oriented aspects, ranging from ergonomic

and cognitive aspects to the technical aspect and beyond to the social nature of the job situation, the organisational structure and peoples' social interactions.

This forces us to point at the cultural dependency of this entire discussion: It is more or less valid within the European and associated Western cultures. However, within the Asian culture, the employee-manager relation has another purport, and an end-user centred approach is not feasible [13], as end users disapprove of being involved at all. The reason is intrinsic to their culture and their perception of their role within the organisation. This cultural diversity is visible within the results of [14].

A European study of differences in employee participation was carried out on past technology innovation and expectations for their future participation in technology planning and implementation [10]. Four parameters were measured: Employee participation in terms of A) 'negotiation/joint decisions', B) 'consultation', C) 'information' and D) 'no involvement'. The study shows that managers and employees in most EU countries agree on the distribution on the four categories for past technology developments both for the planning and implementation activities, while there are severe discrepancies as regards their prognosis for the future. Notably, both with respect to the past observations and the future anticipation there is a considerable difference, within Europe (!), in approach to the process of IT-system implementation and its principles of user involvement (see additional details in [4], in case reference [10] is difficult to get hands at). Viewed in the perspective of the above mentioned success criteria, obstacles and barriers, one might expect the success and failure ratio to be different in the North and South of Europe. However, this need not be the case, as one must see a culture as a whole; people are brought up, acting and behaving within their specific cultural setting, and hence, the success criteria, obstacles and barriers will depend on the dominant, local cultural setting, as also found by [14]. The issue of success and failure criteria is not simple.

Evaluation viewed in a lifecycle perspective

Referring back to the perspective of the different types of evaluation, from the metaphoric tasks adopted from the domain of medicine: evaluation may include screening for options, obstacles and barriers, diagnosing problems within a vast of observations, prognosing risks, while monitoring success indicators and failure factors. Evaluation is the act of measuring properties and characteristics of an object of study. Thus, it is obvious that evaluation activities may address one or many of the entire spectrum of independent variables within a system development or implementation project, from the conception of an idea till the completion of the system's purpose.

Applying the lifecycle model for health information systems as viewed in Figure 1, we see four major phases [3]:

1) The Explorative Phase, which addresses the more strategic issues related to the future development, like objectives, intentions, basic principles, relevance and feasibility (both technically and within the organisation). This phase concludes with a User Requirements Document (URD) including the mentioned aspects, plus an Enterprise model, etc. The URD shall contain the necessary set-up and background information for a development project and its assessment activities, while appropriately taking into account the success and failure parameters. The user assessment within this phase is concerned with for instance, the feasibility, coverage, and compliance of the system to the organization, as well as viability and testability of the URD.
2) The Technical Development Phase, which is concerned with the technical implementation from systems analysis to technical installation and setting up of the daily practice within the context of the new system. Except for real system development projects, the user assessment in this phase is fairly limited. It includes the technical verification (verification of the IT-construct against a technical specification or a contract), early ergonomic and cognitive assessments prior to application of the system into real practice.

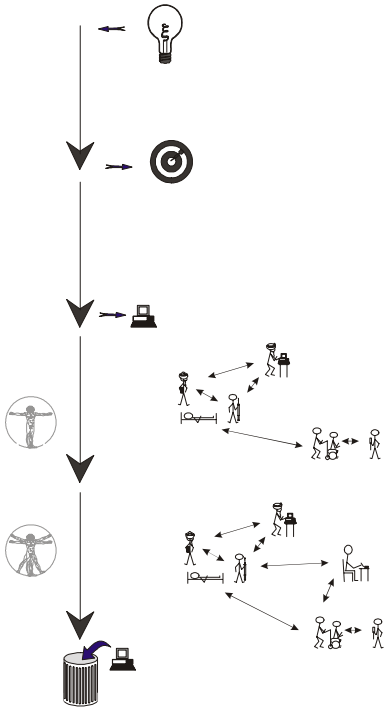

Figure 1: A 4-phased lifecycle model for IT-based solutions. Note that 'phase' means "a segment of work", indicating that the phases may be iterated in parallel.

3) The Adaptation Phase (previously called Maintenance Phase) covers the early stages of real practice of the IT-system in daily operation and is concerned with adaptation of work procedures and system functions to one another. User assessment in this phase turns much more concrete and substantial in terms of ergonomic assessment, cognitive assessment and validation of the functionality[1].
4) The Evolution Phase includes long-term maintenance and further development of the system, both in technical and organisational terms. The assessment activities in this phase are concerned with assessment of unforeseen or adverse effects and long-term effects in a broad organisational perspective, including objectives assessment and impact assessment.

When looking at the different types of health information applications, a pattern of differences in assessment focus emerges, see Figure 2, as also discussed at the joint IMIA WG 13 and 15 working conference in Helsinki [11].

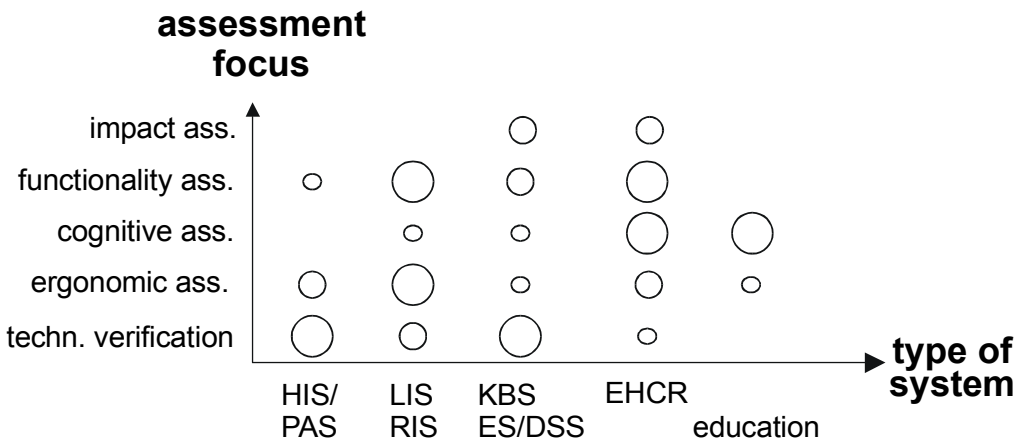

Figure 2: Assessment focus for different types of health information applications. (HIS: Hospital Information System; PAS: Patient Information System; LIS: Laboratory Information System; RIS: Radiology Information System; KBS: Knowledge-Based Systems; ES: Expert Systems; DSS: Decision Support Systems; EHCR: Electronic Health Care Record).

Although this model is hypothetical, this pattern illustrates the relative importance (as signified by the relative area of the circles) of different types of assessment for the success of such health information applications, when looking at the lifecycle as a whole. For instance, a HIS/PAS is concerned with circumscribed, non-mental tasks, performed repeatedly and invariably by the same, large group of staff; the relative importance is on the technical validity of the system, since it is impossible to train a large group how to deal with bugs and technical inadequacies. In this case, the cognitive aspects are less important for repeated interactions with the IT-systems. LIS systems are highly intensive on providing decision-support to the highly complex and data intensive analytical production in clinical pathology (clinical biochemistry), suffering from data plethora, handled by a fairly small and invariant group of staff; consequently, functional and ergonomic aspects of the man-machine interaction are highly significant to achieve efficiency. The EHCR is perceived as the control panel (a kind of cockpit) providing the decision-making basis for a very large, composite and highly variable group of healthcare professionals dealing first-hand with the dynamically changing aspects of a single and particular patient; consequently, important aspects to consider are the cognitive and functional aspects if one wants to avoid a failure. The emphasis on the technical validity for KBS/ES/DSS relates to a strong demand on the validity of their recommendations to a user.

[1)] Ergonomic assessment is concerned with the users' practical and mental workload when physically operating the IT-system. Cognitive assessment is concerned with the compatibility of an IT-system with the real cognitive processes involved in the user's accomplishment of an activity, such as a physician's mental processing when diagnosing a patient. Functionality assessment addresses the fitness of an IT-system with the work processes of the organisation, in which it is operating. [3].

Discussion

In view of the challenges facing healthcare, the observations of the Innsbruck Declaration [1] are confirmed and the consequent recommendations are strongly supported. Methods do exist, but dissemination and an awareness creation is needed. Bibliographies of evaluation studies do exist, but need an ongoing extension. Initiatives to establish recommendations for good evaluation approaches as well as a standard for reporting from evaluation studies are being established under the umbrellas of EFMI's and IMIA's Working Groups on Evaluation. Et cetera. So far, so good.

We have seen above selected reviews within the literature point at people issues and organisational aspects as critical success and failure indicators for IT-based solutions in general. Irrespective of whether or not the above mentioned studies have been designed in a way that does not fully expose potential technical barriers, for instance due to publication bias or (in-)deliberate delimitations in the study approach, the significance of major obstacles residing within the IT-systems' organisational environment is evident. Thus, there are (at least) the three groups of success and failure indicators indicated in Figure 3. The 'people' aspects are concerned with behavioural aspects (psychological, social, cultural aspects). The organisational aspects are concerned with not only management issues (patterns of competence and responsibilities) and structural arrangements (establishment and maintenance of work procedures, principles of communication, etc), but also with vision and values.

There are technical barriers, and will continue to be, as future applications will continue to exploit the technical advances. The number of truly successful applications fulfilling the prospects of the Information Age is still limited; examples hereof may be deduced from the needs pointed out in [6], but include for instance the informed patient, the electronic healthcare record and clinical knowledge-based systems.

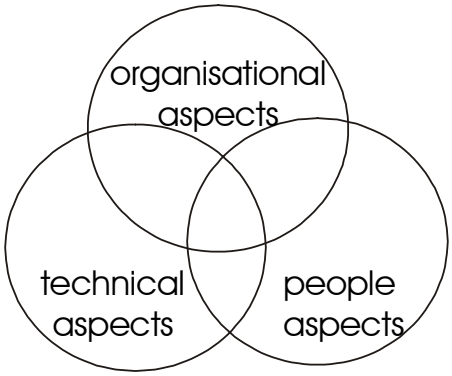

Figure 3: The three groups of factors determining success or failure of IT-based solutions

Then, what is really the future challenge of evaluation within healthcare? The turbulent context of healthcare in general is briefly discussed, pointing at the challenge of having a Transformation Age in parallel with the Information Age, both pointing at a huge need for change management and business reengineering, confirmed by the Delphi study on research needs and priorities in [7]. Unfortunately, diagnostic and prognostic evaluation tools specifically for constructive planning purposes are sparse. A toolbox of evaluation methods is needed that will support the transformation / change management by efficient and effective means for identifying the problem areas and predicting solution within an organisation and among its individuals.

Evaluation of ergonomic and cognitive aspects is a less developed area within evaluation of IT-based solutions, which is desperately needed as the functional complexity of health information applications grows. Functional complexity is destined to grow as simple solutions are always implemented first, thereby pointing at another major challenge: the need for developing far better evaluation methods dedicated to ergonomic and cognitive aspects.

Then the ultimate challenge: The illustration in Figure 3 of the three groups of factors determining success or failure is depicted in 2D, flatland. However, there is a multitude of complexity higher than this: All three groups have a huge solution space, an internal dynamics, patterns of variation in practice, and each are dynamically evolving. To encompass this will raise the figure to a 4D illustration. Today's evaluation methods are at best able to handle a little more than 2D, but not able to capture and far less able to cope with the dynamics of organizations.

References

[1] Ammenwerth E, Brender J, Nykänen P, Prokosch H-U, Rigby M, Talmon J. Visions and strategies to improve evaluation of health information systems; Reflections and lessons based on the HIS-EVAL workshop in Innsbruck. (submitted April 2004).

[2] Bikson TK, Eveland JD. Technology Transfer as a Framework for Understanding Social Impacts of Computerization. In: Smith MJ, Salvendy G, eds. Work With Computers: Organizational, Management, Stress and Health Aspects. Proceedings of the 3rd Conference on Human-Computer Interaction. Amsterdam : Elsevier. 1989;**1**:28-37.

[3] Brender J. Methodology for Assessment of Medical IT-based Systems - in an Organisational Context. Amsterdam:IOS Press, Studies in Health Technology and Informatics 1997;**42**, pp. 295.

[4] Brender J. Methodology for Constructive Assessment of IT-based Systems in an Organisational Context. Int. J. of Med. Informatics 1999;**56**:67-86.

[5] Brender J. Methodological and methodical perils and pitfalls within assessment studies performed on IT-based solutions in healthcare. Technical Report of theVirtual Centre for Health Informatics May 2003; **03-1**. (ISSN 1397-9507), pp. 69.

[6] Brender J. Handbook of Methods for Technology Assessment of IT-Based Solutions within Healthcare. Aalborg: EPJ-Observatoriet, ISBN 87-91424-04-6, June 2004, pp. approx. 250. (in print, in Danish)

[7] Brender J, McNair P, Nøhr C. Research Needs and Priorities in Health Informatics. Int J Med Informatics 2000;**58-59(1)**:257-289.

[8] Crosswell PL. Obstacles to GIS Implementation and Guidelines to Increase the Opportunities for Success. URISA J 1991;**3(1)**:43-56.

[9] Dinan, S. Towards the Transformation Age. Journal of World Futures 2002; **Jan**. (also available on www.transformunity.com, last visited 22nd of February 2004).

[10] Fröhlich D, Gill C, Krieger H. Workplace Involvement in Technological Innovation in the European Community, Vol I: Roads to Participation, European Foundation for the Improvement of Living and Working Conditions, Dublin, 1993.

[11] van Gennip EMSJ, Lorenzi NM. Results of discussions at the IMIA WG 13 and 15 working conference. Int J Med Informatics 1999;**56(1-3)**:177-180.

[12] Haimes YY, Schneiter C. Covey's Seven Habits and the Systems Approach: A Comparative Approach. IEEE transactions on Systems, Man and Cybernetics 1996;**26(4)**:483-487.

[13] Malling P: Implementation of Information Technology in Thailand; Master Thesis (Organisational Psychology) at Copenhagen University, Psychology Laboratory at Copenhagen University, Copenhagen, 1992 (in Danish).

[14] Without Change There is no Progress – Coping with Chaos, a Global Survey. Price Waterhouse, 1997.

[15] Symons V, Walsham G. Evaluation of Information Systems: A Social Perspective. In: Bullinger HJ, Protonotarios EN, Bouwhuis D, Reim F, eds. Information Technology for Organisational Systems, Concepts for Increased Competitiveness. Proceedings of the 1st European Conference - EURINFO '88. Amsterdam : North-Holland. 1988:204-211.